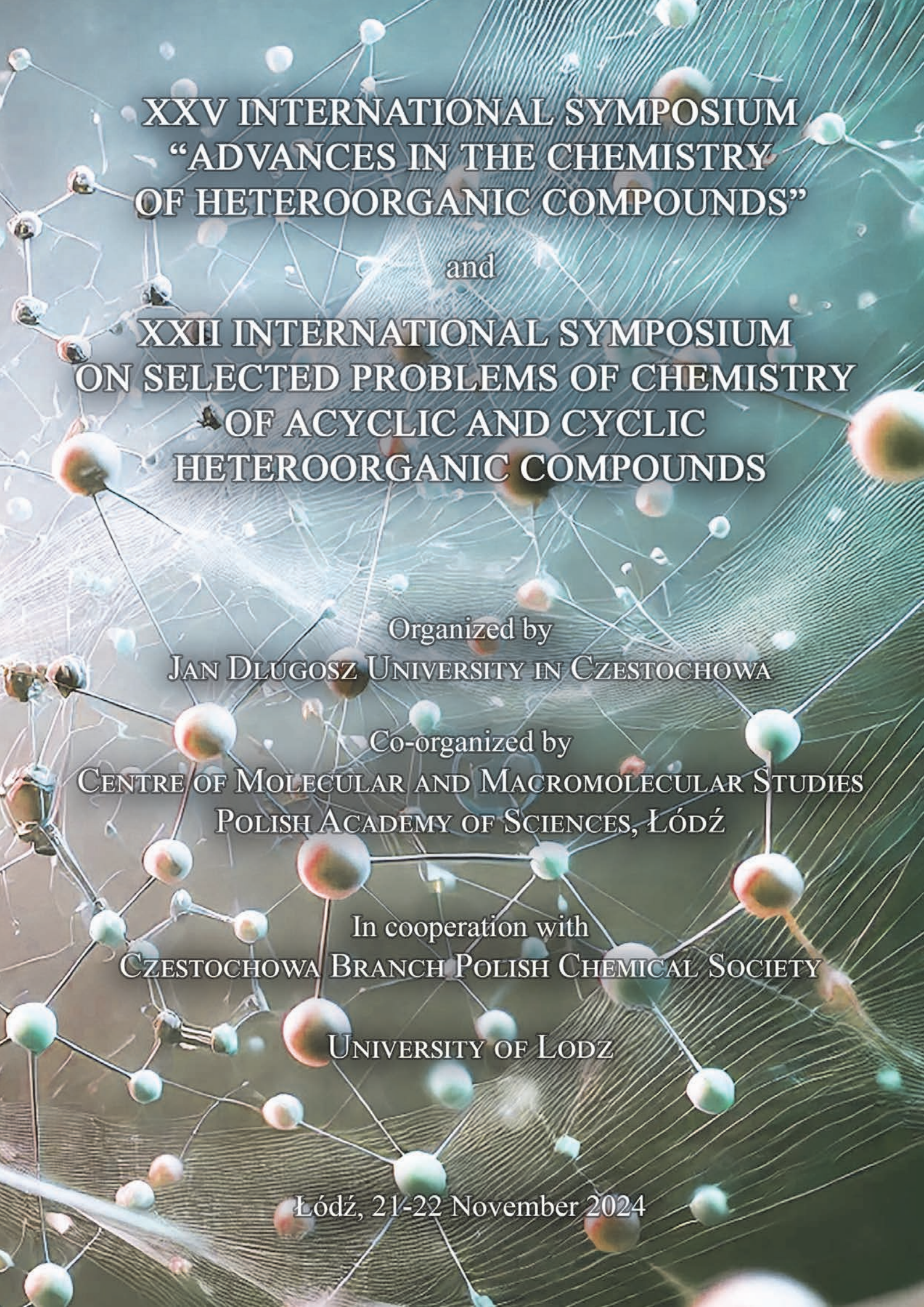

XXV INTERNATIONAL SYMPOSIUM "ADVANCES IN THE CHEMISTRY OF HETEROORGANIC COMPOUNDS"

and

XXII INTERNATIONAL SYMPOSIUM ON SELECTED PROBLEMS OF CHEMISTRY OF ACYCLIC AND CYCLIC HETEROORGANIC COMPOUNDS

Organized by

Jan Dlugosz University in Czestochowa

Co-organized by

Centre of Molecular and Macromolecular Studies
Polish Academy of Sciences, Łódź

In cooperation with

Czestochowa Branch Polish Chemical Society

University of Lodz

Łódź, 21-22 November 2024

XXV International Symposium "Advances in the Chemistry of Heteroorganic Compounds"

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XXV International Symposium
"Advances in the Chemistry of Heteroorganic Compounds"

XXII International Symposium on Selected Problems of Chemistry of Acyclic and Cyclic Heteroorganic Compounds`

November 21, 2024 (Thursday)

9:00 – 9:30	**OPENING**	
SESSION I – chairman: Marian Mikołajczyk		
9:30 – 10:15	PL-01	**Stanisław Penczek** Centre of Molecular and Macromolecular Studies Polish Academy of Sciences, Poland *Polyalkylenephosphates Mimicking Biomacromolecules; Syntheses and Applications*
10:15 – 11:00	PL-02	**Marcin Jasiński** University of Lodz, Poland *Development of synthetic access towards fluorinated pyrazoles of biological importance*
11:00 – 11:30	**COFFEE BREAK**	
SESSION II – chairman: K. Michał Pietrusiewicz		
11:30 – 12:15	PL-03	**Claudio Santi** University of Perugia, Italy *Molecular Iodine as a Versatile Catalyst/Reagent in Organoselenium Mediated Reaction*
12:15 – 13:00	PL-04	**Bert U.W. Maes** University of Antwerp, Belgium *Guaiacols from wood as building blocks for fine & specialty chemicals*
13:00 – 14:00	**LUNCH**	
SESSION III – chairman: Radomir Jasiński		
14:00 – 14:45	PL-05	**Ignacy Janicki** Centre of Molecular and Macromolecular Studies Polish Academy of Sciences, Poland *Z-Selective Horner-Wadsworth-Emmons reactions – development of the new reagents and their application*
14:45 – 15:30	PL-06	**Mao Minoura** Rikkyo University, Japan *Recent Advances in the Development of Triptycene-based Compounds: Can Curiosity-driven Research Contribute to Green Chemistry?*
15:30 – 17:00	**POSTER SESSION I (P1-001 – P1-059)**	

XXV International Symposium
"Advances in the Chemistry of Heteroorganic Compounds"

XXII International Symposium on Selected Problems of Chemistry of Acyclic and Cyclic Heteroorganic Compounds`

November 22, 2024 (Friday)

SESSION IV – chairman: Stanisław Penczek		
9:30 – 10:15	PL-07	**Marc Gingras** Aix-Marseille Université, France *The Sulfur Dance" Around Arenes and Heteroarenes - the Reversible Nature of Nucleophilic Aromatic Substitutions*
10:15 – 11:00	PL-08	**Grzegorz Mlostoń** University of Lodz, Poland *New Cycloaddition Reactions of Levoglucosenone (LGO) and Some exo-Cyclic Enones Derived therefrom*
11:00 – 11:30	**COFFEE BREAK**	
SESSION V – chairman: Piotr Bałczewski		
11:30 – 12:15	PL-09	**K. Michał Pietrusiewicz** Maria Curie-Sklodowska University, Poland *Direct formation of phosphine-boranes by reduction of phosphoryl compounds by BH_3. Stereoselectivity and chemoselectivity issues*
12:15 – 13:00	PL-10	**Karol Bruzik** University of Illinois Chicago, USA *Spiro-Barbiturates and Spiro-Hydantoins as Reversal Agents of General Anesthetics*
13:00 – 14:00	**LUNCH**	
14:00 – 15:00	**POSTER SESSION II (P2-001 – P2-056)**	
SESSION VI – chairman: Grzegorz Mlostoń		
15:00 – 15:45	PL-11	**Wolfgang Weigand** Friedrich-Schiller-Universitaet Jena, Germany *An eventful 30-year scientific hike through the realm of thioketones*
15:45 – 16:30	PL-12	**Luca Sancineto** University of Perugia, Italy *DOE paradigms to tackle synthetic challenges*
16:30 – 16:45	**CLOSING**	

Lectures

PL-01
Polyalkylenephosphates Mimicking Biomacromolecules; Syntheses and Applications

Stanisław Penczek[1], Julia Pretula[1], Krzysztof Kałużyński[1]

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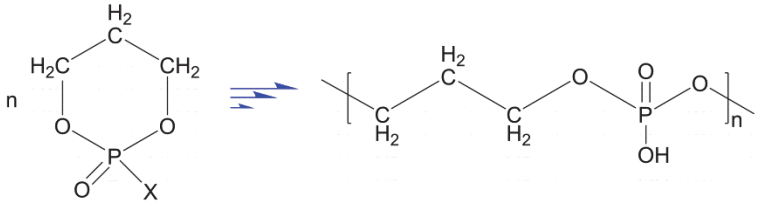
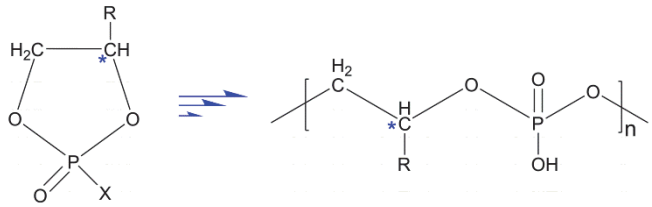
Chain polymerization of cyclic phosphorous monomers and polycondensation were used in syntheses of models of biopolymers; the main chains of DNA and of teichoic acids (TA). TA are responsible for Ca^+ and Mg^+ transport. For the polymerization processes the basic thermodynamic, kinetic and mechanistic features are described. The isokinetic phenomenon was determined for the six-membered cyclic phosphates. These polymers are also related to the fully inorganic polyphosphate, known as food additives.[1]



Scheme 1. X = –H, $–NR_2$ or $–OCH_3$.



Scheme 1. X as in Scheme 1, R = $–CH_2OC(=O)CH_3$; both optical isomers were polymerized separately.

Molar masses (M_n) up to 10^4 g/mol were achieved. Similar structures were prepared by polycondensation. Resulting polymers were then used in our laboratory and by others as nerve guides, in drug delivery, Ca^+ / Mg^+ selective active transport in liquid membranes and syntheses of polymer – inorganic hybrids.[2,3]

References

[1] S. Penczek, J. Pretula, K. Kaluzynski, Poly(alkylene phosphates): From Synthetic Models of Biomacromolecules and Biomembranes toward Polymer-Inorganic Hybrids (Mimicking Biomineralization), *Biomacromolecules* **2005**, 6, 547-551.

[2] S. Penczek, *Models of Biopolymers by Ring-Opening Polymerization*, Ed. S. Penczek, CRC, **2017**.

[3] C. Pelosi, M.R. Tinè, F.R. Wurm, Main-chain water-soluble polyphosphoesters: Multi-functional polymers as degradable PEG-alternatives for biomedical applications, *European Polymer Journal*, **2020**, 141, 110079..

PL-02

Development of synthetic access towards fluorinated pyrazoles of biological importance

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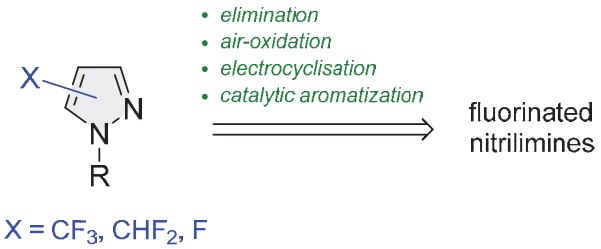
Fluoromethylated pyrazoles are considered privileged structural motifs for drug discovery, and for this reason, they received great attention in the last two decades [1]. In search for new F-containing synthons useful for preparation of the title products we paid attention to fluorinated nitrile imines, which can be easily generated *in situ* via base-mediated dehydrohalogenation of the respective hydrazonoyl precursors [2]. Subsequently, these reactive 1,3-dipoles can easily be trapped with functionalized C=C dipolarophiles to afford various pyrazole derivatives [3]. More interestingly, in certain cases final aromatization of the intermediate pyrazolines can be controlled [4], *e.g.* by the type of solvent used, leading to products of different substitution patterns. Our recent achievements in exploration of nitrile imines as convenient building blocks for preparation of fluorinated pyrazoles will be discussed.



Scheme 1. General structure of title pyrazoles derived from fluorinated nitrile imines.

Acknowledgement

Financial support by the University of Lodz (#19/IGB/2024) is acknowledged.

References

[1] (a) Z. Moussa et al., *Heliyon* **2024**, *10*, e38894; (b) P. K. Mykhailiuk, *Chem. Rev.* **2021**, *121*, 1670–1715.

[2] (a) N. R. Yamaletdinova, R. R. Gataullin, *Helv. Chim. Acta* **2024**, e202400058; (b) Z. Dongxu, *Beilstein J. Org. Chem.* **2023**, *19*, 1741.

[3] (a) G. Utecht-Jarzyńska et al., *RSC Mechanochemistry* **2025**, doi:10.1039/D4MR00075G; (b) K. Świątek et al., *Org. Lett.* **2023**, *25*,24, 4462; (c) N. Zhang et al, *Org. Biomol. Chem.* **2023**, *21*, 5040.

[4] (a) A. Kowalczyk et al., *J. Fluor. Chem.* **2023**, *272*, 110206; (b) A. Kowalczyk et al, *Org. Lett.* **2022**, *24*, 2499.

PL-03

Molecular Iodine as a Versatile Catalyst/Reagent in Organoselenium Mediated Reaction

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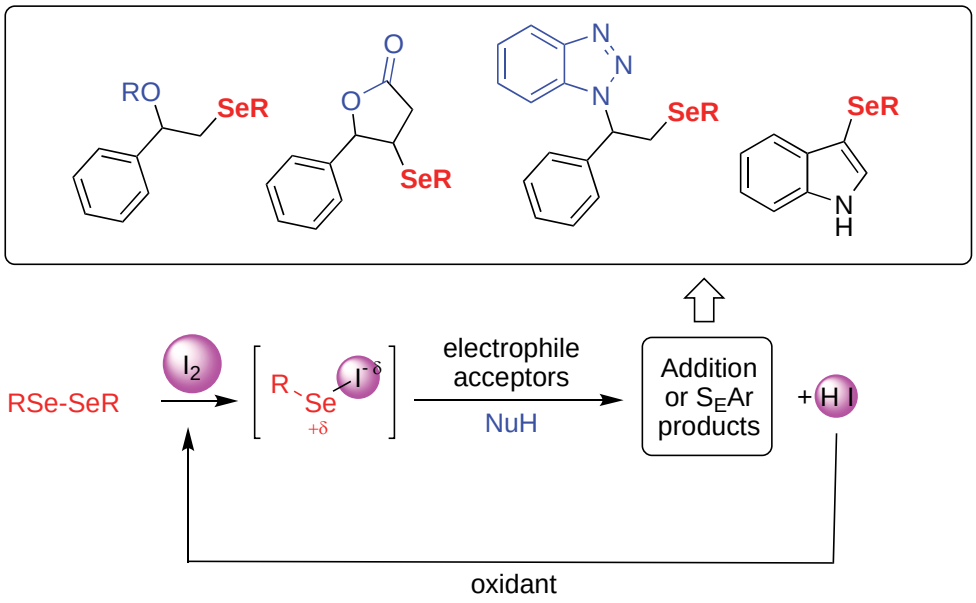
Electrophilic selenenylation of alkenes or arenesx is one of the most commonly used methods to introduce a selenium-containing function into an organic molecule. Several methods have been developed for the preparation of β-hydroxy, β-amido, β-alkoxy and β-acetoxy selenides from alkenes by the addition of phenylselenenyl halides in the presence of the desired nucleophile but also in the selenenylations of activated aromatic systems. [1]

Although it is one of the most studied reactions of the chalcogens, the search for new methods of activating the Se-Se bond to generate electrophilic species in the absence of nucleophilic counterions is still a particularly attractive area of research. In this communication we show how molecular iodine can be used to oxidatively activate diselenides. We have shown that iodine can be used as a catalyst in the presence of another oxidant, thus avoiding the critical problems associated with the toxicity and poor handling of elemental iodine. A novel example in which catalytic amount of diselenide was used for the electrophilic iodination or nitrogen containing heterocycles will be also discussed.



Acknowledgement

Università di Perugia “Fondo per la ricerca di Base”.

References

[1] J. Rafique, J. B. Azeredo, and S. Saba, in Chalcogen Chemistry: Fundamentals and Applications, ed. V. Lippolis, C. Santi, E. J. Lenardão, and A. L. Braga, The Royal Society of Chemistry, **2023**, ch. 11, pp. 280-299..

PL-04

Guaiacols from wood as building blocks for fine & specialty chemicals

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To reach net-zero emissions by 2050, the next generation of chemical technologies to produce bio-renewable chemicals from biomass needs to be developed.[1] Catechol, a specialty chemical with a global annual market of more than 40 ktons, is an important building block for the production of agrochemicals, polymers, flavors, fragrances, pharmaceuticals, agrochemicals and polymers. Currently, its industrial manufacturing involves catalytic hydroxylation of fossil benzene-derived phenol in the presence of hydrogen peroxide.

Recent biorefinery concepts such as lignin-first and mild hydro-pyrolysis technologies have focused on the effective production of monomeric phenolics from native lignin. In the case of softwood, reductive catalytic fractionation (RCF) produces 4-alkylguaiacols with high yield and selectivity. The presence of two oxygen atoms, installed on the arene, makes these 4-alkylguaiacols ideal platform molecules for the synthesis of 4-alkyl-bio-catechol and bio-catechol via O-, and O- and C-dealkylations, respectively.[1-4] Selected applications of the catechols for the synthesis of both new and drop-in chemicals have been developed.[5-8]

Guaicols can be directly transformed into cyclohexanamines. These are interesting substrates for remote C(sp3)-H functionalization typically employing a directing group. A variety of functionalizations have been developed including both carbon-carbon and carbon-heteroatom bond formation. Interestingly, amongst these functionalizations remote alkenylation has only been little studied.[9] Moreover, these reactions still possess limitations with respect to cost and resource efficiency, e.g. requiring more reactive iodinated reactants and superstoichiometric silver salt reagents. Efficient regio- and stereospecific silver-free Pd-catalyzed γ-C(sp3)–H alkenylation of cyclohexanamines and heterocyclic analogues with bromoalkenes have been developed.[9] Mechanistic studies revealed insight into the challenging nature of these transformations and allowed extension towards other electrophiles. When 1,1-dibromoalkenes were used as electrophiles in combination with CuI co-catalyst orthogonal tandem catalysis provided interesting bridged bicyclic nitrogen scaffolds, i.e. 7-alkylidenenormorphans, in one step in a site- and diastereoselective manner.[10]

References

[1] Wu, X.; Liao, Y.; Bomon, J.; Tian, G.; Bai, S.-T.; Van Aelst, K.; Zhang, Q.; Vermandel, W.; Wambacq, B.; Maes, B.U.W.; Yu, J.; Sels, B.F. *ChemSusChem* **2022**, *15*, e2021022.
[2] Bomon, J.; Van Den Broeck, E.; Bal, M.; Liao, Y.; Sergeyev, S.; Van Speybroeck, V.; Sels, B.F.; Maes, B.U.W. *Angew. Chem. Int. Ed.* **2020**, *59*, 3063–3068.
[3] Bomon, J.; Bal, M.; Kumar Achar, T.; Sergeyev, S.; Wu, X.; Wambacq, B.; Lemière, F.; Sels, B.F.; Maes, B.U.W. *Green Chem.* **2021**, *23*, 1995–2009.
[4] Wu, X.; Smet, E.; Brandi, F.; Raikwar, D.; Zhang, Z.; Maes, B.U.W.; Sels, B.F. *Angew. Chem. Int. Ed.* **2024**, *63*, e202317257.
[5] Escudero, J.; Mampuys, P.; Mensch, C.; Bheeter, C.B.; Vroemans, R.; Orru, R.V.A.; Harvey, J.; Maes, B.U.W. *ACS Catal.* **2022**, *12*, 6857–6873.
[6] De Smet, G.; Bai, X.; Mensch, C.; Sergeyev, S.; Gwilherm, E.; Maes, B.U.W. *Angew. Chem. Int. Ed.* **2022**, *61*, e202201751.
[7] Ver Elst, C.; Vroemans, R.; Bal, M.; Sergeyev, S.; Mensch, C.; Maes, B.U.W. *Angew. Chem. Int. Ed.* **2023**, *62*, e202309597.
[8] Renders, E.; Dobi, Z.; Weemaes, K.; Bomon, J.; Mensch, C.; De Smet, G.; Bheemireddy, N.R.; Herrebout, W.; Maes, B.U.W. *ACS Sustainable Chem. Eng.* **2024** https://doi.org/10.1021/acssuschemeng.4c03920 .
[9] Gadde, K.; Bheemireddy, N.R.; Heitkämper, J.; Nova, A.; Maes, B.U.W. *ACS Catal.* **2024**, *14*, 1157–1172.
[10] Biswas, S.; Van Steijvoort, B.F.; Waeterschoot, M.; Bheemireddy, N.R.; Evano, G.; Maes, B.U.W. *Angew. Chem. Int. Ed.* **2021**, *60*, 21988–21996.

PL-05

Z-Selective Horner-Wadsworth-Emmons reactions – development of the new reagents and their application

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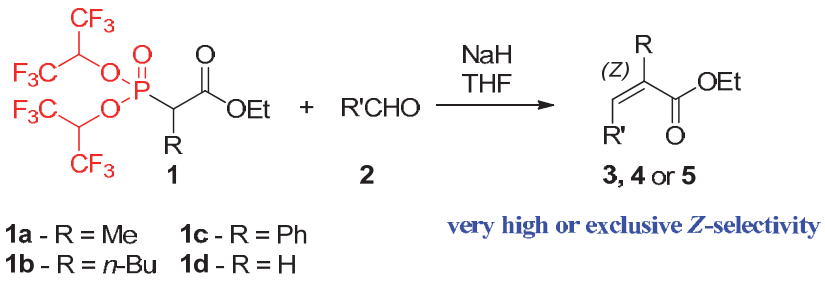
The synthesis of carbon-carbon double bonds is undoubtedly one of the essential areas of the organic chemistry and stereoselectivity is one of the crucial aspects of the alkene forming reactions. One of the most popular reactions for the formation of alkenes is Horner–Wadsworth–Emmons (HWE) reaction which is typically highly *E*-selective. The high *E*-selectivity of the HWE reaction is its important advantage, but it is also a limitation. Nevertheless, the stereoselectivity of the HWE reaction may be modulated by modification of the structure of the phosphonate reagents involved in the reaction. The most popular *Z*-selective versions of the HWE reaction are Still–Gennari and Ando modifications, which are based on the application of bis(2,2,2-trifluoroethyl) phosphonates or diaryl phosphonates, respectively, for the olefination of carbonyl groups.[1-3]

In our research we developed new reagents for the highly *Z*-selective HWE reactions – bis(1,1,1,3,3,3-hexafluoroisopropyl) phosphonates. These reagents can be easily prepared in a simple, straightforward process.[4] The utility of the presented reagents for the synthesis of disubstituted and trisubstituted alkenes was investigated, and will be presented during the lecture.[5]



Scheme 1. New reagents for the *Z*-selective HWE reaction.

References

[1] W. C. Still, C. Gennari, *Tetrahedron Lett.* **1983**, *24*, 4405-4408.
[2] I. Janicki, P. Kiełbasiński, *Adv. Synth. Catal.* **2020**, *362*, 2552 – 2596.
[3] K. Ando, *Tetrahedron Lett.* **1995**, *36*, 4105–4108.
[4] I. Janicki, P. Kiełbasiński, *Synthesis* **2022**, 378-382.
[5] I. Janicki, P. Kiełbasiński, *Molecules*, **2022**, *27*, 7138.

PL-06

Recent Advances in the Development of Triptycene-based Compounds: Can Curiosity-driven Research Contribute to Green Chemistry?

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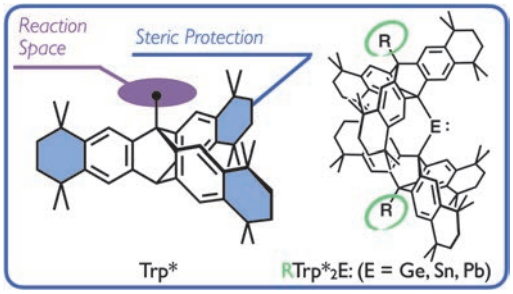
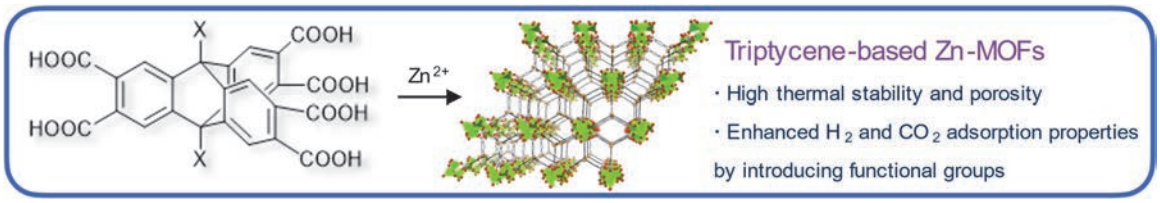
Triptycene (Trp)-based compounds are a fascinating class of compounds characterized by their unique three-dimensional structure. The core structure of triptycene consists of three benzene rings connected by two sp^3 carbon atoms, forming a propeller-like shape.

Recently, we designed and synthesized Trp*, a novel Trp-base aliphatic bulky group that bears bulky fused ring-type substituents at the periphery of Trp framework.



We took advantage of the steric protection ability of the Trp* group to synthesize the thermally stable divalent species, germylene, stannylene, and plumbylene, Trp^*_2E: (E = Ge, Sn, Pb) in which the divalent E atom is attached to aliphatic carbon ligands.

The triptycene molecule has a rigid, three-dimensional structure that provides limited conformational freedom and well-defined spatial orientation. Based on our synthetic molecular design and techniques for curiosity-driven hetero-atom chemistry, we have synthesized Trp-based Compounds for metal–organic frameworks (MOFs) that can store hydrogen. A series of MOFs based on zinc ions and two Trp ligands of different size have been synthesized under solvothermal conditions. The high porosity and thermal stability of these MOFs can be attributed to the highly rigid Trp-based ligands. Their BET specific surface areas depend on the size of the Trp ligands. In contrast to these surface-area data, the H_2 and CO_2 adsorption of these MOFs is larger for MOFs with small pores.



PL-07

The Sulfur Dance" Around Arenes and Heteroarenes - the Reversible Nature of Nucleophilic Aromatic Substitutions

Marc Gingras[1]

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Nucleophilic aromatic substitutions (NAS) are among the most frequently used reactions in organic chemistry.[1] Exchanges of chemical components may occur by different mechanisms (S_NAr, $S_{RN}1$, cS_NAr, S_NArH). We use S_NAr for representing these different mechanistic possibilities. Even if a reversibility was shown in rare cases,[2] it was overlooked in spite of a great number of S_NAr reactions reported since 1854.[3] We disclose the features of a category of reversible NAS in view of their significance and generality in dynamic aromatic chemistry (scheme 1).[4] Exchange of sulfur components surrounding arenes and heteroarenes may occur at 25°C, in a process that one may call a "sulfur dance" (figure 1). The reversible nature of S_NAr was confirmed by three methods. These reversible S_NAr reactions are being implemented in aromatic and in dynamic covalent chemistry (DCC). They can provide libraries of thiaarenes with some selectivity, or conversion of a hexa(thio)benzene asterisk into another one.

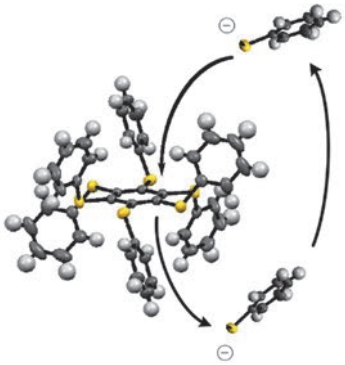
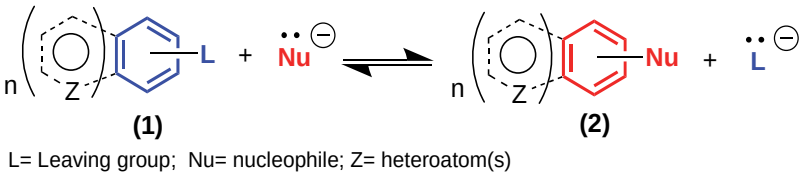


Figure 1. Exchange of sulfur components (thiophenolate anions) by dynamic S_NAr reactions



Scheme 1. Schematic representation of reversible nucleophilic aromatic substitutions.

Here, we present some applications using sulfur-rich polyaromatic architectures and their exalted properties of uses in materials science and nanoscience. It comprises asterisks, oligomers and dendrimers, often incorporating thiophenylene units and (poly-)persulfurated aromatic cores. Polysulfuration is often responsible for multiple redox states, metal-ion coordination,[5] Rigidity-Induced Phosphorescence (RIP) providing the most phosphorescent all-organic crystals (f~100%),[6] cation-selective membranes, cations and anions sensing in coordination polymers, electrochromic switches, biosensors, oxygen sensors,[7] and organic ligands for stabilizing metal nanoparticles.[8]

References

[1] D. G. Brown, J. Boström, *J. Med. Chem.* **2016**, *59*, 4443.
[2] For an early discussion on reversible S_NAr : J. F. Bunnett, R. E. Zahler, *Chem. Rev.* **1951**, *49*, p. 301.
[3] a) Williamson and Scrugham, *Annalen* **1854**, *92*, 316-318; b) Pisani, *Compt. Rend.*, **1854**, *39*, 852.
[4] a) S. Gahlot, J.-L. Schmitt, A. Chevalier, M. Roy, M. Villa, P. Ceroni, J.-M. Lehn, M. Gingras, *Chem. Eur. J.* **2024**, e202400231 (front cover page); b) S. Gahlot, A. Gradone, M. Roy, M. Giorgi, S. Conti, P. Ceroni, M. Villa, M. Gingras, *Chem. Eur. J.* **2022**, *28*, e20220097.
[5] a) A. Fermi, G. Bergamini, M. Roy, M. Gingras, P. Ceroni, *J. Am. Chem. Soc.* **2014**, *136*, 6395; b) M. Villa, M. Roy, G. Bergamini, M. Gingras, P. Ceroni, *Dalton Trans.* **2019**, *48*, 3815 (front cover page).
[6] A. Fermi, G. Bergamini, R. Peresutti, E. Marchi, M. Roy, P. Ceroni, M. Gingras, *Dyes and Pigments* **2014**, *110*, 113.
[7] M. Villa, B. Del Secco, L. Ravotto, M. Roy, E. Rampazzo, N. Zaccheroni, L. Prodi, M. Gingras, S. Vinogradov, P. Ceroni *J. Phys. Chem. C* **2019**, *123*, 49, 29884.
[8] G. Bergamini, P. Ceroni, V. Balzani, M. Gingras, J.-M. Raimundo, V. Morandi, P.G. Merli, *Chem. Commun.* **2007**, 4167.

PL-08

New Cycloaddition Reactions of Levoglucosenone (LGO) and Some *exo*-Cyclic Enones Derived therefrom

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Levoglucosenone (LGO) (**1**) belongs to the group of bio-renovable carbohydrate derivatives which is available in laboratory by the acid catalyzed pyrolysis of cellulose [1] and the recently reported, optimized procedure allows its preparation as enantiopure substance (98% chemical purity) in an advantageous yield of ca. 10% [2]. Due to the presence of an activated C=C bond LGO is a superior candidate for exploration in cycloaddtion reactions not only with 1,3-dipoles ((3+2)-cycloadditions) and heterodienes [(4+2)-cycloadditions) but also with tropothione ((8+2)-cycloaddition, HCO-higher order cycloaddition]. Notably, cycloadditions typically occur in a stereoselective manner from the less hindered *exo*-face of the LGO molecules.

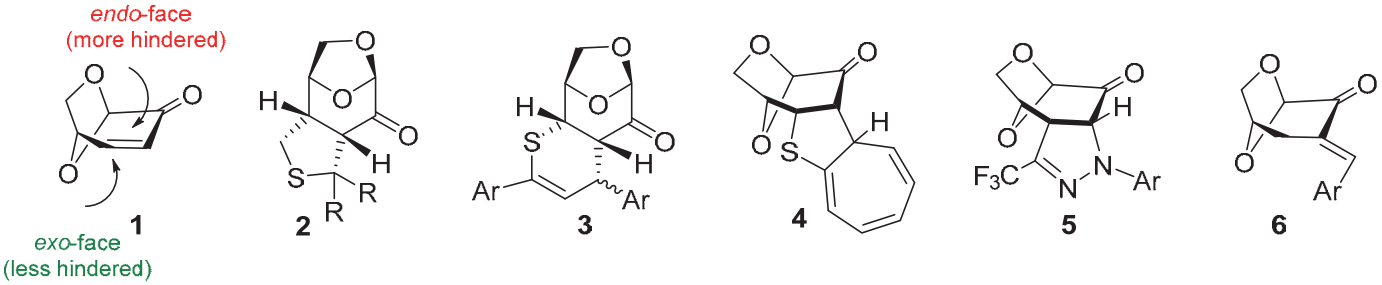

Figure. Levoglucosenone (LGO) (**1**) and its cycloadducts **2** (with thiocarbonyl *S*-methanides), **3** (with thiochalcones), **4** (with tropothione), and **5** (with fluorinated nitrile imines).

Various cycloaddition reactions with reactive substrates like thiocarbonyl *S*-methanides, thiochalcones, tropothione, and fluorinated nitrile imines, leading to cycloadducts of type **2** [3], **3** [4], **4** [5], and **5** [6], respectively, will be discussed.

In extension of the studies with LGO (**1**), the so called HOC reactions (**H**igher **O**rder **C**ycloadditions, (8+2) cycloadditions) of tropothione with selected *exo*-cyclic enones **6** will also be presented [5].

Acknowledgement

Helpful discussions with Professor Zbigniew J. Witczak (Wilkes University) and the gift of samples of **1** as well as of some representative *exo*-enones **6** are acknowledged. Theoretical studies for the HDA reactions of LGO with thiochalcones, carried out by Professor E.-U. Würthwein (University of Munster) are also acknowledged.

References

[1] Y. Tsuchiya, K. Sumi, *J. Appl. Polym. Sci.* **1970**, *14*, 2003.
[2] J. Klepp, W. Dillon, Y. Lin, P. Feng, B.W. Greatrex, *Org. Synth.* **2020**, *97*, 38.
[3] G. Mlostoń, M. Celeda, Z. J. Witczak, in preparation.
[4] G. Mlostoń, K. Urbaniak, M. Palusiak, Z. J. Witczak, E.-U. Würthwein, in preparation.
[5] G. Mlostoń, M. Celeda, M. Palusiak, *Carbohydr. Res.* **2023**, 529, e108844.
[6] G. Mlostoń, K. Urbaniak, M. Palusiak, Z. J. Witczak, E.-U. Würthwein, *Molecules* **2023**, *28*, 7348.

PL-09

Direct formation of phosphine-boranes by reduction of phosphoryl compounds by BH3. Stereoselectivity and chemoselectivity issues

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In the last half-century, tricoordinated phosphorus compounds, phosphines in particular, have gained enormous importance in the field of chemistry of organophosphorus compounds. They are convenient substrates in the synthesis of other phosphorus connections, they serve as reagents in Wittig, Staudinger, Mitsunobu reactions and, importantly, also as ligands in transition metal complexes used as catalysts for many chemical reactions.

The fundamental methods of synthesis of phosphines are based on reactions of nucleophilic substitution at the trivalent phosphorus atom with an organometallic reagent or, conversely, the reaction of a metal phosphide with an organic electrophile. Phosphines exhibit high sensitivity to moisture and oxygen as well as very often unpleasant odours and toxicity. To avoid these problems, the syntheses are most frequently carried out using more robust and benign tetravalent phosphine phosphorus substrates, usually phosphine oxides, and only in the last stage of synthesis, the final compound is reduced to the target phosphine. Reductions of strong P=O bond require use of strong reductants such as metal hydrides or silanes and thereby pose many difficulties, especially in the case of P-chiral phosphine oxides or, when additional functional groups are present in their structures.

A considerable improvement in the synthesis of phosphines has been brought about by the discovery of phosphine-borane complexes that proved to be sufficiently stable and exhibited typical phosphine-like reactivity. The usefulness of phosphine-boranes is determined by the coordinative nature of the phosphine bond to BH_3, which allows for easy unblocking of a free phosphine under mild conditions and with retention of configuration at the phosphorus atom. Interest in the development of new methods of synthesis of these useful equivalents of phosphines is continuously growing. Especially important in this field are protocols which enable direct transformation of P=O to P-BH_3 without isolation of a free phosphine.

The lecture will desribe our recent research efforts directed towards this end. The range of studied compounds encompass secondary and tertiary phosphine oxides, as well as phosphine oxides, phosphinates and phosphonates bearing additional functions in their structures and, in addition, also phosphonium salts. A special focus will be put on stereoselectivity and chemoselectivity of such transformations and on their mechanistic aspects.

PL-10

Spiro-Barbiturates and Spiro-Hydantoins as Reversal Agents of General Anesthetics

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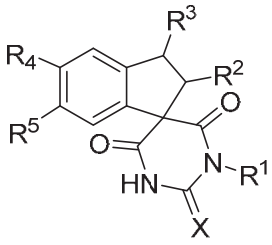
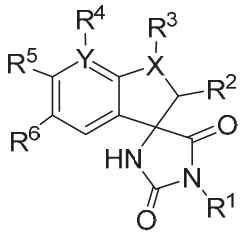
GABA$_A$Rs are pentameric ligand-gated ion channels that play a major role in mediating inhibition in the CNS. They are the target of many widely used positive allosteric modulators (PAMs) of GABA$_A$Rs such as general anesthetics, sedatives, antiepileptics, and anxiolytics. However, close structural analogs of these PAMS are negative allosteric modulators (NAMs) that cause excitation. Comparison of the SAR of inhibitory and excitatory barbiturates suggested that conformationally-constrained spiro-analogs of phenobarbital might have intermediate allosteric activity. More than 50 spiro-analogs and 30 spiro-hydantoins were synthesized and characterized for their ability to enhance desensitization and reverse the action of anesthetics. A number of these compounds reversed the action of anesthetics without having any action on GABA-induced desensitization. These compounds constitute new classes of GABA-ergic drugs that are Null Allosteric Ligands (NALs). They offer the potential of reversing the sedative action of current PAMs and of modulating the behavior of diseases resulting from mutations in GABA$_A$R subunits.



R^1: H, CH_3
R^2: H, CH_3
R^3: H, CH_3
R^4: H, Br
R^5: H, CH_3, iPr, OCH_3, F, Cl, Br
X: Cl_2, S, N, NOH, NCH_3 NNH_2



R^1: H, CH_3
R^2: H, CH_3
R^3: H, CH_3, Br, N_3, NH_2, OH
R^4: H, CH_3
R^5: H, NH_2, NO_2, OH, BnO, Br
R^6: H, CH_3, NH_2, NO_2, OH
X: C, O;
Y: C, N

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Acknowledgement

This work was supported by NIH grant, RO1 GM135550-01 (K. W. Miller) and with support from the Department of Anesthesia, Critical Care & Pain Medicine, Massachusetts General Hospital, Boston.

PL-11

An eventful 30-year scientific hike through the realm of thioketones

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In a recent publication, we have investigated the use of a ferrocenyl α-thienyl thioketone as a proligand for the preparation of [FeFe]-hydrogenase H-cluster mimics.[1,2] This study showed the formation of *ortho*-metalated complex that resembles similar structures of complexes obtained in analogous reactions of aromatic thioketones together with the formation of unexpected arrangement of sulfur and iron atoms, resulting from the ring opening, *i.e.*, dearomatization of the thiophene ring (Fig. 1). In our continuing studies we focused on the reaction of the push-pull ferrocenyl α-thienyl thioketone with $Fe_3(CO)_{12}$ leading to a [FeFe]-hydrogenase mimic complexes catalyzing the hydrogen evolution reaction under visible light irradiation (λ = 405 nm, TON ≈ 230).

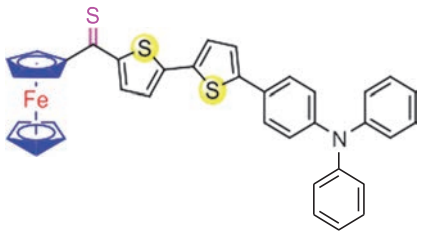
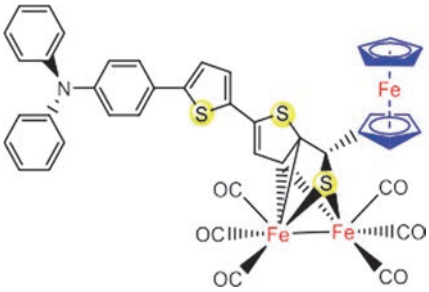


Figure 1. Ferrocenyl α-thienyl thioketone



[FeFe]-hydrogenase mimic

References

[1] A.Q. Daraosheh, H. Abul-Futouh, N. Murakami, K.M. Ziems, H. Görls, S. Kupfer, S. Gräfe, A. Ishii, M. Celeda, G. Mlostoń, W. Weigand, *Materials* **2022**, *15*, 2867.

[2] I.Basma, H. Abul-Futouh, S. J. Abaalkhail, P. Liebing, W. Weigand, *J. Mol. Struct.* **2024**, *1295*, 136630.

PL-12

DOE paradigms to tackle synthetic challenges

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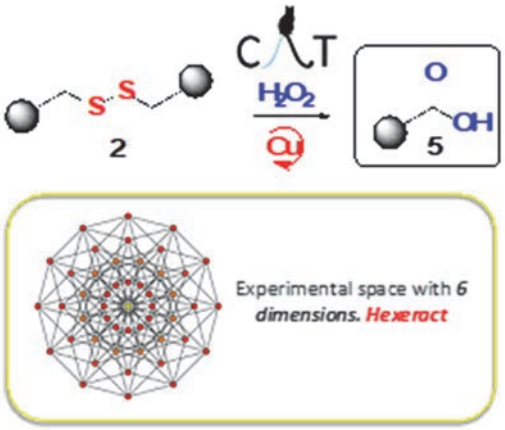
Optimizing reaction conditions is akin to space exploration, with the primary difference being that the domain to be explored is the so called “experimental space”. This experimental space can sometimes be more vast and complex than the cosmos. Therefore, a rational strategy to thoroughly cover this space and increase the likelihood of finding optimal conditions is crucial. The use of Design of Experiment (DoE) paradigms offers a reliable roadmap to make this exploration more effective with a reasonable number of experiments. This invited lecture aims to provide a brief overview of DoE paradigms, implemented using a free software tool [1], and the application in optimizing the reaction conditions for the conversion of disulfides into benzoic acids and in the selenylation of aelechtron rich aromatics.



Acknowledgement
Founding: Ricerca di Base from Italian Ministry of University is gratefully acknowledged

References
[1] R. Leardi *Analytica Chimica Acta* ***2009***, *652, 161*..

Poster presentations

P1-001

Synthesis of Morpholino Nucleoside Thiomonophosphates and Dithiomonophosphates via an Oxathiaphospholane Approach

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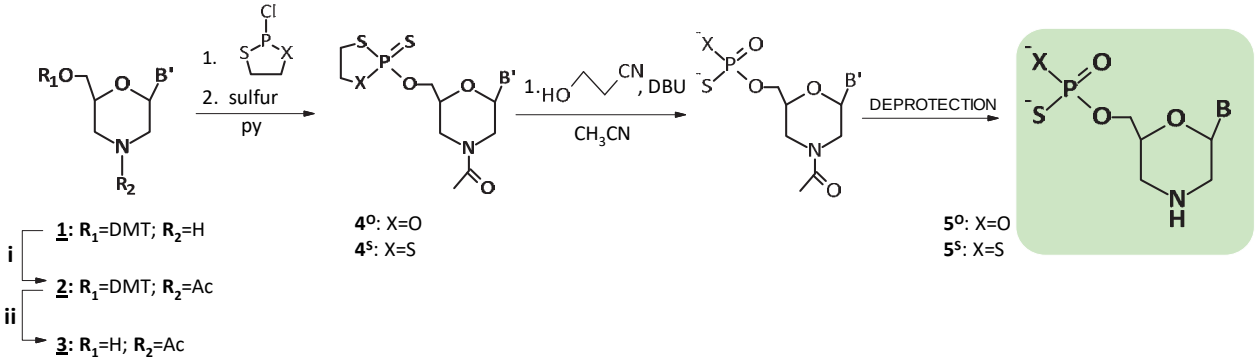
The nucleosides, nucleotides and their analogs have an extensive list of applications raging from substrates and inhibitors in enzyme research to anticancer and antiviral drugs, acting mainly as replication inhibitors. The synthesis of nucleoside 5'-monophosphates (NMPs) has been extensively studied. The modification of of nucleobases and sugars can increase the selectivity and efficacy of nucleos(t)ides against certain viral enzymes. Herein, we present the preparation of morpholino nucleoside thiomonophosphates and dithiomonophosphates using an oxathiaphospholane method. Appropriately protected nucleoside 6'-O-(2-thio)-1,3,2-oxathiaphospholane and 6'-O-(2-thio)-1,3,2-dithiaphospholane react with 3-hydroxypropionitrile in the presence of a strong base catalyst (DBU) to give nucleoside 6'-O-(α-thiotriphosphates) and 6'-O-(α,α-dithiotriphosphates), respectively [1].



The synthesis of modified analogs of nucleoside thiophosphates remains a rather tricky task, mainly because of the rather complicated and extensive purification step required. Nevertheless, our recent advances have significantly increased access to these interesting and promising derivatives. Tiophosphates are potentially interesting models for further studies on the biochemistry.

Acknowledgement

This project was supported by NCS 2021/43/D/ST4/02433.

References

[1] Langner H., Jastrzebska K., Caruthers M., *J. Am. Chem. Soc.*, **2020**, *142*, 16240–16253
[2] Guga P., Stec W.J., In Current Protocols in Nucleic Acid Chemistry, ed. S. L. Beaucage, D. E. Bergstrom, G. D. Glick and R. A. Jones, John Wiley and Sons, Hoboken, N.J., **2003**, p. 4.17.1.

P1-002

Comprehensive analysis of the effect of renewable energy on the stability of the environment

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This work represents a review of the effect of renewable energy on the stability of the environment through generating clean energy with no greenhouse gas emissions and lowering some types of air pollution by using comprehensive analysis of the processes such as consumption and production. It aims to audit the research articles in addition to the aspects and opinions to scrutiny and handle the challenges. Besides, creating an extensive vision aimed at completing research development by analyzing the published papers, patents, and industrial designs in this field. Furthermore, this present study aims to highlight the efficient energy conversion systems and sources of greenhouse gas emissions in an attempt to reach an optimal solution to preserve the environment and climate through modern technologies. Renewable energy has unstable and indirect performance due to changing of the climate in the current era. The unstable characteristics lower the popularization and use of renewable energy resources. According to the energy consumption, analysis and studies of management system refer to the generation of photovoltaic power and multiple models, which are combined with an optimal control solution equation to manage it scientifically with high efficiency, predict wind power capacity data accurately. In addition, the output of generating solar energy, wind power, or photovoltaic power can be flexibly selected and applied to the maximum extent. On the other hand, the energy consumption cost is minimized. Therefore, the utilization efficiency of renewable energy sources by electricity will be improved, and made considerable contributions to improving the capacity of green energy and keeping the environment lower polluted.

P1-003

Synthesis of morpholine-2,5-dione by tandem multicomponent isocyanide reactions Azido-Ugi and Ugi

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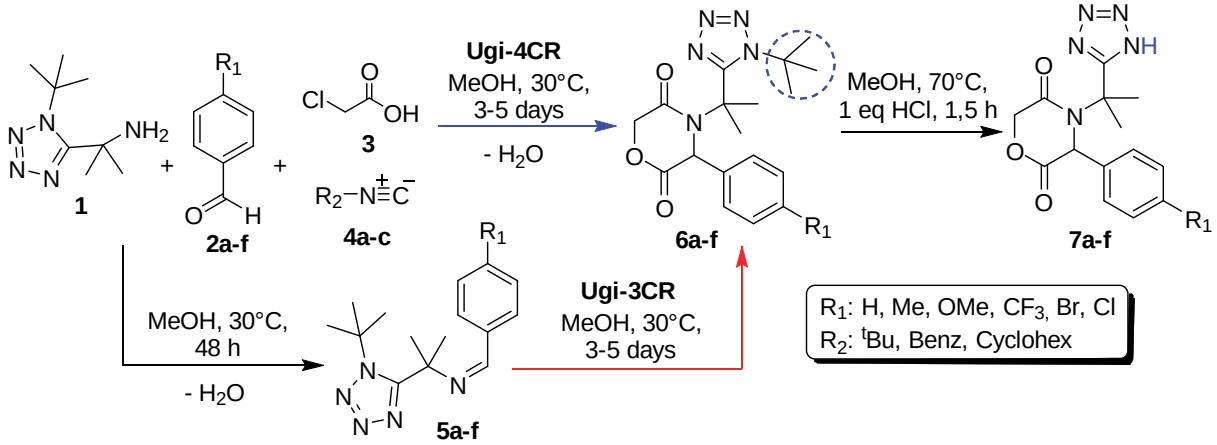
Multicomponent isocyanide reactions (IMCR), including their various tandems, are a powerful tool to achieve the set goals [1]. Clearly, exploring the possibility of creating hybrid molecules by combining azido-Ugi and Ugi reactions is successful, therefore, one of the promising directions to increase the diversity of relevant compounds is to obtain α-amino tetrazoles in the azido-Ugi reaction and further synthesize new peptidomimetics [2].

The syntheses of morpholinediones **6a-f** were carried out at a temperature of 30°C in methanol solution for 5-7 days in a yield of 20-68% (Scheme 1). Stirring compounds **6a-f** in a methanol in presence of $HCl_{36\%}$ leads to forming NH-tetrazole derivatives **7a-f**.



Scheme 1. Synthesis of morpholindiones **6a-f** containing *α*-amino-tetrazole fragment and their reactivity

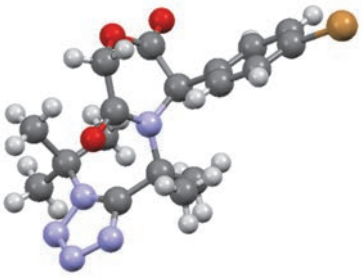


Figure 1. Molecular structure of compound **6a** according to the X-ray diffraction data

Acknowledgement

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References

[1] Z. Sanjun, M. Xiaoming, Z. Wei, *Org. Biomol. Chem.*, **2019**, *17*, 7632-7650.
[2] O. V. Kolomiiets, A. V. Tsygankov, M. N. Kornet at all, *Beilstein J. Org. Chem*, **2023**, *19*, 727–735.

P1-004

Paramagnetic helicenes: π-Curved Blatter radicals through photo-Smiles rearrangement

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Chiral open-shell systems are of fundamental scientific interest and of increasing importance for the development of new functional materials for applications in areas such as optoelectronics, photonics, molecule-based magnets, and information processing. Among chiral systems, conjugated helicenes constitute a particularly important and attractive class of chiral molecules due to their large optical rotations and strong electronic circular dichroism (ECD) signals. A combination of these chiro-optical features of a helicene with a paramagnetic moment of a π-delocalized spin is expected to yield materials with synergistic phenomena, such as magneto-chiral dichroism, Faraday effect, and a large *g* factor. Although such materials have begun to emerge, most of them are radical ions, while electrically neutral paramagnetic helicenes are still scarce [1,2]. Benzo[*e*][1,2,4]triazin-4-yls, such as the prototypical Blatter radical, exhibit exceptional stability, full spin delocalization, and electrochemical and photophysical properties attractive for molecular electronics and spintronics, and paramagnetic photoconductive liquid crystals [3,4]. Herein we report a potentially general method for preparation of a family of paramagnetic helicenes by photocyclization of 8-aryloxybenzo[*e*][1,2,4] triazines. We provide a comparative analysis of the effect of progressive expansion and curving of the π surface on electronic properties probed with UV-vis and EPR spectroscopy, and also with E-chem analysis. The experimental results are augmented with DFT calculations.

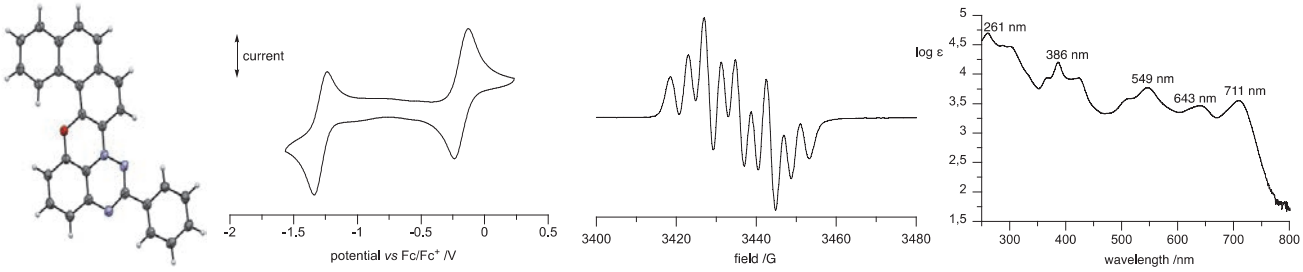

Figure. Crystal structure, CV, EPR and UV-Vis spectra of [5]Hel-Ph.

Acknowledgement

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References

[1] J. Crassous, I. G. Stará, and I. Starý, *Helicenes: Synthesis, Properties, and Applications, **2022**, 1-549*.
[2] C. Shu, Z. Yang, and A. Rajca, *Chem. Rev.* **2023**, 123,11954–12003.
[3] P. Kaszynski, C. P. Constantinides, and V. G. Young, Jr, *Angew. Chem. Int. Ed.* **2016**, 55, 11149 –11152.
[4] M. Jasinski, J. Szczytko, D. Pociecha, H. Monobe, and P. Kaszynski, *J. Am. Chem. Soc.* **2016**, 138, 9421-9424.

P1-005

Why is phenyl azide so unreactive in [3+2] cycloaddition reactions? Demystifying Sustmann's paradigmatic parabola

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The [3+2] cycloaddition (32CA) reactions of phenyl azide with a series of 25 ethylenes of different electronic activation were studied within Molecular Electron Density Theory (MEDT) at the ωB97X-D/6-311G(d,p) computational level to understand the low reactivity of azides participating in 32CA reactions.[1] Analysis of the reactivity indices allowed characterizing phenyl azide as a moderate electrophile and a moderate nucleophile. The relative reaction rate constants k_r of 12 selected 32CA reactions, together with the electrophilicity ω and nucleophilicity *N* indices of the corresponding ethylenes, allowed us to classify these 32CA reactions into four groups: (i) group A, involving supernucleophilic ethylenes and displaying a $k_r > 104$; (ii) group B, involving strained cyclic ethylenes and displaying a $k_r < 102$; (iii) group C, involving strongly electrophilic ethylenes and displaying a $k_r \leq 102$, and (iv) group D, involving moderately electrophilic and nucleophilic ethylenes and displaying a $k_r < 2$ (see Figure 1a). These four groups are characterized in Sustmann's "parabolic correlation" graph,[2] which results from an inaccurate interpretation of the reactivity of phenyl azide, which is not an "ambiphilic species" but rather a moderate electrophile that reacts efficiently only with supernucleophilic ethylenes in reverse electron density flux (REDF) *zw-type* 32CA reactions (see Figure 1b).[3]

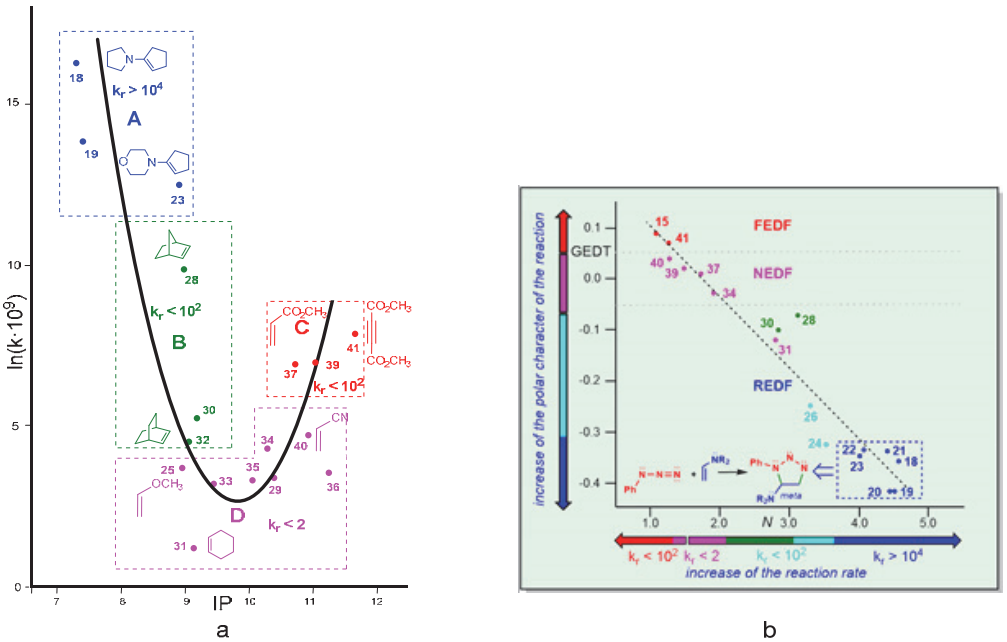

Figure 1. a) Classification of Sustmann's ethylenes into (A) supernucleophilic ethylenes, in blue; (B) strained cyclic ethylenes, in green; (C) strongly electrophilic ethylenes, in red; and (D) weakly electrophilic/nucleophilic ethylenes, in pink; b) correlation between the global electron density transfer (GEDT), which measures the polar character of the 32CA reaction, and the computed relative reaction rate constants k_r

References

[1] L. R. Domingo, M. Ríos-Gutiérrez, P. Pérez, *Org. Chem. Front.*, **2023**, *10*, 5579–5591.
[2] R. Sustmann, R. Schubert, *Angew. Chem., Int. Ed. Engl.*, **1972**, *9*, 840.
[3] L. R. Domingo, M. Ríos-Gutiérrez, *Sci. Rad.*, **2023**, *2*, 1-24.

P1-006

Luminescence properties of 2,4,5-Triphenyl Imidazole

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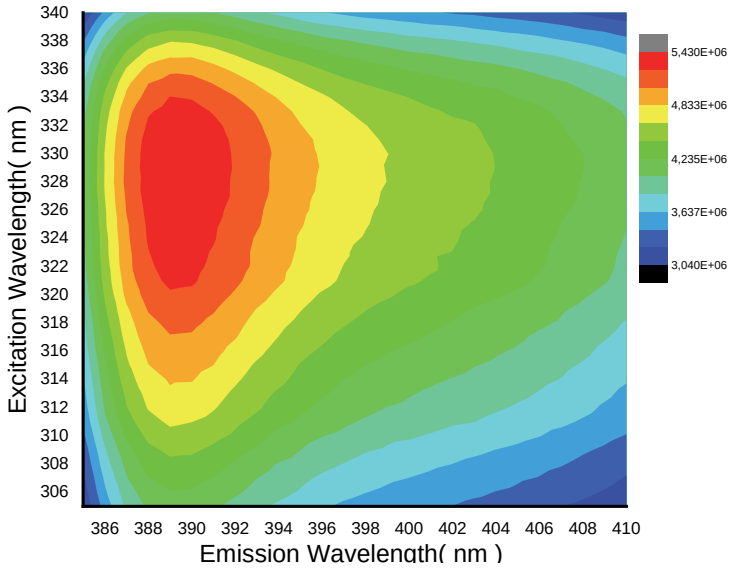
In recent years, there has been a notable surge in research on organic materials with the aim of discovering new materials that can enhance the performance and lower the manufacturing costs of optoelectronic devices [1]. Because of their relatively weak intermolecular interactions, small organic molecules can be investigated in solution, single crystals, or in the form of thin films.

The 2,4,5-Triphenyl Imidazole or TPI for short, was studied as thin film in this work in order to extract various luminescence properties of the material, using the Photoluminescence (PL). The TPI has piqued interest before because of his luminescent features in the phenyl ring [2], therefore we decided to dig deeper and explore more of the material's luminescent properties for potential optoelectronic applications.

The 2,4,5-Triphenyl Imidazole thin film was deposited using the Physical Vapor Deposition (PVD), at a temperature of 129 °C, under a pressure of $2 \times 10^{-5}\ Torr$. The photoluminescent properties were measured using a FluroMax-4 spectrophotometer, we were able to obtain the PL emission and excitation of the TPI, alongside its kinetic luminescence, the PL polarization and anisotropy, and the decay time. We also investigated the variation of the PL emission and decay time at low temperature from 77K to 325K.



Scheme 1. 3D variation of the emission wavelength vs the excitation wavelength of TPI.

Acknowledgement

The thin films used in this paper were obtained and characterized in the Interdisciplinary Centre for Modern Technologies facilities, NCU, Torun, Poland.

References

[1] Wang-Lin Yu, Jian Pei, Yong Cao, and Wei Huang. Hole-injection enhancement by copper phthalocyanine (cupc) in blue polymer light-emitting diodes. Journal of Applied Physics, 2001.

[2] I. El Ouedghiri-Idrissi, Z. Sofiani, et al. Experimental and theoretical study on the optical and morphological properties of highly photoluminescent material 2,4,5-triphenyl imidazole. Opt Quant Electron 56, 491 (2024).

P1-007

Ionically crosslinked composite based on chitosan and cyclodextrin polymer as a novel adsorbent for removal of organic dyes

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Wastewater production has evolved with dye and printing technology to become one of the major sources of soil and water contamination [1]. Most of dyes in textile industries are based on organic compounds which characterize carcinogenic and mutagenic properties. Thus, finding the efficient materials for removal of dye is necessary, e.g. materials based on cyclodextrins (CDs). The CDs are macrocyclic oligosaccharides, obtained from cellulose, and characterized by strong affinity to organic compounds via inclusion complexation. The CD based adsorbents are efficient, rapid and selective for removal of organic dyes e.g. methylene blue [2]. A novel composite based on chitosan and poly(β-cyclodextrin-perylene-3,4,9,10-tetracarboxylic dianhydride) network was designed and applied for removal of organic dyes. The composite strongly adsorbed organic pollutants in compare to metal ions (Zn^{2+}, Ni^{2+}, Cd^{2+}). The studied organic pollutants were acid orange 7 (AO7), methyl orange, (MO), methylene blue (MB) and malachite green (MG) at a concentration of 100 mg/L. The anionic dyes, like AO7 and MO, were removed at least above 90%, while cationic dyes were removed around 10-13%. This huge difference in removal indicates strong preference of anionic dyes which is based on electrostatic interaction between sulphonate group of dyes and cation of amino group of chitosan. The FT-IR spectroscopy showed electrostatic interaction, hydrogen bonding and inclusion complexation as binding forces for adsorption of anionic dyes. The EDX spectroscopy indicated surface interactions during binding of dyes based on appearance of sulphur atom on composite surface. The addition of cyclodextrin polymer allowed to obtain more complexed binding site with stronger affinity to organic pollutants, especially anionic dyes. To sum up, the composite based on chitosan and poly(β-cyclodextrin-perylene-3,4,9,10-tetracarboxylic dianhydride) network seems to be a promising tool for removal of organic pollutants from aquatic environment.

Acknowledgement
The authors gratefully acknowledge Jan Dlugosz University in Czestochowa for the support in presented research.

References
[1] T.F. Cova, D. Murtinho, R. Aguado, A.A.C.C. Pais, A.J.M. Valente, Polysaccharides 2021, 2, 16-38.
[2] J. Lagiewka, A. Nowik-Zajac, A. Pajdak, I. Zawierucha, Carbohydr. Polym. 2023, 307, 120615.

P1-008

Steroid-pyrimidine hybrids as potential agents with high biological activity

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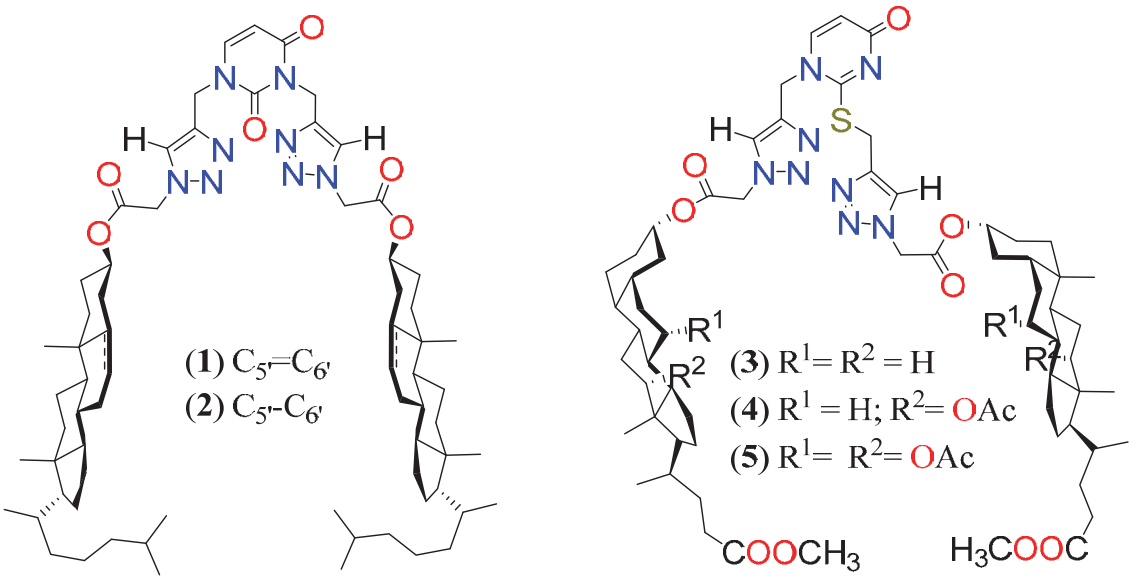
A giant, curved steroid skeleton, the long aliphatic chain with a carboxyl group, and differently reactive hydroxyl groups distinguish bile acids (e.g. lithocholic, deoxycholic, cholic). Their derivatives are valuable materials for synthesising macrocyclic compounds, molecular receptors, and cholophanes [1–3]. Natural steroid conjugates occupy a special place among natural products due to their participation in most metabolic pathways.

An efficient synthesis of 11 new steroid-pyrimidine bioconjugates containing 1,2,3-triazole systems was carried out. Appropriately modified bile acids or sterols and uracil or 2-thiouracil derivatives were subjected to a reaction typical of „click" chemistry. Spectroscopic (^{1}H and ^{13}C NMR, FT-IR), spectrometric (EI and ESI-MS), and theoretical calculations (PM5) analyses of the obtained compounds were carried out. Molecular docking results indicate their antibacterial and antifungal activity [4].



Scheme 1. Selected steroid-pyrimidine conjugates.

References

[1] A. Kawka, H. Koenig, T. Pospieszny, *Studies in Natural Products Chemistry*, **2024**, *82*, 247-283.
[2] A. Kawka, G. Hajdaś, H. Koenig, D. Kułaga, I. Kowalczyk, T. Pospieszny, *J. Mol. Struct.*, **2023**, *1273*, 134313.
[3] A. Kawka, D. Nowak, H. Koenig, T. Pospieszny, *J. Org. Chem.*, **2024**, *89* (11), 7561-7572.
[4] A. Kawka, D. Nowak, H. Koenig, T. Pospieszny, *ACS Omega*, **2024**, doi.org/10.1021/acsomega.4c04800.

P1-009

Regioselective opening reaction of chiral oxiranes dependent on absolute configuration of substrates

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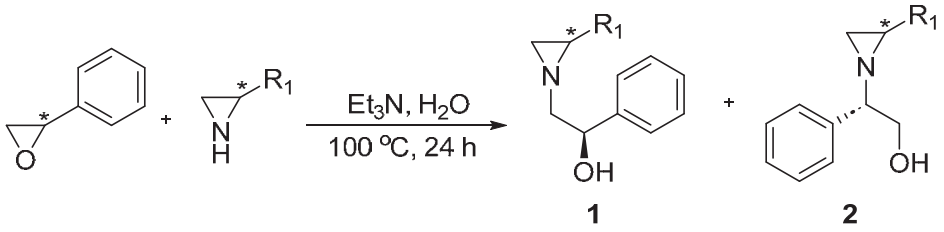
Three-membered ring-opening reactions are categorized as part of the Nobel Prize-winning concept of “click chemistry” in which reactions are formed with high chemical yields and importantly, without unwanted by-products, thus eliminating the need to use chromatographic methods to purify the products.[1] Three-membered rings are amenable to opening reactions using various types of nucleophiles, allowing the introduction of a whole range of substituents and obtaining compounds with the expected structure and activity.[2] Aminoalcohols can be formed by opening reactions of oxiranes with amines, moreover, they are widely used, among other applications, as building blocks for the synthesis of biologically active products,[3] and an example is atenolol - a drug of the β-blocker group, used in the treatment of cardiovascular diseases.[4] Opening of the oxiranes can lead to different regioisomers depending on the amine used. Primary amines usually lead to the regioisomers of type **2**, while secondary amines lead predominantly to compounds of type **1**.[5,6]



Scheme 1. Oxirane opening reaction with aziridine.

The aim of the project was to carry out a series of reactions of chiral oxiranes with chiral aziridines. The application of aziridine as a nitrogen nucleophile in the reaction made it possible to carry out the oxirane opening reaction without the use of additional metal based catalysts, which allows it to be classified as "green chemistry". Importantly, it was possible to establish that the regiochemistry of the resulting product is affected by the stereochemistry of the substrates used. Moreover, as an extension of the conducted research, a regioselective and stereoselective synthesis of the aziridine analogue of the well-known β-blocker, atenolol, was also performed.

References

[1] J. Kaur**,** M. Saxena, N. Rishi, *Bioconjugate Chem.*, **2021**, *32*, 1455-1471.
[2] M. Fallah-Mehrjardi, A. R. Kiasat, K. Niknam, *J. Iran Chem. Soc.*, **2018**, *15*, 2033-2081.
[3] M. Thirumalaikumar, *Org. Prep. Proced. Int.*, **2022**, *54*, 1-39.
[4] Y. Zhou, S. Wu, H. Zhou, H. Huang, J. Zhao, Y. Deng, H. Wang, Y. Yang, J. Yang, L. Luo, *Environ. Int.*, **2018**, *121*, 523-537.
[5] B. Pujala, S. Rana, A. K. Chakraborti, *J. Org. Chem.*, **2011**, *76*, 8768-8780.
[6] Shivani, B. Pujala, A. K. Chakraborti, *J. Org. Chem.*, **2007**, *72*, 3713-3722.

P1-010

The phenomenon of mechanochromism observed under a microscope

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The development of new luminescent organic compounds is increasingly attracting the attention of researchers. Some luminescent organic compounds alter their emission properties in response to external forces such as friction, grinding, or compression. This phenomenon is referred to as mechanochromism.[1] Organic molecules or materials exhibiting mechanochromism can emit different colors of light in various aggregation states.[2] The aim of my research is the synthesis of luminescent coumarin derivatives using modern, environmentally friendly methods. Coumarin is a heterocyclic compound that, due to its natural occurrence and biological activity, is gaining increasing popularity.[3] I strive to obtain products that exhibit luminescence in the solid state, demonstrating Aggregation-Induced Emission (AIE) properties.[4] This phenomenon involves compounds showing emission in the aggregated state, but not emitting light when dissolved in a solvent.[5]

In my research, I have synthesized coumarin derivatives with luminescent properties and the ability to form thin solid layers. The compounds I have obtained exhibit mechanochromism, which can be observed by forming thin solid-state films using solvents of varying nature. By employing microscopic techniques to observe these thin layers, we can identify distinct crystal structures in which the compound crystallizes. Furthermore, utilizing fluorescence techniques allows us to observe the emission from these crystalline systems.

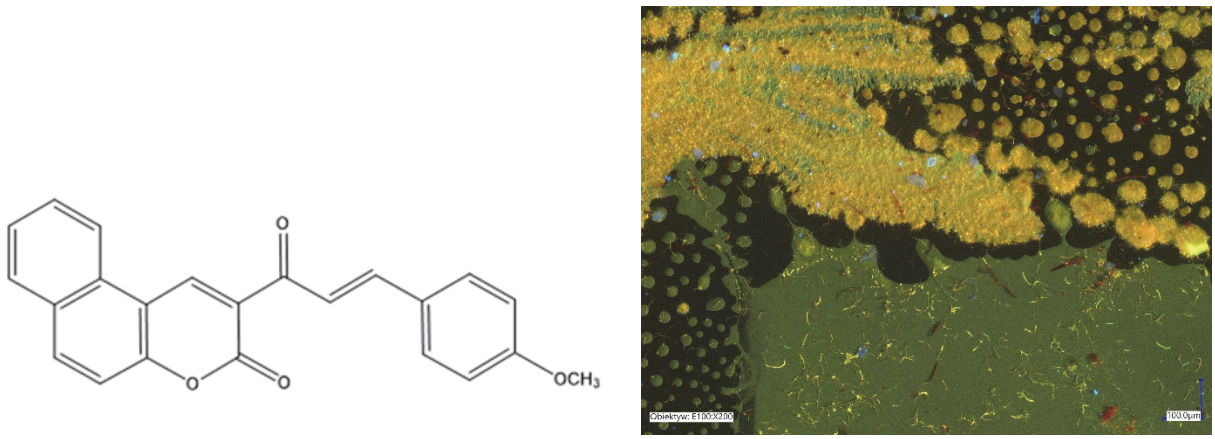

Figure 1. Thin layer of coumarin derivative made by drop casting method using DCM as solvent. Photo taken by fluorescence technique, using a Keyence VHX7000N digital microscope.

References

[1] V. Gokul, D. Devadiga, T.N. Ahipa, *Dye and Pigments*, **2021**, 195, 109692
[2] P.Xue, J. Ding, P. Wang, R. Lu, *J. Mater. Chem. C*, **2016**, 4, 6688
[3] 1. V. C. Basappa, S. Penubolu, D. K. Achutha, A. K. Kariyappa, *J. Chem. Sci.* **2021**, 133, 55.
[4] J. A. Adamczyk, L. Marciniak, M. Rachwalski, A. M. Pieczonka, *Monografia Kwadrans dla chemii*, **2020**, 13.
[5] J. A. Adamczyk, K. Zielonka, S. Kotarba, J. Saramak, I. Głowacki, M. Rachwalski, A. M. Pieczonka, *J. Lumin.*, **2021**, 229, 117668.

P1-011

Can 2′-methylthiamine act as an anti-vitamin of thiamine?

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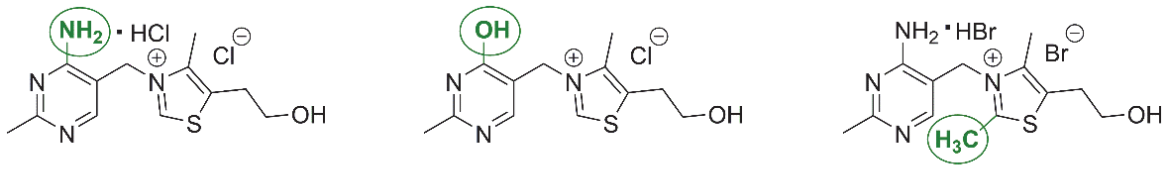
Given the challenges of finding new methods for effective cancer treatment, research in this direction is extremely important [1]. The results of interdisciplinary research into the possibility of using 2′-methylthiamine, an antimetabolite of thiamine (vitamin B1) with an additional methyl group on the C-2 carbon of the thiazole, as a potential cytostatic agent are presented [2]. Its unique structure suggests it may be a promising inhibitor of thiamine pyrophosphokinase and thiamine pyrophosphate-dependent enzymes. The effect of 2'-methylthiamine on HeLa cancer cells and normal fibroblasts was studied in vitro in cell culture and compared with the effects of thiamine and oxythiamine. These studies were complemented by results obtained with computational chemistry tools - molecular docking to enzymes whose substrate or coenzyme is thiamine (or its pyrophosphate), as well as to the transporters that allow the passage of these polar structures across biological membranes into cells.



Scheme 1. Structural comparison of thiamine, oxythiamine, and 2′-methylthiamine.

References

[1] Siegel, R.L.; Miller, K.D.; Jemal, A. *CA Cancer J. Clin.* **2020**, *70*, 7–30.
[2] Malinowska, M.; Czerniecka, M.; Jastrzebska, I.; Ratkiewicz, A.; Tylicki, A.; Wawrusiewicz-Kurylonek, N. *Int. J. Mol. Sci.* **2024**, *25*, 4359.

P1-012

Exploring the Potential of Tetrazole and Triazole as trans-Amide Bond Isosteres in Amino Acid Residues via DFT

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For the discovery of new drugs, improving pharmacokinetic properties and reducing the toxicity of potential drugs are crucial. Isosteres provides a valuable tool for achieving these goals [1, 2]. Our focus was on the amide bond in peptide drugs, inspired by natural compounds containing oxazole and thiazole rings [3]. We conducted a conformational search using models incorporating tetrazole and triazole rings with various methyl substitutions. Our aim was to analyze the conformational properties of alanine residues with either a tetrazole or triazoles ring at the C-terminus peptide bond site using computational methods (DFT), comparing them with alanine analogue. The M062X method, combined with the 6-311++G(d,p) basis set, was employed. We considered three different environments: vacuum, chloroform, and water, utilizing the SMD method. Results indicated that heterocycle substitution significantly influences conformational propensity. Based on our calculations, we identified two compounds with conformational profiles most similar to alanine (Fig. 1).

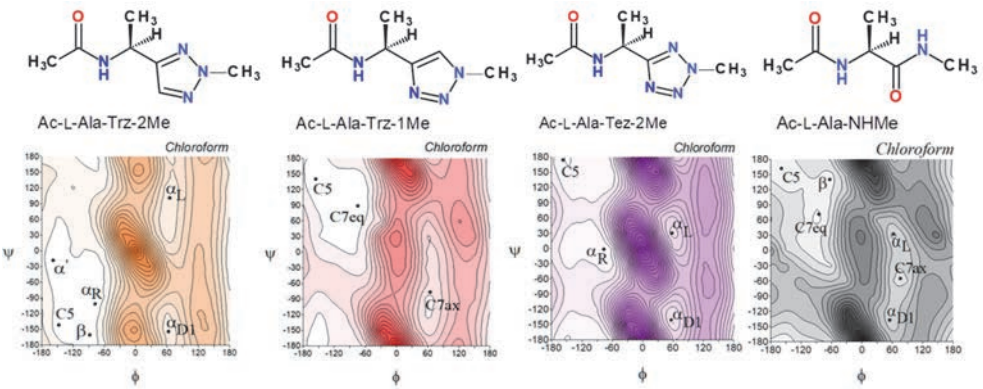

Figure 1. The potential energy surfaces E=f(φ,ψ) for Ac-l-Ala-Trz-2Me, Ac-l-Ala-Trz-1Me, Ac-l-Ala-Tez-2Me, and Ac-l-Ala-NHMe calculated at M06-2X/6–311++G(d,p) method in chloroform. Energy contours are plotted every 1 kcal/mol. The darker colour indicates the high in energy regions and the lighter - low in energy.

Acknowledgement

Calculations have been carried out using resources provided by Wroclaw Centre for Networking and Supercomputing (http://wcss.pl), grant No. 487.

References

[1] D.D. Boehr, R.N. D'Amico, K.F. O'Rourke, *Protein Science*, **2018,** *27*(4), 825-838.
[2] S. Kumari, A.V. Carmona, A.K. Tiwari, P.C. Trippier, *Journal of Medicinal Chemistry*, **2020**, *63*(21), 12290-12358.
[3] M.C. Bagley, J.W. Dale, E.A. Merritt, A. Xiong, *Thiopeptide antibiotics.* Chemical Reviews, **2005**, *105*(2), 685-714.

P1-013

4-Chloro- and 5-Chloro-7-Azaindole-3-Carbaldehydes: Structural Insights, Vibrational Spectroscopy, and DFT Calculations

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In this study, we conduct an in-depth investigation of the molecular structures and vibrational properties of 5-chloro-7-azaindole-3-carbaldehyde (5Cl7AICA) and 4-chloro-7-azaindole-3-carbaldehyde (4Cl7AICA). Infrared (IR) and Raman spectroscopy coupled with density functional theory (DFT) calculations are employed to analyze the structural and spectroscopic characteristics of these compounds. Three DFT methods with dispersion corrections B3LYP-D3, PBE0-D3, and ωB97X-D are used to assess the stability of various molecular dimers.

Single-crystal X-ray diffraction confirms that 5Cl7AICA crystallizes in a monoclinic structure, forming stable dimers through N–H···N hydrogen bonds. Comparative analysis of the two dimeric forms reveals that 5Cl7AICA favors a configuration consistent with its crystal structure, whereas 4Cl7AICA prefers an alternate dimeric arrangement. The study also investigates the influence of internal aldehyde group rotation on the vibrational spectra, providing new insights into the spectroscopic behavior of these chloro-substituted azaindole derivatives. For a more detailed analysis, please refer to our published work [1].

Acknowledgement

The calculations were carried out using resources provided by Wroclaw Centre for Networking and Supercomputing (http://wcss.pl).

References

[1] W. Mucha, J. Bąkowicz, M. Malik, B. Morzyk-Ociepa, *Crystals*, **2024**, *14*, 631.

P1-014

Diradicals based on benzo[*e*][1,2,4]triazin-4-yl: synthesis and study of liquid crystalline properties

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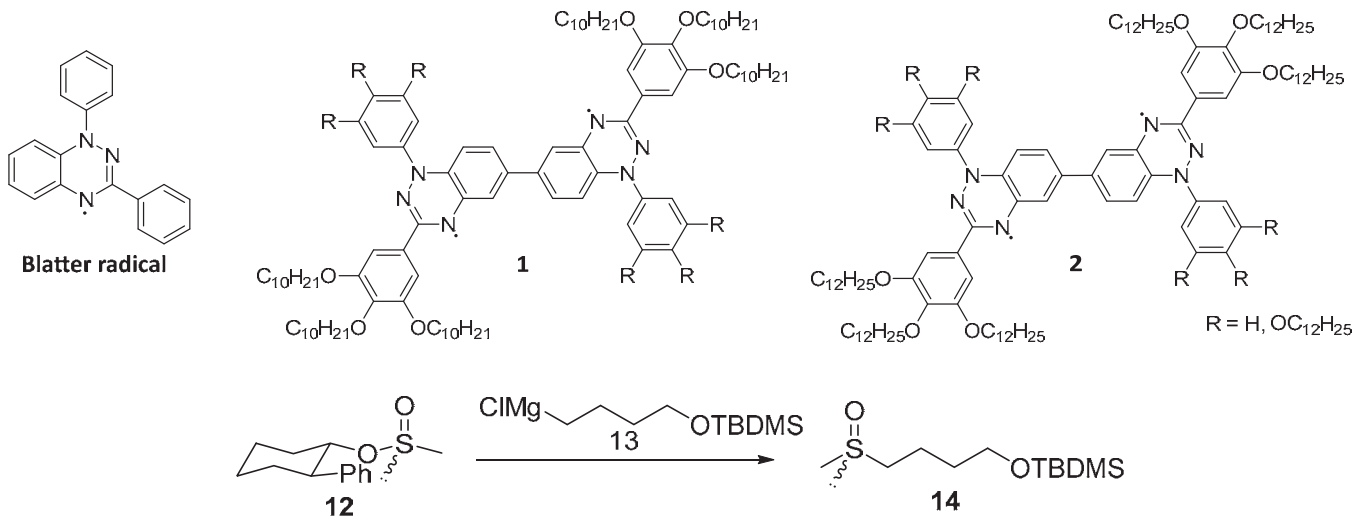
Liquid crystals have been successfully used for many years in TV and smartphone screens, photovoltaics, and field effect transistors [1]. They owe this interest to the anisotropic properties and the ability of molecules to self-organize in an electric field. Moreover, these unusual compounds combine the birefringence of the crystal and the fluidity characteristic of an isotropic liquid.

This project aimed to obtain paramagnetic, high-spin liquid crystal materials **1** and **2** by introducing alkoxy substituents to diradical molecules. For this purpose, the properties of liquid crystals were combined with the properties of stable diradicals based on the Blatter radical (Scheme 1). Stable radicals form an exciting class of compounds with potential use in modern functional materials for electronics and spintronics. Their uniqueness results not only from their exceptional stability caused by π-delocalization of spin but also from their paramagnetic properties and absorption of radiation in a wide range of visible light. In benzotriazinyl diradicals strong magnetic interactions and wider absorption range than in monoradicals open up the possibility of their potential use as building blocks in high-spin materials [2,3] and as NIR dyes [4]. To achieve the intended goal, the method of azaphilic addition of aryl lithium to bisbenzotriazine was used.



Scheme 1. Structures of Blatter radical and diradicals **1** and **2** planned to be obtained in the project.

Acknowledgement

The project was financed by NCN grant 2020/38/A/ST4/00597.

References

[1] Y.-C. Lin, G.-S. Li, P.-J. Yu, E. Ercan, W.-C. Chen., *J. Chin. Chem. Soc.*, **2022**, 69, 1289-1304.
[2] D. Pomikło, A. Pietrzak, R. Kishi, P. Kaszyński, *Mater. Chem. Front.*, **2023**, 7, 4928-4943.
[3] D. Pomikło, P. Kaszyński, *Chem. Eur. J.*, **2023**, 29, e202301069.
[4] S. Zhang, M. Pink, T. Junghoefer, W. Zhao, S.-N. Hsu, S. Rajca, A. Calzolari, B. W. Boudouris, M. B. Casu, A. Rajca, *J. Am. Chem. Soc.*, **2022**, 144, 6059-6070..

P1-015

Preparation of P-diastereomerically pure 4-modified morpholino units for synthesis of P-stereodefineddinucleoside 3′,5′-phosphorothioates

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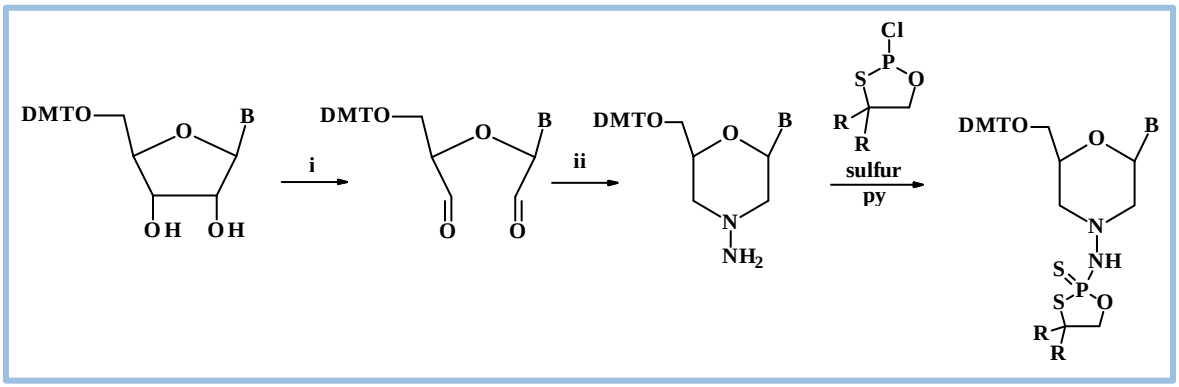
Herein, we present the preparation of P-diastereomerically pure 4-aminomorpholino units for synthesis of **novel P-stereodefinedphosphorothioate of** 4-amino**morpholino analogs**. Synthesis of morpholino nucleosides were performed according to the published protocols[1,2]. Briefly, 5'-*O*-dimethoxytrityl uridine was oxidatively converted in the acyclicdialdehydederivatives,followedby areductive amination-cyclization reaction.Morpholino nucleosides were transformed into corresponding N-(2-Thio-1,3,2-oxathiaphospholane) derivatives of morpholino-type nucleosides (**mB'-^{N}OTPs**, **1**) according to a general procedure published for the synthesis of the standard OTP monomers[3]. **mB'-^{N}OTPs(1)** were isolated as a mixture of P-diastereomers and were characterized by FAB MS and ^{31}P NMR. OTP monomers were separated into P-diastereomers (*fast*-eluting and *slow*-eluting) by preparative HPLC using silica gel column and their diastereomeric purity was confirmed by ^{31}P NMR, ^{1}H NMR, ^{13}C NMR.



B: Ura; **R**,**R**: H, H or -$(CH_2)_5$- typically 50-50% yield

i. $NaIO_4$ (1.2 equiv), anhydrous methanol; **ii.** a) hydrazine (2.5 equiv), H_3BO_3 (2.5 equiv), 6 h; b) $NaCNBH_3$ (2.0 equiv); CH_3COOH (2.0 equiv), 16 h

Scheme 1. Synthesis of OTP monomer.

This proposal aims to expand the library of diastereomerically pure probes with N-modified morpholine moiety available to biochemists and biologists in the hope of future applications in medicine.

Acknowledgement

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References

[1] Langner H., **Jastrzebska K.**, Caruthers M., *J. Am. Chem. Soc.*, **2020**, 142, 16240–16253.
[2] Tarasenko YV, Abramova TV, Mamatuk VI, Silnikov VN. Effective Synthesis of Fluorescently Labeled Morpholino Nucleoside Triphosphate Derivatives. Nucleosides Nucleotides Nucleic Acids, 2016, 35, 32-42.
[3] Guga P., Stec W.J., In Current Protocols in Nucleic Acid Chemistry, ed. S. L. Beaucage, D. E. Bergstrom, G. D. Glick and R. A. Jones, John Wiley and Sons, Hoboken, N.J., **2003**, p. 4.17.1.

P1-016

Axially chiral stable radicals: a promising class of functional materials

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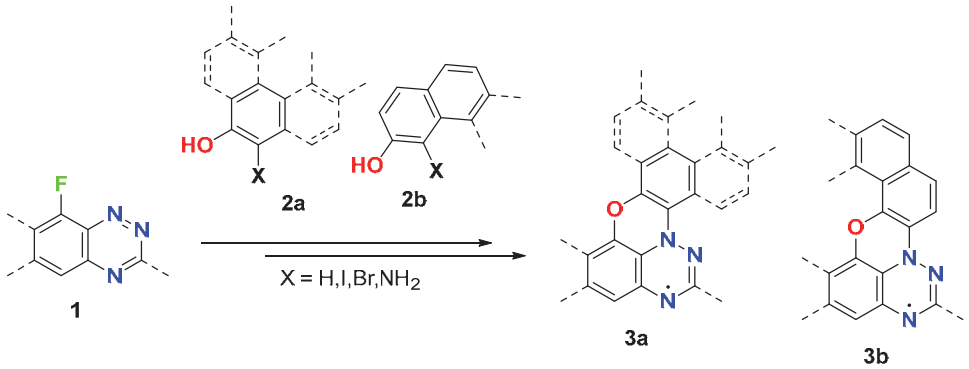
Benzo[e] [1,2,4] triazinyls, or Blatter radicals, are stable free radicals, first reported by Blatter in 1968 [1]. Blatter-type radicals have many interesting physical properties, such as antiferromagnetic or ferromagnetic interactions, spin π-delocalization, narrow electrochemical windows, and low excitation energy, which attract attention from scientists. More importantly, Blatter radicals have excellent stability to air and water and are stable for up to 30 years [2]. In contrast to their nitroxide counterparts, their properties can be modified more easily through simple variations of substituents [3]. Recently three procedures, Pschorr-type cyclization, photocyclization (halogen lamp irradiation) and Bu_3SnH- and TMS_3SiH-assisted cyclization were reported to synthesize the planar Blatter radicals [4-6]. The goal of this project is to use planar Blatter radical as the central paramagnetic structural element of axially chiral paramagnetic derivatives and investigate their chiro-optical and chiro-magnetic properties in solutions, organized media and on metal surfaces as monolayers.



Scheme 1. Preparation of π-extended benzo[e] [1,2,4] triazin-4-yls.

Acknowledgement

This work is supported by the National Science Centre (2020/38/A/ST4/00597)

References

[1] H. M. Blatter and H. Lukaszewsk, Tetrahedron Lett., **1968**, 2701–2705.
[2] Fergus J. M. Rogers, Philip L. Norcott and Michelle L. Coote, Org. Biomol. Chem., **2020**,18, 8255
[3] Yu Ji, Lanxin Long and Yonghao Zheng, Mater. Chem. Front., **2020**, 4, 3433
[4] Bartos, P.; Young, V. G.; Kaszyński, P.Org. Lett. **2020**, 22 (10), 3835–3840.
[5] Paulina Bartos, Małgorzata Celeda, Anna Pietrzak and Piotr Kaszyński, Org. Chem. Front., **2022**, 9, 929
[6] Paulina Bartos, Bindushree Anand, Anna Pietrzak and Piotr Kaszynski, Org. Lett. **2020**, 22, 180-184.

P1-017

Synthesis and properties of fluorinated derivatives of BTBT

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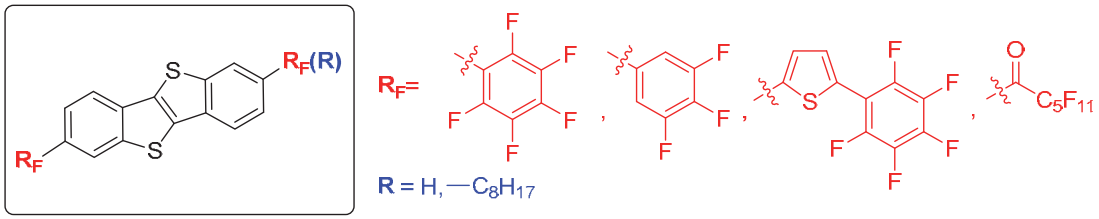
The development of novel organic semiconducting materials is an increasingly active area of research in organic electronics.[1] π-Conjugated small molecules are particularly valuable as active materials in electronic and optoelectronic devices, such as OFETs, OLEDs, and OSCs, due to their electronic and optical properties, which can be precisely modified through molecular structure engineering and functionalization.[2] Among such compounds, [1]benzothieno[3,2-*b*][1]benzothiophene (**BTBT**) derivatives have been extensively studied and applied in organic electronics.[3] Recently, fluorinated **BTBT** derivatives have emerged as promising candidates in the field of organic semiconductors due to their tunable properties and potential for high-performance device fabrication.[4] The introduction of fluorine atoms into the molecular structure can profoundly affect both the electronic and chemical properties of these materials. In contrast to their non-fluorinated counterparts, which typically exhibit p-type charge mobility, fluorinated compounds can act as highly demanded ambipolar or n-type semiconductors.

In this study, we present the synthesis, as well as the optical and thermal characterization, of a series of fluorinated **BTBT** derivatives bearing perfluoroaryl, perfluoro(hetero)aryl, and perfluoroalkanoyl substituents (Scheme 1).



Scheme 1. Structure of fluorinated **BTBT** derivatives.

References

[1] a) R. Ozdemir, D. Choi, M. Ozdemir, G. Kwon, H. Kim, U. Sen, C. Kim, H. Usta, *J. Mater. Chem. C* **2017**, *5*, 2368; b) E. K. Burnett, J. Ly, M. R. Niazi, L. Zhang, S. R. McCuskey, A. Amassian, D. -M. Smilgies, S. C. B. Mannsfeld, A. L. Briseno, *Adv. Mater. Interfaces* **2018**, *5*, 1701607; c) G. Demirel, H. Usta, M. Yilmaz, M. Celik, H. A. Alidagi, F. Buyukserin, *J. Mater. Chem. C* **2018**, *6*, 5314.

[2] R. Ragni, A. Punzi, F. Babudri, G. M. Farinola, *Eur. J. Org. Chem.* **2018**, 3500.

[3] H. Yu, W. Li, H. Tian, H. Wang, D. Yan, J. Zhang, Y. Geng, F. Wang, *ACS Appl. Mater. Interfaces* **2014**, *6*, 5255.

[4] a) P. Kumaresan, S. Vegiraju, Y. Ezhumalai, S. L. Yau, C. Kim, W.-H. Lee, M. -C. Chen, *Polymers* **2014**, *6*, 2645; b) D. E. Martinez-Tong, G. Gbabode, C.Ruzie, B. Chattopadhyay, G. Schweicher, A. R. Kennedy, Y. H. Geertsc, M. Sferrazzaa *RSC Adv.* **2016**, *6*, 44921 c) H. Usta, D. Kim, R. Ozdemir, Y. Zorlu, S. Kim, M. C. Ruiz Delgado, A. Harbuzaru, S. Kim, G. Demirel, J. Hong, Y. -G Ha, K. Cho, A. Facchetti, M. –G. Kim, *Chem. Mater.* **2019**, *31*, 5254.

[5] F. Babudri, G. M. Farinola, F. Naso, R. Ragni, *Chem. Commun*. **2007**, 1003.

P1-018

Helical Polyamines

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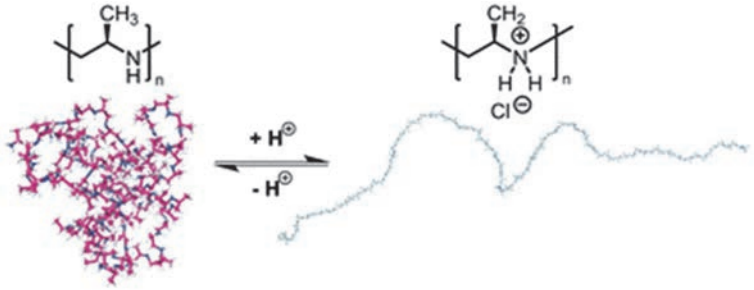
Tacticity is a key characteristic of polymeric materials, contributing to supramolecular organization and imparting new properties to existing materials, which are crucial for applications like chiral catalysis, separation, and sensing.[1] While the microstructure of polymers depends on tacticity, research on polyamines has largely focused on atactic polymers.

To explore secondary structure formation and the impact of protonation, molecular dynamics (MD) simulations were conducted at 300 K to calculate the structure of both protonated and deprotonated forms, confirming the helical structure of isotactic linear polypropylene imines (LPPIs) in water. The calculations were done in an octahedral solvent box (using the TIP3P water model, with 12 Å around the solute) with the GAFF2 force field implemented in Amber22 software.

The findings suggest that non-protonated polymers tend to fold into a globular shape, regardless of their tacticity, and this folding continues up to 20% protonation of the monomer units. In stereoblock copolymers, the main difference observed was the formation of chiral domains during folding—when protonation exceeds 20%, electrostatic repulsion prevents globular folding, and the polymers remain in an elongated state. Re-protonation after folding restores the elongated shape (Fig. 1), suggesting a dynamic system. Duplex and triplex systems were also examined and displayed similar behavior, forming supramolecular assemblies that can be reversed by protonation.[2]



Scheme 1. Chemical behavior of polyamines upon (de)protonation in water.

Acknowledgement

We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2023/016501.

References

[1] Ma, Y. , Shi, L. , Yue, H., Gao, X.,, *Colloids Surf., B.*, **2020** *195*, 111268.
[2] Hagedoorn, D., Michel-Sousy, S., Gostyński, B., Gojzewski, H., Paneth, P., Cornelissen, J., Wurm, F. ***Chem. Sci.***, **2024**, Advance Article.

P1-019

A new insight on the course of the reaction between ethyl oleate and selected nitrile *N*-oxides

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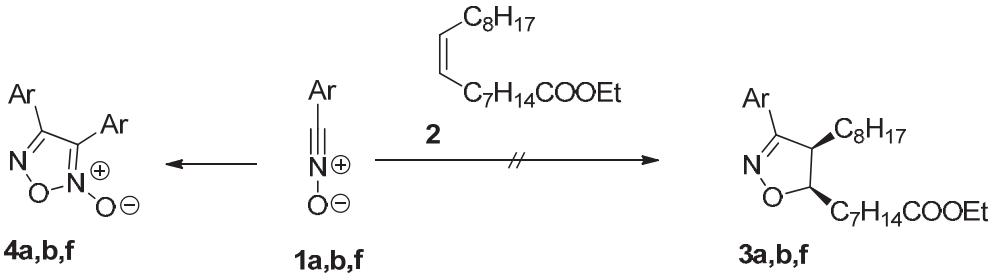
2-Isoxazolines play an important role in medicinal chemistry. This group of compounds constitutes an important molecular segment of many biologically active products [1,2].

The most universal method for obtaining molecular systems of 2-isoxazolines is the [3+2] cycloaddition reactions between nitrile N-oxides and alkenes [3].

A few years ago, Kumar et al. [4] described a protocol for obtaining 2-isoxazolines via the [3+2] cycloaddition scheme based on ethyl oleate as the 2π-electron component and aryl nitrile oxides as the triatomic components (TAC).

However, the described protocol raises many doubts. Therefore, the course of the reaction between ethyl oleate and aromatic nitrile N-oxides was re-examined by our group (Scheme 1).



Ar = Ph (**a**), 4-MeO-C_6H_4 (**b**), 4-NO_2-C_6H_4 (**f**)

Scheme 1. [3+2] cycloaddition between ethyl oleate and aryl-substituted nitrile N-oxides.

Our comprehensive experimental and quantum chemical studies of the [3+2] cycloaddition reactions of ethyl oleate to aryl nitrile N-oxide clearly show that, according to the protocols typical for cycloadditions of nitrile oxides, the title reaction does not lead to the expected 2-isoxazoline analogues. Instead, the corresponding diarylfuroxanes were isolated from the reaction mixtures.

The course of the reaction was explained based on DFT quantum chemical calculations [5].

Acknowledgement

The work was created as a result of the implementation of a scientific activity under the MINIATURA 7 program no. DEC-2023/07/X/ST5/00836 financed by the National Science Center.

We gratefully acknowledge Poland's high-performance Infrastructure PLGrid ACK Cyfronet AGH for providing computer facilities and support within computational grant no PLG/2023/016808.

References

[1] Kumar, G.; Shankar, R.; *Chem. Med. Chem*. **2021**,16, 430–447.
[2] Pandhurnekar, C.P.; Pandhurnekar, H.C.; Mungole, A.J.; Butoliya, S.S.; Yadao, B.G.; *J. Heterocycl. Chem*. **2022**, 60, 1–29.
[3] Fang, R.K.; Yin, Z.C.; Chen, J.S.; Wang, G.W.; Green *Chem. Lett. Rev*. **2022**, 15, 519–528.
[4] Govindaraju, M.; Kumar, G.V.; Kumar, K.A.; *Int. J. Chem. Tech. Res*. **2014**, 6, 886–890.
[5] Dresler, E.; Sadowski, M.; Demchuk, O.M. *Sci. Rad*. **2024**, 3, 108-121.

P1-020

Synthesis of new hybrid alpha-aminophosphonates with a heterocyclic linker as compounds with potential anticancer activity

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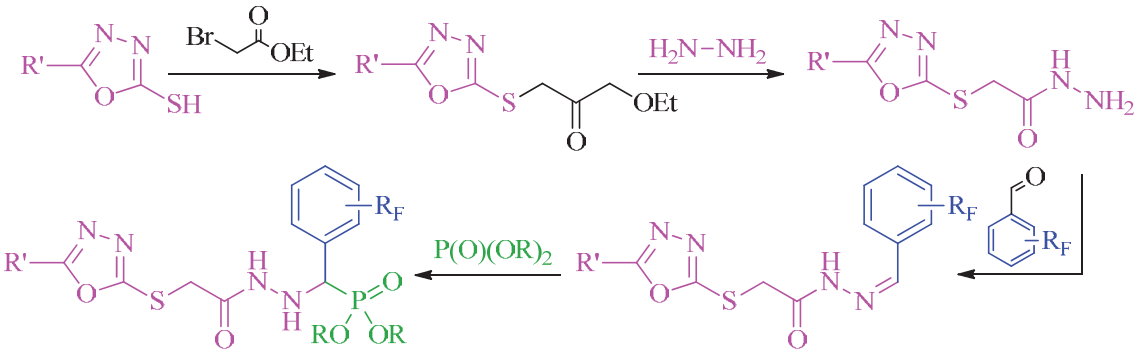
Esters of α-aminophosphonic acids are bioisosters of naturally occurring α-amino acids. Because of this structural similarity, α-aminophosphonates have found applications in medicinal chemistry, exhibiting a variety of biological activities, including anticancer activity. Another group of interesting compounds with medical and pharmaceutical applications are 1,3,4-oxadiazoles. These compounds, which contain nitrogen and oxygen atoms in a five-membered aromatic ring, readily bind to many enzymes and receptors in biological systems, and thus exhibit a wide spectrum of biological activity. Fluorine occupies a special place in medicinal chemistry. Fluorination is seen as a standard strategy for modulating the properties of chemical compounds. Organofluorinated compounds are an important source of candidates for potential therapeutic applications. The combination of these three pharmacophores in a one molecule represents a new approach to the issues of biological activity of α-aminophosphonates. The goal of the project was to synthesize new hybrid α-aminophosphonates with potential anticancer activity (Scheme 1).



Scheme 1. Synthetic approach to hybrid α-aminophosphonates.

Acknowledgement

The research was financially supported by “BESTStudentGRANT” (119/39/UAM/0003).

References

[1] X. Zhou, Meie E. Wang *Pesticide Biochem. Physiology*, **2021**, *172*, 104749;
[2] Tian, Li, Velmurugan, Bai, Wang, Zuo, Hu *Frontiers Chem*. **2022**, *10*, 911453;
[3] X-C. Yang, C-M Zeng, Avula, Peng, Geng, Zhou *Eur. J. Med. Chem.* **2023**, *245*, 114891-114905;
[4] Che J. Y. Lan, Xie, Yin, Wang, Chen, Zhang, Song, Hu Bioorg. *Med. Chem. Lett*. **2016**, *26*, 1310–1313;
[5] Ewies F. E. El-Hussieny, El-Sayed, M..A. Fouad *Eur. J. Med. Chem*. **2019**, *180*, 310-320;
[6] Kwiczak-Yiğitbaşı J. Pirat, Virieux, Volle, Janiak, Hoffmann, Mrzygłód, Wawrzyniak, Barciszewski, Pluskota-Karwatka *RSC Adv*., **2019**, *9*, 24117;
[7] H.-Z. Zhang, Lin-Lang Gan, Cheng-He Zhou *Eur. J. Med. Chem*. **2018**, *144*, 444–492.

P1-021

Diastereoselective synthesis of novel fluorine-containing α-aminophosphonates as potential urokinase inhibitors

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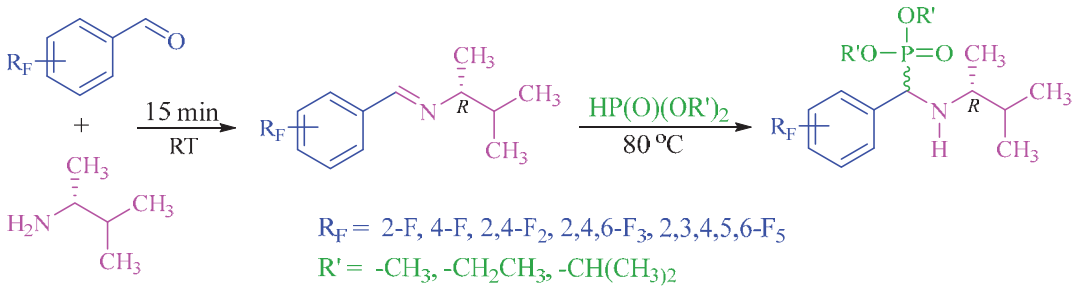
α-Aminophosphonates are esters of α-aminophosphonic acids and structural analogues of natural α-amino acids, in which the carboxyl group is replaced by a phosphonate group containing relatively stable C-P bonds. The similarity in structure between α-aminophosphonates and amino acids causes the former to exhibit a number of very interesting biological properties [1-4] including anticancer activity. For this reason, α-aminophosphonates are attractive compounds for medicinal chemistry. The presence of fluorine atoms in the molecules of α-aminophosphonates can have a significant impact on their biological activity and pharmacokinetic properties. In the search for effective drugs to fight cancer, there has been increased interest from research groups in urokinase [5,6]. Urokinase is involved in the processes that lead to the invasion of cancer cells that attack healthy tissue and migrate with the blood, forming metastases to distant organs [7].

The aim of the project was to synthesize new fluorine-containing α-aminophosphonates, conduct structural studies of the obtained compounds and determine their pharmacokinetic profile. The title α-aminophosphonates were synthesized by diastereoselective hydrophosphorylation of chiral imines obtained by reacting (*R*)-2-methyl-3-butylamine with fluorinated benzaldehyde derivatives (Scheme 1).



Scheme 1. Scheme of the synthesis of fluorinated α-aminophosphonates.

The obtained compounds were characterized by spectroscopic (^{1}H NMR, ^{13}C NMR, ^{31}P NMR and ^{19}F NMR) and spectrometric (HRMS) methods. Pharmacokinetic studies were performed using SwissADME analysis.

Acknowledgement

The research was financially supported by “ADVANCEDBestStudentGRANT”(117/39/UAM/0004).

References

[1] Q. Wang, L. Yang, H. Ding, X. Chen, H. Wang, X. Tang, *Bioorg. Chem*. **2016**, *69*, 132–139.
[2] X-C. Yang, C-M. Zeng, S. R. Avula, X-M. Peng, R-X. Geng, C-H. Zhou, *Eur.J. Med. Chem*. **2023**, *245*, 114891-114905.
[3] E. F. Ewies, M. El-Hussieny, N. F. El-Sayed, M. A. Fouad *Eur. J. Med. Chem*. **2019**, *180*, 310-320.
[4] J. Tian, R. Ji, H. Wang, S. Li, G. Zhang, *Frontiers Chem*. **2022**, *10*, 911453.
[5] P. S. Farag, A. M. AboulMagd, M. M. Hemdan, A. I. Hassaballah *Bioorg. Chem*. **2023**, *130*, 106231.
[6] B. J. Buckley, A. Aboelela, E. Minaei, L. X. Jiang, Z. Xu, U. Ali, K. Fildes, C. Cheung, S. M. Cook, D. C. Johnson, D. A. Bachovchin, G. M. Cook, M. Apte, M. Huang, M. Ranson, M. J. Kelso *J. Med. Chem*. **2018**, *61*, 8299-8320.
[7] A. H. Mekkawy, M. H. Pourgholami, D. L. Morris *Med. Res. Rev*. **2014**, *34*, 918–956.

P1-022

Synthesis and analysis of film-forming properties of imine derivatives of salicylaldehyde

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In my research, I undertook the synthesis and description of properties of a remarkably interesting group of chemical compounds – imines of salicylaldehyde. Imines are known for their diverse physicochemical properties. Their broad applicability allows these compounds to be used in many areas of life, ranging from the production of drugs used in the treatment of epilepsy or hypertension, to the creation of organic light emitting diodes.[1,2] The objective of this research was to synthesize imines that are derivatives of salicylaldehyde and aniline derivatives substituted with different alkyl groups. I focused on comparing their luminescent properties and to investigate their properties by creating thin solid layers.

The modification of substituents around the luminescent core of a molecule affects the film-forming properties. Additionally, changing the solvent used to create the thin solid layer also significantly impacts the quality of the thin film.

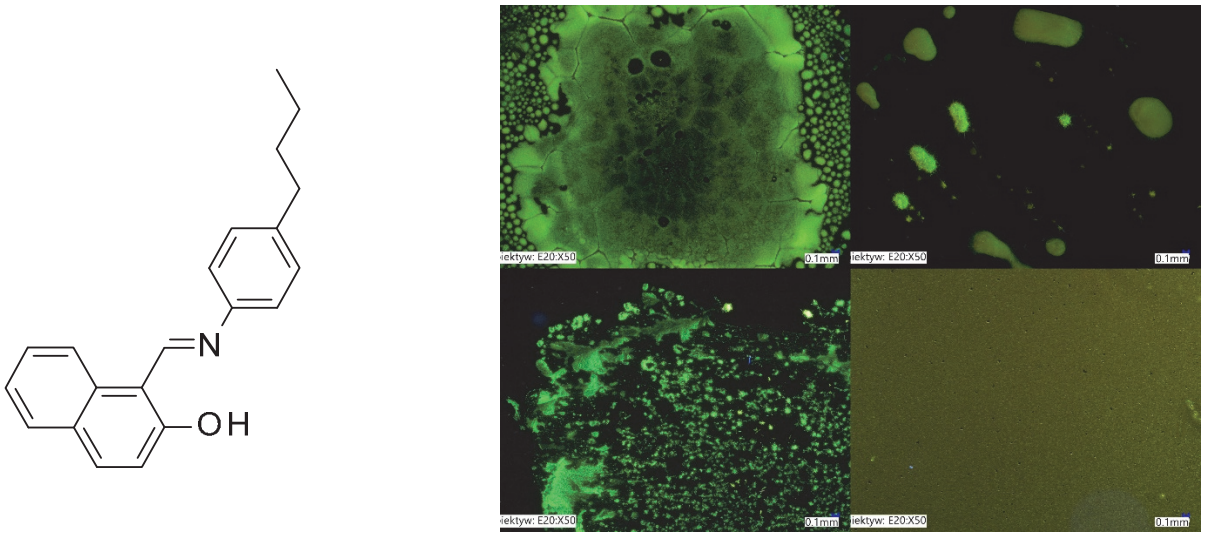

Figure 1. Thin layer of imine derivative made by drop casting method using diffrent solvents. Photo taken by fluorescence technique, using a Keyence VHX7000N digital microscope.

References

[1] J.Shu, T. Ni, X. Liu, B. Xu, L. Liu, W. Chu, K. Zhang, W. Jiang. *Dyes and Pigments* **2021,** *195*, 109708
[2] A. Nowicka, H. Liszkiewicz, W. P. Nawrocka, Wiadomości Chemiczne **2014**, *68*, 191-193.

P1-023

Molecular modeling of non-covalent interactions between ibotenic acid and graphene oxide models

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It is a known fact that some mushrooms contain psychoactive compounds. Some of them are even collected deliberately for that reason, which is however not a new phenomenon[1]. *Amanita muscaria* is one of widest-recognized examples. It contains structural analogs of glutamic acid[2] and γ-aminobutiric[3] acid (GABA), which is ibotenic acid and its derivative - muscimol.

In order to enable detection of ibotenic acid with a chemical sensor, we decided to examine interactions between potential material for such sensor – graphene oxide (GO) and ibotenic acid. We studied such systems, both isolated and soluted (in water, methanol and chloroform) using subsequent GFN2/GBSA and DFT/PCM calculations. Sample of our results, using benzoic acid as GO model is shown below in Figure1.

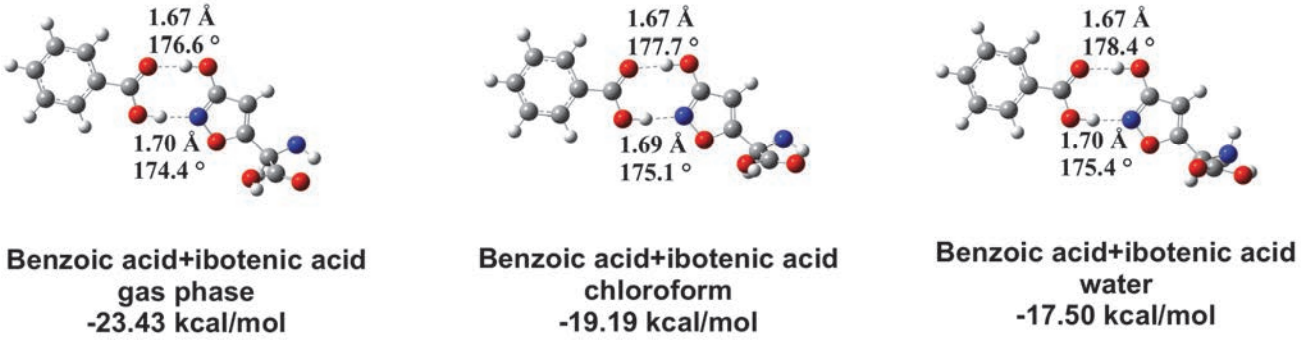

Figure 1. Structures of derived non-covalent complexes of ibotenic acid and benzoic acid in vacuum, chloroform and water.

Acknowledgement

Calculations have been carried out using resources provided by Wroclaw Centre for Networking and Supercomputing (https://wcss.pl).

References

[1] M. R. Lee, E. Dukan, I. Milne, *J. R. Coll. Physicians Edinb.*, **2018**, *48*, 85–91.
[2]J. Stříbrný, M. Sokol,B. Merová, P. Ondra, *Int. J. Legal Med.*, **2012**, *126*, 519–524
[3] D. Michellot, L. M. Melendez-Howell, *Mycol. Res.*, **2003**, *107 (2)*, 131–146.

P1-024

Theoretical and experimental NMR studies of cannabidiol

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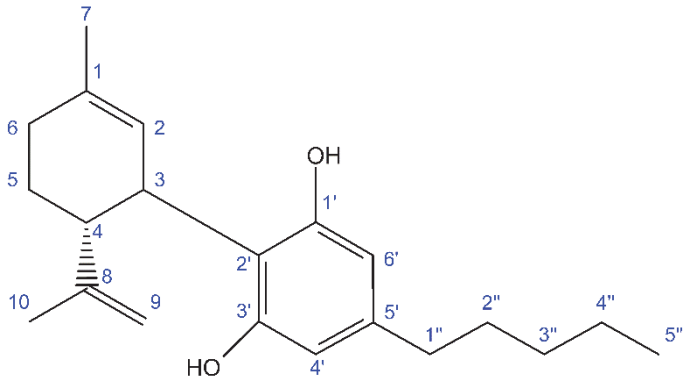
Out of the 125 identified cannabinoids found in the *Cannabis sativa* plant, cannabidiol (CBD) is the most abundant compound. Contrary to tetrahydrocannabinol (THC), it does not produce psychoactive effects of marijuana. CBD is a universal antiepileptic drug, treating various forms of the drug-resistant disease. Beyond its medical application, CBD is widely marketed as a versatile supplement, particularly in the form of oil concentrations. CBD oil is promoted for its benefits in anxiety and pain management and sleep enhancement. CBD has been extensively studied for its biological properties. Some of its well-documented properties include: anti-inflammatory, neuroprotective and anxiolytic activities. CBD is an important compound for therapeutic development. To further explore CBD's properties and molecular structure, we employed Nuclear Magnetic Resonance spectroscopy (NMR). The experiment involved analyzing a CBD sample in chloroform using the 400 MHz ultra-shield Bruker NMR spectrometer and TMS as internal standard. Both ^{1}H and ^{13}C spectra were obtained. In addition to experimental data, computational predictions were obtained using the GIAO[1,2] method within Density Functional theory[3] (DFT). Two functionals B3LYP and PBE0 were selected and combined with the aug-cc-pVTZ basis set. The predicted nuclear shieldings and spin-spin coupling constants allowed for a comparison with the experimental data and aided in a deeper understanding of CBD's structure.



Scheme 1. Chemical formula with atom numbering of cannabidiol (CBD).

Acknowledgement

Calculations have been carried out using the Wroclaw Centre for Networking and Supercomputing (http://wcss.pl).

References

[1] R. Ditchfield, "Self-consistent perturbation theory of diamagnetism. 1. Gauge-invariant LCAO method for N.M.R. chemical shifts," *Mol. Phys.*, **27** (1974) 789-807.

[2] K. Wolinski, J. F. Hilton, and P. Pulay, "Efficient Implementation of the Gauge-Independent Atomic Orbital Method for NMR Chemical Shift Calculations," *J. Am. Chem. Soc.*, **112** (1990) 8251-60.

[3] P. Hohenberg and W. Kohn, "Inhomogeneous Electron Gas," *Phys. Rev.*, **136** (1964) B864-B71.

P1-025

Synthesis of 2-amino-1-thia-3-azaspiro[4.5]dec-2-en-4-one derivatives and their inhibitory activity towards 11β-HSD1

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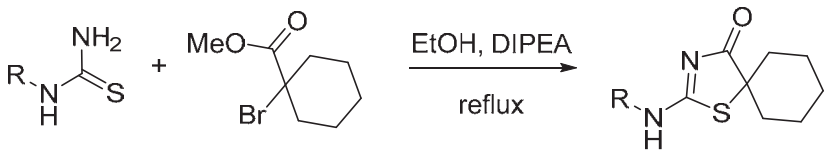
Glucocorticoids belong to the group of steroid hormones produced by the adrenal cortex and they are necessary for the proper maintenance of metabolic and homeostatic functions of the human body. Glucocorticoids secretion is regulated peripherally by the hypothalamic-pituitary-adrenal (HPA) axis in a double feedback fashion, but also at the tissue level by 11β-hydroxysteroid dehydrogenase type 1 (11β-HSD1) and type 2 (11β-HSD2). 11β-HSD1 is an enzyme that catalyzes the intracellular conversion of inactive cortisone into biologically active cortisol, while 11β-HSD2 catalyzes the reverse reaction. Excess glucocorticoids disrupt the body's metabolic management, which leads to the development of metabolic disorders such as abdominal obesity, insulin resistance or dyslipidemia. The disorders in regulation of the activity of 11β-HSD1 is the pathogenetic basis of diseases such as obesity or type 2 diabetes, which are related and constitute important components of the metabolic syndrome. Therefore, inhibition of 11β-HSD1 represents a promising therapeutic concept for the treatment of diseases associated with metabolic syndrome.

Among the many different groups of organic compounds tested in recent years for the inhibition of 11β-HSD1, 2-aminothiazol-4(5*H*)-one derivatives deserve attention. High inhibitory activity is characterized, among others, by compounds containing the spiro rings system of thiazolone and cyclohexane. A number of spiro-cyclohexyl- 2-aminothiazol-4(5*H*)-one derivatives with different substituents (methyl, allyl, isopropyl, t-butyl, adamantyl, cyclohexyl, cyclopentyl) in the amino group were synthesized. These compounds were prepared by reacting the corresponding *N*-substituted thiourea derivatives with methyl 1-bromocyclohexane carboxylate (Scheme 1). [1-5] They were tested towards 11β-HSD1 activity inhibition. Most of them are characterized by high inhibitory activity, comparable to carbenoxolone, and higher selectivity. The percentage of 11β-HSD1 inhibition at the inhibitor's concentration of 10 μM ranges from 48 to 94% and IC_{50} up to 40 nM.



Scheme 1. Synthesis of 2-amino-1-thia-3-azaspiro[4.5]dec-2-en-4-one derivatives.

References

[1] R. Studzińska, R. Kołodziejska, D. Kupczyk, W. Płaziński, T. Kosmalski, *Bioorg. Chem.* **2018**, *79*, 115.

[2] R. Studzińska, D. Kupczyk, W. Płaziński, S. Baumgart, R. Bilski, R. Paprocka, R. Kołodziejska, *Int. J. Mol. Sci.*, **2021**, *22*, 8609.

[3] D. Kupczyk, R. Studzińska, R. Bilski, S. Baumgart, R. Kołodziejska, A. Woźniak, *Molecules*, **2020**, *25*, 4233.

[4] D. Kupczyk, R. Studzińska, S. Baumgart, R. Bilski, T. Kosmalski, R. Kołodziejska, *Molecules*, **2021**, *26*, 2612.

[5] S. Baumgart, D. Kupczyk, A. Archała, O. Koszła, P. Sołek, W. Płaziński, A. Płazińska, R. Studzińska, *Int. J. Mol. Sci.*, **2023**, *24*, 7252.

P1-026

Reactivity of Chalcogen-Based Michael Acceptors: Thiol-Trapping NMR Assay

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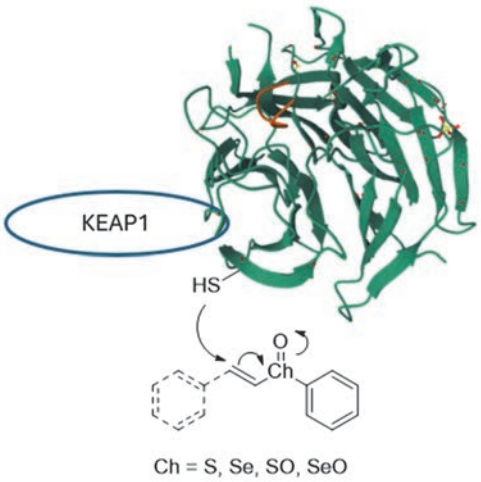
The Nrf2-KEAP1 pathway is a critical regulator of cellular defence mechanisms against oxidative stress, controlling the expression of antioxidant and detoxifying enzymes.[1] Under normal conditions, KEAP1, a cysteine-rich protein with reactive thiol groups on the surface, facilitates the degradation of Nrf2 through the ubiquitin-proteasome system. However, oxidative or electrophilic stress leads to modifications of KEAP1 cysteine residues, disrupting its interaction with Nrf2, allowing Nrf2 to translocate to the nucleus and bind to the antioxidant response element (ARE), initiating the transcription of cytoprotective genes. Modulating this pathway, by covalent interactions with these free –SH groups, presents promising therapeutic potential for diseases associated with oxidative stress, including neurodegenerative disorders such as Alzheimer's and Parkinson's disease.[2,3]

In this study, we investigated the reactivity of selenium- and sulfur-based Michael acceptors with model thiols, aiming to explore their potential as modulators of the Nrf2-KEAP1 pathway. By employing ^{1}H, ^{13}C, and ^{77}Se NMR spectroscopy. Tested compounds exhibit varying reactivity towards studied thiols and react through different mechanisms. The findings provide insight into the reactivity of selenium-containing compounds and their sulfur analogues, suggesting that chalcogen-based Michael acceptors could effectively target KEAP1 thiol groups, potentially leading to Nrf2 pathway activation.[4,5] This opens avenues for the development of novel therapeutic agents that mitigate oxidative stress and its related pathologies.[6]



Scheme 1. Thiol-trapping of chalcogen-based Michael acceptors and KEAP1.

References

[1] M. De Freitas Silva, L. Pruccoli, F. Morroni, G. Sita, F. Seghetti, C. Viegas, Molecules, **2018**, 23 (7), 1803.
[2] M. C. Egbujor, M. Petrosino, K. Zuhra, L. Saso, Antioxidants, **2022**, 11 (7), 1255.
[3] D. H. Cuadrado, M. Rojo, M. Well, Free Radical Biol. Med., **2021**, 173, 19-36.
[4] N. Al-Rifai, H. Rücker, S. Amslinger, Chem. – Eur. J., **2013**, 19 (45), 15384–15395.
[5] D. Caprioglio, A. Minassi, C. Avonto, G. Appendino, Phytochem Rev, **2020**, 19 (6), 1307–1321.
[6] F. Kenari., Sz. Molnar, P. Perjesi, Molecules, **2021**, 26 (14), 4332.

P1-027

Piano-stool iron(II)/ruthenium(II) ionic complexes bearing different *N,N*-heterocyclic ligands with anti-cancer and anti-oxidative properties

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Anti-cancer agents are drawing attention of the scientific community in recent time due to their wide range of biochemical applications in order to fight the disease at grassroot level.[1] Metal-organic complexes containing transition metals like Fe, Ru etc. are being massively investigated for their exquisite anti-mitotic properties.[2] The search for an appropriate ligand that effectively controls the stability and reactivity of metal complexes continues to play an essential role in organometallic chemistry.[3]

Herein, we reported a series of iron and ruthenium cyclopentadienyl carbonyl ionic complexes bearing 2-(2′-pyridyl)benzothiazole/benzoxazole/benzimidazole, (2-pyridyl)methylene α-naphthylamine/β-naphthylamine ligands.[4] Diffraction of single crystals of some of these salts using XRD along with NMR, ESI-MS, FTIR and elemental analyses revealed their subsequent structures. Computational calculations were carried out to explain their relative stability.

The antiproliferative potential of the investigated complexes have been tested against three human cancer cell lines, i.e. A549 (pulmonary carcinoma), Hep G2 (hepatocellular carcinoma) and MCF7 (mammary adenocarcinoma) by neutral red uptake assay. Generally, the complexes were of at least an order of magnitude more active than corresponding ligands. Interestingly, as revealed by dihydrorhodamine 123 oxidation assay, the complexes tended to reduce reactive oxygen species production in exposed cells while pure ligands seemed to act as oxidation promoters.

References

[1] B. Rudolf, A. Kubicka, M. Salmain, M. Palusiak, A.J. Rybarczyk-Pirek, S. Wojtulewski, *J. Organometal. Chem.* **2016**, *801*, 101-110..

[2] a) S. Das, M. Strachanowska, P. Wadowski, M. Juszczak, P. Tokarz, A. Kosińska, M. Palusiak, A. Rybarczyk-Pirek, K. Wzgarda-Raj, S. Vasudevan, A. Chworos, K. Woźniak, B. Rudolf, *Sci. Rep.* **2024**, *14*, 5634. a) A. Kosińska, S. Wojtulewski, M. Palusiak, P. Tokarz, B. Rudolf, *Organometallics*, **2021**, *40*, 663-673. b) M. Juszczak, S. Das, A. Kosińska, A.J. Rybarczyk-Pirek, K. Wzgarda-Raj, P. Tokarz, S. Vasudevan, A. Chworos, K. Woźniak, B. Rudolf, *Dalton Trans.*, **2023**, *52*, 4237-4250.

[3] a) A. Welsh, L. Rylands, V.B. Arion, S. Prince, G.S. Smith, *Dalton Trans.* **2020**, *49*, 1143-1156. b) G.S. Smith, B. Therrien, *Dalton Trans.*, **2011**, *40*, 10793-10800.

[4] S.J. Carrington, I. Chakraborty, J.M.L. Bernard, P.K. Mascharak, *Inorg. Chem.* **2016**, *55*, 7852-7858. b) A.K. Pramanik, M.S. Jana, S. Kundu, T.K. Mondal, *J. Mol. Struct.* **2012**, *1017*, 19-25.

P1-028

Condensation Reaction of Thiourea Derivatives with Dicarbonyl Compounds- Synthesis and Evaluation of their Potential Biological Activity

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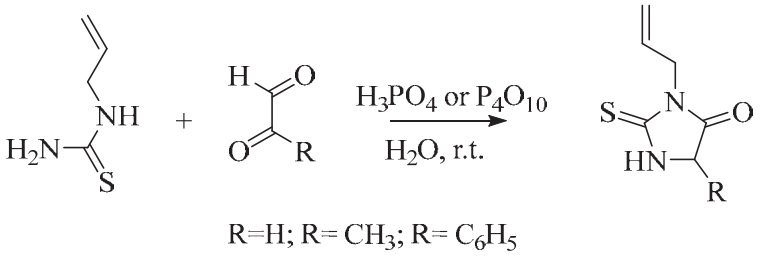
Imidazoles are a widely used group of compounds that exhibit a range of biological activities, including antibacterial, antifungal, and antiprotozoal effects. These compounds have been the subject of numerous studies due to the potential for their chemical structure modification. Over the years, the development of new compounds based on the imidazole structure has led to improved antimicrobial activity and revealed previously unknown applications for this class of drugs. New substitutions have enabled the use of imidazoles as anti-inflammatory and analgesic agents, and in the treatment of cancer, viral infections, depression, and tuberculosis.

A series of imidazole derivatives were synthesized through condensation reactions of dicarbonyl compounds- glyoxal, methylglyoxal, and phenylglyoxal with N-allylthiourea, and their potential biological activity was assessed. The chemical reactions were carried out under various conditions (synthesis in an aqueous medium using P_4O_{10} at different concentrations of substances, and with H_3PO_4), allowing the identification of the optimal synthesis method, for which the efficiency was in the range of 46%-50%.

The potential biological activity was evaluated *in silico* using the PASS Online program. The results showed that, in terms of mechanism of action, the obtained compounds are likely to be effective inhibitors of chloride peroxidase (87% probability). From a pharmacological perspective, they showed the highest potential activity against ischemia and stroke (93%).



Scheme 1. The reaction scheme of thiourea derivatives with dicarbonyl compounds..

Further synthesis of other imidazole derivatives is planned, using different N-substituted thiourea derivatives and dicarbonyl compounds, along with *in vitro* studies of the biological activity of the synthesized compounds.

References

[1] G. Baccolini, C. Boga, C. Delpivo, G. Micheletti, Tetrahedron Letters 2011, 52, 14, 1713-1717.
[2] PASS online, http://pharmaexpert.ru/PASSonline/predict.php, (access 12.03.2024r.).

P1-029

Synthesis of Pyrazinopyrrolopyrimidine–Benzylpiperidine Derivatives and Evaluation of their Inhibitory Activity against Acetylcholinesterase

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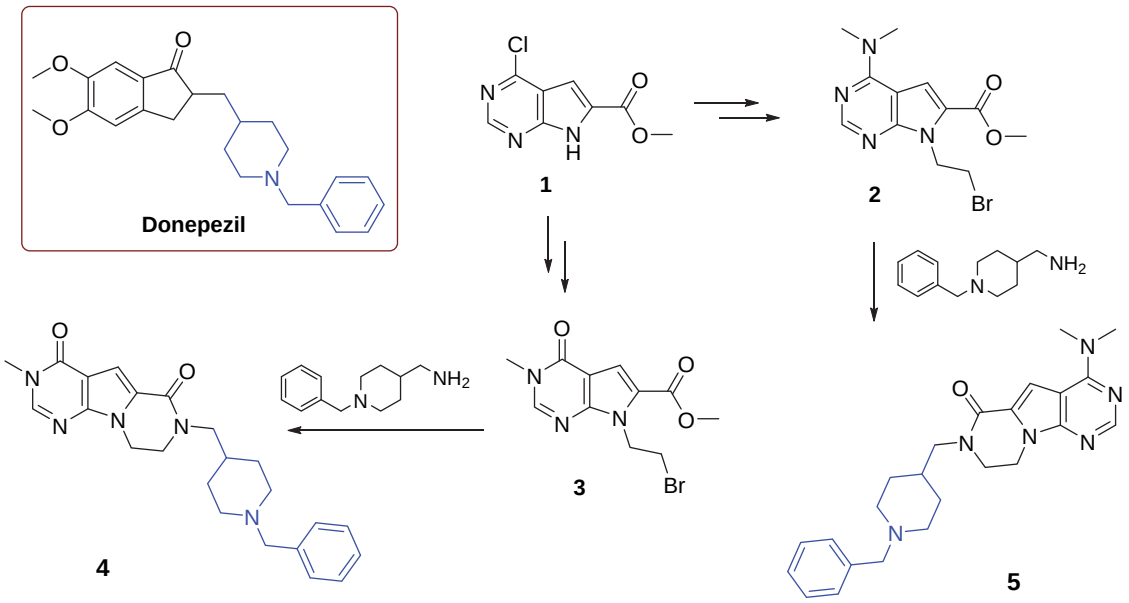
Acetylcholinesterase plays an important role in the symptomatic treatment of Alzheimer's disease and other neurodegenerative diseases. This enzyme catalyzes the hydrolysis of the neurotransmitter acetylcholine. The known acetylcholinesterase inhibitors are donepezil, tacrine, galantamine, and rivastigmine, but the search for new inhibitors remains relevant due to their side effects. One of the strategies for obtaining effective acetylcholinesterase inhibitors is the synthesis of hybrids of heterocyclic compounds based on the structure of donepezil [1]. Taking into account our previous studies on the identification of acetylcholinesterase inhibitors containing a pyrazino[1',2':1,5]pyrrolo[2,3-*d*]pyrimidine scaffold [2], we modified this tricyclic structure by introducing a benzylpiperidine substituent into the pyrazine ring (Scheme 1).



Scheme 1. Synthesis of target pyrazinopyrrolopyrimidine–benzylpiperidine derivatives **4**, **5**.

The target 8,9-dihydropyrazino[1',2':1,5]pyrrolo[2,3-*d*]pyrimidine derivatives **4**, **5** were obtained by refluxing the carboxylate **2** or **3** with an excess of [(1-benzylpiperidin-4-yl)methyl]amine. A two-step synthesis of 7-(2-bromoethyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine-6-carboxylates **2** and **3** was developed from synthetically available methyl 4-chloro-7*H*-pyrrolo[2,3-*d*]pyrimidine-6-carboxylate **1** [2].

The synthesized pyrazinopyrrolopyrimidine–benzylpiperidine derivatives **4** and **5** were evaluated for their ability to inhibit acetylcholinesterase. Compounds **4** and **5** inhibited enzyme activity with an IC_{50} value of 9.99±0.36 and 10.09±0.23 μM, respectively. The obtained data can be used for the development of potent acetylcholinesterase inhibitors with a pyrazino[1',2':1,5]pyrrolo[2,3-*d*]pyrimidine core.

References

[1] R.T. Kareem, F. Abedinifar, E.A. Mahmood, A.G. Ebadi, F. Rajabi, E. Vessally, *RSC Adv.*, **2021**, *11*, 30781.
[2] L. Muzychka, O. Muzychka, O. Smolii, *Chem. Biodivers.*, **2024**, e202401874..

P1-030

Microbiological bioreduction of bulky-bulky pyrimidine derivatives

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Production of enantiomerically pure compounds is essential for drug development and often involves asymmetric synthesis which allows creating chiral compounds.

In general, many enantioselective reactions are supported by a number of different catalysts including biocatalysts which operate under mild conditions and provide high specificity for substrates.

The natural selectivity for a certain stereoisomer makes biocatalysts more sustainable and greener catalysts in asymmetric reactions in comparison to traditionally used transition metals. Heavy metal catalysts do not always give satisfactory results with respect to enantiomeric excesses. Moreover, their use is associated with significant costs and often leads to environmental pollution.

The reaction conditions for biocatalysts are atmospheric pressure, room temperature and aqueous solutions, which positively results in environmental protection and lowers the costs of the process. Due to the highly advanced biotechnology and molecular biology, it is now possible to create enantiomerically pure building blocks of many pharmaceuticals. Most biologically active compounds have a heterocyclic unit present in their structures. This includes a pyrimidine ring that may have antioxidant, antibacterial, antiviral, antifungal, antituberculosis and anti-inflammatory properties.

This research focused on applying biocatalysts to the selective desymmetrization of carbonyl compounds derived from pyrimidine bases leading to the secondary alcohols with a defined absolute configuration. This bioreduction was carried out in the presence of the commonly used yeast *Saccharomyces cerevisiae*, the microbiological preparation Blossom Protect containing two strains of *Aureobasidium pullul*ans: DSM 14940 and 14941. The influence of some parameters on the efficiency of biocatalysis, i.e. substrate concentration and pH of the reaction medium, was evaluated.

In a relatively simple, economical and ecological synthesis, secondary alcohols were obtained with a good degree of conversion and high optical purity up to 99% ee.

Biocatalysis offers economic and environmental benefits as an alternative to conventional methods, becoming a powerful tool in the synthesis of crowded alcohols.

P1-031

Asymmetric reduction of new benzofuryl and benzothiophenyl *α*-amino ketones

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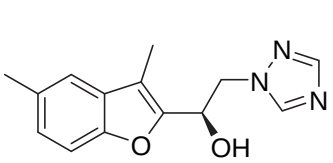
Heterocyclic compounds occupy a central position in organic chemistry. These compounds play an important role in the design and discovery of new pharmacologically active molecules. Heterocycles provide scaffolds on which pharmacophores can arrange to yield potent and selective drugs. Oxygen and sulfur containing heterocyclic systems exhibit diverse biological and pharmacological activities due in part to the similarities with many natural and synthetic molecules with known biological activity. Both benzofuran and benzothiophene derivatives display the wide range of biological properties including antihyperglycemic, analgesic, antiparasitic, antimicrobial, antifungal, antitumor, antidepressant, etc. [1,2].

Asymmetric transfer hydrogenation (ATH) is established as an excellent reduction method due to its versatility, operational simplicity, avoiding the use of explosive hydrogen gas, catalysts resistant to moisture and air oxidation, and high stereoselectivity. Applying this method for the reduction of various *α*-functionalized ketones, benzofuryl *β*-amino alcohols with primary and secondary amine groups were obtained with very high enantioselectivity.[3] *β*-Amino alcohols containing azole rings were also obtained.[4] Continuing these studies, the synthesis of chiral benzofuryl and benzothiophenyl *β*-amino alcohols containing different azoles was developed. For this purpose *α*-amino ketones were synthesized by the reactions of the corresponding *α*-bromo ketones with 1*H*-imidazole, 1*H*-1,2,4-triazole, 2-aminothiazole, 1*H*-1,3-benzimidazole, and 1*H*-benzotriazole. The asymmetric reduction was carried out with formic acid as a hydrogen source, catalyzed by both, RhCl[(*R*,*R*)-TsDPEN](C_5Me_5) and RhCl[(*S*,*S*)-TsDPEN](C_5Me_5), in dichloromethane at reflux for 24-48h. All new benzofuryl and benzothiophenyl *β*-amino alcohols were obtained in high yields and excellent enantioselectivities (90-99%). The absolute configuration of products was confirmed by means of ECD spectroscopy supported by theoretical calculations. Selected racemic and optically active amino alcohols were tested against four bacterial and two fungal species. Among the benzofuran derivatives, compounds 1 and 2 were found to be the most active against *Malassezia furfur*, and among the benzothiophene derivatives – compounds 3 and 4.



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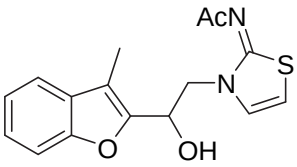

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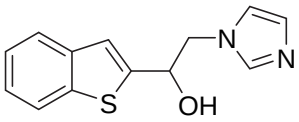

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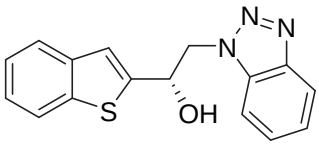

(*S*)-4
rac-4

Acknowledgement
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References

[1] H. K. Shamsuzzaman, *Eur. J. Med. Chem*. **2015**, 97, 483-504.
[2] R. S Keri. et al., *Eur. J. Med. Chem*. **2017**, *138*, 1002-1033.
[3] A. Tafelska-Kaczmarek, M. Krzemiński, M. Ćwiklińska, *Tetrahedron* **2017**, *73*, 3883-3897.
[4] A. Tafelska-Kaczmarek, R. Kołodziejska, M. Kwit, B. Stasiak, M. Wypij, P. Golińska, *Materials*, **2020**, *13*, 4080.

P1-032

Antioxidant potential of new derivatives of 2-(cyclopentylamino)thiazol-4(5H)-one

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Malignant tumours are a global health issue and one of the leading causes of death worldwide. The currently used anti-cancer drugs increasingly yield insufficient results and cause severe side effects. Therefore, it is necessary to search for new chemical compounds with high anticancer activity. Derivatives of 2-aminothiazol-4(5H)-onu (pseudothiohydantoins) are a class of compounds characterised by a broad spectrum of biological activities, including anticancer effects. Compounds belonging to this group exhibit strong anticancer activity through the inhibition of enzymes such as cyclin-dependent kinase 1, cyclin-dependent kinase 2, carbonic anhydrase, and human mitotic kinesin Eg5 [1-4]. The mechanisms mentioned above highlight the strong anticancer properties of 2-aminothiazol-4(5H)-onu derivatives; however, there is emerging evidence that these compounds may also exert their effect by modulating reactive oxygen species (ROS) in cancer cells (an increase in ROS levels in cancer cells induces their apoptosis). A series of nine new N-cyclopentyl pseudothiohydantoin derivatives were synthesized in the reaction of cyclopentylthiourea with the corresponding α-bromo esters [5]. Depending on the substituent present in the α-bromo ester molecule, the reactions were conducted under different conditions. The level of reactive oxygen species was tested on five cancer cell lines (Caco-2, PANC-1, U-118 MG, SK-MEL-30, MDA-MB-231) that were previously exposed to the obtained compounds at a concentration of 500 µM. The study showed that the highest increase in ROS was noted for the PANC-1 line. Furthermore, a high increase in ROS production was observed for the U-118 MG, Caco-2, and SK-MEL-30 lines [5]. Based on the results obtained, it can be concluded that pseudothiohydantoin derivatives have the potential to modulate ROS, therefore further research in this direction is justified/needed.

References

[1] M.T.M, Nemr, et al., *RSC Adv*. **2021**, *11*, 26241–26257.
[2] N.E.A.A., El-Sattar, et al., *Chem. Pharm. Bull*. **2021**, *69*, 106–117.
[3] S.P., Khathi, et al., *Bioorg. Med. Chem. Lett*. **2018**, *28*, 2930–2938.
[4] Chen, et al., *Bioorg. Med. Chem. Lett.* **2007**, *17*, 2134–2138.
[5] S. Baumgart et al., *Int. J. Mol. Sci*. **2023**, *24*(8), 7252.

P1-033

Synthesis of *8*-substituted xanthine derivatives as TPH1 inhibitors

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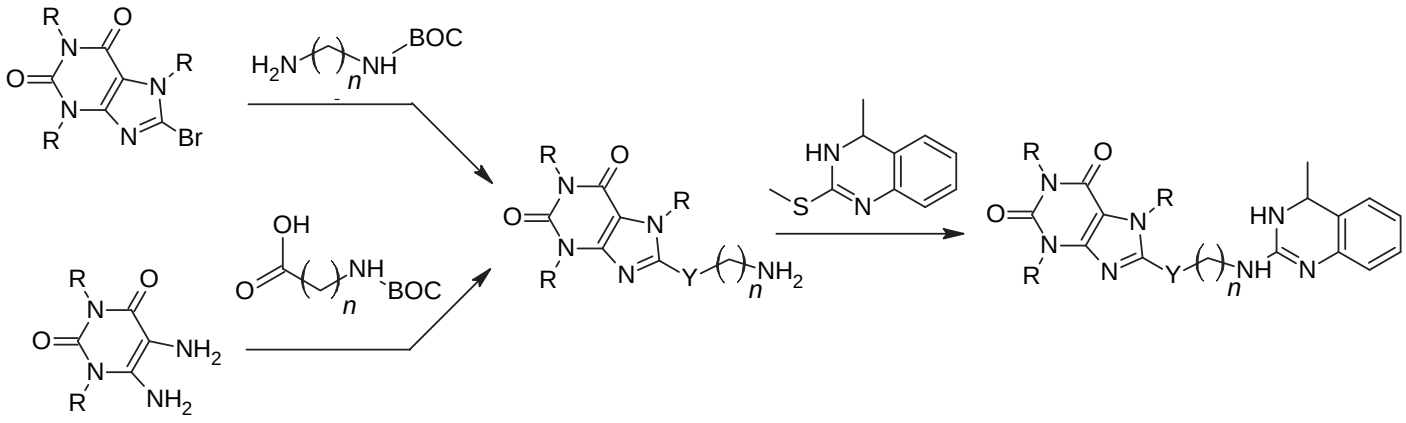
Tryptophan hydroxylase 1 (TPH1) s an enzyme involved in the biosynthesis of serotonin [1]. Recent reports indicate the role of this enzyme in carcinogenesis and the potential use of its inhibitors in cancer treatment [2-3]. An interesting group of TPH1 inhibitors with favorable pharmacokinetic properties may be xanthine derivatives [1].

In our research, we obtained a set of potential TPH1 inhibitors from the group of *N*-alkyl-4-methyl-3,4-dihydroquinazolin-2-amine derivatives of *8*-substituted xanthines. We have developed a fast synthesis method that allowed us to obtain compounds with an efficiency of over 55%. The molecules were obtained by reacting the appropriate amine with 4-methyl-2-(methylsulfanyl)-3,4-dihydroquinazoline in the presence of TEA. The obtained compounds showed moderately strong inhibitory activity to TPH1. We elucidated biological activity using molecular modeling methods, including ligand-protein docking and hybrid QM/MM methods.



Scheme 1. Method of obtaining designed inhibitors.

Acknowledgement

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References

[1] J. Yoon, W.I. Cho, et. al. *Bioorg Med Chem Let*t. **2023**, 94, 129461.
[2] J. Ren J, Z. Mo Z, et. al. *Asian Biomed (Res Rev News).* **2024**, 18(4), 171-179.
[3] J. Zhang, Z. Guo, et. al. *BMC Cancer*. **2022,** 26, 22(1), 457..

P1-034

Synthesis of *β*-Carbonyl Phenyl Selenides with *o*-Ester Group as Antioxidant and Anticancer Agents

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Organoselenium compounds are well known for their unique antioxidant, anticancer and anti-inflammatory properties. They result from a specific Se moiety enclosed in a structure that provides the physicochemical properties necessary for effective drug-target interactions [1] e.g. they can mimic the activity of several selenoenzymes, including the antioxidant enzyme glutathione peroxidase (GPx) [1]. In this work, we investigated the influence of the ester motif on the bioactivity of *β*-carbonyl selenides. For this purpose, the first *β*-carbonyl phenyl selenides having an *o*-ester group were synthesized, and we assessed whether this modification changes their antioxidant and anticancer properties [2].

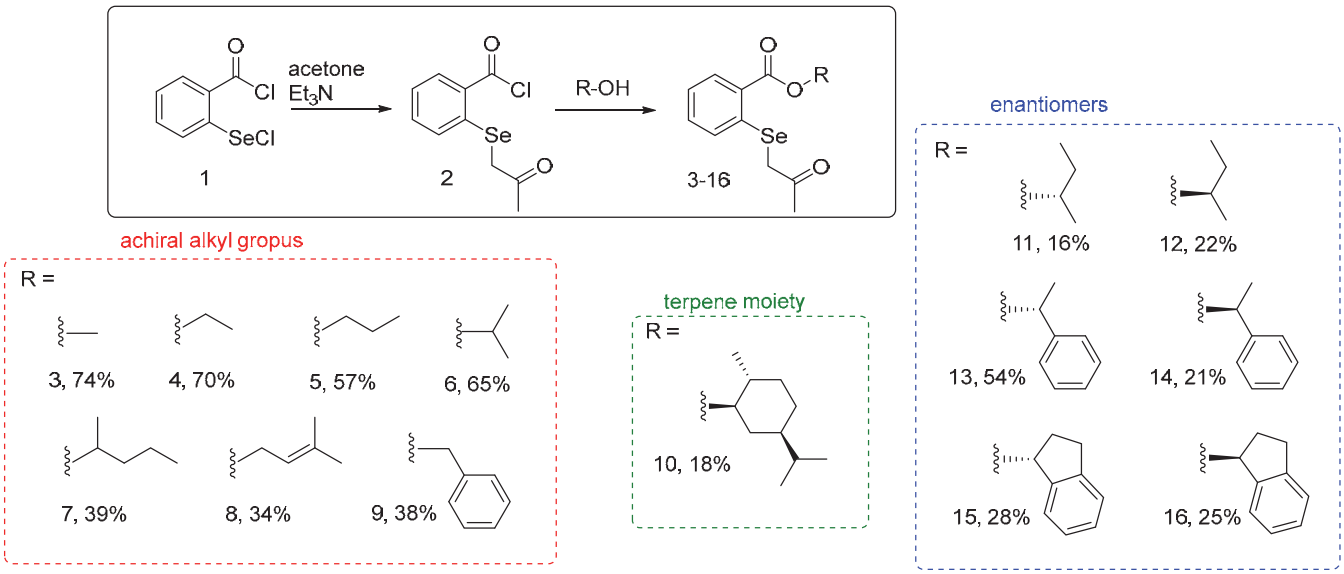

Figure 1. Synthesis of *β*-carbonyl phenyl selenides with *o*-ester group.

Acknowledgement

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References

[1] M. Obieziurska-Fabisiak; A. J. Pacuła-Miszewska; A. Laskowska; J. Ścianowski, *Arkivoc*, **2023**, *v*, 212-23.

[2] A. Laskowska, A. J. Pacuła-Miszewska, M. Obieziurska-Fabisiak, A. Jastrzębska, A. Długosz-Pokorska, K. Gach-Janczak, J. Ścianowski, *Materials*, **2024**, *17*, 899.

P1-035

(8+2)-Cycloadditions (*HOC's*) of Tropothione with the Phosphoryl Group Activated Dithioesters

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In recent years rapidly growing interest in 'higher order cycloadditions' (*HOC's*; transition state involves more than 6π electrons) can be observed [1]. Tropothione (**1**) owns 8π electrons and it is considered as a perfect model to be explored in the (8+2)-cycloadditions with different 2π electron donors, e.g α,β-unsaturated ketones [2], thioketones [3], etc. In a recent publications we reported the (8+2)-cycloadditions of **1** with levoglucosenone (**2**) and some exocyclic enones **3** derived therefrom [4]. Two letter substrates belong to the group of α,β-unsaturated ketones.

In this communication. first (8+2)-cycloadditions of **1** with highly activated dithioesters **4** (the C=S group acts as a 2π electron donor), possessing the phosphoryl functionality –P(O)(OR)$_2$ will be discussed (**Figure 1**). A test reaction with methyl thiobenzoate (**5**) was also carried out for comparison reasons.

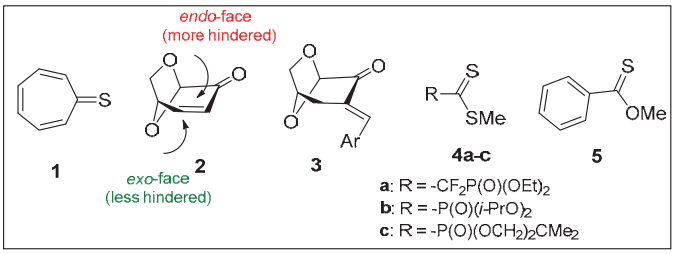
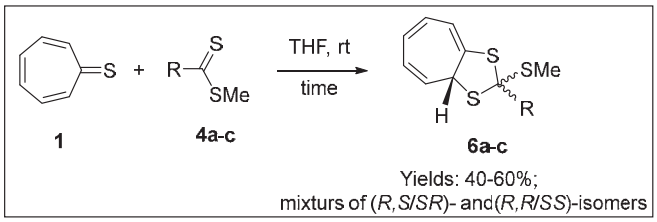


Figure 1. Compounds studied in the (8+2)-cycloadditions with tropothione (**1**).



Scheme 1. The (8+2)-cycloadditions of tropothione (**1**) with the phosphoryl group activated dithioesters **4**.

Reactions occurred under mild conditions (THF solution, rt) in a regioselective manner yielding bicyclic cycloadducts **6** (cyclohepta[*d*][1,3]dithioles) as mixtures of diastereoisomers in a ratio ca. 5:3. Under the same conditions methyl thiobenzoate (**5**) was also tested but no formation of the anticipated cycloadducts with **1** was observed.

Pure products **6** were isolated by preparative layer chromatography (SiO_2, CH_2Cl_2 as an eluent) but separation of the (*R*,*S*/*S*,*R*) and (*R*,*R*/*S*,*S*) diastereoisomers was unsuccessful (Scheme 2).

Structures of the obtained (8+2) cycloadducts (oily materials) were elucidated by means of spectroscopic methods and postulated molecular formulae were confirmed based on the registered HRMS spectra.

Acknowledgement

Authors thank Prof. Serge Masson (Can University, France) for the gift of samples of all phosphorylated dithioesters **4**.

References

[1] For selected reviews, see: a) D. McLeod, M.K. Thøgersen, N.I. Jessen, K.A. Jørgensen, C.S. Jamieson, X.-S. Xue, K.N. Houk, F. Liu, R. Hoffmann, *Acc. Chem. Res*. **2019**, *52*, 3488; b) S. Frankowski, M. Romaniszyn, A. Skrzyńska, Ł. Albrecht, *Chem. Eur. J*. **2020**, *26*, 2120; c) N.I. Jessen, D. McLeod, K.A. Jørgensen,, *Chem* **2022**, *8*, 20.
[2] S. Frankowski, A. Skrzyńska, Ł. Albrecht, *Chem. Commun*. **2019**, *55*, 11675,
[3] I. Bagna, M. Celeda, W. Weigand, G. Mlostoń, under preparation.
[4] G. Mlostoń, M. Celeda, M. Palusiak, *Carbohydr. Res*. **2023**, *529*, e108844..

P1-036

Chemoenzymatic, one-pot transformation of alcohols to alkenes in water

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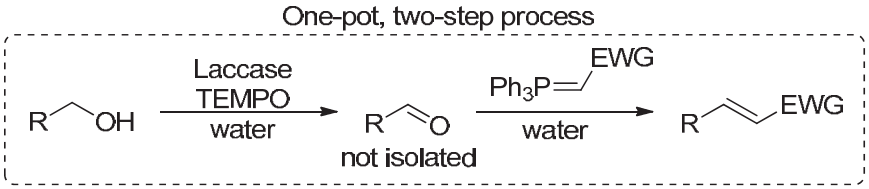
The one-pot alcohol oxidation-Wittig reaction process is an attractive approach for the synthesis of alkenes. [1] In earlier literature reports it was presented that the Wittig reaction with stabilized ylides can proceed in water, which is a green alternative for common organic solvents. [2] In this communication a one-pot, two step process involving laccase mediated alcohol oxidation and subsequent Wittig reaction in water is reported.



Scheme 1. One-pot transformation of alcohols to alkenes utilizing laccase oxidation and Wittig reaction in water.

References

[1] Y. Gu, S-K. Tian, *Top. Curr. Chem.* **2012**, *327*, 197-238.
[2] J. Dambacher, W. Zhao, A. El-Batta, R. Anness, C. Jiang, M. Bergdahl, *Tetrahedron Lett.* **2005**, *46*, 4473-4477.

P1-037

New class of (di)nucleotide analogues containing rigid phosphate chain – properties and biological activity

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Mono- and dinucleoside polyphosphates (such as NTP, Np2N or Np4N) have gained significant attention from many research groups due to their numerous biological functions and potential pharmacological applications. Such molecules have been widely identified in both mammals [1] and eukaryotic organisms [2]. For example, the presence of dinucleoside polyphosphates such as Ap2A, Ap3A or Ap4A has been demonstrated in releasable platelet pellets derived from human cells [3], while adenosine triphosphate (ATP) is a source of energy for utilization and storage at the cellular level [4]. Meanwhile, both of these classes of compounds can modulate the activity of the purinergic P2X7 receptor. Meanwhile, increased activity of this receptor is one of the hallmarks of breast cancer [5].

Hence, a new class of (di)nucleotide analogues (Figure 1) with a stiffened pseudopolyphosphate chain structure was synthesized by introducing a butyn-1,4-diol group. The obtained compounds were tested for their stability, and their cytotoxicity against cancerous cell lines exhibiting high levels of the P2X7 receptor as well as non-cancerous cells was determined.

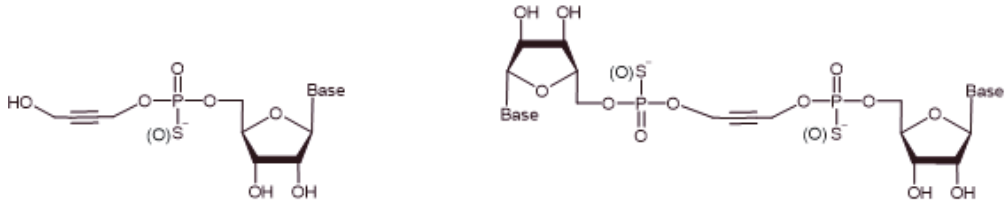

Figure 1. *Chemical structure of the obtained nucleoside and dinucleoside triphosphate analogues*

Acknowledgement

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References

[1] Basile, G., Taglialatela-Scafati, O., Damonte, G., Armirotti, A., Bruzzone, S., Guida, L., Franco, L., Usai, C., Fattorusso, E., De Flora, A., & Zocchi, E. (2005). ADP-ribosyl cyclases generate two unusual adenine homodinucleotides with cytotoxic activity on mammalian cells. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(41), 14509–14514.

[2] A.G. McLennan (Ed.), Intracellular Functions of ApnN: Eukaryotes, CRC Press, Boca Raton, FL (1992), pp. 151-203

[3] Magnone, M., Basile, G., Bruzzese, D., Guida, L., Signorello, M. G., Chothi, M. P., Bruzzone, S., Millo, E., Qi, A. D., Nicholas, R. A., Kassack, M. U., Leoncini, G., & Zocchi, E. (2008). Adenylic dinucleotides produced by CD38 are negative endogenous modulators of platelet aggregation. *The Journal of biological chemistry*, *283*(36), 24460–24468.

[4] Dunn, J., & Grider, M. H. (2023). Physiology, Adenosine Triphosphate. In *StatPearls*. StatPearls Publishing.

[5] Du, Y., Cao, Y., Song, W., Wang, X., Yu, Q., Peng, X., & Zhao, R. (2024). Role of the P2X7 receptor in breast cancer progression. *Purinergic signalling*, 10.1007/s11302-024-10039-6. Advance online publication.

P1-038

Comparison of biological properties of selected aminoalkylphosphonic acids and analogous amino acids using chemoinformatic and bioinformatic methods

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Amino phosphonic acids AA^P [1-3], synthetic analogs to natural amino acids AA^C [4] (Fig. 1), have attained a position of prominence in bioorganic and medicinal chemistry. These classes of amino acids were compared using chemoinformatic and bioinformatic methods.

AA^P AA^C

Figure 1. Compared Amino Acids – structures and abbreviations [5].

Chemoinformatic analyses were conducted using tools such as Molinspiration [6] and SwissTargetPrediction [7-10] allowing for prediction of molecular properties and potential bioactivity.

The preliminary results highlighted interesting interactions with G protein-coupled receptors, ion channels, and enzymes, which will be further examined. In the next phase, molecular docking studies will be performed using AutoDock Vina [11] to investigate the binding affinities of these compounds to their predicted protein targets, focusing on receptors and enzymes. This integrative approach will help to understand the potential biological significance of amino phosphonic acids compared to their amino acid analogs. The preliminary results suggest significant variations in bioactivity profiles, which may have implications for future drug design and therapeutic applications.

References

[1] Kafarski, P.; Mastalerz, P. *Beitr. Wirkst. Forsch.* **1984**, *21*, 1-110.
[2] Kafarski, P.; Lejczak, B. *Phosphorus, Sulfur, Silicon Relat. Elem.* ***1991***, *63*(1–2), 193–215.
[3] Kukhar, V.P.; Hudson, H.R. In Book: Aminophosphonic and Aminophosphinic Acids. Chemistry and Biological Activity. Eds. Kukhar, V.P.; Hudson, H.R.; Wiley& Sons Ltd: Chichester, New York, Weinheim, Brisbane, Singapore, Toronto, **2000**.
[4] Kudzin, Z.H.; Kudzin, M.H.; Drabowicz, J.; Stevens, C.V. Curr. Org. Chem. **2011**, 15, 2015-2071.
[5] Drabowicz, J.; Jakubowski, H.; Kudzin, M.H.; Kudzin, Z.H. The nomenclature of 1-aminoalkylphosphonic acids and derivatives: evolution of the code system. Acta Biochim. Pol. **2015**, 62, 139-150.
[6] Molinspiration Cheminformatics free web services, Slovensky Grob, Slovakia, website-calculation of Molecular Properties and Bioactivity Score-Predict Bioactivity tool (https://www.molinspiration.com / accessed on 1 October 2024)
[7] SwissTargetPrediction (http://www.swisstargetprediction.ch/ accessed on 1 October 2024)
[8] Daina, A.; Michielin, O.; Zoete, V. *Nucl. Acids Res.*, **2019**, *47*, W357-W364.
[9] Daina, A., Zoete, V. *Commun. Chem*. **2024**, **7**, 105.
[10] Gfeller, D.; Michielin, O., Zoete, V. *Bioinformatics*, **2023**, *29*, 3073-3079.
[11] Trott, O.; Olson, A.J. *J. Comput. Chem*. **201**0, *31*, 455-461..

P1-039

The Synthesis of p-Quinol Derivatives as a New Class of Potential Antimicrobial Compounds

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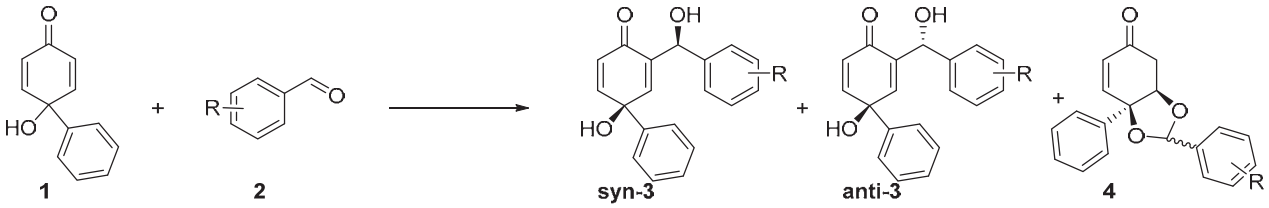
P-Quinols and their analogs are classes of heteroorganic compounds frequently found in may bioactive natural products.[1] They can also serve as key synthetic building blocks [2] and possess various biological activity including antimicrobial activity.[3]

Thus, the synthesis of new *p*-quinol analogues is of great importance. As compounds of particular interest we choose fused dioxolanes and Morita-Baylis-Hillman adducts. The proposed products can be synthesised *via* reaction of p-quinols with aromatic aldehydes (Scheme 1). Both types of Baylis-Hillman adducts (**3**) can be obtained as diastereoisomeric mixtures as well fused dioxolanes (**4**). The influence of conditions on the reaction course will be presented. As biological activity of chiral compounds is depended on stereochemical configuration, all isomers should be tested as potent antimicrobial drugs.The influence of the structural changes in the molecule on the antimicrobial activity will be discussed.



Scheme 1. The studied reaction between *p*-quinol and aromatic aldehydes.

Acknowledgement

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References

[1] S. Urban, J.W. Blunt, M.H.G. Munro, *J. Nat. Prod.* **2002**, *65*, 1371–1373.
[2] D. Magdziak, S.J. Meek, T.R.R. Pettus, *Chem. Rev.* **2004**, *104*, 1383–1429.
[3] D. Koszelewski, P. Kowalczyk, J. Samsonowicz-Górski, A. Hrunyk, A. Brodzka, J. Łęcka, K. Kramkowski, R. Ostaszewski, *Int. J. Mol. Sci.* **2023**, *24*, 1623.

P1-040

Synthesis of Dithiocarbamates on a Nanodiamond Carrier as Potential Cytostatics

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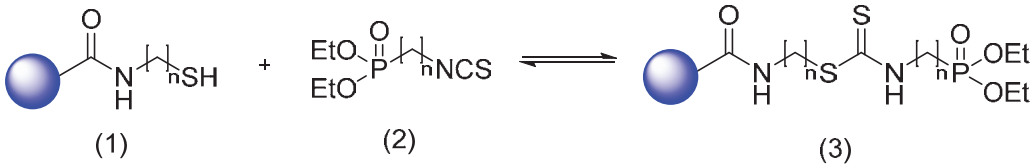
Natural isothiocyanates (ITCs), such as sulforaphane, exhibit anticancer, antimicrobial, and antioxidant properties. It has also been shown that phosphonic analogs of sulforaphane (2) inhibit the growth of cancer cells *in vitro* and induce their apoptosis.[1] However, the therapeutic potential of synthetic ITCs is often limited by their low bioavailability. For this reason, numerous studies are being conducted on various molecular carriers that can enhance cell membrane permeability and slow down the removal of active compounds from cells.



Scheme 1.

In light of this, an attempt was made to obtain ITC conjugates with a nanodiamond carrier by utilizing the reversible reaction of ITCs with thiol groups present on the chemically modified surface of nanodiamond powder. The use of a nanomaterial carrier to transport a masked form of anticancer-active isothiocyanates (2) raises the expectation that such conjugates will exhibit higher bioavailability and, consequently, greater anticancer activity.

References

[1] Ł. Janczewski, *Molecules*, **2022**, *27*, 1750-1805.

P1-041

Gene silencing nanoparticles formed by oligofunctionalized carboranes or metallacarboranes cores conjugated with anti-sense DNA-oligonucleotides

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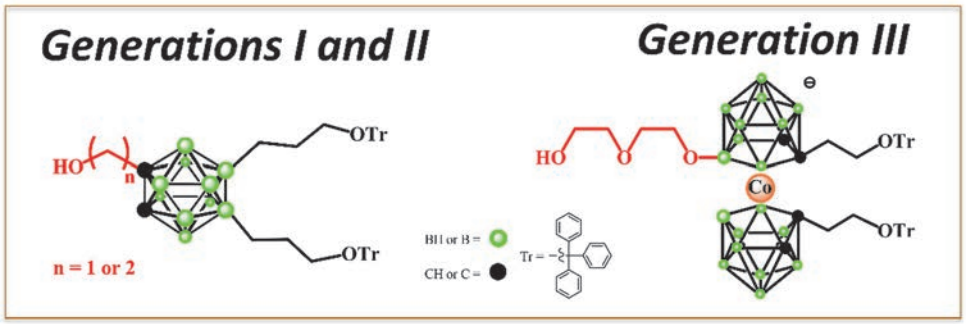
In the Laboratory of Medicinal Chemistry of the Institute of Medical Biology several methods of oligofunctionalization of carboranes and metallacarboranes have been developed and some of them were used to synthesize conjugates of boron clusters and DNA-oligonucleotides [1-4]. These conjugates serve as building blocks in construction of new type of bionanoparticles capable of silencing the expression of targeted genes, the Epidermal Growth Factor Receptor (EGFR) [2] or EGFR and c-MYC (myelocytomatosis oncogene) genes simultaneously [3]. Replacing carborane core by its complex with a metal ion, metallacarborane affects the topology of formed bionanoparticles modyfiying their properties such as stability and gene silencing activity [5]. Herein we present methods of oligofunctionalization of 1,2-dicarba-*closo*-dodecaborane and cobalt-bis(1,2-dicarbollide)ate (COSAN) and their use for preparation of functional, bioactive boron cluster-DNA based nanoconstructs.



Scheme 1. Carborane and metallacarborane platforms used in synthesis of conjugates of boron clusters and antisense oligonucleotides as building blocks for gene silencing nanoparticles.

Acknowledgement

This work was supported by the National Science Center, Poland, grant No 2015/16/W/ST5/00413; the Bio-Med-Chem Doctoral School of the University of Lodz support and contribution from the Statutory Fund of IMB PAS is also appreciated.

References

[1] K. Śmiałkowski, C. Sardo, Z.J. Leśnikowski, *Molecules* **2023**, *28*, 4118-4135

[2] D. Kaniowski, K. Ebenryter-Olbinska, K. Kulik, S. Janczak, A. Maciaszek, K. Bednarska-Szczepaniak, B. Nawrot, Z.J. Leśnikowski, *Nanoscale*, **2020**, *12*, 103–114.

[3] K. Bednarska-Szczepaniak, K. Ebenryter-Olbińska, G. Gajek, K. Śmiałkowski, J. Suwara, L. Fiedorowicz, Z.J. Leśnikowski, *Chem. Eur. J.*, **2024**, *30*, e202303531

[4] S. Janczak, A. Olejniczak, S. Balabańska, M.K. Chmielewski, M. Lupu, C.Viñas, Z.J. Leśnikowski, *Chem. Eur. J.* **2015**, *21*, 15118-15122.

[5] K. Śmiałkowski, K. Bednarska-Szczepaniak, K. Kulik, J. Suwara, B. Grűner, B. Nawrot, Z.J. Leśnikowski, ACS Nano, *prepared for submission*.

P1-042

P-steredefined phosphorothioate oligodeoxyribonucleotides containing morpholino pyrimidine units

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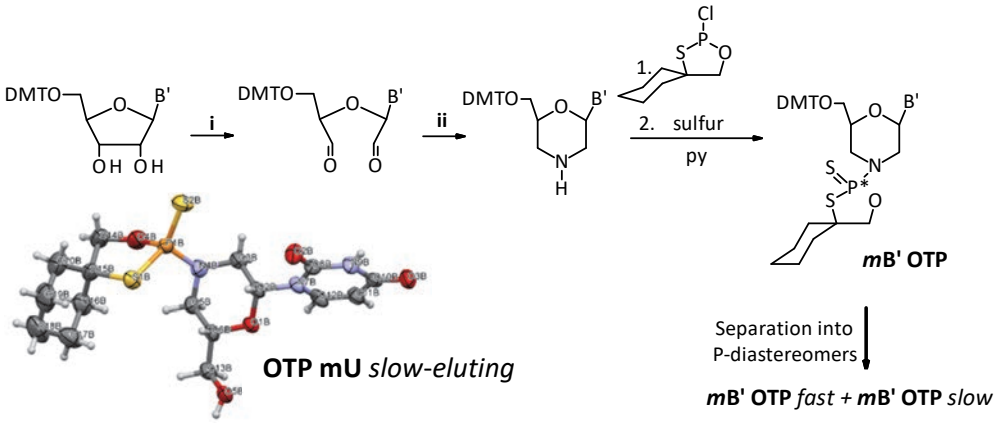
We present a modified OTP method to the synthesis of novel P-stereodefined phosphorothioate analogs of "morpholino" nucleic acids (sTMO) and provide valuable structural insights into their stereochemistry. We present the preparation of P-diastereomerically pure morpholino pyrimidine units for synthesis of P-stereodefined TMO (*mB'* OTPs, B': Ura, Cyt^{Bz}; Scheme 1). Synthesis of morpholino nucleosides were performed according to the published protocols[1]. Briefly, 5'-*O*-dimethoxytrityl uridine was oxidatively converted in the acyclic dialdehyde derivative, followed by reductive cyclization upon treatment with $NaCNBH_3$. Morpholino nucleosides were transformed into corresponding oxathiaphospholane derivatives of morpholino-type nucleosides (*m*B' OTPs) according to a general procedure published for the synthesis of the standard OTP monomers[2]. OTPs were synthesized with a good yield and effectively separated into pure P-diastereomers (their diastereomeric purity was confirmed by ^{31}P NMR, ^{1}H NMR, ^{13}C NMR). Analysis of the crystallographic data showed that slow-eluting mU-OTP has the P atom of the S_P absolute configuration, according to the Cahn–Ingold–Prelog rules, where the endocyclic sulfur atom has a higher priority than the exocyclic one. Further research will focus on the preparation of **P-stereodefined phosphorothioate oligonucleotides containing morpholino pyrimidine units.** The studies of thermal stability of complexes of P-stereodefined oligomers with complementary DNA and RNA templates is planned.



Scheme 1. i. $NaIO_4$ (1.2 equiv), anhydrous methanol; $(NH_4)_2B_2O_7$ (1.2 equiv), 6 h; **ii**. $NaCNBH_3$ (2.0 equiv); CH_3COOH (2.0 equiv), 16 h.

Acknowledgement

This project was supported by NCS 2021/43/D/ST4/02433.

References

[1] Langner H., Jastrzebska K., Caruthers M., *J. Am. Chem. Soc.*, **2020**, 142, 16240–16253.
[2] Guga P., Stec W.J., In Current Protocols in Nucleic Acid Chemistry, ed. S.L. Beaucage, D.E. Bergstrom, G.D. Glick and R.A. Jones, John Wiley and Sons, Hoboken, N.J., **2003**, p. 4.17.1.

P1-043

Influence of the presence of morpholino purine nucleotides in the P-steredefined phosphorothioate oligodeoxyribonucleotides on the thermal stability of PS-DNA:RNA complex

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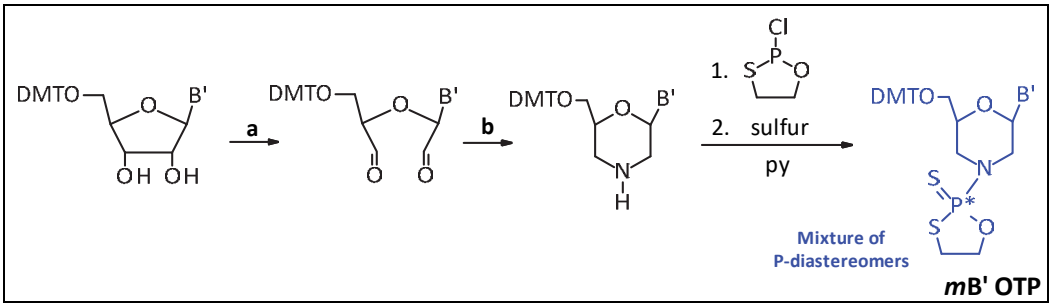
Recently, P-stereorandom Thiophosphoramidate Morpholino Oligonucleotides (TMO) were synthesized using the phosphoramidite approach[1] and these constructs that exhibit interesting biological properties and significant therapeutic potential[2]. Therefore, we are curious whether these biological activities can also be elicited by oligomers with proper absolute configuration of phosphorus atoms. The successful completion of this project may allow for the identification of the most biologically active stereoisomers of TMO-based drugs or the use of sTMO as molecular probes in biochemical studies.

Herein, we present the preparation of P-diastereomerically pure morpholino units for **synthesis of novel P-stereodefined phosphorothioate of morpholino analogs** (*mB'* OTPs, B': Ade^{Bz}, Gua^{iBu}; Scheme 1). Synthesis of morpholino nucleosides were performed according to the published protocols[1]. Briefly, 5'-*O*-dimethoxytrityl uridine was oxidatively converted in the acyclic dialdehyde derivative, followed by reductive cyclization upon treatment with $NaCNBH_3$. Morpholino nucleosides were transformed into corresponding 1,3,2-oxathiaphospholane derivatives of morpholino-type nucleosides (*m*B' OTPs) according to a general procedure published for the synthesis of the standard OTP monomers[3]. *m*B' OTPs were isolated as a mixture of P-diastereomers and were characterized by FAB MS and ^{31}P NMR.



Scheme 1. Synthesis of OTP monomer: **a.** $NaIO_4$ (1.2 equiv), anhydrous methanol; $(NH_4)_2B_2O_7$ (1.2 equiv), 6 h; **b**. $NaCNBH_3$ (2.0 equiv); CH_3COOH (2.0 equiv), 16 h.

The P-diastereomers were separated by silica gel HPLC and used for solid-phase synthesis of stereodefined [All-R_P-] and [All-S_P-PS]-oligomers (11-mers containing morpholino purine units). The thermal stability of complexes of P-stereodefined oligomers with complementary DNA and RNA templates was measured.

Acknowledgement

This project was supported by NCS 2021/43/D/ST4/02433.

References

[1] Langner H., Jastrzebska K., Caruthers M., *J. Am. Chem. Soc.*, **2020**, 142, 16240–16253.
[2] a) Dumbović G., Braunschweig U., K. Langner H., Smallegan M., Biayna J., Hass E.P., Jastrzebska K., Blencowe B., Cech T.R., Caruthers M.H., Rinn J.L., *Nature Comm.*, **2021**, 12, 3308, 1-19; b) Le B. T., Paul S., Jastrzebska K., Langer H., Caruthers M.H., Veedu R.N., *PNAS*, **2022**, 119, 1-8.
[3] Guga P., Stec W.J., In Current Protocols in Nucleic Acid Chemistry, ed. S.L. Beaucage, D.E. Bergstrom, G.D. Glick and R.A. Jones, John Wiley and Sons, Hoboken, N.J., **2003**, p. 4.17.1.

P1-044

Enantioselective Organocatalytic Addition of 1,3-Dicarbonyls to Sulfur (VI) Michael Acceptors

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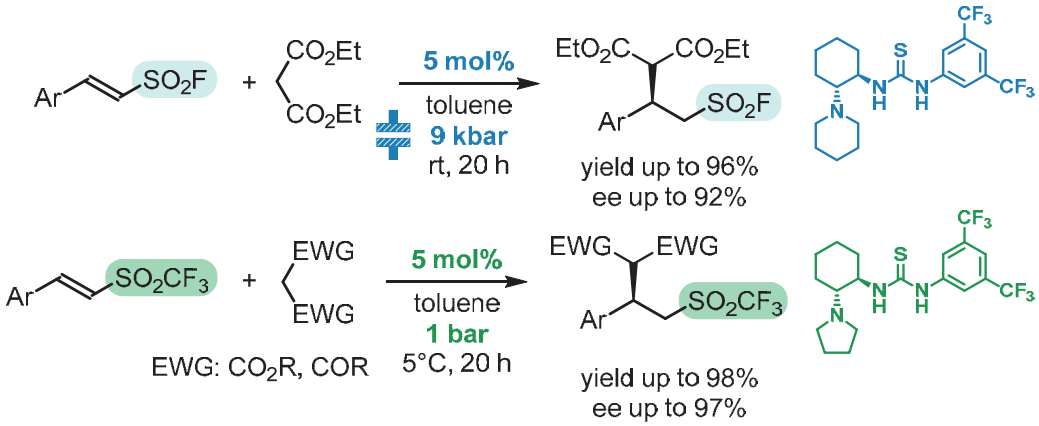
β-Substituted vinyl sulfones are Michael acceptors underexplored in asymmetric organocatalysis. These compounds have structural similarity to β-nitrostyrene, suggesting analogous organocatalytic activation approach in asymmetric Michael addition. [1] Homochiral products of such additions can be interesting building blocks for further synthesis. [2] Sulfonyl fluorides are especially valuable class of compounds with relatively high hydrolytic stability under wide range of conditions. Use of -SO_2F group in organic synthesis and sulfur fluoride exchange - next generation of click chemistry - is still growing. [3] One important application concerns their use as irreversible enzyme inhibitors. [4]

In our work, we focused on enantioselective synthesis of sulfonyl fluorides and sulfones via organocatalytic addition of malonates to unsaturated precursors: $ArCH{=}CHSO_2F$ and $ArCH{=}CHSO_2CF_3$. Literature examples of this type of reaction are scarce, and SO_2F group usually undergoes subsequent cyclization with release of the fluoride anion. [5] However, these compounds are much less reactive than β-nitrostyrenes and the addition of malonates to $ArCH{=}CHSO_2F$ is very slow under classical conditions.



Scheme 1. Structures of Blatter radical and diradicals **1** and **2** planned to be obtained in the project.

The reactivity problem of the reaction involving sulfone fluorides was overcome by the use of hyperbaric conditions (9 kbar). [6] The high-pressure approach allowed to obtain novel enantiomerically enriched ester derivatives of sulfonyl fluorides with high yields and enantiomeric excesses up to 92%. More reactive β-arylethylene triflones allow for synthesis of other 1,3-dicarbonyl derivatives under atmospheric pressure. Moreover, examples of enantioselective additions of 1,3-dicarbonyl compounds to other sulfone Michael acceptors will be presented.

References

[1] Okino, T.; Hoashi, Y.; Takemoto, Y. *J. Am. Chem. Soc.* **2003**, 125, 12672–12673.
[2] Uraguchi, D.; Nakamura, S.; Sasaki, H.; Konakade, Y.; Ooi, T. *Chem. Comm.* **2014**, 50 (26), 3491–3493.
[3] Barrow, A. S. et. al., *Chem. Soc. Rev.***2019**, *48*, 4731-4758.
[4] Brouwer, A. J. et. al. *J. Med. Chem.* **2012**, 55, 10995–11003; Brouwer, A. J. et. al. *Bioorg. Med. Chem.* **2011**, 19, 2397–2406.
[5]Chen, X.; Zha, G.; Bare, G. A. L.; Leng, J.; Wang, S.; Qin, H. *Adv Synth Catal* **2017**, 359, 3254–3260.
[6] Kopyt, M.; Tryniszewski, M.; Barbasiewicz, M.; Kwiatkowski, P. *Org. Lett.* **2023**, *25*, 6818–6822.

P1-045

Synthesis and characterization of new bio-inspired organic luminophores with potential chiroptical properties

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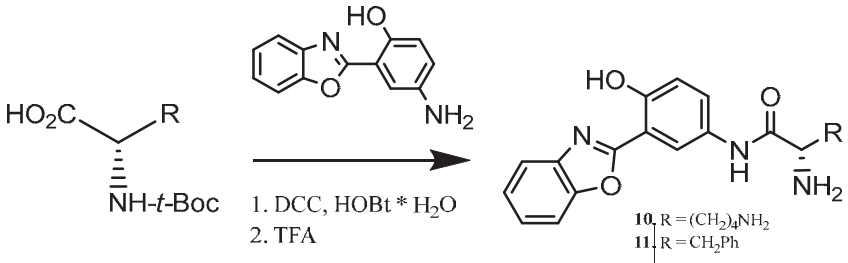
Among the large group of organic semiconductor dyes there exists a particular class supporting a process called excited state intramolecular proton transfer (ESIPT). These dyes, thanks to the inherently occurring intramolecular hydrogen bond, typically exhibit dual emission properties strongly dependent on the environment as well as fluorescence enhancement in the solid state.[1] Recently, it has been reported that coupling ESIPT molecules with bio-inspired chiral moieties may lead to compounds capable of emitting circularly polarized light (CPL).[2] Since, to the best of our knowledge, there no systematic studies on the use of amino acids as chirality sources are reported, we have designed and synthesized new amino acid amides based on ESIPT capable heterocycles.

Enantiomerically pure L-*N*-(3-(benzo[d]oksazo-2-yl)-4-hydroxyphenyl)lysinamide **10** and L-*N*-(3-(benzo[d]oksazo-2-yl)-4-hydroxyphenyl)phenylalanineamide **11** were obtained via the synthetic scheme displayed in Scheme 1. After conducting solubility tests of the new compounds in a number of solvents their optical properties were studied with the use of UV-vis absorption and photoluminescence (PL) spectroscopy. The compounds **10** and **11** displayed solvent dependent dual emission stemming from their ability to undergo the ESIPT process. Introduction of amino acid groups strengthens the ESIPT band and improves solubility in polar systems compared to parent amine compounds. Film-forming properties of amino acid amides were studied and thin films of **11** were spin-coated from DMF solutions, followed by investigations of structural and optical properties by means of atomic force microscopy and UV-vis/PL spectroscopy, respectively. Thin films of phenylalanineamide **11** exhibited high quantum yield of emission,Φ_f = 40,1 %. Further studies of amino acid amides in thin films, including the CPL emission propertieswill enable to determine the crucial parameters for elaboration of the more efficient ESIPT dyes containing the bio-inspired molecular motifs.



Scheme 1. Synthesis of of amide **11**.

Acknowledgement
This work was supported by the National Science Centre, Poland (UMO-2021/43/D/ST5/02786).

References

[1] O. K. Abou-Zied, R. Jimenez, E. H. Z. Thompson, D. P. Millar, F. E. Romesberg, *J. Phys. Chem. A,* **2002**, *106*, 3665–3672.
[2] C. Xue, Y. Jiang, H.-X. Wang, C. Du, L. Xu, T. Li, M. Liu, *Angew. Chem. Int. Ed.*, **2022**, *61*, e202205633.

P1-046

Novel 2-Adamantylpyrene Fluorophores: Synthesis and Properties

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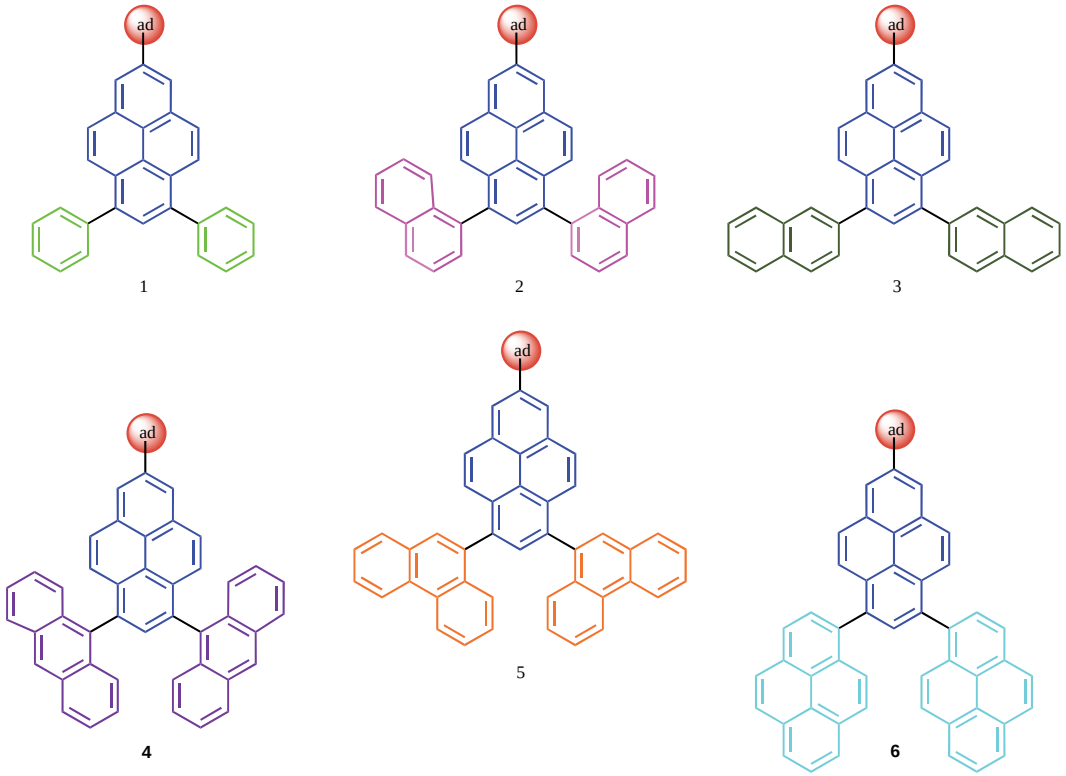
Fluorescent compounds have found applications in various fields of science and technology, including the production of fluorescent paints, organic light-emitting diodes, environmental probes, and biomolecular markers. One important class of fluorescent organic compounds is polycyclic aromatic hydrocarbons (PAHs) and their derivatives. Among these, pyrene and its derivatives have attracted considerable attention due to their high quantum yields, long fluorescence lifetimes, and excellent thermal and photostability.[1,2]

In this work, we report the synthesis of new fluorophores based on 2-adamantylpyrene (Scheme 1). The brominated intermediates were subjected to Suzuki coupling with boronic acids, resulting in compounds with extended π-electron systems.[3] The obtained compounds emit light in the blue to green range, and the fluorescence intensity depends on the structure of the aromatic substituents. The observed π-π interactions between aromatic systems influence both the shape of the spectra and the emission intensity. These new fluorophores offer potential for further modifications to fine-tune their light emission propertiestives attract significant attention due to their high quantum yields, long fluorescence lifetimes, and excellent thermal and photostability.



Scheme 1. Novel 2-Adamantylpyrene Fluorophores.

References

[1] T. M. Figueira-Duarte, K. Müllen, *Chem. Rev.*, **2011**, *111*, 7260–7314.
[2] X. Feng, J.-Y. Hu, L. Yi, N. Seto, Z. Tao, C. Redshaw, M. R. J. Elsegood, T. Yamato, *Chem. Asian J.*, **2012**, *7*, 2854-2863.
[3] A. Wrona-Piotrowicz, A. Makal, J. Zakrzewski, *J. Org. Chem.*, **2020**, *85*, 11134–11139.

P1-047

IPr*^{F} – the first class of sterically-hindered, fluorinated N-heterocyclic carbenes

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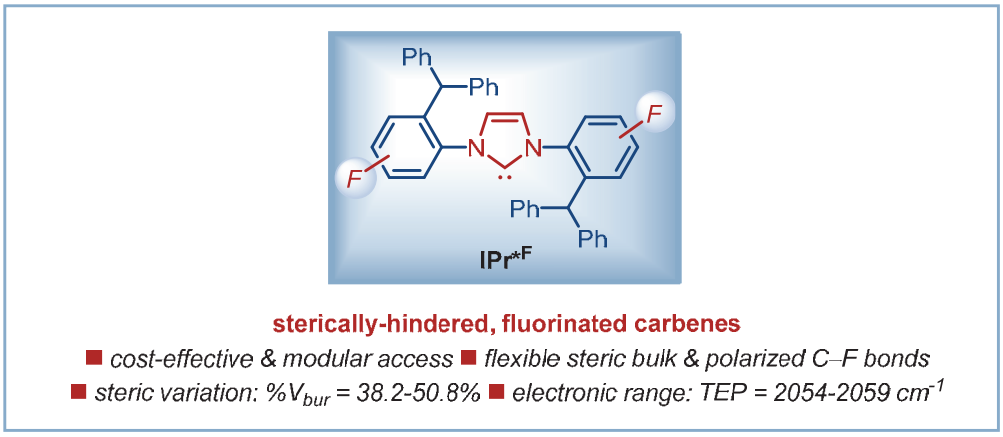
Sterically-hindered N-heterocyclic carbenes (NHCs) have received major interest due to high stabilization of the reactive metal centers, which has paved the way for the synthesis of stable and reactive organometallic compounds with broad applications in main group chemistry, inorganic synthesis and transition-metal-catalysis.[1] Simultaneously, the introduction of fluorine atoms has attracted considerable interest in molecular design owing to the high electronegativity and the resulting polarization of carbon–fluorine bonds.[2] Herein, we present an efficient, one-pot synthesis of the first class of sterically-hindered, fluorinated N-heterocyclic carbenes and their complexes, as well as the evaluation of steric, electron-donating and π-accepting properties.[3] Considering the unique properties of carbon–fluorine bonds, we anticipate that this novel class of fluorinated carbene ligands will find widespread application in stabilizing reactive metal centers.



Scheme 1. IPr*^{F} – Highly Hindered, Fluorinated N-Heterocyclic Carbenes

Acknowledgement

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References

[1] (a) Q. Zhao, G. Meng, S. P. Nolan, M. Szostak, *Chem. Rev*. **2020**, *120*, 1981-2048; (b) P. Gao, M. Szostak, *Coord. Chem. Rev*. **2023**, *485*, 215110; (c) T. Zhou, G. Utecht-Jarzyńska, M. Szostak, *Coord. Chem. Rev*. **2024**, *512*, 215867; (d) A. Gómez-Suárez, D. J. Nelson, S. P. Nolan, *Chem. Commun.* **2017**, *53*, 2650-2660; (e) H. V. Huynh, *Chem. Rev*. **2018**, *118*, 9457-9492.

[2] (a) D. O'Hagan, *Chem. Soc. Rev*. **2008**, *37*, 308-319; (b) R. Berger, G. Resnati, P. Metrangolo, E. Weber, J. Hulliger, *Chem. Soc. Rev*. **2011**, *40*, 3496-3508; (c) P. K. Mykhailiuk, *Chem. Rev.* **2021**, *121*, 1670-1715.

[3] G. Utecht-Jarzyńska, S. Shi, P. Gao, S. Jarzyński, M. M. Rahman, R. Lalancette, R. Szostak, M. Szostak, *Chem. Eur. J*. **2024**, e202402847..

P1-048

Electrophile-Dependent Reactivity of Lithiated *N*-Benzylpyrene-1-Carboxamide

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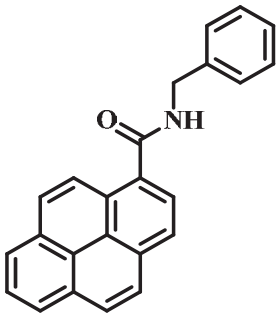
Pyrene-1-carboxamides are readily available compounds, which exhibit interesting photophysical properties both in solution and in a solid state. Considering the increasing current interest in the development of synthetic pyrene chemistry, we became interested in exploring its synthetic potential. It was found that *N*-*tert*-butylpyrene-1-carboxamide undergoes deprotonative lithiation selectively at the C2 position, which may contribute to the synthesis of new, strongly emitting pyrenyl fluorophores [1,2].

In 2003, Murai reported that the reaction of *N*-benzylbenzamide with butyllithium, followed by quenching with EtI, led to the formation of a mixture of products resulting from competitive benzylic and directed *ortho*-lithiation [3].



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Herein, we report that **1** undergoes not only reactions analogous to those described by Murai, but also unexpected cyclization *via* carbolithiation of the pyrene K-region, which leads to the formation of new luminescent polycyclic nitrogen compounds, bearing the *aza*-benzo[*c*,*d*]pyrene (azaolympicene) skeleton. We also determined basic photophysical properties (absorption and emission spectra and emission quantum yields) of selected compounds [4].

References

[1] A. Wrona-Piotrowicz, M. Ciechańska, J. Zakrzewski, R. Métivier, A. Brosseau, A. Makal, *Dyes & Pigments*, **2018**, *125*, 331-338.
[2] A. Wrona-Piotrowicz, M. Ciechańska, J. Zakrzewski, A. Makal, *J. Photochem. Photobiol. A: Chem.*, **2016**, *330*, 15-21.
[3] T. Murai, H. Aso, Y. Tatematsu, Y. Itoh, H. Niwa, S. Kato, *J. Org. Chem.*, **2003**, *68*, 8514-8519.
[4] M. Ciechańska, A. Wrona-Piotrowicz, Karolina Koprowska, A. Makal, J. Zakrzewski, *Molecules*, **2022**, *27*, 3930.

P1-049

Synthesis of new derivatives of 2-(cyclohexylamino)thiazol-4(5*H*)-one: potent inhibitors of 11β-hydroxysteroid dehydrogenase type 1 with potential anticancer activity

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11β-Hydroxysteroid dehydrogenase type 1 (11β-HSD1) is a microsomal enzyme that is expressed mainly in the liver, adipose tissue, immune cells, and skeletal muscles [1]. It catalyzes the conversion of inactive cortisone into physiologically active cortisol [1]. Together with 11β-hydroxysteroid dehydrogenase type 2 (11β-HSD2), which catalyzes the reverse reaction, it forms a system responsible for regulating cortisol levels in the human body [1].

Increased expression of 11β-HSD1, especially in tissues such as liver and visceral adipose tissue, has been linked to the pathogenesis of diseases that contribute to the occurrence of metabolic syndrome (MS), i.e. obesity, hypertension and type 2 diabetes [2]. The use of 11β-HSD1 inhibitors in patients with type 2 diabetes leads to a reduction in blood glucose levels, and thus leads to a reduction in insulin resistance and central obesity [3]. On the other hand, excessive expression of 11β-HSD1 in the tumor microenvironment leads to a local increase in cortisol levels, and thus leads to immunosuppression and thus promotes the development of neoplastic disease and the formation of metastases. In transgenic mice with implanted melanoma treated with 11β-HSD1 inhibitors (carbenoxolone and PF-915275), tumor growth was inhibited [4]. Therefore, the search for 11β-HSD1 inhibitors is currently a promising direction in the search for drug candidates, with the possibility of use in the treatment of metabolic diseases or cancers.

In order to search for new inhibitors of 11β-hydroxysteroid dehydrogenase type 1, nine new derivatives of 2-(cyclohexylamino)thiazol-4(5*H*)-one with different substituents at the fifth carbon of the thiazole ring were synthesized and tested. The reaction between cyclohexylthiourea and the appropriate α-bromoester was carried out under different conditions depending on the α-bromoester used. The obtained derivatives were tested for 11β-HSD1 inhibition. Most of the compounds tested turned out to be strong 11β-HSD1 inhibitors (compounds at a concentration of 10 μM inhibit 11β-HSD1 activity in the range of 27–94%). The antiproliferative activity of all nine compounds was tested on five human cancer cell lines (Caco-2, PANC-1, U-118 MG, SK-MEL-30, MDA-MB-231) using the MTS assay. The obtained results showed that most of the compounds showed strong activity on the cells of colon adenocarcinoma (Caco-2), breast adenocarcinoma (MDA-MB-231) and malignant melanoma (SK-MEL-30) cell lines.

References

[1] K. Chapman, M. Holmes, J. Seckl, *Physiol. Rev.* **2013**, 93(3):1139-206.
[2] J.J. Winnick, C.J. Ramnanan, et.al., *Am. J. Physiol. Endocrinol. Metab*., **2013**, 304(7):747-56.
[3] T. Böhme, C.K. Engel, et.al., *Bioorg. Med. Chem. Lett*., **2013**, 23, 4685-4691
[4] M.D. Taves, S. Otsuka, et.al., *J. Clin. Invest*., **2023**, 133(18):e164599.

P1-050

Synthesis of ethyl and 2,2,2,-trifluoroethyl carbamates of selected biogenic amines

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Biogenic amines occur naturally in food of plant and animal origin. They are formed as a result of decarboxylation of appropriate amino acids under the influence of microorganisms. It is extremely important to monitor the level of these food compounds, because in high concentrations they can cause health problems, e.g. migraines, stomach and intestinal problems and allergies. In fresh food, the level of amines is usually low, and their increase indicates the presence of undesirable bacteria, which is associated with food spoilage. Higher concentrations of biogenic amines are observed in fermented foods, which results from the action of decarboxylases present in various microorganisms.

HPLC analysis using the synthesis step of derivatives with good chromophore systems is currently the most commonly used method for the analysis of biogenic amines. Determination of biogenic amines in food samples is not easy due to their low concentration, high polarity, lack of chromophores or low absorption in UV-VIS light.

The presented studies will discuss the results of reactions of selected biogenic amines and polyamines: putrescine, cadaverine, spermidine and spermine with ethyl and 2,2,2-trifluoroethyl chloroformates to the corresponding carbamates. The structures of the obtained compounds were confirmed by 1H, 13C and 19F NMR analysis. The developed derivatization methods were used to analyze biogenic amines using GC, GC-MS and LC-MS.

Acknowledgement
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P1-051

CF_3/CHF_2-Nitrile imines: Useful building blocks for the synthesis of fluorinated systems

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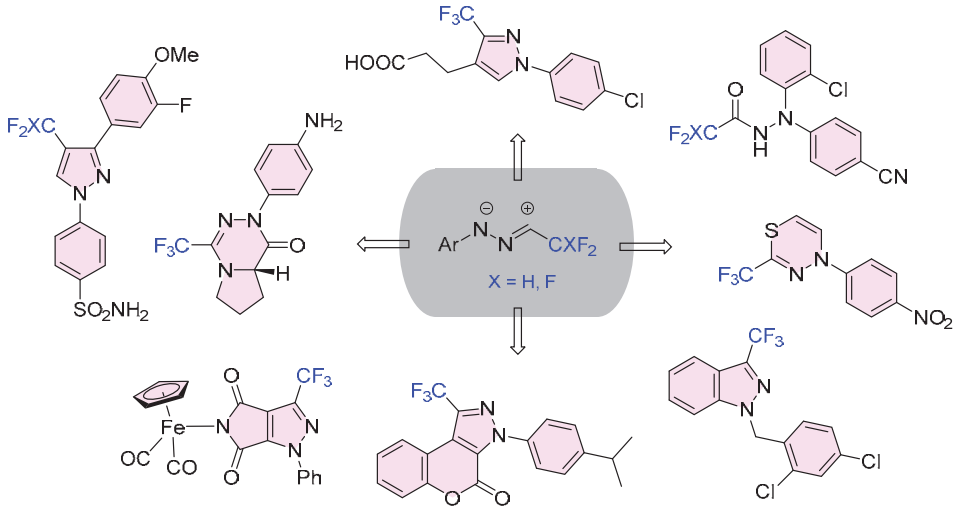
Nitrile imines are highly reactive, in situ-generated 1,3-dipolar reagents, often applied in the synthesis of five- and six-membered heterocycles through (3+2)- and (3+3)-cycloaddition reactions, respectively.[1] In search of convenient F-containing building blocks for preparation of heterocyclic systems of interest in the context of agricultural, pharmaceutical, and material sciences applications, an easy access to CF_3- and CHF_2-nitrile imines has been demonstrated.[2] Here we summarize our efforts in the chemistry and applications of the title intermediates in organic synthesis.[3]



Scheme 1. Structures of the title 1,3-dipole and selected products obtained therefrom.

Acknowledgement

Financial support by the University of Lodz (IDUB #9/DGB/2022, #8/DGB/2022, #19/IGB/2024) is acknowledged.

References

[1] C. Jamieson, K. Livingstone, *The nitrile imine 1,3-dipole. Properties, reactivity and applications*; Springer **2020**; Cham, Switzerland.
[2] Z. Dongxu, *Beilstein J. Org. Chem.* **2023**, *19*, 1741; (b) N. R. Yamaletdinova, R. R. Gataullin, *Helv. Chim. Acta* **2024**, e202400058.
[3] For selected original work, see: (a) K. Świątek et al., *Org. Lett.* **2023**, *25*,24, 4462; (b) N. Zhang et al, *Org. Biomol. Chem.* **2023**, *21*, 5040; (c) A. Kowalczyk et al., *Org. Lett.* **2022**, *24*, 2499; (d) A. Kowalczyk et al., *J. Fluor. Chem.* **2023**, *272*, 110206; (e) G. Utecht et al., *Org. Biomol. Chem.* **2018**, *16*, 1252.

P1-052

Enantioselective Michael addition of aldehydes to maleimides catalyzed by chiral aziridine alcohols

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Succinimides are attractive targets in organic synthesis, as they are present in natural products and drug candidates [1] and can be transformed into other valuable compounds. The asymmetric Michael addition of carbonyl compounds to N-substituted maleimides is an important method for to obtain optically pure succinimides, which are valuable synthetic targets and precursors of biologically interesting substances [2].

In this communication, we present our research on the synthesis of chiral ligands containing an aziridine ring in their structure. The key starting material to obtain aziridine derivatives will be an optically pure ester derived from N-trityl-aziridine-2-carboxylic acid, which can be obtained by the conversion of readily available and relatively inexpensive α-amino acids such as L- and D-serine. Chiral aziridine alcohols are efficient catalysts in enantioselective additions of aldehydes to maleimides. The change in the absolute configuration of the stereogenic center located at the aziridine moiety on the stereochemical outcome is also discussed.

References

[1] Z. Zhao, J. Yue, X. Ji, M. Nian, K. Kang, H. Qiao, X. Zheng, *Bioorganic Chemistry* **2021**, *108*, 104557.
[2] C. E. Grünenfelder, H. Wennemers, *Angew. Chem. Int. Ed.* **2016**, *55*, 8571..

P1-053

Bioinformatics analysis of interactions between neplanocin A and adenosine dependent protein

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Neplanocin A ((−)-NPA) emerged as a target of intense investigations of many research groups, mainly due to its broad spectrum of antiviral activity. It proved to be effective against numerous RNA and DNA viruses, particularly against vaccinia virus, vesicular stomatitis virus, parainfluenza virus type 3, reovirus type 1, human rotavirus and human immunodeficiency virus (HIV-1). Beside the strong antiviral activity, (−)-NPA also reveals weak antibacterial or antifungal properties[1] and significant cytotoxicity against several cell types, including leukemic (L1210) [2], breast[3], colon[4], prostate, liver, stomach and lung cancer cells[5]. (−)-NPA is a potent inhibitor of histone H3-lysine79 (H3K79) methyltransferase[6] and S-adenosylhomocysteine (AdoHcy)[7] hydrolase that alters the S-adenosinemethionine-dependent methylation reactions and in consequence hampers the biosynthesis of cellular and viral rybonucleic acids and proteins. (−)-NPA also inhibits CSC as well as restricts migration and invasiveness of the breast cancer cells which are extremely important from the point of view of metastatic potential of a tumor[6]. Although the mode of cytotoxic action of (−)-NPA is not completely clarified, it was reported that its toxicity may be resulted from the induction of signalling pathways leading to apoptosis[6]. Bioinformatics analysis were conducted between adenosine dependent proteins and neplanocin A with adenosine as control, to further understand how neplanocin A acts with aforementioned proteins. To test this molecular docking was performed with (−)-NPA as ligand and various adenosine binding proteins as receptor. The model preparation was done with MGL Tools and molecular docking using Autodock 4.2.6.

Acknowledgement

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References

[1] E. De Clercq *Antimicrob. Agents Chemother.*, 1985, 28 , 84 —89
[2] M. Inaba , K. Nagashima , S. Tsukagoshi and Y. Sakurai , *Cancer Res.*, 1986, **46** , 1063 —1067
[3] A. Hayden , P. W. M. Johnson , G. Packham and S. J. Crabb , *Breast Canc. Res. Treat.*, 2011, **127** , 109 —119
[4] E. K. Tam , T. M. Nguyen , C. Z. Lim , P. L. Lee , Z. Li , X. Jiang , S. Santhanakrishnan , T. W. Tan , Y. L. Goh , S. Y. Wong , H. Yang , E. H. Ong , J. Hill , Q. Yu and C. L. Chai , *ChemMedChem*, 2015, **10** , 173 —182
[5] G. Chandra , Y. W. Moon , Y. Lee , J. Y. Jang , J. Song , A. Nayak , K. Oh , V. A. Mulamoottil , P. K. Sahu , G. Kim , T. S. Chang , M. Noh , S. K. Lee , S. Choi and L. S. Jeong , *J. Med. Chem.*, 2015, **58** , 5108 —5120[6] L. Zhang , L. Deng , F. Chen , Y. Yao , B. Wu , L. Wei , Q. Mo and Y. Song , *Oncotarget*, 2014, **5** , 10665 —10677
[7] R. T. Borchardt , B. T. Keller and U. Patel-Thombre , *J. Biol. Chem.*, 1984, **259** , 4353 —4358.

P1-054

Heterocyclic dehydroabietylamine derivatives: synthesis and biological evaluation

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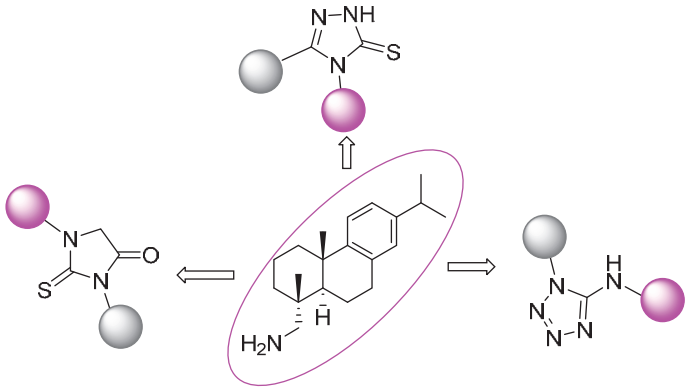
Dehydroabietylamine (DHAAm) is also known as leelamine and belongs to the compounds that are important building blocks in medicinal chemistry.[1-3] DHAAm, an abietane-type diterpenoid derivative, is a relevant modified product of dehydroabietic acid obtained from *Pinus* rosin. Some synthetic derivatives of dehydroabietylamine exhibit significant and diverse biological activities *e.g.* antibacterial, antioxidant, antiviral, antileishmanial, antimalarial and anticancer activities.[4,5]

Nitrogen-containing heterocyclic compounds like pyrrole, pyrrolidine, pyridine, imidazole, pyrimidines, pyrazole, indole, quinoline, oxadiazole, azole, benzimidazole, *etc*., are used as the key scaffold to construct new molecules for pharmacology.

Herein, we present a simple and effective approach for the synthesis of a diverse array of potentially biologically active DHAAm derivatives with heterocyclic five-membered rings in the core. The modifications were performed by derivatizations of the NH_2 moiety in DHAAm structure leading to 1,2,4-triazole-3-thione, 2-thioxoimidazolidin-4-one and tetrazole derivatives. The newly synthesized compounds were screened for their biological activity.



Scheme 1. General structure of DHAAm derivatives.

References

[1] M.A. Gonzalez, J. Clark, M. Connelly, F. Rivas, *Bioorg. Med. Chem. Lett*., **2014**, *24*, 5234-5237.
[2] K.B. Singh, X. Ji, S.V. Singh, *Mol. Cancer Ther.*, **2018**, *17*, 2079-2090.
[3] Y.Y. Jung, J.Y. Um, G. Sethi, K.S. Ahn, *Int. J. Mol. Sci*., **2022**, *23*, 9848-9864
[4] N.V. Heise, S.J. Meyer, R. Csuk, T. Mueller, *Eur. J. Med. Chem*., **2024**, *276*, 116667-116673.
[5] K. Kovaleva, E. Mamontova, O. Yarovaya. O. Zakharova, A. Zakharenko, O. Lavrik, N. Salakhutdinov, *Mol. Divers.*, **2021**, *25*,2389-2397.

P1-055

In Silico Evaluation of Diketopiperazine (DPK) Derivatives as Potential Inhibitors for G-Protein-Coupled Receptors (GPCRs)

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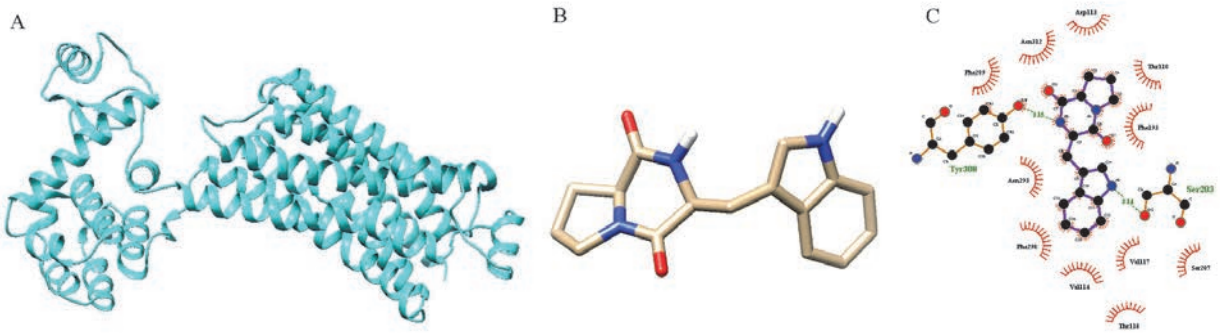
G-protein-coupled receptors (GPCRs) are a diverse group of membrane proteins that mediate critical physiological processes by converting extracellular signals into intracellular responses. One key GPCR, the β2-Adrenergic Receptor (β2-AR), plays a pivotal role in smooth muscle relaxation, bronchodilation, and cardiovascular function, making it an important therapeutic target for conditions such as asthma and hypertension. Diketopiperazines (DPKs), as cyclic peptides, have emerged as promising scaffolds for inhibiting protein interactions and modulating receptor activity, offering a novel therapeutic approach with potentially fewer side effects compared to traditional small-molecule inhibitors [1-3].

In this study, five DPK derivatives were obtained from PubChem and evaluated for their binding affinity to the 3D structure of β2-AR (PDB ID: 2RH1) using molecular docking studies conducted with Autodock 4.6 and MGLTools. Binding energy and hydrogen bond formation were assessed for each compound to determine their interaction efficiency [4,5]. Among the five compounds, tryptophan-proline diketopiperazine exhibited the highest binding affinity, with a binding energy of -5.89 kcal/mol and the formation of two hydrogen bonds. This enhanced interaction is attributed to the aromatic nature of tryptophan, which promotes strong π-π stacking interactions, and the rigidity of proline, which allows for optimal fitting within the receptor's binding pocket. Hydrophobic interactions further stabilized the complex.

The study highlights that diketopiperazine derivatives, particularly tryptophan-proline diketopiperazine, are promising inhibitors of the β2-Adrenergic Receptor. The compound's aromaticity and rigidity enhance its interaction with the receptor, providing valuable insights into the design of peptide-based inhibitors for β2-AR and other GPCR-related diseases, with the potential for improved specificity and fewer side effects.



Scheme. A, β2-Adrenergic Receptor, B. Tryptophan_proline diketopiperazine, and C. Interaction of Ligand-Protein via DimPlot, Ser203 and Tyr308 have H.bond with the ligand.

References

[1] Bojarska, J., **2021**. Cyclic dipeptides.
[2] Bojarska, J., **2021**. A Global Review on Short Peptides: Frontiers and Perspectives
[3] Sammes, P.G.**1957**. Naturally occurring 2,5-dioxopiperazines and related compounds.
[4] Cherezov V, **2007** High-resolution crystal structure of an engineered human beta2-adrenergic GPCR .
[5] Morris, G. M**. 2009**. Autodock4 and AutoDockTools4: automated docking with selective receptor flexibility..

P1-056

Optimization of brexpiprazole synthesis using green chemistry methods

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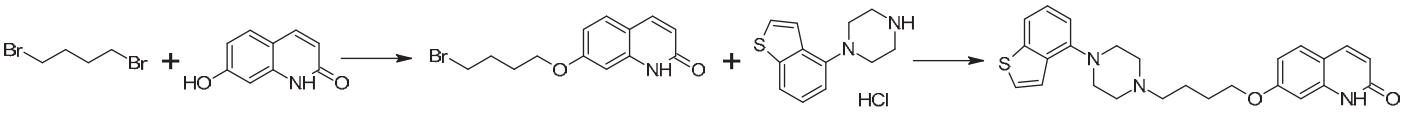
Brexpiprazole is an atypical antipsychotic and a novel D2 dopamine and serotonin 1A partial agonist called a serotonin-dopamine activity modulator. Although it is structurally similar to aripiprazole, brexpiprazole has different binding affinities for dopamine and serotonin receptors and also has less potential for a partial agonist-mediated adverse effect. Brexpiprazole, also known as Rexulti®/Rxulti®, is used as an adjunctive therapy for adults with major depressive disorder (MDD) and schizophrenia in countries such as the US, Canada and Brazil. It has recently been introduced in the US for the treatment of agitation associated with Alzheimer's disease dementia (AADAD). As a result of strong demand and price increases, sales of Rexulti®/Rxulti® achieved a significant increase of 16% (+20% CER) year-on-year. [1-3]

The currently described methods for synthesizing Brexpiprazole are multistage processes, with each stage often taking several hours. Furthermore, these reactions frequently yield low product quantities. Traditional methods involve the use of costly reagents and substantial amounts of harmful solvents, which must then be removed from the reaction mixture, further prolonging the overall synthesis time. [4]

Given the increasing demand for Brexpiprazole, we aimed to enhance its synthesis process to align not only with green chemistry principles but also with the “6R” framework (reduce, reuse, recycle, redesign, remanufacture, and recover). The innovation in this project focuses on reducing or even completely eliminating harmful solvents by using phase transfer catalysts (PTC). By removing solvents from the reaction system, we mitigate disposal issues, resulting in a more environmentally friendly process.

Additionally, we explored the use of microwave irradiation or ultrasound to significantly reduce reaction times—from several hours to mere minutes or even seconds—during single synthesis stages. Various synthetic routes, solvents, and bases were tested to optimize the yield and purity of the product. Optimal conditions were identified for both stages of the synthesis, and we also investigated a one-pot synthesis approach for Brexpiprazole.

In conclusion, we successfully obtained the desired product with a yield exceeding 80% using water as the solvent, demonstrating an efficient, sustainable, and high-yield synthesis process for Brexpiprazole.



Scheme 1. Reaction of obtaining brexpiprazole.

References

[1] Das S, Barnwal P, Winston A B, Mondal S, Saha I., Ther Adv Psychopharmacol., **2016**, Feb;6(1):39-54.

[2] Lundbeck reached record revenue of DKK 20 billion in 2023 with strong growth momentum set to continue in 2024, **2024**

[3] FDA Approved Drug Products: REXULTI (brexpiprazole) tablets for oral use, **2023**

[4] Romanelli, M.N., Braconi, L., Gabellini, A., Manetti, D., Marotta, G., Teodori, E., Molecules, **2024**, 29, 68.

P1-057

Synthesis and structural studies of azo derivatives of calix[4]arenes based on the structure of 2-azabicycloalkanes

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Calix[4]arene can undergo various reactions one of which is an aromatic electrophilic substitution. They can be exemplified by coupling reactions with a diazonium salt, resulting in azocalix[4]arenes. The conjugated diazo bond (-N=N-) present in the azocalix[4]arene molecule at the *para* position is a good chromophore group, which makes these compounds suitable for UV-vis and FT-IR spectroscopic studies.

For this purpose, we synthesized mono azocalix[4]arenes from *para*-aminobenzoic acid following the literature protocol [1] and combined them with chiral amines and alcohols based on the 2-azabicycloalkane backbone (Fig. 1). In addition to the synthesis, FT-IR and UV-vis measurements were carried out, and the final product structures, IR spectra, and UV-vis spectra were simulated based on Kohn-Shan DFT theory, using the B3LYP [2] method and 6-31G** functional basis set [3].

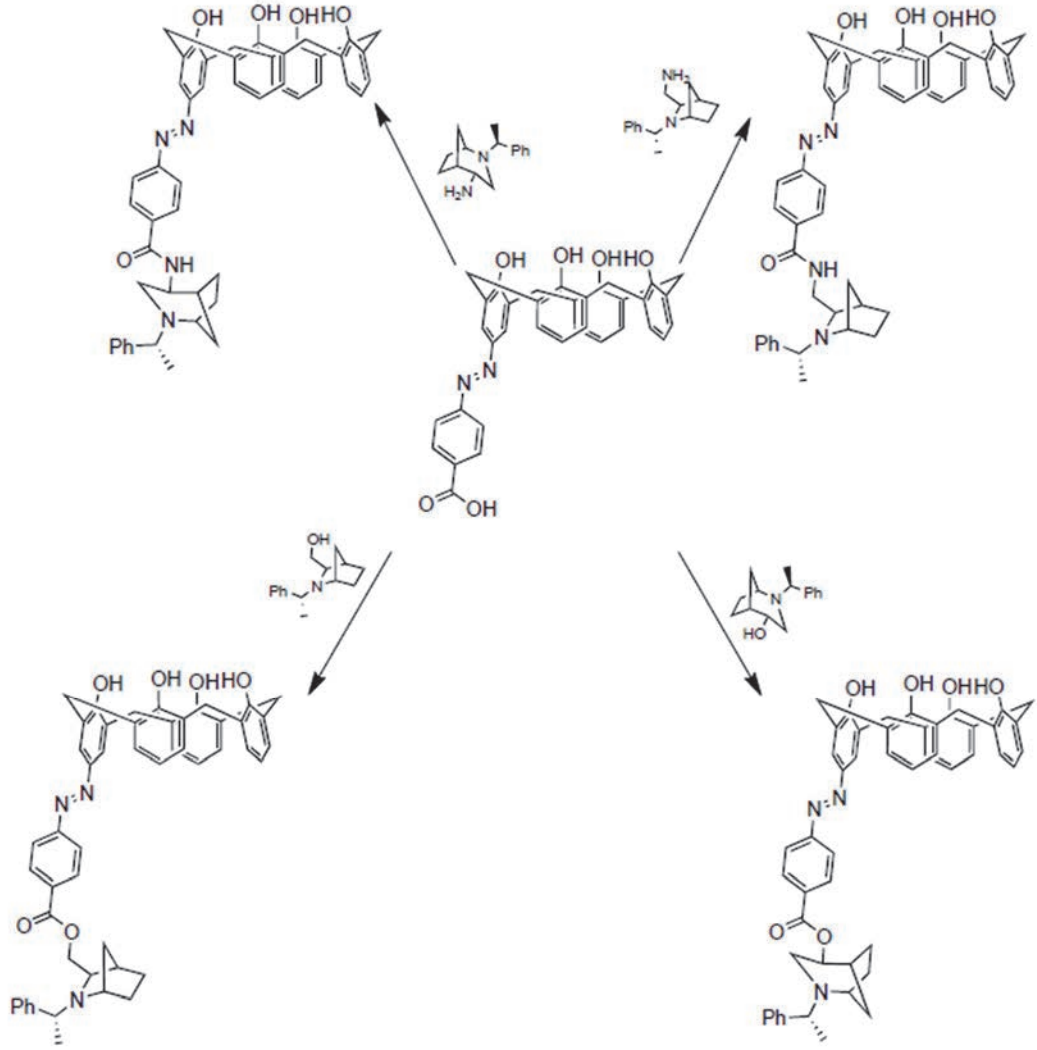

Figure 1. Preparation of 2-azabicycloalkane derivatives coupled with mono azocalix[4]arene.

References

[1] S.-Y. Yao; Y.-X. Yue; A.-K. Ying; *Angew. Chem. Int. Ed.* **2023**, 62, e202213578.
[2] D. Becke, *J. Chem. Phys*. **1993** 98 5648–5652.
[3] R. Ditchfield, W. J. Hehre, and J. A. Pople, *J. Chem. Phys.*, **1971** 54 724.

P1-058

Synthesis of cyclic peptides containing bicyclic proline analogues

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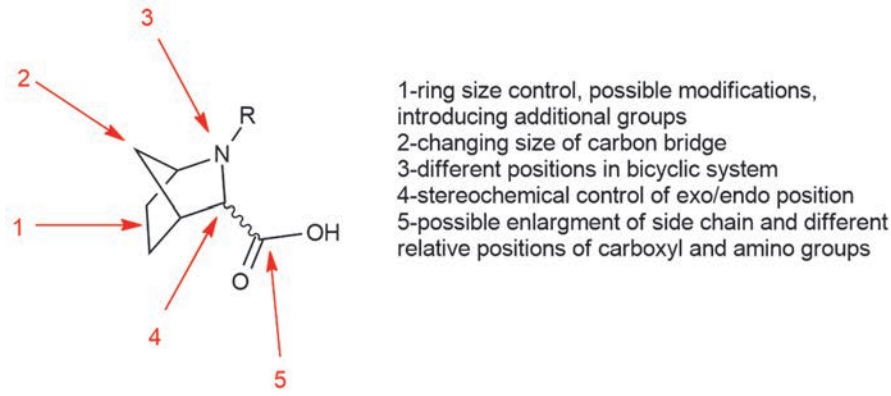
Azabicycloalkane systems can be synthesized using a wide variety of reactions. Depending on the method applied, reactions can be modified by adjusting parameters such as substrate structures, different auxiliary reagents, or catalysts. One of the most popular methods is the aza-Diels-Alder reaction, which offers a highly versatile approach to the synthesis and can lead to a wide range of structures. The obtained azabicycloalkane compounds can be converted into bicyclic amino acids in subsequent reactions. [1-3]



Scheme 1. Modification possibilities and versatility of azabicycloalkane systems.

Azabicycloalkane derivatives have various biomedical applications, such as ledipasvir, an active component of a drug against hepatitis C.[4] They are also used in asymmetric catalysis, e.g. in epoxidation, hydrogenation, addition and many other reactions. [5,6] We believe that in the future they will have an impact on peptide chemistry. On my poster, I will present the current knowledge about the synthesis and applications of these interesting compounds, as well as the plans to use these compounds in the synthesis of cyclic peptides.

References

[1] O. O. Grygorenko, Bicyclic β-amino acids. *Tetrahedron*, **2015**, *71*, 5169–5216 (2015).
[2] A. Trabocchi, D. Scarpi, A. Guarna, Structural diversity of bicyclic amino acids. *Amino Acids*, **2008**, *34*, 1–24.
[3] G. F. Vafina, G. R. Yakhina, T. V Khakimova, L. V Spirikhin, F. Z. Galin, M. S. Yunusov, Synthesis and Stereochemistry of Some 3-Azabicyclo[3.3.1]nonane Derivatives. *Russ. J. Org. Chem.*, **2003**, *39*, 49–56.
[4] J. O. Link, et al. Discovery of ledipasvir (GS-5885): A potent, once-daily oral NS5A inhibitor for the treatment of hepatitis C virus infection. *J Med Chem*, **2014**, *57*, 2033–2046.
[5] E. Wojaczyńska, New 2-azanorbornyl derivatives: Chiral (N,N)-donating ligands for asymmetric catalysis. *Tetrahedron Asymmetry*, **2011**, *22*, 161–166.
[6] H. Nakano, N. Kumagai, H. Matsuzaki, C. Kabuto, H. Hongo, Enantioselective addition of diethylzinc to aldehydes using 2-azanorbornylmethanols and 2-azanorbornylmethanethiol as a catalyst. *Tetrahedron Asymmetry*, **1997**, *8*, 1391-1401.

P1-059

The unexpected result of the guanylation reaction of azabicycloalkane thiourea

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Today guanidines are used in different areas: as a propellant in airbags, as catalysts, ligands, molecular adhesives, sweeteners, and in polymerization. Their most important role is played in medicinal chemistry as components of pharmaceuticals. At the same time, it is known that derivatives of 2-azabicycloalkanes also have variable biological activity, but are less studied. For this reason, combining of these two fragments: guanidine and 2-azabicycloalkane is very interesting.

To this aim, we started with a multi-step synthesis of 2-azabicycloalkane amine as a reagent for preparation of the corresponding thiourea (Fig.1) [1]. We tested this compound as a new guanylation reagent. For the guanylation reaction, we chose one of the latest methods for the synthesis of guanidine derivatives from thiourea and amine [2], which looked promising for the azabicycloalkane compounds under study. During our studies, we obtained an unexpected result: thioguanidine, a compound not described in the literature, was formed in addition to guanidine (Fig. 2).

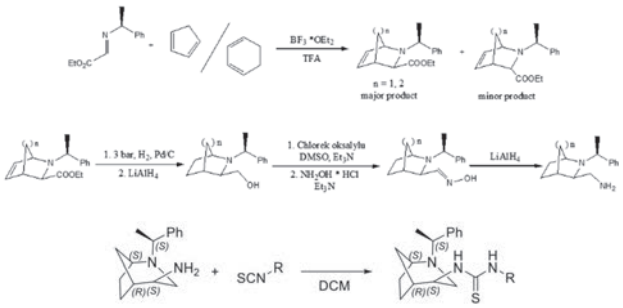

Figure 1. Synthesis of 2-azabicycloalkane thiourea.

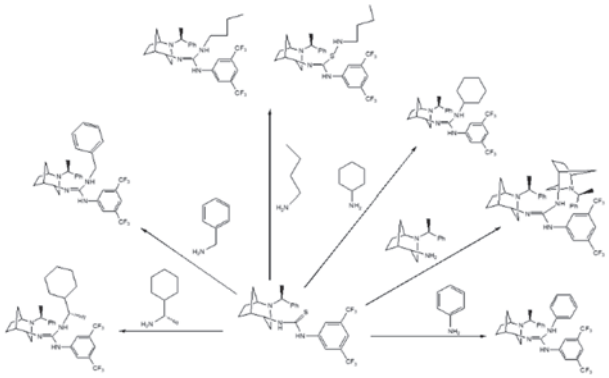

Figure 2. The results of studying 2-azabicycloalkane thiourea as a guanylating reagent.

References

[1] F. Steppeler, D. Iwan, R. Gaida, M. Denel-Bobrowska, A. B. Olejniczak, E. Wojaczyńska, *Biomedicine & Pharmacotherapy*, **2023**, 164, 114908.

[2] H.-J. Rong, C.-F. Yang, T. Chen, Y.-Q. Wang, B.-K. Ning, *Tetrahedron Lett.* **2019**, 60**,** 150970.

P2-001

Synthesis of new Hsp90 protein inhibitors- benzoxazole geldanamycin congeners containing ester moiety

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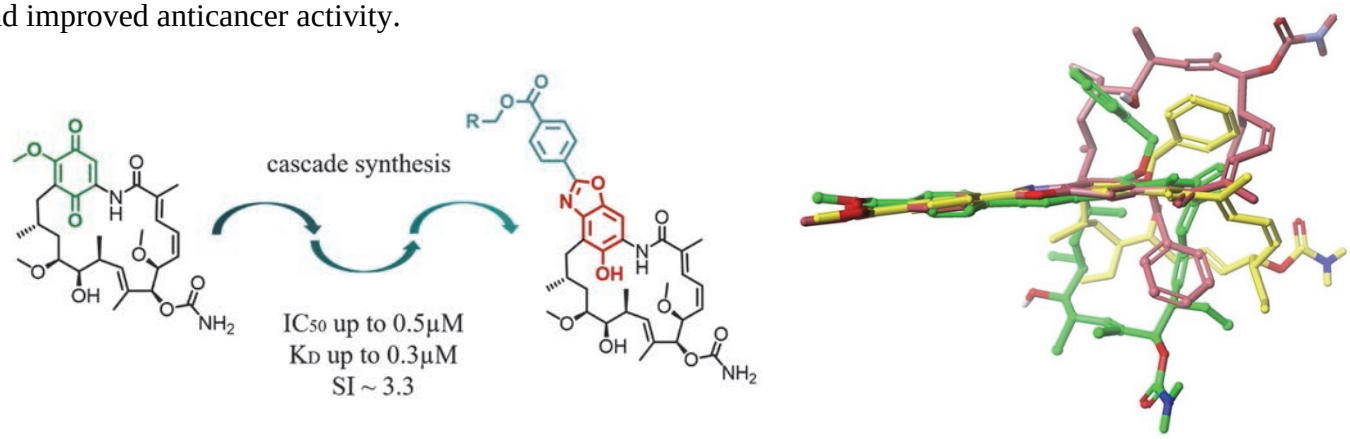
Geldanamycin **GDM** as an antibiotic belongs to ansamaycin family and exhibits anticancer potency [1]. Despite its interesting biological profile, **GDM** reveals dangerous toxic effect which eliminates its further medicinal use. However, the unwanted toxic effect is a result of metabolic reactions of **GDM** benzoquinone core with e.g. glutathione. Utilizing recently proposed cascade heterocyclic transformation of benzoquinone core into benzoxazole moiety, new **GDM** congeners have been obtained [2,3]. Introduction of ester moiety not only improved physicochemical properties but also enhanced affinity to target *Hsp90* [3]. We examined the influence of substituent structure on biological properties, toxicity and affinity toward heat-shock protein *Hsp90* (SAR analysis). This study led to obtaining new more potent **GDM** derivatives with a lower toxicity and improved anticancer activity.



Scheme 1. Cascade synthesis and atropisomerization in **GDM**.

Acknowledgement
Research was partially financed by NCN project Opus 13 no. UMO-2017/25/ST5/00291.

References

[1] N. Skrzypczak, P. Przybylski Nat. Prod. Rep. 2022, 39, 1678-1704.
[2] N. Skrzypczak, K. Pyta, W. Bohusz, A. Leśniewska, M. Gdaniec, P. Ruszkowski, W. Schilf, F. Bartl, P. Przybylski, J. Org. Chem. 2023, 88, 9469-9474.
[3] A. Leśniewska, A. Buczkowski, P. Ruszkowski, W. Schilf, M. Gdaniec, F. Bartl, P. Przybylski, unpublished data.

P2-002

5-Chlorobenzotriazole: Structural Analysis, Vibrational Spectra, and DFT Calculations

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5-Chlorobenzotriazole (ClBTA) is a compound with demonstrated biological activity [1], but its solid state structure has not yet been thoroughly investigated due to difficulties in crystallization. We employed density functional theory (DFT) calculations using the ωB97X-D/6-31++G(d,p) method to analyze the three tautomeric forms of this compound and 13 of their dimeric combinations. A comparison of the theoretical vibrational spectra with experimental FT-Raman and FT-IR spectra indicates that ClBTA exists in the solid state in two tautomeric forms, 1*H*-ClBTA and 3*H*-ClBTA, connected by N−H···N hydrogen bonds. Additionally, our research suggests the possibility of tetramer formation, analogous to the structure of MeBTA [2, 3].

Acknowledgement
The calculations were carried out using resources provided by Wroclaw Centre for Networking and Supercomputing (http://wcss.pl).

References
[1] F. López-Vallejo, R. Castillo, L. Yépez-Mulia, J. L. Medina-Franco, *J. Biomol. Screen.*, **2011**, *16(8)*, 862-868.
[2] R. K. Belter, F. R. Fronczek, *CCDC 1971683: Experimental Crystal Structure Determination*, **2019**.
[3] E. Kołodziejczyk, M. Lewańska, M. Malik, B. Morzyk-Ociepa, *J. Mol. Struct.*, **2023**, *1294 Part 2*, 136489.

P2-003

Sonochemical synthesis of 1,3,5-aminotriazines in the light of the Principles of Green Chemistry

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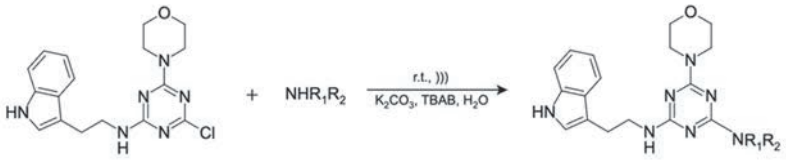
Over the years, numerous research conducted on 1,3,5-triazines has shown great versatility of these compounds. From cosmetic ingredients to photochemistry, 1,3,5-triazine derivatives exhibit a broad spectrum of applications [1]. Due to its relatively low cytotoxicity and high reactivity, s-triazine core plays a major role in the pharmaceutical industry [2, 3]. Binding such powerful heterocyclic framework with different ligands led to discovery of multiple compounds with an array of biological properties, turning s-triazine derivatives into a class of prominent anticancer, antibacterial, antimicrobial, anti-HIV and CNS agents.

Since s-triazine derivatives seem to be indispensable in the modern drug design industry, our research aimed to provide a way to conduct the synthesis in the most sustainable manner, that could prove useful not only in the laboratory scale, where the reaction waste is negligible, but also in the industry, where, due to much bigger scale, the least harmful and wasteful protocol is required.

The research was conducted on tryptamine and morpholine modified 1,3,5-triazine core, to which different amines were attached as the third ligand. Reaction with each amine was then analyzed using the DOZN^{TM} 2.0 tool, resulting in outstanding scores regarding every one of the 12 Principles of Green Chemistry.

Short reaction time, varying from 10 to 40 minutes, contributed to obtaining the best possible score for the 6th principle (Design for Energy Efficiency), whereas using water as a reaction solvent allowed for achieving excellent score for the 3rd (Less Hazardous Chemical Synthesis) and 5th (Safer Solvents and Auxiliaries) principle. Altogether, calculations regarding examined sonochemical protocol revealed its astonishing performance in terms of the 12 Principles of Green Chemistry, proving the method's greater sustainability over the conventional protocols.



Scheme 1. Scheme of sonochemical synthesis of 1,3,5-triazine derivatives.

Acknowledgement

The research study was founded by the FutureLab PK (Project No. 92 RakOUT – the search for a small molecule drug candidate for personalized therapy of colorectal cancer).

References

[1] D. Kułaga, A. K. Drabczyk, P. Zaręba, J. Jaśkowska, J. Chrzan, K. E. Greber, K. Ciura, D. Plażuk , E. Wielgus, *Ultrasonics Sonochemistry*, **2024**, 108, 106951
[2] D. Bareth, S. Jain, J. Kumawat, D. Kishore, J. Dwivedi, S. Z. Hashmi, *Bioorganic Chemistry*, **2024**, 143, 106971
[3] J. Kumawat, S. Jain, S. Patel, N. Misra, P. Jain, S. Z. Hashmi, J. Dwivedi, D. Kishore, *Journal of Molecular Structure*, **2024**, 1313, 138668

P2-004

Versatile reactivity of benzo[*b*]phosph-3-yl triflates

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We previously presented the application of benzo[*b*]phosph-3-yl triflates in the ring opening reaction [1] as well as in Suzuki-Miyaura coupling[2]. Herein, we want to elucidate the reactivity of benzo[*b*]phosph-3-yl triflates towards alkyl Grignard reagents.[3]

Acknowledgement
This work was partially supported by standard university statutory funding.

References

[1] Ł. Ponikiewski, S. Sowa *J. Org. Chem.*, **2021**, *86*, 14928−14941.
[2] A. Brzyska, S. Majewski, Ł. Ponikiewski, M. Zubik-Duda, A. Lipke, A. Gładysz-Płaska, S. Sowa, *J. Org. Chem.*, **2023**, *88*, 7901-7917.
[3] A. Maciąg, Ł. Ponikiewski, P. Kubica. S. Sowa *unpublished*

P2-005

Effect of 3-aryl substituent on the fluorescent properties of benzo[*b*]phosphole oxides

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Recently, the 3-arylbenzo[*b*]phosphole oxides become an essential motif in the chemistry of benzophosphole oxides.[1] Since their discovery in 2018,[2] the access to these compounds was significantly broadened.[3] In 2023, we reported their synthesis by Suzuki-Miyaura coupling.[4] In addition, we characterized their fluorescent properties. In this poster, we present deeper insight into their photooptical properties.

Acknowledgement
This work was partially supported by standard university statutory funding

References

[1] (a) Y. Tokura, Y. Kijima, M. Miura, K. Hirano, *Chem. Commun.* **2022**, *58*, 12208–12211. (b) Y. Tokura, S. Xu, K. Yasui, Y. Nishi, K. Hirano, *Chem. Commun.* **2024**, *60*, 2792–2795. (c) Y. Tokura,; Xu, S.; Kamiyoshi, I.; Hirano, K. *Org. Lett.* **2024**, *26*, 5269–5273.
[2] Patent: KR2018/34925 A, **2018**.
[3] (a) K. Nishimura, K. Hirano, M. Miura, *Org. Lett.*, **2020**, *22*, 8, 3185–3189. (b) Xu, S.; Nishimura, K.; Saito, K.; Miura, H. M. *Chem. Sci.* **2022**, *13*, 10950. (c) Patent: CN115703809 A, **2023.**
[4] A. Brzyska, S. Majewski, Ł. Ponikiewski, M. Zubik-Duda, A. Lipke, A. Gładysz-Płaska, S. Sowa, *J. Org. Chem.*, **2023**, *88*, 7901-7917.

P2-006

The Au(III) catalytic effect on the molecular mechanism of the [3+2] cycloaddition reaction between (Z)-C,N-diphenylnitrone and nitroethene: MEDT computational study

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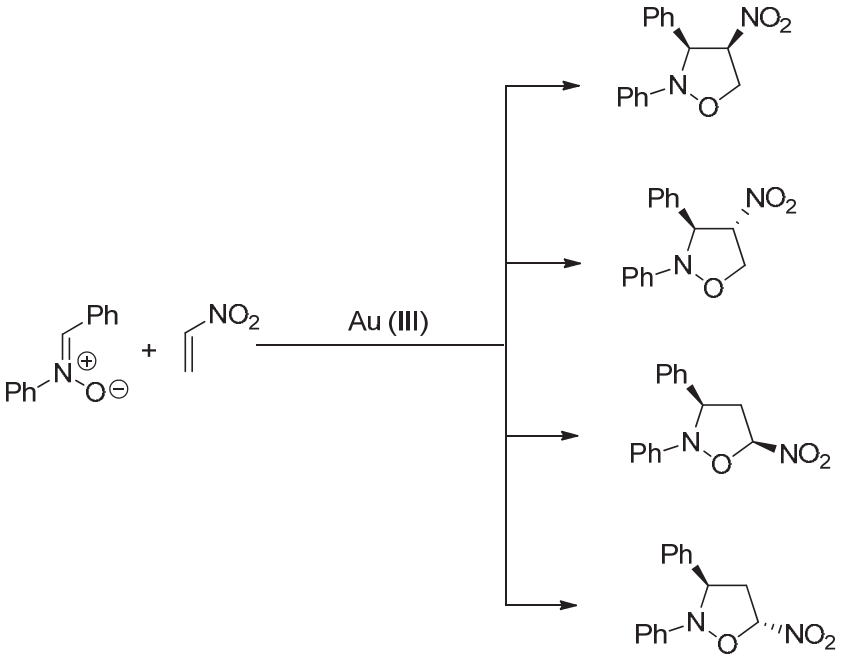
The regio- stereoselectivity and the molecular mechanism of the Au(III)-catalysed [3+2] cycloaddition reaction of (Z)-C,N-diphenylnitrone with nitroethene were explored in the light of the DFT calculations. We found, that the presence of the Au(III) molecular segments, in the reaction environment, dramatically has changed the cycloaddition mechanism. In particular, the observed, single step mechanism under the thermal conditions, is replaced to stepwise, zwitterionic mechanism on three from four theoretically possible paths. Its is interesting, that we identified the firstexample of the stepwise mechanism leading to the 5-nitroisoxazolidine molecular segment. Earlier, only [3+2] cycloadditions leading to the 4-nitroisoxazolidines were incidentally described as a stepwise processes.



Scheme 1. Theoretical possible paths opf the Au(III)-catalysed (3+2)-cycloaddition reaction between (Z)-C,N-diphenylnitrone and nitroethene.

Acknowledgement

We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2024/017194.

P2-007

Stability of acyclic nitronic acids

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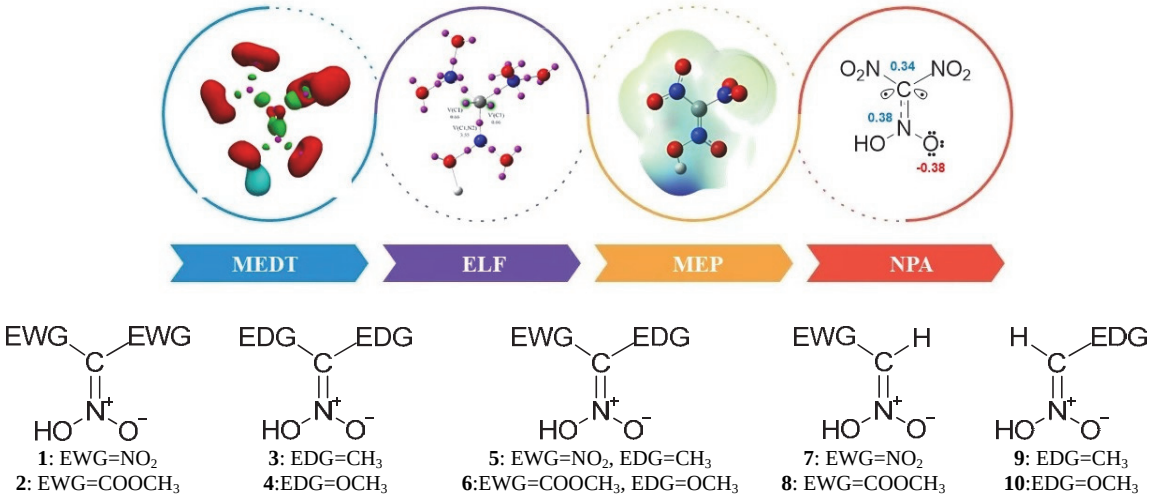
The electronic structure and stability of acyclic nitronic acids were studied in the framework of Molecular Electron Density Theory (MEDT) [1]. Depending on the different substituents, the analyzed compounds can be classified as *pseudo(mono)radical* or zwitterionic nitronic acids [2]. ELF topological analysis of the electron density of nitronic acids containing in their structure EWG substituent (-NO_2 (1); -$COOCH_3$ (2); -NO_2, -CH_3 (5); -$COOCH_3$, -OCH_3 (6); -NO_2, -H (7); -$COOH_3$, -H (8)) permits establishing a *pseudo(mono)radical* electronic structure with a *pseudoradical* centres at the C1 carbon atom. In turn, ELF analysis of the compounds containing substituent belonging to the EGD group (-CH_3 (3); -OCH_3 (4); -CH_3, -H (9); -COH_3, -H (10)) and based on the presence of C1-N2 double bond and absence of *pseudoradical* centre allows for the classification of these compounds as a zwitterionic nitronic acids. Nitronic acids containing EDG substituents in their structure are the most stable among the analyzed nitronic acids. In turn, nitronic acids containing EWG groups are characterized by higher reactivity in chemical reactions compared to other analyzed nitronic acids [2].



Scheme 1. Analyzed acyclic nitronic acids **1-10**.

Acknowledgement

We gratefully acknowledge the Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2023/016638.

References

[1] L.R. Domingo, *Molecules*, **2016**, *21*, 1319.
[2] A. Kącka-Zych, *J. Mol. Graph. Model.*, **2024**, *129*, 108754.

P2-008

Selected [4+2] cycloadditions with the participation of methylcyclopentadiene: DFT study

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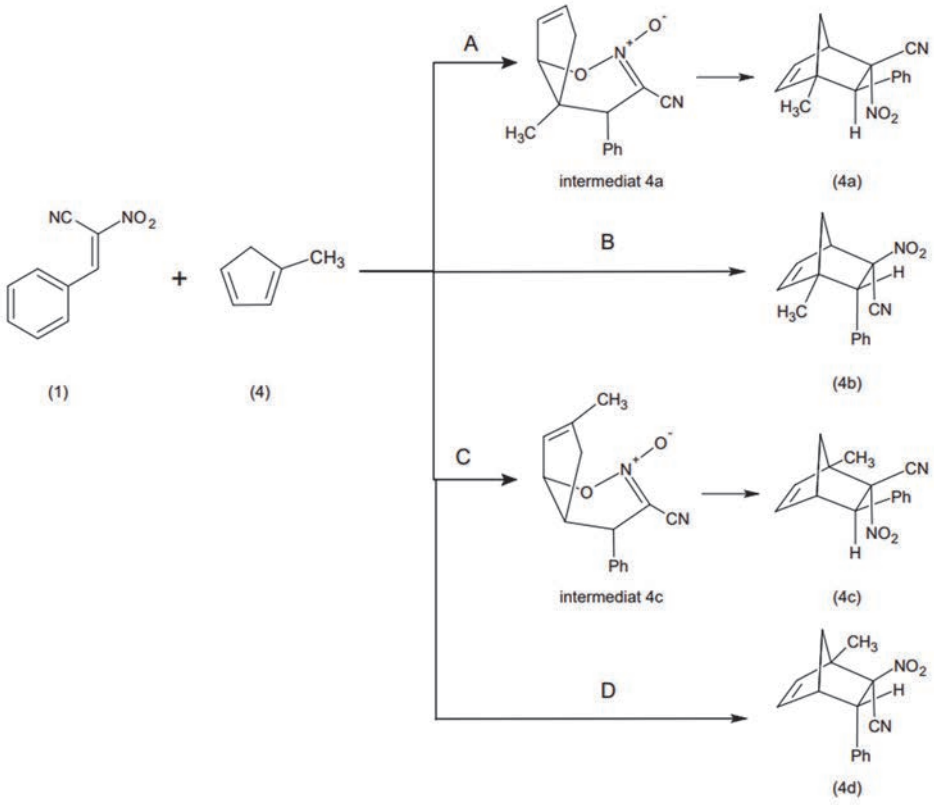
As a result of the reaction [4+2] of cycloaddition of various cyclopentadienes with olefins, norborene derivatives are obtained. Norborenes and their derivatives are very important chemical units widely used, among others, in modern synthetic chemistry or as building blocks. According to the latest available literature reports, it is possible to use norborene scaffolds as potential chemotherapeutic agents. This particularly important use of these substances is related to their high reactivity and the biological properties it gives to other molecules.

We conducted quantum-chemical calculations for the [4+2] cycloaddition reaction involving 2-phenyl-1-cyano-1-nitroethene **(1)** and the isomers of methylcyclopentadiene **(2-4)**. The calculations encompassed the determination of geometric, thermodynamic, and kinetic parameters. Our analysis revealed that reaction pathways leading to products with the nitro group in the "endo" position proceed via a two-step mechanism, whereas those yielding products with the nitro group in the "exo" position follow a one-step mechanism.



Scheme 1. The [4+2] cycloaddition reactions between 2-phenyl-1-cyano-1-nitroethene **1** and 1-methylo-1,3-cyclopentadiene **4**.

Acknowledgement

All presented calculations were performed on the "Ares" supercomputer located at the CYFRONET Academic Computer Center in Cracow. We would like to thank Infrastructure PLGrid and ACK CYFRONET for providing computer equipment and support within computational grant no. PLG/2023/016654.

P2-009

The key structural and electronic properties of (1*E*,3*E*)-1,4-dinitro-1,3-butadiene

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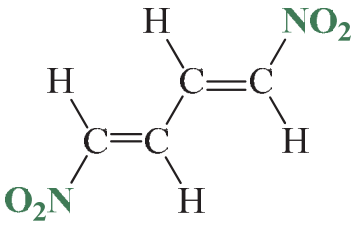
The chemistry of conjugated nitrodienes is becoming increasingly popular. These molecules are successfully applied in cycloaddition to synthesize six-membered rings in Diels-Alder reactions. Nitrodienes can be also applied to obtain bis-compounds in [3+2] cycloaddition. Moreover, the presence of a nitro group in the structure provides a possibility of further modification of the products. The simplest symmetrical representative of conjugated nitrodienes is (1E,3E)-1,4-dinitro-1,3-butadiene. Although the first mentions of the compound date back to the early 1950s, the compound has not yet been examined thoroughly enough.



Scheme 1. The structure of the studied (1E,3E)-1,4-dinitro-1,3-butadiene.

Therefore, in the presented research, a comprehensive study of (1E,3E)-1,4-dinitro-1,3-butadiene has been described. For this purpose, an experimental study including the synthesis process as well as an evaluation of the spectral characteristics has been conducted. So as to better understand the properties of this compound, a computational study of reactivity indices based on MEDT and also an assessment of pharmacokinetics and biological activity according to ADME and PASS methodologies have been made. On this basis, some future application trends of (1E,3E)-1,4-dinitro-1,3-butadiene have been proposed.

Acknowledgement

The presented research was supported by the PLGrid Infrastructure. All presented calculations were performed on the "Ares" supercomputer located at the CYFRONET Academic Computer Center in Cracow. We would like to thank Infrastructure PLGrid and ACK CYFRONET for providing computer equipment and support..

References

[1] K. Kula, B. Synkiewicz-Musialska, M. Sadowski, *Molecules*, **2024**, *29(2)*, e542.
[2] L. R. Domingo, *Scientiae. Radices.*, **2024**, *3(3)*, 157-186.

P2-010

Syn-propanethial S-oxide as the TAC in selected [3+2] cycloaddition processes: MEDT study

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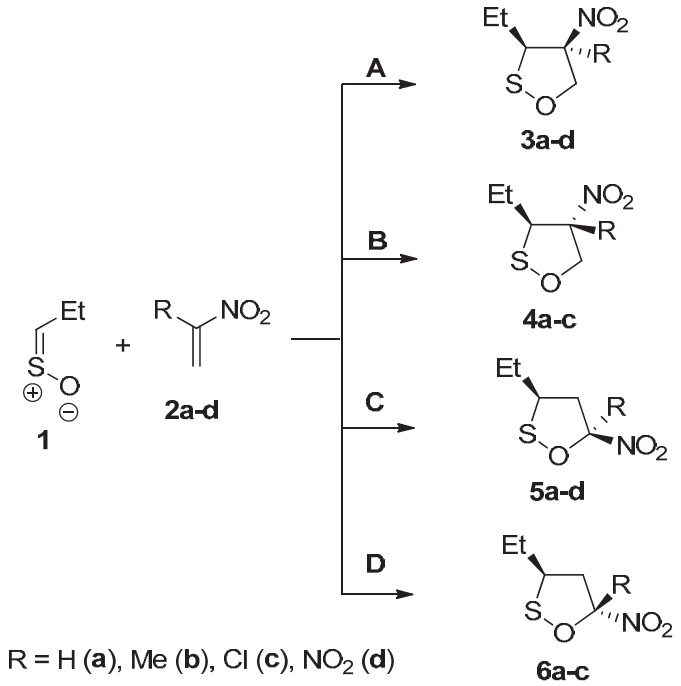
A computational study of *Syn*-propanethial S-oxide (**1**), as a new TAC for [3+2] cycloaddition reactions, was conducted. The study employed MEDT approach.[1] As alkene components various nitroethenes (**2a-d**) were applied. Local reactivity descriptors N_k (local nucleophilicity) and ω_k (local electrophilicity) of S-oxide **1**, were determined.[2] Mechanisms of the reactions (Scheme 1) were computationally studied. The reference cycloadducts of **1** and **2a**, namely **3a-6a**, were also screened for bioactivity using *in silico* molecular docking. Gasussian 16 C.01,[3] and AutoDock Vina implemented by SwissDock[4,5] software was used perform the computations.



Scheme 1. Theoretically possible, regio- and stereoisomeric paths of the [3+2] cycloaddition between *Syn*-propanethial S-oxide (**1**) and 1-R-1-nitroethenes (**2a-d**).

Acknowledgement

Research was supported in part by PL-Grid infrastructure. Computations were performed on "Prometheus" at CYFRONET.

References

[1] L.R. Domingo, *Molecules*, **2016**, 21, 1319.
[2] L.R. Domingo, M. Ríos-Gutiérrez, P. Pérez, *Molecules*. **2016**, 21, 748.
[3] M.J. Frish, et al. Gaussian 16 Revision C.01.
[4] M. Bugnon et al. *Nucleic Acids Research*, **2024**, *52*, W324–W332.
[5] J. Eberhardt, D. Santos-Martins, A.F. Tillack, S. Forli, *J. Chem. Inf. Model.*, **2021**, 61, 3891–3898.

P2-011

[3+2] cycloaddition reactions between aryl azides and ethyl propiolate

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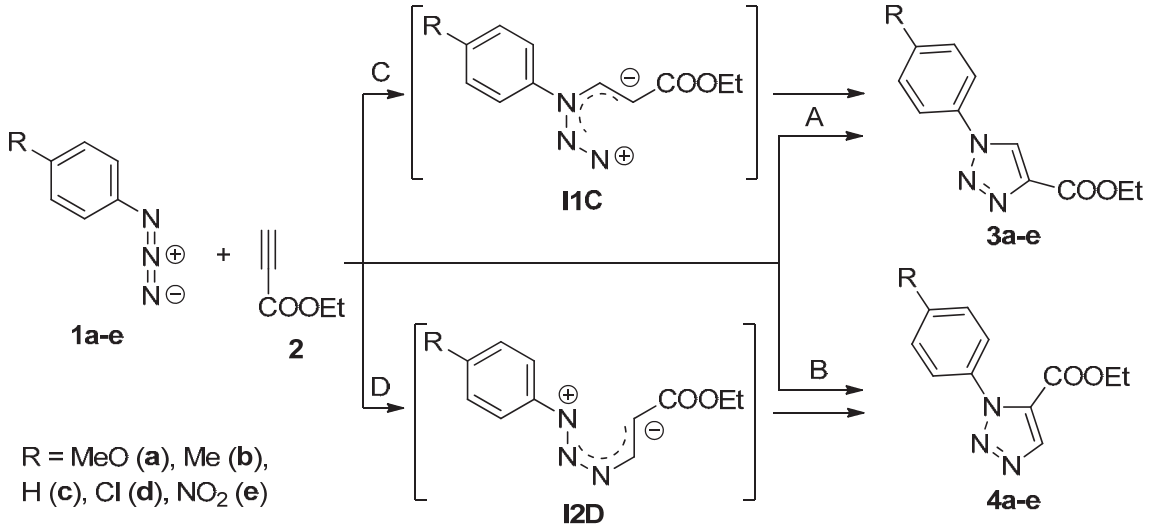
The molecular mechanism of the [3+2] cycloaddition reactions between aryl azides and ethyl propiolate was evaluated in the framework of the Molecular Electron Density Theory. It was found that independently of the nature of the substituent within the azide molecule, the cycloaddition process is realized via a polar but single-step mechanism [1]. All attempts of localization as postulated earlier by Abu-Orabi and coworker's [2] zwitterionic intermediates were not successful. At the same time, the formation of zwitterions with an "extended" conformation is possible on parallel reaction paths. The ELF analysis shows that the studied cycloaddition reaction leading to the 1,4-triazole proceeds by a two-stage one-step mechanism. It also revealed that both zwitterions are created by the donation of the nitrogen atom's nonbonding electron densities to carbon atoms of ethyl propiolate.



Scheme 1. Theoretical possible ways of the [3+2] cycloaddition reactions between aryl azides **1a-e** and ethyl propiolate **2**.

Acknowledgement

We gratefully acknowledge the Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2023/016659.

References

[1] E. Dresler, P. Woliński, A. Wróblewska, R. Jasiński, *Molecules* **2023**, *28*, 8152.

[2] S.T. Abu-Orabi, M.A. Atfah, I. Jibril, F.M. Mari'i, A.A.-S. Ali, *J. Heterocycl. Chem.* **1989**, *26*, 1461–1468.

P2-012

Synthesis of 1,2,4-triazine sulfonamides by Buchwald-Hartwig reactions

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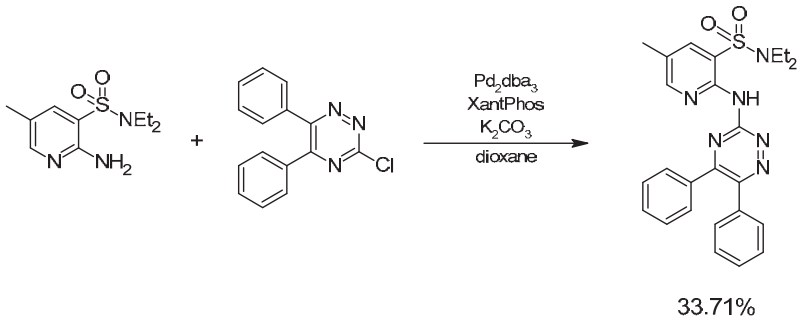
Sulfonamides are organic compounds containing a sulfonamide group, $-SO_2NR_2$, where R = H, alkyl, aryl. Sulfonamides are compounds with potential anticancer activity [1]. The most important method of obtaining sulfonamides is through nucleophilic substitution reactions between sulfonyl halides and amines. There are also many more methods for obtaining sulfonamides, such as oxidative amination reactions of thiols, reactions of sulfonyl halides with *N*-silylamines, reactions of sulfonyl hydrazides with amines, reactions of sulfonates with amines, electrochemical reactions such as the electrochemical cleavage process of sulfonimides and in the electrochemical sulfonamidation of aromatic rings, as well as in many organometallic coupling reactions of litho-organic compounds or Grignard compounds, including with the specific reagent *t*-BuONSO or with DABSO [2]. More important methods for obtaining sulfonamides in organometallic coupling reactions are coupling reactions using palladium catalysts, including the Suzuki reaction (using borates) and the Buchwald-Hartwig reaction. The Buchwald-Hartwig reaction is an *N*-arylation reaction of amines. This reaction can also be used to form secondary and tertiary sulfonamides by reacting primary sulfonamides with aryl halides [3 – 4]. In addition, many methods are known for obtaining chiral sulfonamides in asymmetric reactions, for example, in the palladium-catalyzed arylation reaction of cyclic imines [5].

My research concerns the synthesis of sulfonamides containing a 1,2,4-triazine ring via organometallic Buchwald-Hartwig coupling reactions using palladium catalysts. The 1,2,4-triazine ring is present in many anticancer compounds.



Scheme 1. Synthesis of 1,2,4-triazine sulfonamides by the Buchwald-Hartwig reaction.

Acknowledgement

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References

[1] N. V. Heise, S. J. Meyer, R. Csuk, T. Mueller, *Eur. J. Med. Chem*., **2024**, 276, 116667,
[2] M. S. A. El-Gabya, Y. A. Ammarb, M. I.H. El-Qalieia, A. M. Alia, M. F. Husseina, F. A. Faraghally, *Egypt. J. Chem*., **2020**, 63, 12, 5289-5327.
[3] E. Garnier, J. Audoux, E. Pasquinet, F. Suzenet, D. Poullain, B. Lebret, and G. Guillaumet, *J. Org. Chem.*, **2004**, 69, 23, 7809-7815.
[4] S. Shekhar, T. B. Dunn, B. J. Kotecki, D. K. Montavon and Steven C. Cullen, *J. Org. Chem*., **2011**, 76, 11, 4552–4563.
[5] Z. B. Zhao, L. Shi, F. J. Meng, Y. Lia and Y. G. Zhou, *Org. Chem. Front*., **2019**, 6, 1572-1576.
[6] M. Kocúrik, J. Bartáček, P. Drabina, J. Váňa, J. Svoboda, L. Husáková, V. Finger, M. Hympánová, M. Sedlák, *J. Org. Chem*., **2023**, 88, 21, 15189–15197.

P2-013

Discovery of a New Polymorph of 5-Methoxy-1*H*-Indole-2-Carboxylic Acid: Structural and IR Characterization with DFT Calculations

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We report the discovery and comprehensive analysis of a new polymorph of 5-methoxy-1*H*-indole-2-carboxylic acid (MI2CA), characterized using single crystal X-ray diffraction, infrared (IR) spectroscopy, and density functional theory (DFT) calculations. Crystallizing in the monoclinic space group $P2_1/c$, this novel polymorph exhibits a distinct dimeric structure stabilized by double O−H···O hydrogen bonds, significantly differentiating it from the previously known form [1, 2]. Hirshfeld surface analysis revealed the role of N−H···O and C−H···O interactions in the crystal packing, providing deeper insights into the molecular organization. DFT calculations using the ωB97X-D functional with two basis sets showed strong agreement with experimental data, particularly in describing the intermolecular interactions within dimeric and trimeric models. Comparative IR spectroscopy further highlighted clear distinctions between this new polymorph and the earlier form [1, 2], confirming the influence of altered hydrogen bonding patterns. This study enhances the understanding of MI2CA polymorphism and underscores its potential relevance for future pharmacological applications. Further details of these findings can be found in our published work [3].

Acknowledgement

The calculations were carried out using resources provided by Wroclaw Centre for Networking and Supercomputing (http://wcss.pl).

References

[1] B. Morzyk-Ociepa, D. Michalska, A. Pietraszko, *J. Mol. Struct.*, **2004**, *688*, 87-94.
[2] B. Morzyk-Ociepa, *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, **2009**, *72*, 236-243.
[3] J. Polak, J. Bąkowicz, B. Morzyk-Ociepa, *Molecules*, **2024**, *29*, 2201.

P2-014

Incorporation of Formyl Group into RNA: Cyanohydrin's Role

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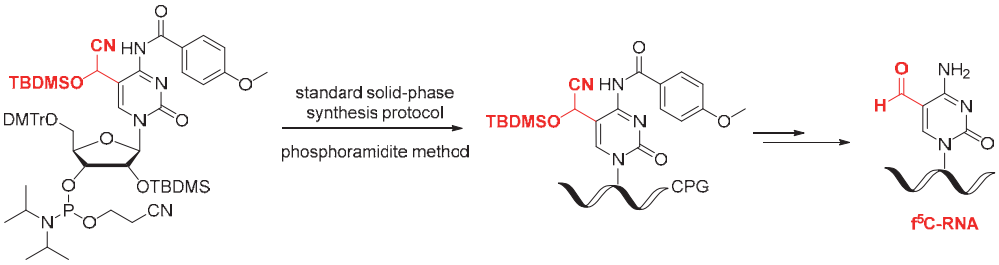
5-Formylcytidine (f^5C) in RNA plays a critical role in various cellular processes. This modification was found at the wobble position of the anticodon loop of human mitochondrial mt-$tRNA^{Met}$ (hmt-$tRNA^{Met}$).[1] The absence of f^5C impairs mitochondrial translation and respiration, highlighting its importance.[2] In mRNA, f^5C participates in the oxidative demethylation cycle of 5-methylcytidine (m^5C), which suggests potential regulatory roles, though its exact biological functions remain unclear.[3]

Standard solid-phase phosphoramidite synthesis of f^5C-RNA has been challenging due to the instability of the formyl group, which is sensitive to acidic conditions, oxidizing agents, and amines. Efforts documented in the literature to incorporate f^5C via classic approaches [4, 5] or post-synthetic strategies [6] are not without limitations. To address these issues, a novel post-synthetic strategy has been developed, utilizing a 5-cyanohydrin precursor which can be selectively converted into f^5C under mild acidic conditions. This strategy operates within a 5'-*O*-DMTr-2'-*O*-TBDMS protection system and offers a new practical and efficient formyl incorporation into RNA chain with no additional step of oligomer deprotection.

This innovative strategy opens the door to further exploration of formyl-modified RNA oligomers and their roles in gene expression regulation, mitochondrial function, and other cellular processes.



Scheme 1. Strategy of f^5C incorporation into oligomer RNA via cyanohydrin precursor.

Acknowledgement

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References

[1] Moriya J. et al., *Biochemistry*, **1994**, *33*, 2234-2239.
[2] Nakano S. et al., *Nat. Chem. Biol*., **2016**, *12*, 546-551.
[3] Huang W. et al., *Chemical Science*, **2016**, *7*, 5495-5502.
[4] Michaelides I. N. et al., *Chem. Eur. J.*, **2017**, *23*, 15894-15898.
[5] Tanpure A. A. et al., *ChemBioChem*., **2017**, *18*, 2236–2241.
[6] Podskoczyj K. et al., *Chem. Commun.*, **2021**, *57*, 12540-12543.

P2-015

Construction of stable ring-fused [1,2,4]triazinyl radicals

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In the last decade, there has been a rapidly growing interest in purely organic materials desired for new technologies, such as well-defined large polycyclic aromatic hydrocarbons (LPAHs). Particularly interesting are paramagnetic LPAH with an electron spin extensively delocalized in the π system, which due to their magnetic properties, low band gap and favorable electrochemical behavior can be used in organic electronics and spintronics.

We have developed four synthetic methods to access ring-fused [1,2,4]triazin-4-yl radicals [1-4]. This discovery gave access to several dozen new derivatives and opened the possibility of further exploration of paramagnetic nanographenes in the context of information storage and processing. Recently, we have explored two platforms of such LPAHs where the centrepiece is the [1,2,4]triazinyl – an exceptionally stable radical, annulated into the π-system of a LPAH through edges e and f. New achievements in the synthesis of LPAHs based on [1,2,4]triazin-4-yl radical and their characterization by spectroscopic (UV-vis, EPR), electrochemical, and magnetic methods will be presented.

Acknowledgement
This study was supported by the National Science Centre (NCN grant no. 2022/47/D/ST4/03462).

References

[1] P. Kaszyński, C. Constantinides, V. Young, Jr., *Angew. Chem.* **2016**, 128, 11315–11318.
[2] P. Bartos, B. Anand, A. Pietrzak, P. Kaszyński, *Org. Lett.* **2020**, *22*, 180 –184.
[3] P. Bartos, V. Young, Jr., P. Kaszyński, *Org. Lett.* **2020**, *22*, 3835–3840.
[4] P. Bartos, M. Celeda, A. Pietrzak, P. Kaszyński, *Org. Chem. Front.* **2022**, *9*, 929–938.

P2-016

Chemical modifications of the saccharide arm of pimaricin- macrolactone antibiotic

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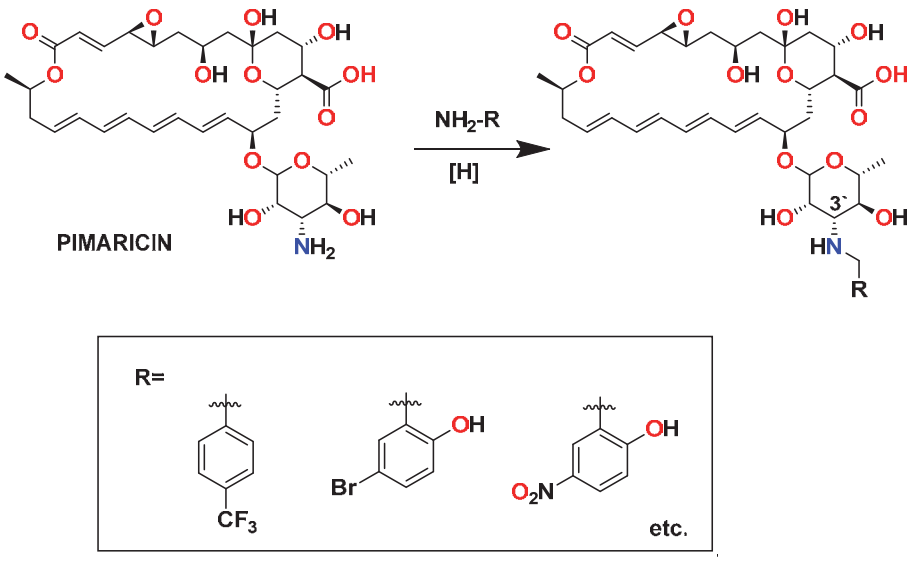
Macrolides are chemical compounds which characteristic feature is the presence of macrocyclic lactone- aglycone with attached sugar units in the structure of antibiotic. Macrolide antibiotics can be divided due to the side of aglycone ring. Lactone macrolides are distinguished by those having 14-,15-membered aglycone rings (such as clarithromycin and azithromycin) but also antibiotics with much larger rings such as pimaricin (**PIM**). Due to their antibacterial (clarithromycin and azithromycin) and antifungal properties (pimaricin), these compounds have been used in the treatment of respiratory diseases or fungal skin infections. The antifungal mechanism of action of polyene antibiotics is based on disrupting the integrity of the fungi biomembrane. The mechanism of pimaricin action hasn`t been already explained. [1-4]

The synthesis of new pimaricin derivatives aims to obtain compounds characterized by more effective antifungal activity and physicochemical properties in relation to the parent antibiotic. I have synthesized new derivatives of **PIM** with modified sugar arm of antibiotic (**Scheme 1.)**. The structure of a new derivatives of pimaricin antibiotic was confirmed using a number of spectroscopic and spectrometric methods (FT-IR, 1D and 2D NMR, ESI-MS).



Scheme 1. Modification of saccharide arm of pimaricin (PIM).[5].

References

[1] Przybylski, P. Curr. Org. Chem., **2011**, 15, 328–374.
[2] Janas, A.; Przybylski, P. European Journal of Medicinal Chemistry **2019**, *182*, 111662.
[3] Janas, A.; Pyta, K.; Gdaniec, M.; Przybylski, P. *J. Org. Chem.* **2022**, *87* (5), 3758–3761.
[4] Aparicio, J. F.; et.al. **2016**, *100*, 61–78.
[5] Smolarz, E.; Schilf, W.; Przybylski, P. Unpublished data **2024**.

P2-017

Regioselective protection of tylosin functional groups

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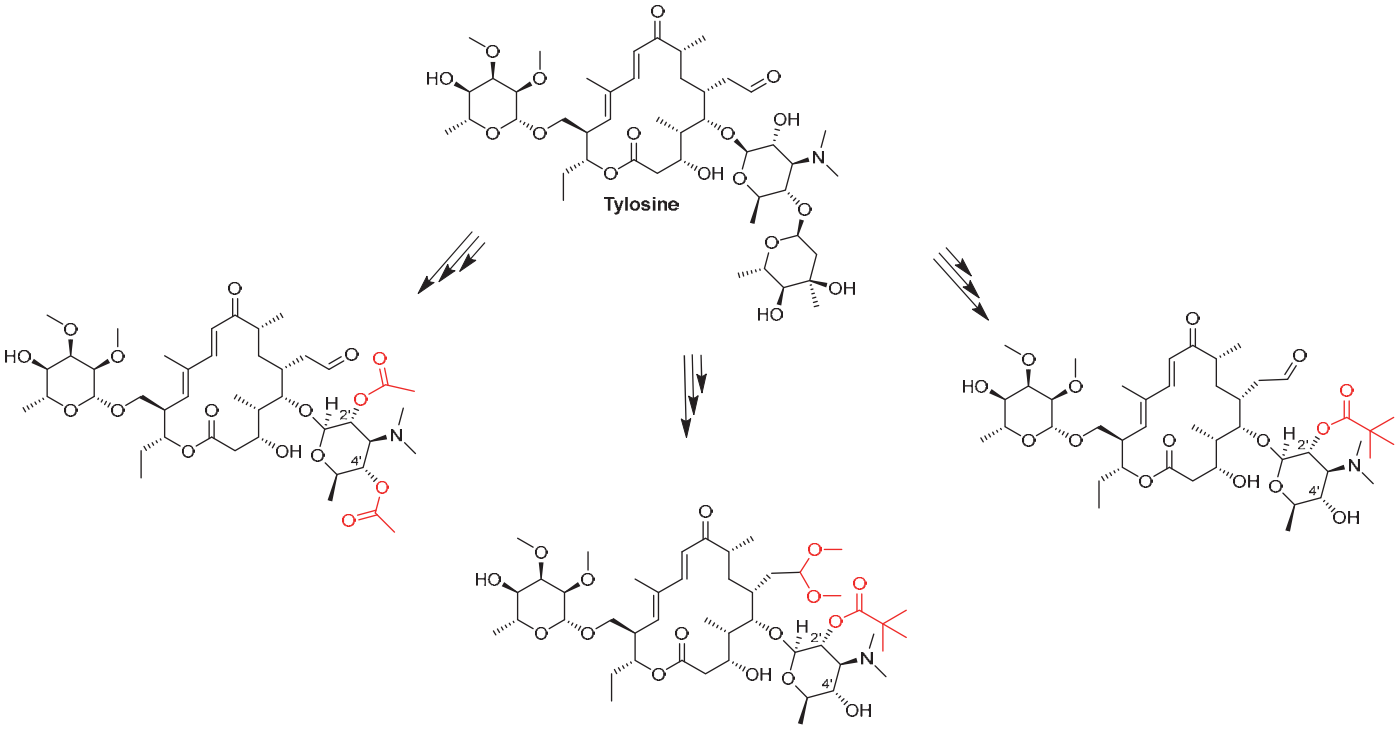
Macrolides belong to a class of antibiotics characterized by a macrocyclic ring containing a lactone moiety to which one or more saccharide units are attached via a glycosidic bond. Macrolides are a broad class of antibiotics including compounds having an aglycone composed of a 12-16 membered ring. The biological activity of macrolide antibiotics includes bacteriostatic or bactericidal activity with inhibit the growth or reproduction of bacteria[1]. One of the antibiotics representing the class of 16-membered macrolide antibiotics has shown unexpected anticancer activity and this antibiotic is spiramycin[2]. Other representatives of 16-membered macrolide antibiotics include josamycin and tylosin. Tylosin is an antibiotic used in veterinary medicine to treat and prevent diseases caused by gram-positive bacteria, and also has limited use against gram-negative bacteria[3]. The aim of my research is to regioselectively block tylosin hydroxyl groups in the C(2') and C(4') positions, which is necessary to perform out further modifications that may lead to obtaining biologically active compounds.



Scheme 1. Modifications of tylosin antibiotic – regioselective protection of hydroxyl group.

References

[1] A. Janas and P. Przybylski, *European Journal of Medicinal Chemistry*, 2019, **182**, 111662.
[2] K. Klich, K. Pyta, M. M. Kubicka, P. Ruszkowski, L. Celewicz, M. Gajecka and P. Przybylski, *J. Med. Chem.*, 2016, **59**, 7963–7973.
[3] B. Arsic, J. Barber, A. Čikoš, M. Mladenovic, N. Stankovic and P. Novak, *International Journal of Antimicrobial Agents*, 2018, **51**, 283–298.

P2-018

Preliminary studies of 1,5-benzoxazepine derivatives as potential histamine H_3 receptor antagonists

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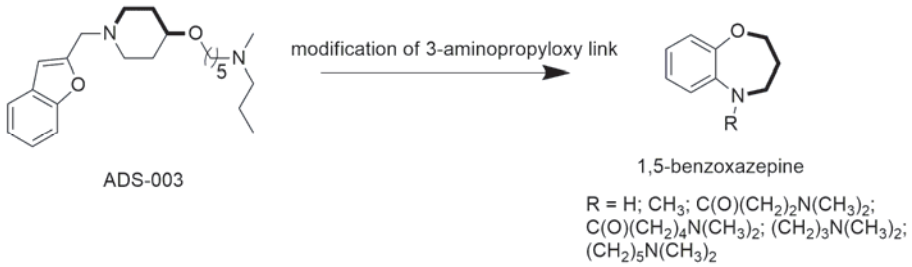
Treatment of neurodegenerative diseases is currently the most important goal of research conducted by many centers in Europe and the world. An important point in the emergence or development of the disease is the dysfunction of the nervous system. Therefore, the concentrations of individual neurotransmitters, e.g. dopamine or serotonin, play an important role. Our research focuses mainly on H_3 receptors, which play an important role in many processes in the brain.[1]

We aimed to evaluate how the rigidification of the characteristic 3-aminopropyloxy linker (present in many potent histamine H_3 receptor antagonists) by incorporating it into 1,5-benzoxazepines affects the potency of histamine H_3 receptor antagonists. In addition, the acetyl- and butyrylcholinesterase inhibition and anticancer activity of the selected compounds were evaluated.[2]



Scheme 1. Structure of the most active compounds of H_3 receptor antagonist and structural modification of benzoxazepine derivatives.

References

[1] K. Nikolic, S. Filipic, D. Agbaba, H. Stark, CNS Neurosci.Ther., **2014**, *20(7)*, 613.
[2] M. Stefaniak-Napieralska, K. Walczyński, M. Iwan, A. Korga-Plewko, N. Szałaj, A. Więckowska, M. Staszewski, *Future Med. Chem.*, **2024**, *16(3)*, s.197-204.

P2-019

Characterization of modified (-)-cytisine-squaramides with different amino acid motifs as compounds with potential antioxidative properties

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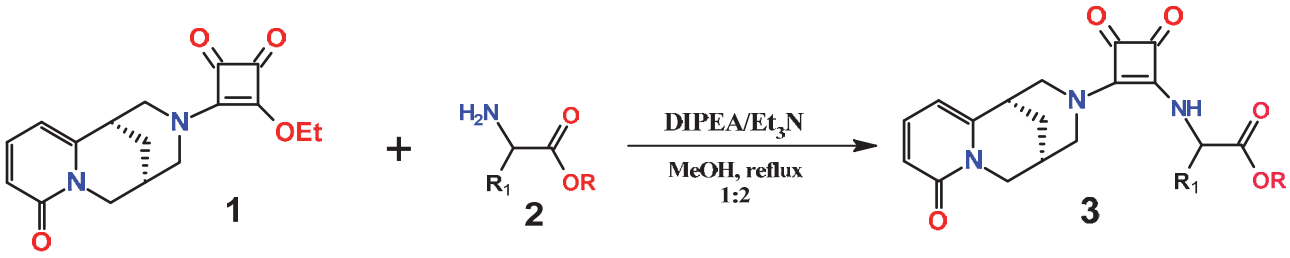
The research deals with the synthetic ways of squaric acid (**SqA**) ester groups conversion into corresponding bis-squaramides by naturally occurring compounds. The antiproliferative as well as anticancer activity of **SqA** and squaramides has already been demonstrated and confirmed by several research groups [1,2]. In our project, we decided to acquire a library of conjugates of cytisine-squaramide with amino-esters. (-)-Cytisine belongs to the group of quinolizidine alkaloids, and for further synthetic procedures is extracted from legume seeds. This alkaloid has been shown to have a broad spectrum of properties due to its interaction with nicotinic acetylcholine receptors (nAChRs) and metal ion coordination, which in the future may contribute to slowing the progression of CNS diseases, and its derivatives may even prevent the development of Parkinson's disease (PD) [3]. **SqA** acts as a rigid scaffold (**Scheme 1**) for both modifications possessing high stereospecificity - an essential feature for receptor ligands. Particular amides produced from both amino acids and SqA are found to have anion-binding properties [4]. Mono-cytisine-squaramid conjugated with amino acid esters can enhance the physical properties and their affinity to molecular targets, enabling potent bioactive products to be gained.



Scheme 1. Synthesis reaction of cytisine-squaramide conjugates with amino acids esters motifs.

The choice of amino acids and their esters for preparing syntheses was based on preliminary checking the probability of fitting values *in silico* using SwissTargetPrediction [5]. The library of synthesized compounds, represented generally as 3, was characterized by spectral methods and compared by amino acid moieties introduced, and corresponding synthetic conditions. The analysis of antioxidant activity was performed for each synthesized compound based on the ability to inhibit 2,2-diphenyl-1-picrylhydrazyl (DPPH), which represents reactive oxidant species (ROS) found to be produced in human organisms.

Acknowledgement

The research was accomplished with the financial support of IDUB within the framework of the project “Inicjatywa Doskonałości - Uczelnia badawcza” (ID-UB 134/34/UAM/0018). Besides, golden rain tree seeds for cytisine extraction (*Laburnum anagyroides*) were provided by the Botanical Garden staff of Adam Mickiewicz University.

References

[1] J. Chasák, V. Šlachtová, M. Urban, L. Brulíková, *Eur. J. Med. Chem.*, **2021**, *209*.
[2] Z. Y. Liu *et al.*, *Eur. J. Med. Chem.*, **2013**, *65*, 187–194.
[3] A. K. Przybył, M. Kubicki, R. Jastrzab, *J. Inorg. Biochem.*, **2014**, *138*, 47–55.
[4] R. B. P. Elmes and K. A. Jolliffe, *Supramol. Chem.*, **2015,** *27*, 321–328.
[5] SwissTargetPrediction: http://www.swisstargetprediction.ch/index.php.

P2-020

Influence of the size of the reducing agent on the catalysis process occurring on electrodes modified with a polymer of Ni(II) complex with (±)-*trans*-*N,N'*-bis(salicylidene)-1,2- cyclohexanediamine

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Ni(II) complexes with *salen* and its derivatives find application in electrode modification. The resulting electrodes are used in specific heterogeneous catalysis [1].

Electrodes modified with a polymer of Ni(II) complex with (±)-*trans*-N,N'-bis(salicylidene)-1,2-cyclohexanediamine were obtained by anodic electropolymerization, in solution of the complex, in positive potential ranges. The catalytic properties were studied against ferrocene and *tert*- butylferrocene.

The mode of oxidation of reductants on the modified electrode depends on the thickness of the polymer film. With increasing film thickness, the oxidation of ferrocene exclusively on the electrode surface decreases and the catalytic effect increases.

In the case of tert butylferrocene, the relationships are analogous but involve different film thicknesses. For example, on electrodes modified with polymer films, obtained during the recording of 5 to 7 cycles, ferrocene is oxidized directly on the electrode surface, while *tert*-butylferrocene is oxidized both on the electrode surface and through catalysis. In contrast, on film-modified electrodes obtained during recording from 18 to 22 cycles, ferrocene is oxidized in two ways, and *tert*- butylferrocene is oxidized exclusively by catalysis. Such result can allow determination of *tert*-butylferrocene in the presence of ferrocene on electrodes modified with thinner films, by the catalysis signal as well as determination of ferrocene in the presence of *tert*-butylferrocene on electrodes modified with thicker films, by the signal from the reaction on the electrode surface.

The dependence of the mode of oxidation of the reducing agent on the thickness of the polymer films allows the design of specific modified electrodes, allowing only catalysis to occur, or a process occurring only on the electrode surface, or both processes simultaneously. Such result can enable the use of such electrodes in the selective analysis of compounds with different molecular sizes, although exhibiting the same electrochemical characteristics.

References

[1] T.S. Martins, J.L. Bott-Neto, P.A. Raymundo-Pereira, E.A. Ticianelli, S.A.S. Machado, *Sens. Actuators B: Chem.*, **2018**, *276*, 378–387.

P2-021

Impact of Sulfur Oxidation on the Structural, Optical, and Electronic Properties of Benzothieno[3,2-*b*][1]benzothiophene (BTBT) Derivatives

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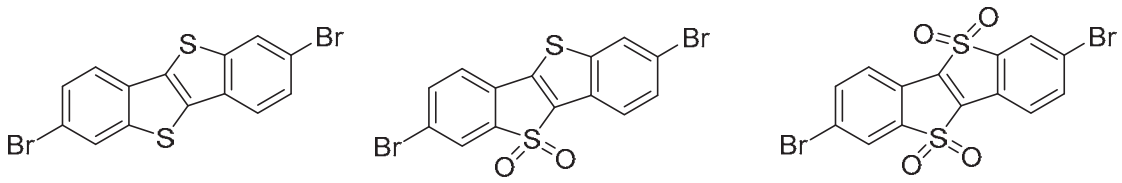
In this poster, we present a comparative study on the effects of sulfur oxidation on the structural, optical, and electronic properties of the BTBT derivatives, with a focus on 2,7-dibromo BTBT (**2,7-diBr-BTBT**) and its oxidized forms, 5,5-dioxide (**2,7-diBr-BTBTDO**) and 5,5,10,10-tetraoxide (**2,7-diBr-BTBTTO**). The target compounds were synthesized *via* BTBT bromination, followed by sequential oxidation with *m*-CPBA. Comprehensive characterization was carried out using spectroscopic techniques, X-ray crystallography, thermal analysis, and quantum chemical calculations. Our results show that sulfur oxidation significantly impacts crystal packing, enhances thermal stability, lowers frontier orbital energy, and reduces the energy gap.



Scheme 1. Structure of 2,7-DiBr-BTBT; 5,5-*S*-dioxide 2,7-DiBr-BTBTDO; 5,5, 10,10-*S*,*S*-tetraoxide 2,7-DiBr-BTBTTO.

The oxidized compounds display red-shifted absorption and emission spectra, large Stokes shifts, and an impressive quantum yield above 99%. The presence of bromine atoms in 2,7-diBr-BTBT S-oxides provides an opportunity for straightforward functionalization via Heck or Suzuki cross-coupling reactions. This allows for easy tuning of their properties, paving the way for new compounds with potential optoelectronic and fluorescence-based applications.

P2-022

Micelle encapsulated luminescent iridium(III)$(ppy)_2$L complexes – preparation and biological studies

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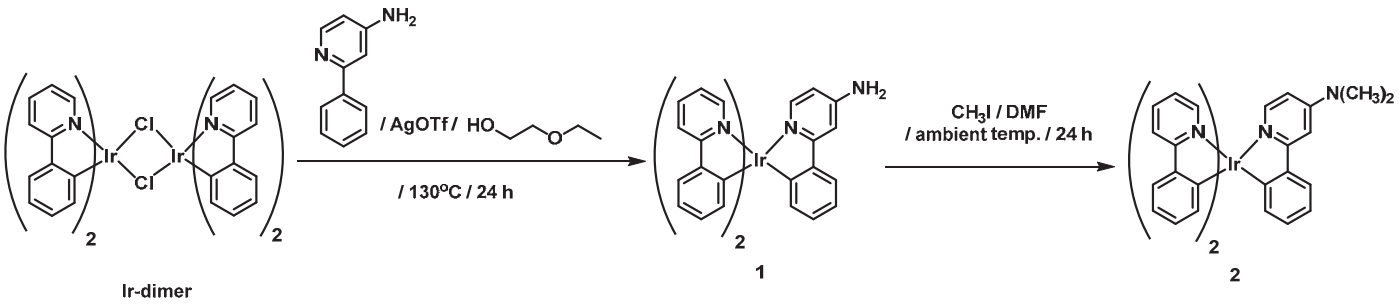
Biological potential of luminescent cyclometalated Ir(III) complexes as imaging and therapeutic agents is often hindered by lack of their solubility in water. We addressed this problem by synthesis and encapsulation of the two brightly luminescent iridium(III)$(ppy)_2L_1$ or L_2 (ppy = 2-phenylpyridine, L_1 = 2-phenylpyridine-4-amine **1**, L_2 = 2-phenylpyridine-4-dimethylamine **2**) complexes into pluronic F-127 block copolymer to form water soluble Ir-loaded micelles. Obtained micellar constructs were biologically studied. In particular they were used as luminescent probes in complex multicellular organisms such as: a) water-living phantom midge larva of *Chaoborus flavicans* M. and b) *Lepidium sativum* L. plant. Furthermore, micelle encapsulation allowed to bypass of the bacterial cell wall barrier and, thus, to penetrate inside *S. aureus* and *E. coli* cells. Our approach provides a reliable strategy for development of new Ir-theranostic agents in the future.[1]



Scheme 1. Synthesis of compound **1** and **2**.

Acknowledgement

The financial support of the NCN, grant OPUS UMO-2018/29/B/ST5/00055 is kindly acknowledged.

References

[1] A. Kowalczyk, R. Karpowicz, Ł. Szczupak, M. Gapińska, A. Gorski, N. Dutkiewicz, R. J. Kutta, K. Kowalski, *J. Organomet Chem.*, **2024**, *1006*, 123017.

P2-023

Glycoconjugates of 3-lup-20(29)-ene-3β,28-diol - synthesis of selected models using the concept of *click chemistry* and preliminary assessment of biological activity

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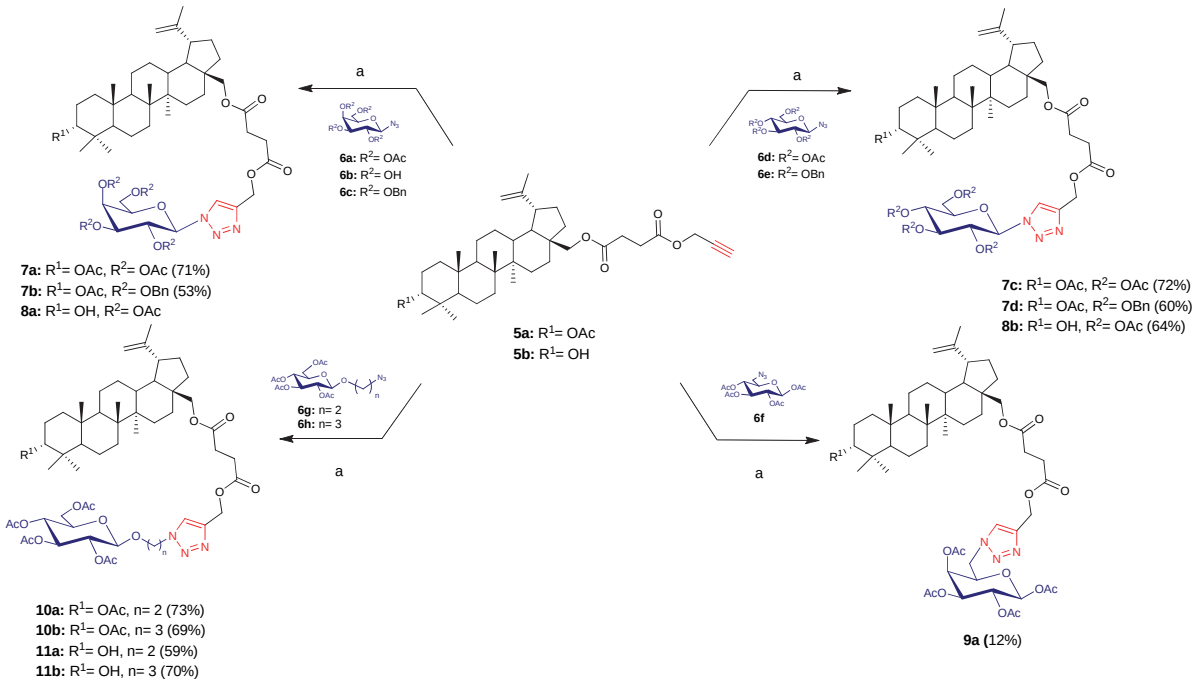
Scientific articles and patents available in databases show wide interest in 3-lup-20(29)-ene-3β,28-diol (BN, betulin) among scientists. Easy availability, low price and attractive in terms of modifications of the parent structure of betulin provide an opportunity to design new BN derivatives with favorable pharmacokinetic properties, especially greater bioavailability [1]. BN as a natural bioactive compound is widely available and in its skeleton has an active functional groups (C3-OH, C28-OH), which create the possibility of structural modifications. For the synthesis of new molecular hybrids of 3-lup-20(29)-ene-3β,28-diol was used glycoconjugation because, as reported in the literature, the attachment of a sugar unit to skeleton of bioactive compound can have a positive effect, i.e. improvement of solubility and the possibility of targeting a specific molecular target [2]. The attachment of sugar units to the BN backbone, enable the glycoconjugate to be directed to a specific molecular target, which in turn increases the selectivity of the potential therapeutic agent. Studies on the synthesis of new derivatives of 3-lup-20(29)-ene-3β,28-diol (BN), not described in the scientific literature so far (*Scheme 1*), as well as tests of their cytotoxicity against selected cell lines, both cancerous and healthy, are presented. The assessment of cytotoxicity was performed on colon cancer cells (HCT-116), breast cancer cells (MCF-7) and human fibroblasts (NHDF).



Scheme 1. Synthesis of BN glycoconjugates.
Reagents and Conditions: (a) $CuSO_4 \cdot 5H_2O$, NaAsc, *i*-PrOH/THF (1:1, *v*:*v*), r.t., 7 days.

References

[1] J. Patočka, *J. Appl. Biomed.*, **2003**, *1* (1), 7–12.
[2] G. Pastuch-Gawołek, J. Szreder, M. Domińska, M. Pielok, P. Cichy, M. Grymel, *Pharmaceutics*, **2023**, 15(3), 913.

P2-024

Tropone hydrazides in [10+2]-hetero-higher-order cycloaddition for the synthesis of polyheterocyclic scaffolds

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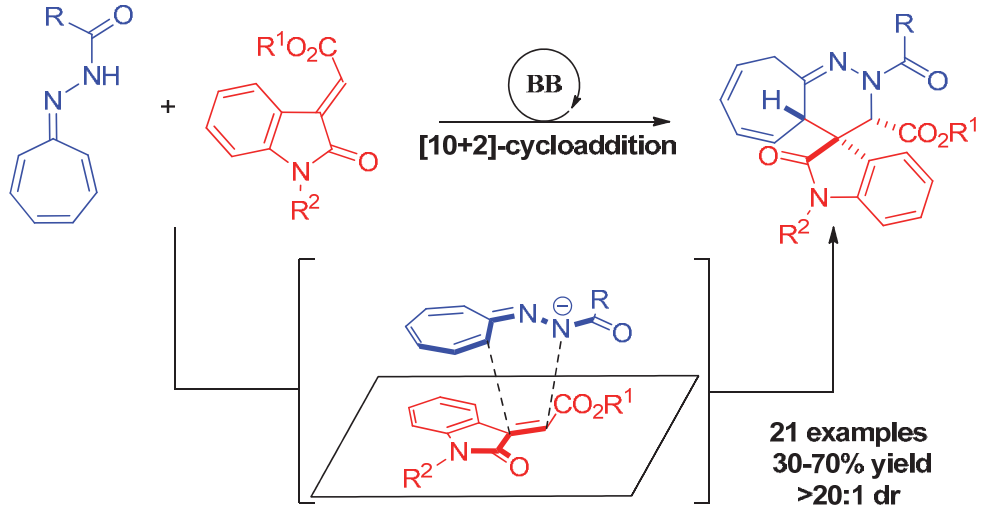
Cycloadditions are a crucial and powerful tool in modern organic synthesis, allowing for the facile preparation of complex carbo- and heterocyclic compounds. [1] Cycloadditions can be defined as processes that enable the annulation of a new ring systems starting from acyclic precursors. Their popularity and interest stem from several advantages, such as good atom economy, defined and predictable regioselectivity, and the ability to create multiple chemical bonds in a single transformation. In recent years, the interest of chemists has focused on higher-order cycloadditions, which can be defined as processes proceeding with the participation of overall more than 6π- electrons in a given transformation. [2] The synthetic potential of this type of transformation has not yet been fully explored, mainly due to the difficulty in achieving complete stereo- and regioselectivity of the reaction [3].

In our research, we present a [10+2]-hetero-higher-order cycloaddition between tropone hydrazides (acting as 10π-components) and 3-alkylidene oxindoles (acting as 2π-components). [4] The reaction proceeded in a fully peri- and diastereoselective manner under Brønsted base catalysis. Using this strategy, we prepared a series of structurally diverse tetrahydropyridazines in good to excellent yields. Furthermore, the potential of the obtained cycloadducts was confirmed in selected chemoselective transformations.



Scheme 1. Tropone hydrazides in [10+2]-hetero-higher-order cycloaddition.

Acknowledgement

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References

[1] L. Klier, F. Tur, P. H. Poulsen, K. A. Jørgensen, *Chem. Soc. Rev.*, **2017**, *46*, 1080-1102.
[2] V. Nair, G. Anilkumar, *Synlett.*, **1998**, *3*, 301-312.
[3] J. H. Rigby, *Org. React.*, **2004**, *49*, 331-335.
[4] A. Cieśliński, A. Przydacz, L. Sieroń, A. Skrzyńska, Ł. Albrecht, *Adv. Synth. Catal.*, [under revision].

P2-025

Synthesis and Optoelectronic Properties of Novel BTBT S-Oxides

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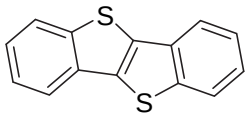
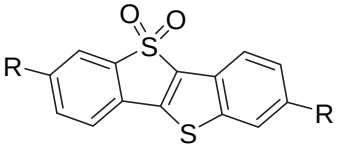
The study focuses on the synthesis and characterization of benzothienobenzothiophene (BTBT) S-oxides derivatives, a class of heterocyclic compounds with promising optoelectronic properties. Various 2,7-dialkyl BTBT S-oxides were synthesized via controlled oxidation of the corresponding BTBT derivatives . These compounds exhibit, excellent thermal stability and strong self-organization capabilities. Optical measurements revealed a significant bathochromic shift in absorption and emission spectra with increasing oxygen content and fluorescence quantum yields reaching up to 97.6% in DCM solution for didodecyl BTBT tetraoxide (**diC12-BTBTTO**). The tendency to form highly organized thin films and high fluorescence quantum yields make these materials particularly suited for optoelectronic and fluorescence-based applications.

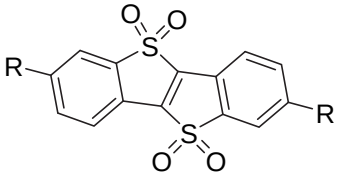


BTBT



diC6-BTBTDO R = C_6H_{13}

diC12-BTBTDO R = $C_{12}H_{25}$



diC6-BTBTTO R = C_6H_{13}

diC12-BTBTTO R = $C_{12}H_{25}$

Acknowledgement

Authors thank for financial support from the Centre of Molecular and Macromolecular Studies, Polish Academy of Sciences.

References

[1] Hirosato Monobe, Lingling An, Ping Hu, Bi-Qin Wang, Ke-QingZhao, and Yo Shimizu *Molecular Crystal and Liquid Crystals.*, **2017**, *647*, 119-126.
[2] Hideaki Ebata, Takafumi Izawa, Eigo Miyazaki, Kazuo Takimiya, Masaski Ikeda, Kuwabara Hirokazu, Yui Tatsuto. *Journal of the American Chemical Society.*, **2007**, *129, 15732-3.*
[3] Gedda Murali, Yengen Emre, Faber Hendrik, Paulus Faber, Tang Ming-Chun, Giustino Feliciano, Anthopoulos Thomas D. *Advanced Materials.*,**2027**,*vol 3#7 art. No.2003137.*

P2-026

The role of dispersion interactions in the stabilization of selected inclusion complexes

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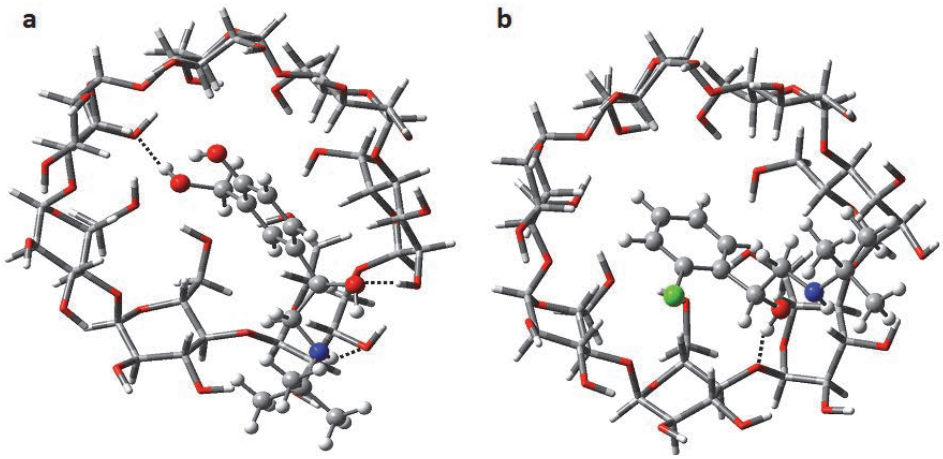
The present study deals with inclusion complexes of β-cyclodextrin with selected anti-asthmatic drugs, which are of increasing interest due to their use in enhancing the bioavailability and stability of organic compounds. Such inclusion can improve water solubility, modify the site of drug delivery or alter the time profile [1,2]. The subjects of this study were two anti-asthmatic drugs: salbutamol (SAL), known for its short duration of action, and tulobuterol (TUL), which exhibits long-lasting biological activity. Energetic and structural aspects of complexation were studied using the standard B3LYP/6-31+G(d,p) method. To account for dispersive interactions, Grimme's D3 and D3BJ empirical corrections were applied both in the gas phase and in aqueous media, the latter using a polarizable continuum model (PCM). This choice of computational methods allows for reliable structural and energetic results at low computational cost.

Preferred conformers of the investigated drugs, whose stability is provided mainly by intramolecular hydrogen bonds, were identified. Two orientations of drug molecules inside β-cyclodextrin were analyzed: head-first (first ring) and tail-first (first chain) orientations. The study compared four low-energy SAL complexes with β-cyclodextrin and TUL with the same carrier. The results indicate that dispersion interactions play a key role in stabilizing the inclusion complexes of β-cyclodextrin and the anti-asthmatic drugs studied. These interactions were estimated to be about 38 kcal/mol for SAL and 33 kcal/mol for TUL. Moreover, it can be concluded that the applied dispersion corrections D3 and D3BJ give similar results for the complexes in question. The results of the calculations confirmed that the head orientation was preferred for both drugs, with stabilization energies of slightly less than 8 kcal/mol for SAL and slightly more than 0.5 kcal/mol for TUL, respectively.



Scheme 1. Low-energy β-CD/SAL (a) and β-CD/TUL (b) complexes calculated by the B3LYP-D3/ 6-31+G(d,p) method in the gas phase.

Acknowledgement

All calculations were performed using WCSS hardware and software. The authors also thank the University of Opole for financial support.

References

[1] J. Wankar, N.G. Kotla, s. Gera, s. Rasala, A. Pandit, Y.A. Rochev, *Adv. Funct. Mater.*, **2020**, *30*, 1909049.
[2] B. Tian, S. Hua, J. Liu, *Carbohydr. Polym.*, **2020**, *232*, 115805.

P2-027

Dearomative, aminocatalytic formal normal-electron-demand aza-Diels–Alder cycloaddition in the synthesis of tetrahydrofuropyridines

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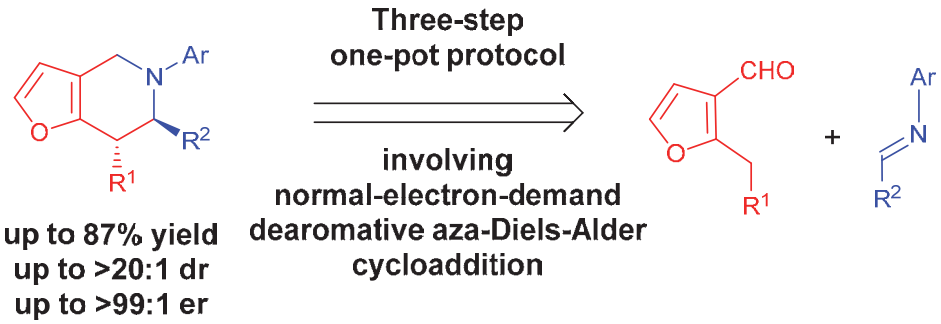
In this communication the application of dearomative formal normal-electron-demand aza-Diels–Alder cycloaddition in the synthesis of tetrahydrofuropyridines is described. The developed approach utilizes aminocatalytic activation of 2-alkyl-3-furfurals that proceeds *via* formation of the dearomatized dienamine intermediate that serves as synthetic equivalent of furo-2,3-quinodimethane – a potent, yet hardly-accessible diene.. Initially obtained cycloadducts have been subjected to subsequent transformations providing access to tetrahydrofuropyridines or functionalized cinnamates in a three-step one-pot fashion. The mechanism of the process has been evaluated by experiments. and DFT calculations.



Scheme 1. Synthetic approach utilized in presented work.

Acknowledgement

This project was realized within the Sheng programme (grant number: UMO-2018/30/Q/ST5/00466) from the National Science Centre, Poland. This contribution has been completed while MD was the Doctoral Candidate in the Interdisciplinary Doctoral School at the Lodz University of Technology, Poland.

References

[1] M. Dyguda, A. Przydacz, Ł. Albrecht *Chem. Commun.*, **2023**, *59*, 12903–12906.

P2-028

Synthesis and Hemolytic Studies of Bile Acid Dimers with 1,2,3-Triazole Linkers

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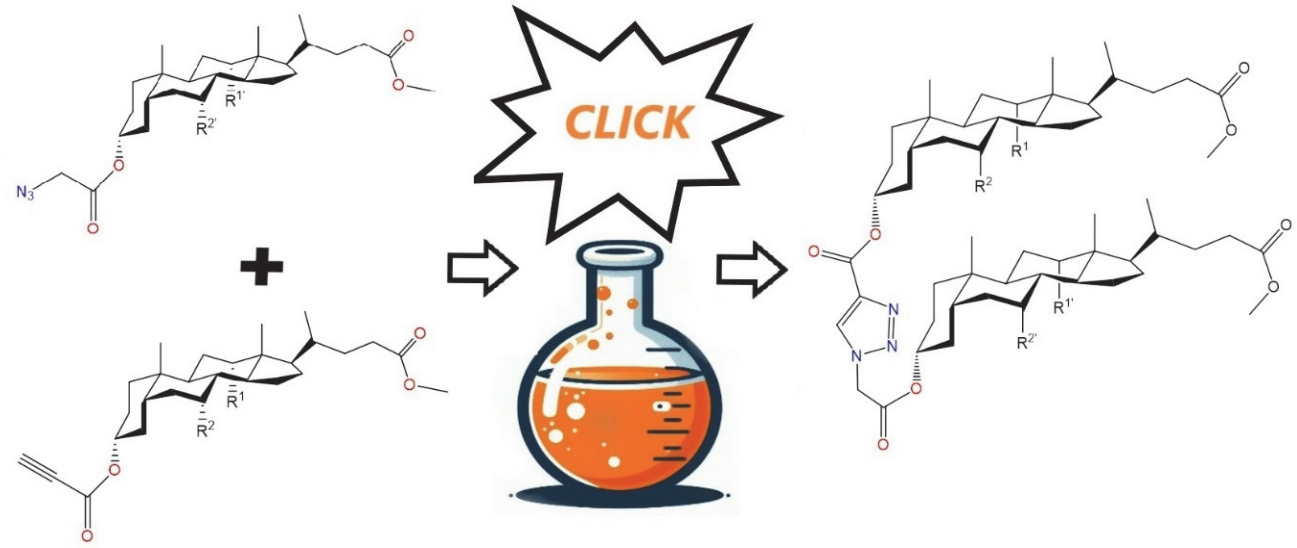
Novel bile acid dimers were synthesized via a Cu(I)-catalyzed Huisgen cycloaddition, also known as the "Click Chemistry" reaction [1-2]. This efficient synthetic approach is characterized by high yields and the ability to proceed under mild and biocompatible conditions [3-6]. Obtained bile acid dimers were thoroughly characterized using ^{1}H and ^{13}C NMR, FT-IR spectroscopy and ESI-MS.

The pharmacological potential of these dimers was initially explored through *in silico* predictions using the PASS method (Prediction of Activity Spectra for Substances), indicating a broad range of potential bioactivities. *In vitro* hemolytic assays performed on human erythrocytes demonstrated a marked reduction in hemolytic activity compared to the parent compounds, suggesting enhanced biocompatibility and reduced cytotoxicity. Furthermore, molecular docking studies were carried out to examine the binding interactions of selected dimers with biological targets, further supporting their potential as therapeutic candidates.



Scheme 1. Model representation of the reaction for obtaining steroid dimers using „Click Chemistry".

References

[1] R. Bansal, A Suryan, *ACS Bio Med. Chem Au*, **2022**, 2(4), 340-369.
[2] G. Hajdaś, D. Kułaga, H. Koenig, K. Sosnowska, L. Mrówczyńska, T. Pospieszny, *ACS Omega*, **2024**, 9(37), 39277-39286
[3] G. Hajdaś, A. Kawka, H. Koenig, D. Kułaga, K. Sosnowska, L. Mrówczyńska, T. Pospieszny, *Steroids*, **2023**, 199, 109282.
[4] A. Kawka, G. Hajdaś, D. Kułaga, H. Koenig, I. Kowalczyk, T. Pospieszny, *J. Mol. Struct*., **2023**, 1273, 134313.
[5] J. M. Baskin, C. R. Bertozi, *QSAR & Comb. Sci*., **2007**, 26(11-12), 1211–1219.
[6] M. Meldal, F. Diness, *Trends Chem*., **2020**, 2(6), 569-584.

P2-029

Cobalt Carbonyl Furopyrimidine Nucleosides with 5-Alkynyl Substituent and their Anticancer Activity

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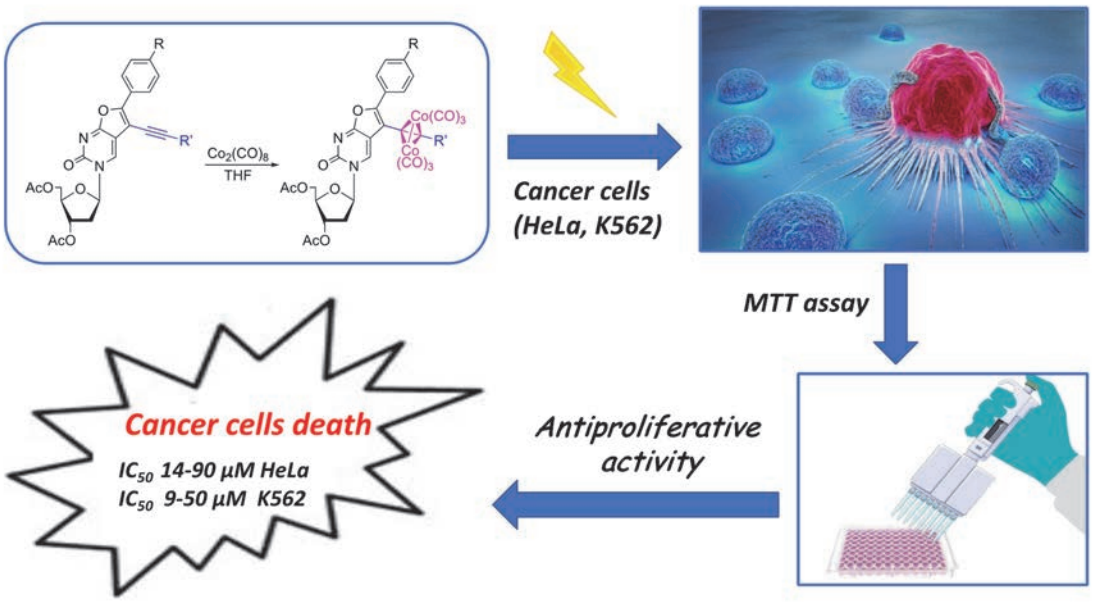
Dicobalt hexacarbonyl 5-alkynyl furopyrimidine nucleoside analogs, with 4-alkylphenyl substituents attached at the C-6 base position, designed in the form of ribose acetyl esters, were synthesized. Attached at the C-5 position were propargyl alcohol, its methyl ether and acetate derivatives, homopropargyl alcohol, and the 4-alkylphenyl-substituted alkynyl groups.[1] The structure of 5-(3-acetoxyprop-1-yn-1-yl)-6-*p*-tolyl-2′-deoxyribofuranosyl-furo[2,3-*d*]pyrimidin-2-one was determined by X-ray crystallography. Alkyne functions were coordinated to a dicobalt hexacarbonyl unit. The cytotoxic activity of each of dicobalt modified nucleosides on cancer cells of different phenotypes was determined *in vitro*. The investigated compounds showed antiproliferative effects with median inhibitory concentration (IC_{50}) values in the ranges of 14–90 and 9–50 μM for HeLa and K562 cells, respectively. The formation of reactive oxygen species in the presence of modified nucleosides was determined in K562 cells. The results indicate that the mechanism of action for the studied compounds may be related to the induction of oxidative stress.[2]



Acknowledgement

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References

[1] Kaczmarek, R.; Twardy, D. J.; Olson, T. L.; Korczyński, D.; Andrei, G.; Snoeck, R.; Dolot, R.; Wheeler, K. A.; Dembinski, R. *Eur. J. Med. Chem.* **2021**, *209*, 112884.
[2] Kaczmarek, R.; Radzikowska-Cieciura, E.; Królewska-Golińska, K.; Dolot, R.; Wheeler, K. A.; Chavez, F. A.; Dembinski, R. *ACS Med. Chem. Lett.* **2023**, *14*, 962–969.

P2-030

NHC-Catalyzed 1,4-Elimination in the Dearomative Activation of 3-Furaldehydes towards (4+2)-Cycloadditions

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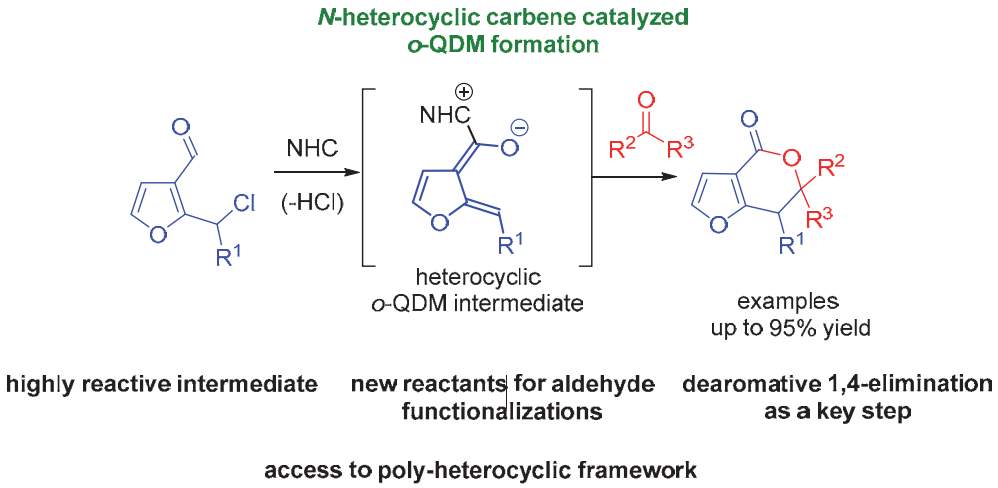
The (hetero)arenes belong to the fundamental and most abundant group of organic molecules, therefore the chemistry of this class of compounds is an important field of research.[1] The modification of (hetero)aromatic structures involving the dearomative reactions carried out with the use of organocatalysis has become a particularly interesting area.[2] Reactive compounds with strong tendency to rearomatize, such as ortho-quinodimethanes (o-QDM) and their hetero-derivatives, represent a class of intermediates offering an access to novel and interesting transformations. The formation these types of intermediates from heteroaromatic aldehydes is feasible in NHC organocatalysis, with the resulting catalyst-bound QDM derivatives readily participating in dearomative transformations.

A dearomative formal (4+2)-cycloaddition reaction between 2-substituted 3-furaldehydes derivatives and isatins or α,α,α-trifluoroacetophenones as electrophiles has been established under NHC-catalysis.[3] This approach utilizes the process of hydrogen chloride 1,4-elimination leading to a highly reactive NHC-bound heterocyclic o-QDM intermediates derived from 3-furaldehydes, which play a key role in the process. By using this strategy, a series of structurally diverse 6,7-dihydro-4H-furo[3,2-c]pyran-4-ones was prepared in 41-85% yields (Scheme 1).



Scheme 1.

Acknowledgement

This project was realized within the Sheng programme (grant number: UMO-2018/30/Q/ST5/00466) from the National Science Centre, Poland.

References

[1] a) T. K. Das, A. T. Biju, *N-Heterocyclic Carbene (NHC)-Catalyzed Transformations for the Synthesis of Heterocycles in: Prog. in Heterocycl. Chem.*, G. W. Gribble, J. A. Joule (Eds.), Elsevier 2020, 31, 1– 82; b) R. Song, Z. Jin, Y. R. Chi, *Chem. Sci.* **2021**, *12*, 5037–5043.

[2] A. Przydacz, A. Skrzyńska, Ł. Albrecht, *Angew. Chem. Int. Ed.* **2019,** *58*, 63–73.

[3] A. Przydacz, A. Topolska, A. Skrzyńska, Ł. Albrecht, *Adv. Synth. Catal.* **2022**, *364*, 1–7.

P2-031

Co-amorphization of candesartan cilexetil with polyphenols: mechanochemical and solvent-based approaches

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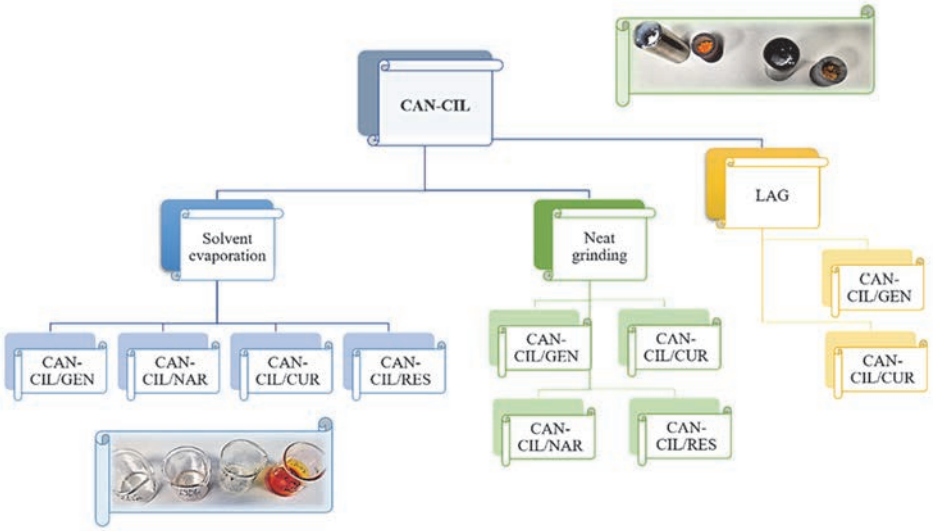
Co-amorphization emerges as a strategic approach to enhance solubility and bioavailability of APIs (active pharmaceutical ingredients), and when combined with a judiciously selected nutraceutical co-formers, reveals the potential for dual-acting pharmaceutical products. This study is focused on the synthesis of co-amorphous pharmaceutical solid dispersions of poorly soluble antihypertensive drug – candesartan cilexetil (CAN-CIL) belonging to angiotensin II receptor blockers, in conjunction with four polyphenols: naringenin (NAR), genistein (GEN), resveratrol (RES) and curcumine (CUR), as co-formers. Polyphenols occupy a unique place in science as the class of bioactive natural products. They are one of the widespread groups of substances in flowering plants, occurring in all vegetative organs as well as in flowers and fruits. The biological properties of polyphenols include antioxidant, anticancer and anti-inflammatory effects [1].

During the synthesis, the solvent evaporation method and the mechanochemical ball milling were used. It is worth emphasizing that mechanochemistry has become an important subject of interest in pharmaceutical sciences and a green, high-yielded approach to the synthesis multicomponent pharmaceutical solids. Moreover, mechanochemical methods, especially "neat grinding", meet the rules of Green Chemistry, at least due to the limited use of solvents and the reduction of the amount of waste. Mechanochemical methods, such as ball milling, are the most widely used techniques that have shown their potential to generate stable co-amorphous systems [2].

In this research, we describe the synthesis of co-amorphous solid dispersions and their characterization using XRPD, FT-IR, DSC techniques. Selected co-amorphous solid dispersions were also characterized by *in vitro* release profiles.



Scheme 1. Synthesis methods of selected CAN-CIL systems with polyphenols.

Acknowledgement

The work was financed by the National Science Centre (NCN), Poland based on the decision number UMO-2019/33/N/ST5/01602.

References

[1] Ferrazzano, G. F., et al., „Plant Polyphenols and Their Anti-Cariogenic Properties: A Review". *Molecules*, **2011**, 16, 1486–507.

[2] Silva, J. F. C.,et al. „Introduction to Pharmaceutical Co-Amorphous Systems Using a Green Co-Milling Technique". *Journal of Chemical Education*, **2023**, 100, 1627–32..

P2-032

Synthesis of new ciprofloxacin analogues conjugated with isothiocyanates as compounds with potential antimicrobial properties

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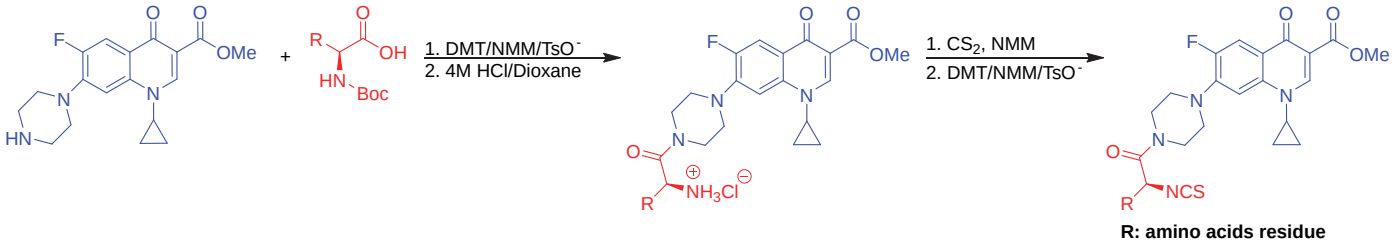
Isothiocyanates (ITCs) are an important class of biologically active compounds that have been the focus of research for many years. They are found in cruciferous vegetables (including Brussels sprouts, radishes, broccoli, or horseradish) and are formed as a result of a reaction of glucosinolates with myrosinases.[1] In addition to their anticancer properties, ITCs are also characterized by antimicrobial properties on both Gram-(-) and Gram-(+) bacteria strains.[2] Ciprofloxacin, is one of the most popular antibiotics of the fluoroquinolone group. It is used to treat bacterial infections, such as urinary tract infections and pneumonia, and has the strongest effect against Gram-(-) bacteria.[3]



The aim of this project was to synthesize new ciprofloxacin analogs conjugated to isothiocyanates derived from natural amino acids, which have not been described in the literature. Previous studies performed at the Institute of Organic Chemistry showed that isothiocyanate derivatives of natural amino acids have satisfactory antimicrobial activity on *S. aureus* and *E. coli* strains.[4] The combination of these two classes of biologically active compounds is aimed at obtaining final products with improved antimicrobial properties.

The target compounds were obtained in a multi-step synthesis, in which the first step involved the coupling of ciprofloxacin methyl ester with *N*-Boc blocked natural amino acids in the presence of a triazine coupling reagent DMT/NMM/TsO$^-$ and subsequent deprotection of the Boc protecting group. In the final step, the hydrochlorides were converted to isothiocyanates in a two-step reaction using carbon disulfide in an alkaline medium, followed by a desulfurizing reagent DMT/NMM/TsO$^-$. All obtained compounds will be tested for antimicrobial activity.

References

[1] Ł. Janczewski, *Molecules*, **2022**, *27*, 1750.
[2] L. Romeo, R. Iori, P. Rollin, P. Bramanti, E. Mazzon, *Molecules* **2018**, *23*, 624.
[3] A. Abacki. *Pol. J. Chem*. **2005**, *77*, 2405
[4] Ł. Janczewski, D. Kręgiel, B. Kolesińska. *Molecules*, **2021**, *26*, 2740..

P2-033

Sustainable synthesis of the quinone derivatives and their evaluation as antimicrobial agents and tyrosinase inhibitors

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Quinones are versatile reagents that have been used as oxidants, synthetic intermediates, and chemotherapeutics. [1] Interestingly, even very simple alkylquinones, such as thymoquinone display an impressive range of biological activity, including anticancer properties (Figure 1).[2] Studies have shown that subtle changes in the quinone structure greatly affect therapeutic efficacy, so synthetic methods for the assembly of various libraries would be useful for assessing structure-activity relationships. [3]

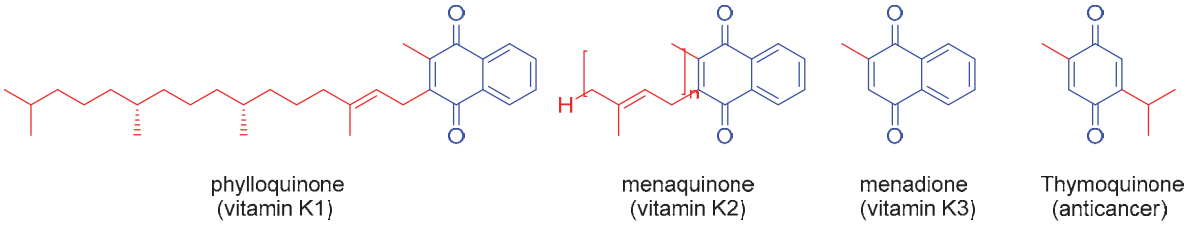
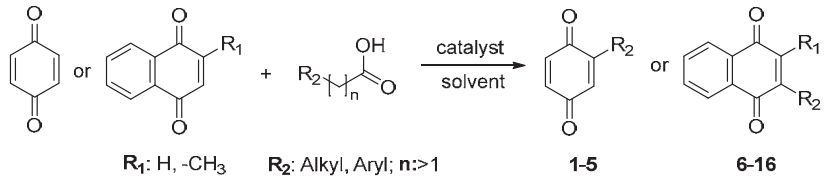


Figure. 1. Representatives of 1,4-quinone derivatives with reported antimicrobial activity.

Traditional methods for quinone functionalization have relied on transition-metal catalysis, although recent advances in free-radical chemistry have provided attractive alternatives.[1] However, reported protocols suffer from some inconveniences such as application of toxic organic solvents. Therefore, the development of new synthetic protocols for the derivatives of 1,4-quinones which eliminate mentioned obstacles remains desirable.

A series of lipophilic 1,4-quinone derivatives was synthesized *via* decarboxylative coupling reaction under sustainable conditions (Scheme 1).



Scheme 1. Synthesis of 1,4-quinone derivatives *via* decarboxylative coupling reaction.

All of the new compounds were tested for their biological properties *in vitro* and demonstrated high antimicrobial activity against selected pathogenic bacterial strains. The MTT assay revealed that the newly obtained agents are less toxic to normal cells than parental 1,4-quinones. Furthermore, the compounds studied were revised as mushroom tyrosinase inhibitors The influence of the particular structural changes in the molecule on the antimicrobial activity is discussed.

Acknowledgement

This work was supported by the Polish National Science Centre project no. OPUS 2023/49/B/NZ7/02469.

References

[1] A. Hamsath, J. D. Galloway, R. D. Baxter, *Synthesis* **2018**, *50*, 2915.
[2] S. Breyer, K. Effenberger, R. Schobert, *ChemMedChem* **2009**, *4*, 761.
[3] H. R.Nasiri, M. G. Madej, H. Schwalbe, *J. Med. Chem.* **2013**, *56*, 9530.

P2-034

Compounds with potential anticancer activity and the ability to monitor treatment processes

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According to global data, one of the leading causes of death is cancer.[1] Despite the development of new therapeutic methods, the late detection of the disease often results in metastasis to other organs, which is a common cause of death.

Literature reports indicate that iron-based *"piano-stool"* metal carbonyl complexes containing an *N*-maleimidato ligand exhibit anticancer properties against HL-60 (human promyelocytic leukemia) cell lines and low toxicity towards normal cells.[2] Meanwhile, compounds with fluorescent properties are widely used in biological research as various markers, allowing for the imaging of biological processes and the visualization of the distribution of chemical substances in cells and tissues.[3]

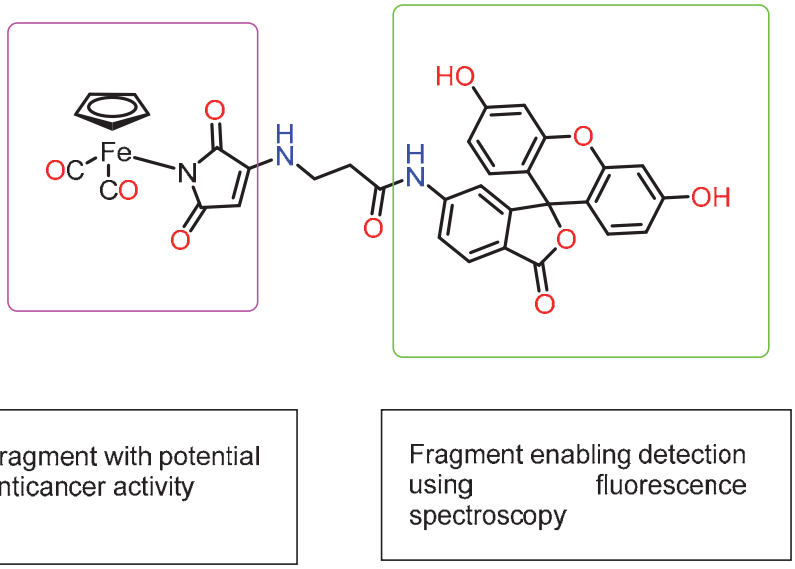

Figure 1. Iron "piano-stool" metal carbonyl complex containing a fluorescent fragment.

We have decided to synthesize derivatives of iron *"piano-stool"* metal carbonyl complexes that include a fluorescent fragment. The metal carbonyl part of the compound is expected to be responsible for its potential anticancer activity, while the fluorescent fragment will enable detection of the compound using fluorescence spectroscopy (Figure 1).

Acknowledgement
The research was funded by the University of Łódź through the Student Research Grants (SGB).

References

[1] R. L. Siegel, A. N. Giaquinto, A. Jemal, *CA Cancer J Clin.*, **2024**, *74(1)*, 12-49.
[2] D. Wysokiński, P. Lewandowska, D. Zątak, M. Juszczak, M. Kluska, D. Lizińska, B. Rudolf, K. Woźniak, *Toxicol. Res.*, **2019**, *8*, 544-551.
[3] R. R. Nair, J. M. An, J. Kim, D. Kim, *Coord. Chem. Rev.*, **2023**, 215336.

P2-035

Synthesis of new bisphosphonate-betulin conjugates

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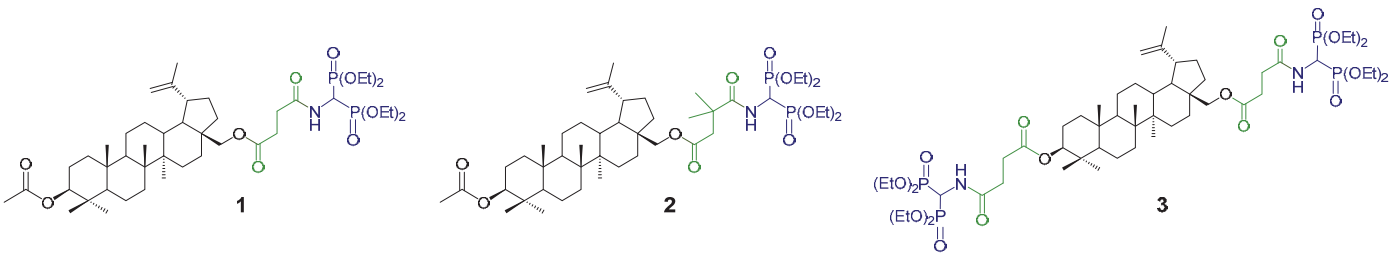
Bisphosphonates (BPs) are a well-established group of drugs that have been used for decades in the prevention and treatment of osteoporosis and cancer treatment-induced bone loss. Their unique properties such as high bone affinity, enzymatic stability as well as a multidirectional biological activity prompt the creation of BP conjugates. The benefit of using such molecular hybrids may be not only the synergistic and/or additive effects of the two compounds but also the targeted action of the resulting conjugate due to the presence of bisphosphonate moiety, which could act as a bone-directing carrier.[1]

We have decided to create BP conjugates with betulin, a natural product with a high safety profile and a broad spectrum of biological activity including anticancer, antibacterial, and antiviral activities.[2] The designed conjugates differed in the type of linker used and the number of bisphosphonate moieties attached (mono- **1, 2** or disubstituted **3** derivatives). The proposed synthesis proceeds under mild reaction conditions and gives good yields of products. In addition, as we have shown, the reaction can be assisted by ultrasound, which significantly reduced the reaction time (from 48 hours to 2 hours) and improved the overall product yield (up to 92%). All new conjugates have been fully characterized and tested for their biological properties *in vitro*.



Scheme 1. Structures of obtained bisphosphonate-betulin conjugates **1**, **2** and **3**.

Acknowledgement

This work was supported by the Silesian University of Technology (Poland) BKM Grant No. 04/020/BKM24/1101 and the Excellence Initiative - Research University programme implemented at the Silesian University of Technology, year 2024-2026 (04/020/SDU/10-21-02).

References

[1] K. B. Farrell, A. Karpeisky, D. H. Thamm, S. Zinnen, *Bone Rep.*, **2018**, *9*, 47–60.
[2] S. C. Jonnalagadda, P. Suman, D. C. Morgan, J. N. Seay, *Stud. Nat. Prod. Chem.*, **2017**, *53*, 45–84.

P2-036

α-Amino acid esters derivatives of botulin - synthesis and properties

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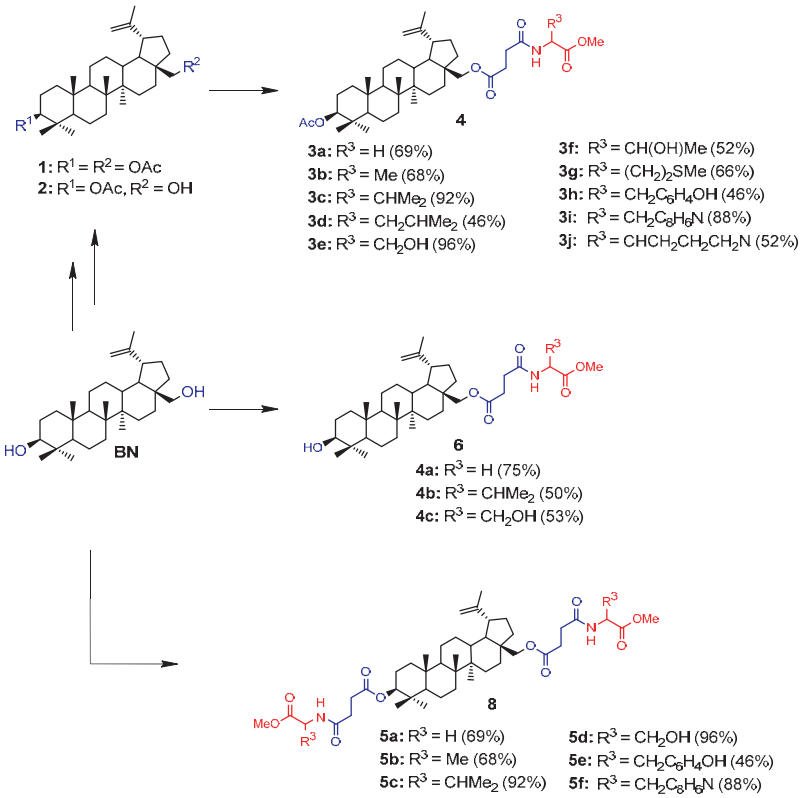
3-Lup-20(29)-eno-3β,28-diol, known as betulin (BN) is one of the most common pentacyclic triterpenes (lupan type) occurring in nature [1]. It is easily accessible natural active compound that can be extracted from the bark of many birch species (e.g. *Betula pubescens*), using organic solvents (e.g. methanol, acetone). Among the properties of BN, the most attention is drawn to its anticancer properties, as well as its anti-inflammatory and hepatoprotective effects [2]. Due to the limited solubility and bioavailability in a polar environment, the parent BN skeleton is subject to various structural modifications, e.g. by introducing α-amino acids into the leading structure, which are biocompatible molecules with the human body. This treatment aims to improve the physicochemical and pharmacokinetic properties.

We synthesized nineteen new molecular hybrids of BN (**3**-**5**). Then, the obtained derivatives of betulin we tested for inhibition of the proliferation of selected cancer cell lines (HCT 116 and MCF-7).



Scheme 1. Synthetic route for the preparation of new molecular hybrids of BN (**3**-**5**).

References

[1] S. Rastogi et al. *J Ethnopharmacol.*, **2015**, *159*, 62-83

[2] S. Amiri, S. Dastghaib, et al. *Biotechnol. Adv.*, **2020**, *38*, 107409-107448.

P2-037

Friedel-Crafts type acylation of ferrocene and pyrene with unprotected amino acids

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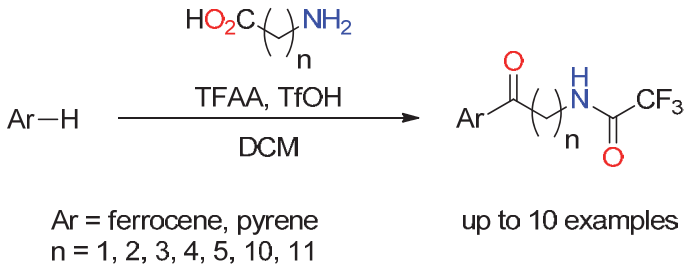
Aminoketones play important roles as biologically active compounds and essential building blocks in synthetic and medicinal chemistry. [1, 2]

Herein, we report the first synthesis of *N*-trifluoroacetyl amidoketones by the direct acylation of electron-rich arenes (ferrocene and pyrene) with unprotected amino acids. The acylation is achieved using a trifluoroacetic anhydride/triflic acid system, previously used for the functionalization of ferrocene and pyrene with carboxylic acids. [3, 4]

We postulate a mechanism that includes the *in situ* conversion of unprotected amino acids to reactive *N*-trifluoroacetamides mixed anhydride species. Protonated by triflic acid, these generate appropriate carbocations, which attack the electron-rich arenes to form *N*-trifluoroacetyl amidoketones.

The obtained *N*-trifluoroacetyl amidoketones can be easily deprotected and converted to the corresponding aminoketones. Both ferrocenyl and pyrenyl amidoketones can be used as versatile building blocks for the synthesis of more complex compounds, such as molecular probes or optoelectronic materials. Additionally, some of the pyrenyl amidoketones exhibit mechanofluorochromic properties.



Scheme 1. Acylation of ferrocene and pyrene with unprotected amino acids.

References

[1] L. A. T. Allen, R.-C. Raclea, P. Natho, P. J. Parsons, *Org. Biomol. Chem.*, **2021**, *19*, 498.
[2] M. M. Hammouda, K. M. Elattar, *RSC Adv.*, **2022**, *12*, 24681.
[3] D. Plażuk, J. Zakrzewski, *Synth. Commun.*, **2004**, *34*, 99-107.
[4] R. Flamholc, D. Plażuk, J. Zakrzewski, R. Metivier, K. Nakatani, A. Makal, K. Woźniak, *RSC Adv.*, **2014**, *4*, 31594-31601.

P2-038

New metallocarbonyl derivatives of bisphosphonates and bisphosphonic acids

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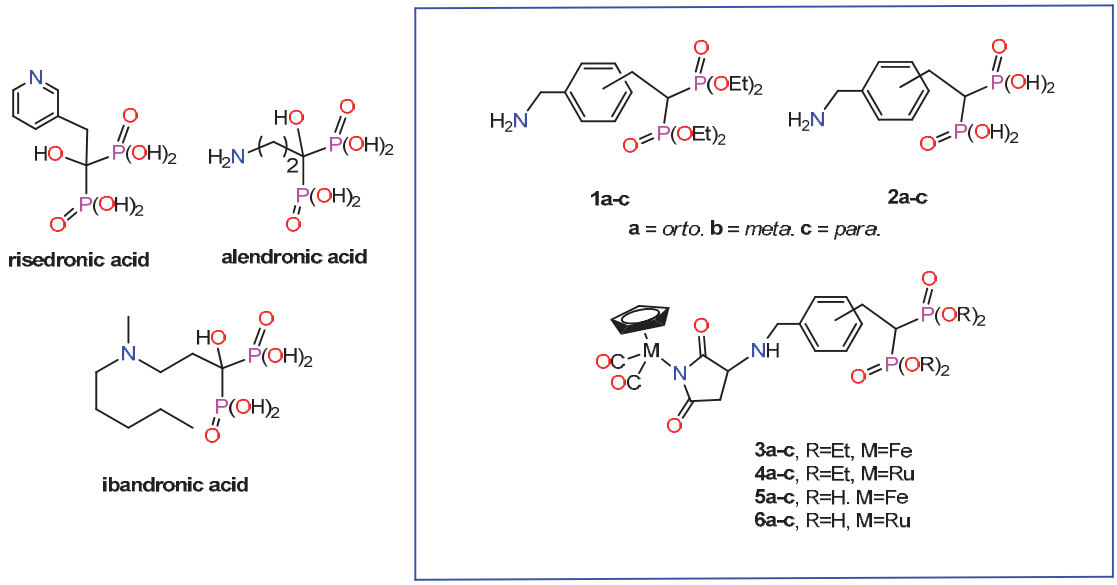
Organophosphorus compounds, including bisphosphonates and bisphosphonic acids, are characterized by high biological activity. As a result, they are used as treatments for osteoporosis, Paget's disease, bone metastases, and multiple myeloma. Common bisphosphonates used in medicine include etidronate, alendronate, risendronate, and ibandronic acid. Unfortunately, these compounds can cause serious side effects, ranging from jaw necrosis to atrial fibrillation, excessive inhibition of bone remodeling, hypocalcemia, inflammatory reactions in muscles, and bone pain. Therefore, new therapeutic molecules that do not cause such severe side effects are continuously being sought.[1 – 3]

It seems advisable to introduce an organometallic group into the structure of bisphosphonates or bisphosphonic acids, as this may alter their physicochemical properties and biological activity.



Scheme 1. Bisphosphonic acids used in medicine along with their novel analogues.

Acknowledgement

This research received funding from the University of Łódź through grant no. IDUB 38/2021.

References

[1] E. Chiarella, C. Nisticò, A. D. Vito, H. L. Morrone, M. Mesuraca, *Biomedicines*, **2022**, *10(5)*, 1146.
[2] E. M. Lewiecki, *Ther. Adv. Chronic Dis.*, **2010**, *1(3)*, 115-128.
[3] F Fatoye, P Smith, T Gebrye, G Yeowell, *BMJ Open*, **2019**; *9*, e027049.

P2-039

Mechanochemistry as A Green Approach for Sulfur and Selenium Addition Reaction to Secondary Phosphine Oxides

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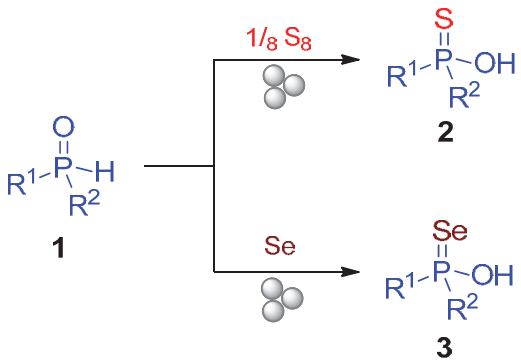
Mechanochemistry has emerged as a green and sustainable synthetic strategy, offering an alternative to traditional solution-based methods in organic chemistry [1-5]. Our recent research has focused on applying mechanochemical techniques to the study interconversions of selected heteroatom-containing compounds [6-7]. Among studied procedures, we have also investigated the addition reactions of sulfur and selenium to selected secondary phosphines oxides **1** under solvent-free conditions. The preliminary findings of these studies will be presented in this communication.



Scheme 1. Addition reaction of sulfur or selenium to secondary phosphine oxide **1**.

References

[1] Calcio Gaudino E., Grillo G., Manzoli M., Tabasso S., Maccagnan S., Cravotto G., Molecules, **2022**, 27(2), 449
[2] Crawford D., Casaban J., Haydon R., Giri N., McNally T., James S.L., Chemical Science, **2015**, 6(3),1645– 1649
[3] Kumar R., Kumar S., Pandey M.K., Kashid V.S., Radhakrishna L., Balakrishna M.S., European Journal of Inorganic Chemistry, **2018**, 8, 1028–1037
[4] Lamola J.L., Adeyinka A.S., Malan F.P., Moshapo P.T., Holzapfel C.W., Maumela M.C., New Journal of Chemistry, **2022**, 46(10), 4677–4686
[5] Goodwin C. A. P., Réant B. L. L., Vettese G. F., Kragskow J. G. C., Giansiracusa M. J., DiMucci I. M, Lancaster K. M., Mills D. P., Sproules S., Inorganic Chemistry, **2020**, 59(11),7571–7583
[6] Wróblewska A., Bugaj K., Łagiewka J., Girek T., Rabai J., Drabowicz J., Phosphorus, Sulfur, and Silicon and the Related Elements, **2023**, 198(6), 513-516,
[7] Bugaj K., Pokora-Sobczak P., Mielniczak G., Sancineto L., Santi C., Drabowicz J., Phosphorus, Sulfur, and Silicon and the Related Elements, **2023,** 199, 461-469, doi.org./10.1080/10426507.2023.2281474.

P2-040

Photo-biocatalytic synthesis of optically active amines

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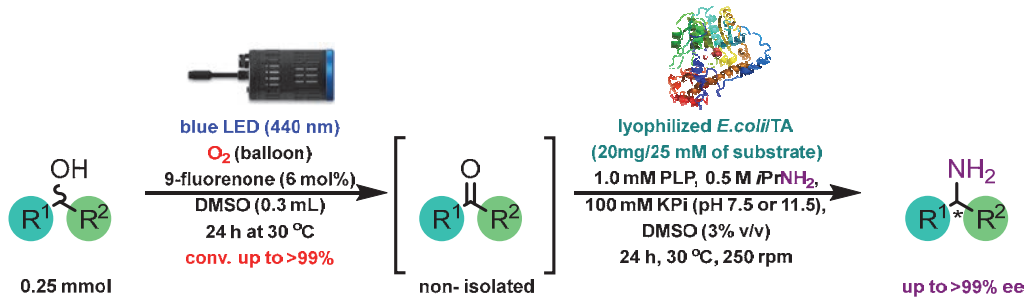
Optically active amines are essential in the field of organic chemistry and pharmacology. Their unique properties make them crucial in development of new active pharmaceutical ingredients (APIs) [1,2]. Many of the classical industrial synthetic methods toward enantiomeric compounds are characterized by moderate yields. In contrast, the newer methods reported in the literature are often developed for the reactions carried out on a small scale, ruling out their use in the industry.



Scheme 1. Photo-biocatalytic synthesis of optically active amines using 9-fluorenone-O_2-blue LED-*E.coli*/TA system.

In this study, we present a two-step photo-enzymatic one-pot linear cascade for synthesizing optically active amines from racemic alcohols. This sequential procedure consists of 9-fluorenone-catalyzed photooxidation of racemic (hetero)benzylic alcohols under 440 nm blue LEDs irradiation followed by transaminase-catalyzed reductive amination of the *in situ* formed ketone. The amine products were obtained in both stereogenic forms with 31-99% conv. and 90-99% ee, respectively.

Acknowledgement

This research was funded by the National Science Center (NCN) of Poland grant "OPUS 24" (Grant No. 2022/47/B/ST4/00139). Statutory support by the Faculty of Chemistry at Warsaw University of Technology (WUT) is also acknowledged. N.A. and A.R. acknowledge financial support from the IDUB project ("Scholarship Plus" program for Ph.D. students). The University of Graz and the Field of Excellence BioHealth are recognized for financial support.

References

[1] M. Fuchs, J.E. Farnberger, W. Kroutil, *European J Org Chem.*, **2015**, *32*, 6965-6982.
[2] S. Simić, E. Zukić, L. Schmermund, K. Faber, C. K. Winkler, W. Kroutil, *Chemical Reviews*, **2022,** *122*, 1052-1126.

P2-041

ADH-Catalyzed Biooxidation of (Hetero)aromatic *sec*-Alcohols to Ketones Employing Vinyl Acetate as Acetaldehyde Surrogate

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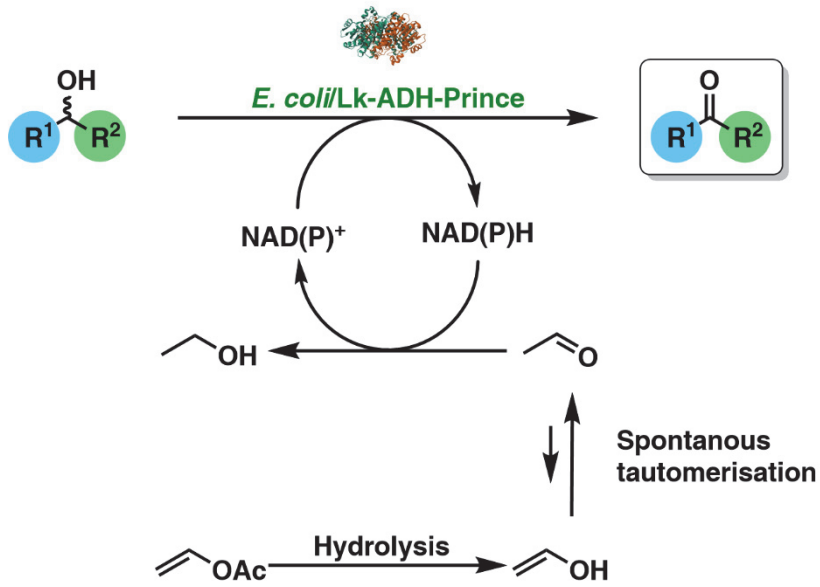
The oxidation of alcohols to form carbonyl compounds is one of the most fundamental processes in synthetic organic chemistry [1]. Herein we apply a simple chemoenzymatic system composed of the recombinant variant of an alcohol dehydrogenase deduced from *Lactobacillus kefir* (*E. coli*/Lk-ADH Prince) and vinyl acetate as an *in situ* acetaldehyde surrogate to oxidize a series of (hetero)aromatic *sec*-alcohols. Preparative scale reactions yielded ketones with 77−96% conversion in up to 83% isolated yield [2].



Scheme 1. Oxidation of (hetero)aromatic *sec*-alcohols using *E. coli*/Lk-ADH Prince.

Acknowledgement

This research was funded by the National Science Center (NCN) of Poland grant “OPUS 24” (Grant No. 2022/47/B/ST4/00139) and the Warsaw University of Technology within the “Excellence Initiative: Research University (IDUB)” program in the framework of the “Young PW” starting grant. A.R. acknowledges financial support from the IDUB project (“Scholarship Plus” program for Ph.D. students). The Faculty of Chemistry at the Warsaw University of Technology (WUT) is also acknowledged for statutory support. The University of Graz and the Field of Excellence BioHealth are acknowledged for financial support..

References

[1] J. E. Bäckvall (Ed.), Modern Oxidation Methods. Wiley-VCH Verlag GmbH & Co. KGaA; **2004**.
[2] A. Rudzka, T. Reiter, W. Kroutil, P. Borowiecki, *ChemCatChem*, **2024**, e202400803.

P2-042

Low-Molecular-Weight Salicylic Aldehyde Semicarbazones and Thiosemicarbazones as Grown Inhibition Agents of Phytopathogenic Fungi

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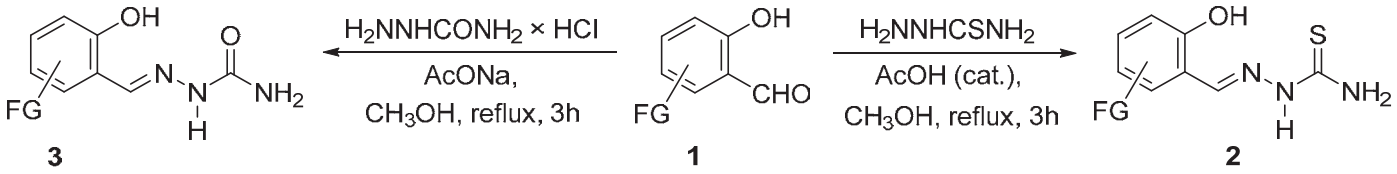
Research on new compounds against plant pathogens is economically important because the ones with the highest toxicity are withdrawn from the environment [1].

A series of semicarbazones and thiosemicarbazones, derivatives of salicylaldehydes **1** bearing alkyl, chlorine, bromine, or hydroxyl substituents in the phenyl ring, were prepared and tested as antifungal agents of phytopathogenic species producing laccase. The target low-molecular-weight (LMW) thiosemicarbazones **2** and semicarbazones **3** were synthesized by condensation of thiosemicarbazide or semicarbazide hydrochloride with an equimolar amount of salicylaldehydes **1** under classical conditions by heating in methanol in the presence of AcOH catalyst or AcONa addition, respectively (Scheme 1).



Scheme 1. Synthesis of thiosemicarbazones **2** and semicarbazones **3** from aldehydes **1**; FG = H, OH, alkyl, Cl, Br, Ph.

All synthesized compounds **2** and **3** were tested against *Botrytis cinerea* and *Cerrena unicolor* at a basal concentration of 50 µM using the cultivation method on a potato dextrose agar plate containing the tested compound. The growth inhibition potency was determined by calculating the percentage of mycelium inhibition growth compared with a control plate without a tested compound [2]. We identified a new class of fungal growth-inhibitor LMW thiosemicarbazones **2** and semicarbazones **3** that contained naturally occurring salicylaldehyde units **1** functionalized with a large substituent. Additionally, semicarbazide and thiosemicarbazide fragments contained “amide” and “thioamide” units that served as decoys resembling biogenic metal ligands. The SAR of the obtained particles and their fungicidal activity was discussed. The optimized derivatives are promising antifungal agents that can be further developed as candidates for agricultural use in the cultivation of crops and seeds for the production of edible and industrial oils, including those for biofuel production.

Acknowledgement

The current authors’ statutory research activity at the Department of Organic and Medicinal Chemistry and the Department of Micro, Nano and Bioprocess Engineering, Faculty of Chemistry, Wroclaw University of Science and Technology (Poland), supported this work.

References

[1] Official Journal of the European Union Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 Concerning the Placing of Plant Protection Products on the Market and Repealing Council Directives 79/117/EEC and 91/414/EEC, *Off. J. Eur. Union*, **2009**, *24*, 1–50.

[2] H. Maniak, K. Matyja, E. Pląskowska, J. Jarosz, P. Majewska, J. Wietrzyk, H. Gołębiowska, A. Trusek, M. Giurg, *Molecules*, **2024**, *29*, 2212.

P2-043

New approach for bioimaging with fluorescent and organometallic labels

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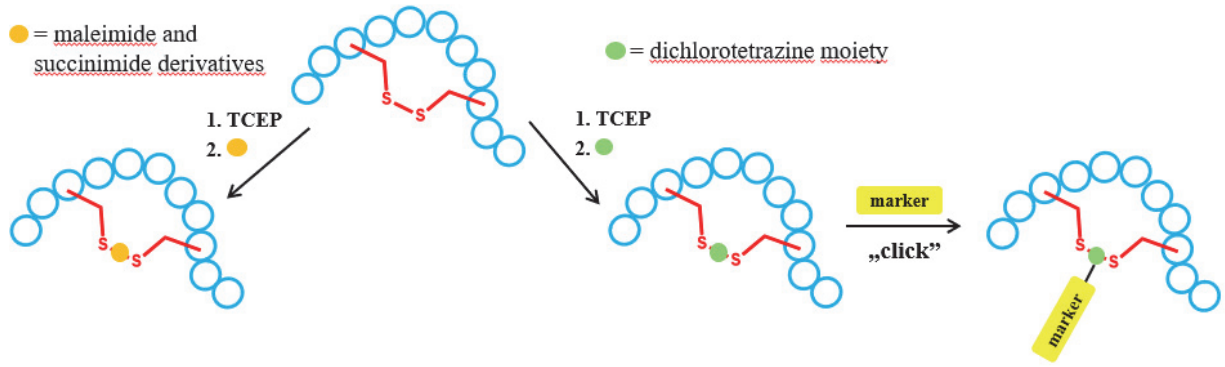
With the intensive development of medicine and science, scientists are increasingly interested in targeted therapy using modified peptides and proteins.[1] The ability to selectively form chemical bonds in biological environment has long been a target of research for chemists interested in modifications biological material. These modifications allow for example to monitor processes occurring in living cells and to track the progress of therapy. Modifications of proteins by "artificial stitching" such as stapling[2] or rebridging[3] enable the introduction of fluorescent or metallocarbonyl markers into their structure, which are easy to detect using spectroscopic methods. Properly designed synthetic molecules introduced into cells can not only act as various types of sensors or markers, but also constitute an element of targeted therapy (e.g. therapeutic peptides).[4]

In this communication, we want to present a strategy for introducing fluorescent markers (containing a pyrene fluorophore) and metallocarbonyl markers ($CpFe(CO)_2(\eta^1$-imidato) derivatives) into biomolecules (Scheme 1). The results we have obtained are interesting both from the scientific and application perspectives. The obtained compounds can be used in imaging biochemical processes occurring in living organism.



Scheme 1. Strategies of introducing metallocarbonyl and fluorescent markers.

Acknowledgement

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References

[1] A. Chi-Lung Lee, J. L. Harris, K. K. Khanna, J.-H. Hong, *Int. J. Mol. Sci.*, **2019**, *20*, 2383.
[2] M. Grison, G. M. Burslem, J. A. Miles, L. K. A. Pilsl, D. J. Yeo, Z. Imani, S. L. Warriner, M. E. Webb, A. J. Wilson, *Chem. Sci.*, **2017**, *8*, 5166.
[3] S. L. Kuan, T. Wang, T. Weil, *Chem. Eur. J.*, **2016**, *22*, 17112.
[4] J. L. Lau, M. K. Dunn, *Bioorg. Med. Chem.*, **2018**, *26*, 2700.

P2-044

High-pressure assisted conjugate addition of alcohols to *β*,*β*-disubstituted *β*-trifluoromethyl enones and esters

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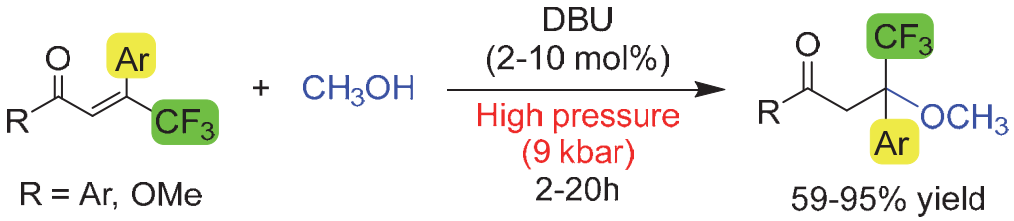
Conjugate addition of alcohols to *α*,*β*-unsaturated carbonyl compounds is generally a difficult reaction and its effectiveness is limited to simple Michael acceptors (e.g. acrylates, simple enones containing an alkyl substituent in the *β*-position) and mostly primary alcohols.[1] The corresponding additions with acceptors having an aryl substituent in the *β*-position are practically ineffective.

We focused our attention on oxa-Michael reaction of alcohols with *β*-trifluoromethyl *β*,*β*-disubstituted enones and esters (Scheme 1), enabling formation of novel sterically congested racemic ethers. Unfortunately, DBU-catalyzed 1,4-addition of methanol to *α*,*β*-unsaturated *β*-CF_3 Michael acceptors, which also contain *β*-aryl substituents, led to the formation of very small amount of products under atmospheric pressure (yield < 15%). In this communication we demonstrate that such reactions can be successfully carried out under high-pressure conditions (9 kbar) with low loading of DBU (2-10 mol%). Using this method, a group of very interesting *β*-alkoxyl *β*-trifluoromethyl ketones and esters was obtained with moderate to high yield.



Scheme 1.

References

[1] Murtagh, J. E.; McCooey, S. H.; Connon, S. J. *Chem. Commun.*, **2005**, *2*, 227-229.

P2-045

High-Performance Light Emitters Achieved through Multiple Substitutions in 10-(Diphenylphosphoryl)-Anthracenes

Vivek Vivek[1,2], Marek Koprowski[1], Ewa Różycka Sokołowska[3], Marika Turek[3], Bogdan Dudziński[1], Krzysztof Owsianik[1], Łucja Knopik[1,2], Piotr Bałczewski[1,3]

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A series of unknown 10-(Diphenylphosphoryl) anthracenes **4a-j** was synthesized *via* the C-P-O to C-P(=O) rearrangement and the *phospho*-Friedel-Crafts-Bradsher reaction, and fully characterized. All the anthracene derivatives **4a-j** were synthesized in a one-pot, three-step reaction. Initially, the process involved the conversion of the dibenzylic alcohols **1a-j** into the phosphinite intermediates **2a-j** using NEt_3 and PPh_2Cl, which were then rearranged to phosphine oxide **3a-j** using trimethylsilyl trifluoromethanesulfonate.[1] Subsequently, the mixture underwent cyclization through the novel *phospho*-Friedel-Crafts-Bradsher reaction (*phospho*-F-C-B) under acidic conditions.[2] The obtained group of compounds will be further investigated to assess their viability in organic optoelectronics by analyzing their photophysical, photochemical, and thermal properties.

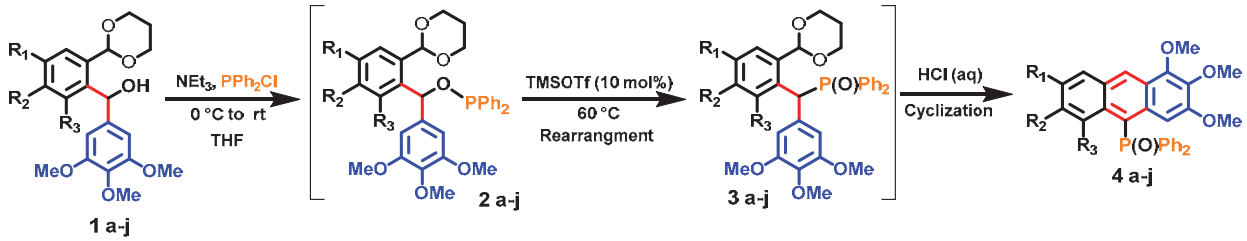

Fig 1. Synthesis of 10-(Diphenylphosphoryl) anthracenes **4a-j**.

Acknowledgement

This research was funded by the National Science Center (Poland), grant number 2019/33/B/ST4/02843 (2019–2024). And, I would like to acknowledge the Bio-Med-Chem Doctoral School at the University of Łódź and Łódź Institutes of the Polish Academy of Sciences for sponsoring this conference..

References

[1] P.Y. Renard, P. Vayron, E. Leclerc, A. Valleix, C. Mioskowski, *Angew. Chem. Int. Ed.* **2003**, *42*, 2389-2392.

[2] Skondensowane węglowodory aromatyczne podstawione grupami fosforoorganicznymi, sposób ich wytwarzania, związki pośrednie oraz zastosowanie. P.Bałczewski**,** B.Dudziński, M.Koprowski, Ł.Knopik. K.Owsianik Zgłoszenie patentowe. P-438275, **26.06.2021**.

P2-046

Exploring methods for the synthesis of alkynyl-substituted anthracenes

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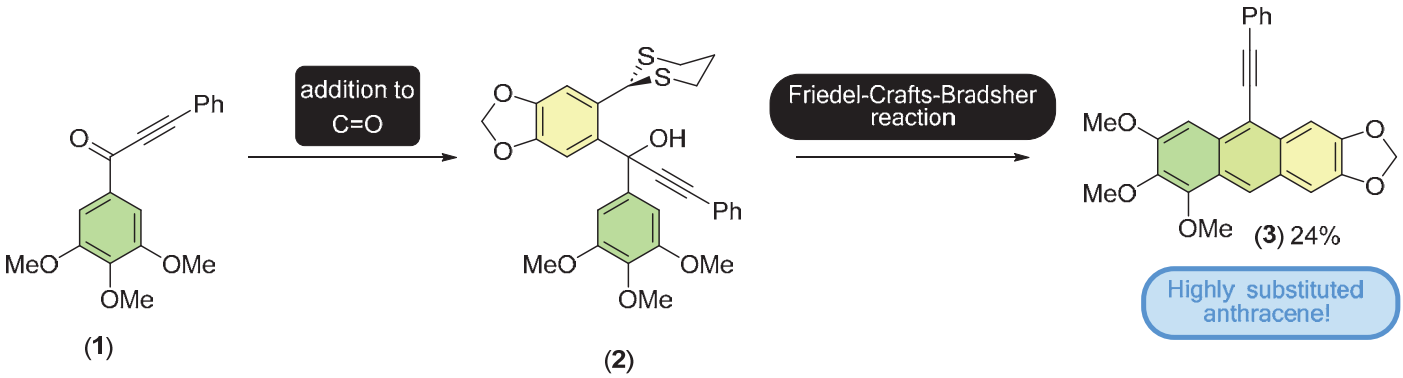
There has been a substantial increase of interest in the field of new materials for applications such as Organic Light Emitting Diodes (OLEDs), Field Effect Transistors (FETs) or oxygen-sensing.[1] A group of most promising candidates for these materials are acenes – known for their electroluminescent properties.[2] However, this group of compounds is also known for their destabilization with increasing number of aromatic rings as well as the number of electron-donating groups. One of the methods for the stabilization of acenes is to substitute them with an alkynyl moiety.[3]

In this work we present a method for the synthesis of a highly-substituted anthracene derivative **3** containing an alkynyl group. The synthesis consists of the addition to the carbonyl group of compounds **1** with the formation of diaryl propargyl methanol **2** and its further Friedel-Crafts-Bradsher cyclization to the desired anthracene. We also have explored alternative synthetic methods, however due to the high reactivity of molecule **2** none were as successful. Anthracene derivative **3** is formed in 24% yield and its spectrophotometric properties are reported. Upon excitation it emits blue light, with the wavelength close to the long-sought blue OLED emitter.



Scheme 1. Graphical abstract of the synthesis of a highly-substituted alkynyl-containing anthracene **3**.

References

[1] L. Lerena, R. Zuzak, S. Godlewski, A. Echavarren, *Chem. Eur. J.*, **2024**, *e202402122*.
[2] J. Anthony, *Chem. Rev.*, **2006**, *12*, 5028- 5048.
[3] M. Müller, L. Ahrens, V. Brosius, J. Freudenberg, U. Bunz, *J. Mater. Chem. C*, **2019**, *45*, 14011-14034.

P2-047

Tuning the fluorescent properties of 10-anthrylphosphonates *via* substituents modification

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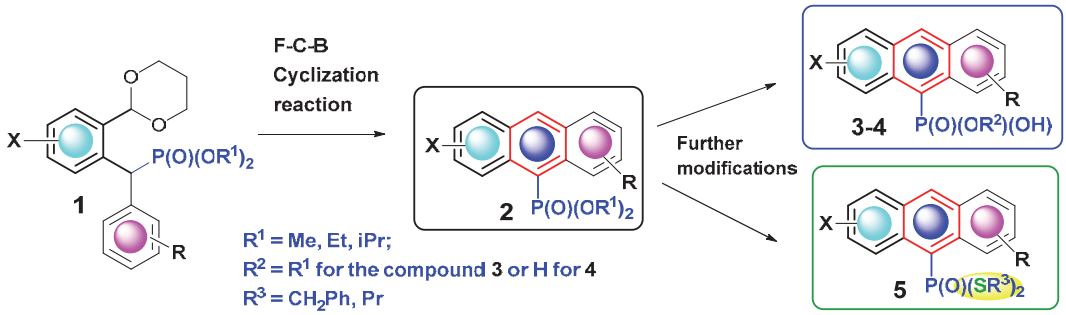
Phosphonates play an important role in many fields of chemistry [1]. Among them, multiply substituted antrylophosphonates have not been sufficiently studied, despite the promising properties, and the systems with a high degree of ring substitution are practically unknown. The low availability of this type of compounds is due to synthetic limitations in general methods for obtaining anthrylphosphonates which are characterized by harsh reaction conditions. Moreover, anthrylphosphonates are starting compounds for obtaining other phosphorus-substituted anthracene derivatives, such as anthrylphosphonic acids, which show the ability to form self-assembled monolayers (SAMs), which are important in material chemistry. [2].



Scheme 1. A new method for the synthesis of highly substituted 10-anthrylphosphonates and their derivatives.

Herein, we introduce a new, facile method for the preparation of 10-anthrylphosphonates **2** based on the Friedel-Crafts-Bradsher cyclization reaction (F-C-B), a method which uses dialkyl diarylmethylphosphonates **1** as key substrates. Additionally, the products **2** of further modifications, such as phosphonic acid monoesters **3**, phosphonic acids **4**, and phosphonodithioates **5**, will be presented. The greatest synthetic advantage of the method we developed, is the use of mild reaction conditions at all stages of the synthesis which results in good yield of the whole process (Scheme 1). Moreover, the studies on photophysical properties (UV absorption, fluorescence, fluorescence quantum yields, Stokes shifts) of the obtained compounds confirmed that the multiple substitution of the anthracene backbone with functional groups of differentiated electron properties, is beneficial for tuning the photophysical properties.

Acknowledgement

This research was funded by the National Science Center, grant number UMO-2019/33/B/ST4/02843, and supported by the Bio-Med-Chem Doctoral School.

References

[1] a) R. Jojart et al. *Bioorg. Chem.*, **2021**, 104914; b) Y. Shi et al. *J. Med. Chem.* **2022**, *65*, 4291; c) J. Hopkins et al. *Chem. Mater.* **2022**, *34*, 1, 140;

[2] a) A. Cattani-Scholz et al, *Langmuir*, **2012**, *28* 7889 b) Y. Zhou et al, *Physical Chemistry Chemical Physics*, **2018**, *20*, 20513.

P2-048

Theoretical insight into different types of complexation with pyridine

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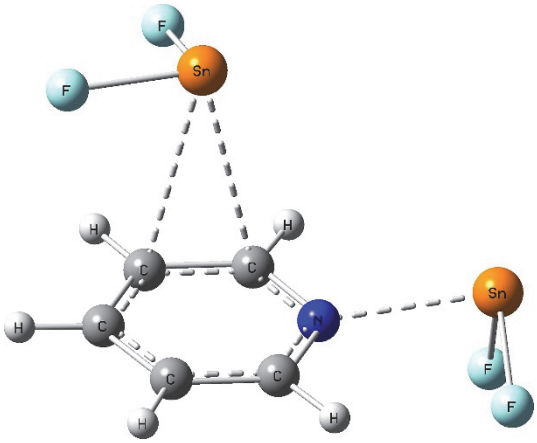
Pyridine constitutes a prime example of a monodentate ligand containing nitrogen as an electron donor. Its single lone pair is capable of complexing a diverse range of metal centers, including the Sn(II) center of tin dihalides SnX_2.[1] Additionally, the aromatic π-electron cloud of pyridine can potentially act as a Lewis base toward the acidic metal center of SnX_2.[2] In this work, the two types of complexation are characterized theoretically in a series of model complexes formed by pyridine and SnX_2 (Scheme 1).



Scheme 1. Calculated equilibrium structure of the pyridine·$2SnF_2$ complex showing two types of complexation.

Acknowledgement

The author gratefully acknowledges Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH) for providing computer facilities and support within computational grant no. PLG/2023/016589.

References

[1] P. Matczak, *Appl. Organometal. Chem.*, **2019**, *33*, e4811.
[2] P. Matczak, *Comput. Theoret. Chem.*, **2023**, *1226*, 114192.

P2-049

The antimicrobial activity of complexes with selected metal ions and carbothioamidopyrazoles as ligands

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The treatment of infectious diseases remains an important and challenging problem due to a combination of factors, including emerging infectious diseases and the increasing number of multidrug-resistant microbial pathogens. Despite the large number of antibiotics and chemotherapeutic agents available for medical use, the emergence of both old and new antibiotic resistance in recent decades has revealed a substantial medical need for new classes of antimicrobial agents.[1] Many biologically active compounds used as drugs exhibit modified pharmacological and toxicological properties when administered in the form of metal-based compounds. Metal ion complexes are an interesting group of compounds that play an important role in many biological systems.[2]

Various metal ions commonly used, such as copper(II), cobalt(II), and nickel(II), are known for forming low molecular weight complexes, which can be more active than the corresponding ligands against several diseases.[3] Carbothioamidopyrazole derivatives have been used as ligands in the formation of transition-metal complexes.

The aim of these studies is the synthesis and evaluation of the antibacterial properties of complexes with Cu(II), Co(II), and Ni(II) ions and carbothioamidopyrazole ligands.

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Acknowledgement

Financial support from the Medical University of Lodz (grant No. 503/3-066-02/503-31-001 Elzbieta Budzisz).

References

[1] F. Prestinaci, P. Pezzotti, A. Pantosti, *Pathog. Glob. Health.*, **2015**,109, 309–318.

[2] E. Namiecinska, B. Sadowska, M. Wieckowska-Szakiel, A. Dołega, B. Pasternak, M. Grazul, E. Budzisz, *RSC Adv*. **2019**, 9, 38629–38645.

[3] M. Sobiesiak, I.-P. Lorenz, P. Mayer, M. Wozniczka, A. Kufelnicki, U. Krajewska, M. Rozalski , E. Budzisz, *Eur. J. Med. Chem*., *46* (2011) 5917-5926.

P2-050

A New Look at the Mechanism of Cocrystal Formation and Coformers Exchange in Processes Forced by Mechanical and/or Thermal Stimuli – *ex situ* and *in situ* Studies of Low-Melting Eutectic Mixtures

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Typically, knowledge of the mechanochemical formation of binaries is limited to information on the composition of the starting materials (input data) and the structure of the final products (output data). Attempts at *in situ* analysis of intermediate products are still rare and most conclusions about the reaction mechanism are based on ex situ analysis and macroscopic observations. [1]

Our work aims to introduce an NMR-based methodology that at the atomic level will provide information about the mechanism of cocrystal formation and shed new light on this area. The key step that will make this project reasonable is the right selection of appropriate models. Certainly, low-melting eutectic binary systems belong to this group. Our study focuses on ethenzamide (ET) cocrystals with three different dicarboxylic acids, all of which can be easily formed by neat mechanochemical grinding or hot-stage melting. NMR techniques, supported by theoretical calculations, allowed to provide details about the pathway of the reaction mechanism with atomic accuracy. It was found that the formation of ET cocrystals is a complex process that requires five steps. Each step has been recognized and described. Variable temperature 1D and 2D MAS NMR experiments allowed to track physicochemical processes taking place in a molten state. Moreover, it was found that in a multicomponent mixture consisting of all four components, ET, EMA, GLU, and MAL, ET in the molten phase behaves as a specific selector choosing only one partner to form binary cocrystals according to energy preferences.

The process of exchange of coformers in binary systems during grinding, melting, and NMR measurements is described. The stabilization energies (E^{stab}) and molecular electrostatic potential (MEP) maps computed for the cocrystals under discussion and their individual components rationalize the selection rules and explain the relationships between individual species. [2]

Acknowledgement

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References

[1] P. A. Julien, T. Friščić, Cryst. Growth Des., **2022**, *22*, 5726–5754.
[2] M. K. Dudek, K. Trzeciak, L. Tajber, J. Zając, S. Kaźmierski, E. Pindelska, T. Makowski, M. Svyntkivska, M. J. Potrzebowski, *Chem. - Eur. J.*, **2024**, *30*, e202302138.

P2-051

PTC in the polyenolate-mediated [10+2]-cycloaddition for the synthesis of α,α-disubstituted amino acid precursors

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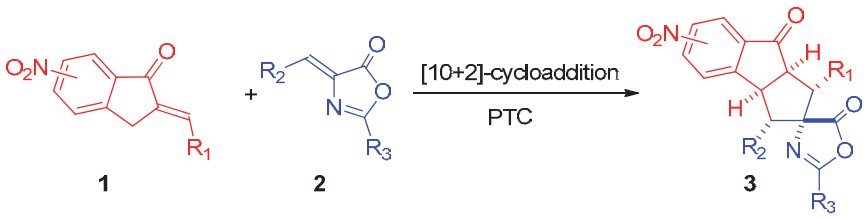
Cycloaddition reactions constitute a powerful tool for the construction of diverse carbo- and heterocyclic scaffolds from acyclic precursors.[1] The Diels-Alder reaction and 1,3-dipolar cycloadditions are the most prominent examples and they are very well described in literature.[2,3] However, higher-order cycloadditions, that occur with the participation of overall more than 6π-electrons, are the area of research that has received increased attention recently.[4] HOC reactions are challenging because of difficulties with controlling their regio-, chemo- and stereoselectivity.

In this project a formal [10+2] higher-order cycloaddition between 2-arylideneindan-1-ones **1** and α-alkylidene azlactones **2** was presented. The reaction is realized under Brønsted-base catalysis utilizing the phase transfer catalysis approach. By using this strategy, a series of structurally diverse compounds **3** containing a polycyclic scaffold was prepared in 79-99% yields. In addition, the potential of the obtained [10+2]-cycloadducts has been confirmed by transformations, including the synthesis of a highly valuable α,α-disubstituted N-protected α-aminoester.



Scheme 1. Polyenolates in the formal [10+2] cycloaddition involving 2-arylideneindan-1-one and α-alkylidene azlactone.

Acknowledgement

This project was realized within the Opus programme (grant number: UMO-2021/41/B/ST4/03385) from the National Science Centre, Poland.

References

[1] A. Moyano, R. Rios, *Chem. Rev.* **2011**, *111*, 4703-4832.
[2] A. Grillo, B. M. Bizzarri, *Catalysts* **2022**, *12*, 150-168.
[3] M. Breugst, H.-U. Reissig, *Angew. Chem. Int. Ed.* **2020**, *59*, 12293-12307.
[4] N. I. Jessen, D. McLeod, K. A. Jørgensen, *Chem* **2022**, *8*, 20-30.
[5] J. Dybowska, A. Przydacz. A. Skrzyńska, Ł. Albrecht. *Adv. Synth. Catal.* 10.1002/adsc.202400792.

P2-052

New tools in heavy metal detection: synthesis and spectroscopic characterization of selected water-soluble styryls derivatives of quinolines and 1,10-phenanthrolines

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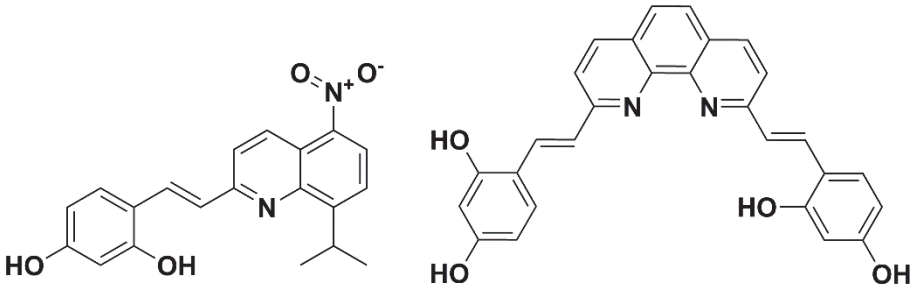
Water-soluble ligands based on quinoline or 1,10-phenanthroline core are relatively poorly studied compounds. Developing efficient and convenient syntheses of them would result in new interesting applications because of the importance of 1,10-phenanthrolines and quinolines. [1] Our studies describe novel and practical ways to introduce a polyphenol group under mild reaction conditions. Moreover, we apply Perkin condensation to synthesize a vinyl (or styryl) analog of 1,10-phenanthroline and quinolines derivatives with phenol function. This reaction also demonstrates a new, simple, and efficient strategy for converting methyl derivatives of 1,10-phenanthroline or quinoline. [1] We anticipate that the new way of converting methyl will find wide application in chemical synthesis.



Scheme 1. Types of water-soluble 1,10-phenanthroline and quinoline used in our research.

Quantum chemical calculations using density functional theory and B3LYP/6-311++G(d,p) with Grimme's dispersion correction approach predict the existence and relative stability of different spatial *cis(Z)*- and *trans(E)*-conformers of styryl derivatives of quinolines and 1,10-phenanthrolines, which exhibit different electronic distribution and conjugation within the molecular skeleton, dipole moments, and steric interactions, leading to variations in their photophysical behavior and various applications. For example, thanks to their ability to selectively bind to specific ions, styryl derivatives of quinolines and 1,10-phenanthrolines are used in chemical sensors for detecting heavy metal ions, such as copper and mercury, which is significant in environmental protection and chemical analysis. We will show how our water-soluble ligands fit into this idea.

Acknowledgement

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References

[1] J. E. Nycz, N. Martsinovich, J. Wantulok, T. Chen, M. Książek, J. Kusz, *Molecules*, **2024**, 29, 1341.

P2-053

Spectroscopic characteristics of new α-aminoacid betulin derivatives

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Betulin (3-Lup-20(29)-eno-3β,28-diol, BN) is pentacyclic triterpene occurring naturally in bark of many birch species such as *Betula pendula*, *Betula pubescens* or *Betula verrucosa* [1]. It possesses many useful biological characteristics, including antimicrobial, antioxidative, anti-inflammatory and cytostatic properties [2]. However, it's large carbon skeleton limits it's water solubility, therefore decreasing bioavailability and cell penetration. To overcome this problem, a small, preferably polar molecule such as amino acid or sugar can be attached to parent skeleton of BN. Aside from bioavailability improvement, some cancer cells can mistake such attached molecules with nutrients, which can increase drug's selectivity towards cancer cells [3].

The aim of this work is to present newly synthesized betulin conjugates with α-aminoacids, along with their NMR characteristics.

References

[1] S. Amiri, S. Dastghaibb, M. Ahmadiet al. *Biotechnol Adv.*, **2020**, *38*, 107409–107447.
[2] Jäger, S. et. al. *Molecules*, **2008**, *13* (12), 3224–3235.
[3] Youssef, D. et al. *Bioorganic & Medicinal Chemistry Letters*, **2009**, *19* (22), 6364–6367.

P2-054

Catalyzed Asymmetric Formal [3 + 3] Annulation of 2-enoyl-Pyridine *N*-Oxide with Benzyl Methyl Ketone

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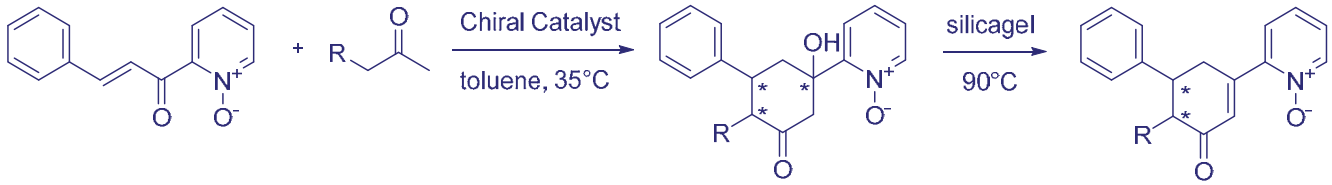
Heteroaromatic rings and the corresponding N-oxides appear as a structural motif in many compounds with exceptional properties [1,2]. The presence of the N^+-O^- bond is the reason for the special properties and diverse usefulness of azaaromatic N-oxides [3]. Among many derivatives, there are products with specific biological properties, used as pharmaceuticals, cosmetics and detergents, others are used in organic reactions. In this last context, particularly interesting are heteroaromatic N-oxides having several places in their structure susceptible to transformations, preferably asymmetric ones, and allow for significant and sterically controlled expansion of the skeleton [4,5]. The use of tandem reactions as a synthesis tool gives the possibility of obtaining complex products quickly and relatively easily in a one pot experiment [6].

We present studies on the selectivity in the catalyzed formal [3+3] annulation reaction of (E)-2-(3-phenylacryloyl)pyridine N-oxide when an unsymmetrical ketone is used in the reaction [7]. The possibility of stereoselective outcome was checked using salts of natural amino acids, as well as chiral bifunctional derivatives containing amino groups and thiourea or squaramide fragments as organocatalysts. Spectroscopic analysis of the isolated product and analysis of the reaction course was carried out, taking into account the obtained regio- and stereoselectivity.



Scheme 1. Michael/aldol/dehydration sequence reactions of (E)-2-(3-phenylacryloyl)pyridine with an unsymmetrical ketone.

It was possible to achieve the formation of a trisubstituted cyclohexenone with two stereogenic centers in a regio- and stereoselective manner. Depending on the type of catalyst applied, opposite enantiomers of the *trans*-diphenylsubstituted product were obtained ((*R*,*R*) or (*S*,*S*)).

References

[1] S. Youssif, *Arkivoc* **2001**, *1*, 242–268.
[2] C. Gonzalez-Bello, L. Castedo, Six-Membered Heterocycles: Pyridines in Modern Heterocyclic Chemistry; Alvarez-Builla, J., Vaquero, J. J., Barluenga, J., Eds.; Wiley-VCH: Weinheim, Germany, 2011; pp 1431−1525.
[3] Z. Wrzeszcz, R. Siedlecka, Molecules **2020**, *25*, 330.
[4] A.V. Kutasevich, V.P. Perevalov, V.S. Mityanov, *European J. Org. Chem*. **2021**, 357–373.
[5] D. Wang, L. Désaubry, G. Li, M. Huang, S. Zheng, *Adv Synth Catal*. **2021**, *363*, 2–39.
[6] N. Wang, Z. Wu, J. Wang, N. Ullah, Y. Lu, *Chem. Soc. Rev.*, **2021**, *50*, 9766–9793.
[7] Z. Wrzeszcz, R. Siedlecka, *Symmetry* **2024**, *16*, 104..

P2-055

Impact of the alpha-thio-modified ATP analogues on the cell migration in 2D and 3D culture conditions

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The rate of cell migration is one of the most important features that determine the progression of cancer cell and metastasis, as well as tissue regeneration. Although the exact regulatory mechanisms are not yet fully understood, it has been shown that one of the main factors that can influence these processes are extracellular nucleotides, mainly extracellular ATP [1,2]. ATP *via* interaction with surface receptors and other membrane-bound proteins may induce signaling pathway controlling cell motility. However, due to the rapid hydrolysis of unmodified ATP, its stable analogues seem to be better tools for regulation of cell movement. For this purpose, a series of ATP analogues containing sulphur instead of one or both of the non-bridging oxygen atoms at the α-phosphate group were synthesized. Synthesis were performed using modified oxathiaphospholane method [3,4,5], where appropriately protected adenosine 5'-*O*-(2-thio-1,3,2-oxathiaphospholane) or 5'-O-(2-thio-1,3,2-dithiaphospholane) was reacted with the pyrophosphate analogue in the presence of DBU as a base catalyst. Obtained ATP analogues were separated according to their chromatographic mobility using RP HPLC and tested as diastereomerically pure α-thio modified ATP analogues.

Obtained compounds were tested for their impact on the migration of highly metastatic cancer cells, like osteosarcoma, pancreatic and breast cancer cells to assess their usefulness in anti-metastatic treatment. The use of three-dimensional cellular models, beside the scratch assay, transwell chambers, better reflects the real conditions inside the body thus cancer spheroids were used to study cell motility in the presence of the tested derivatives. The involvement of obtained derivatives on the viability and morphology were also determined. Additionally, for the selected derivatives, assessment of the potential usefulness in tissue regeneration was also investigated.

Acknowledgement
This project was supported by the grant 2023/49/B/ST4/03288 from National Science Centre in Poland.

References
[1] McEwan, et al., *Life Sciences*, **2021**, *283*, 119850.
[2] Suwara et. al. *Curr Med Chem*. **2023**, *30*, 1232-1255.
[3] D. Blaziak et al. *Org. Biomol. Chem*., **2010**, 8, 5505-5510.
[4] Pawlowska et. al. ACS Omega **2024**, *9*, 9348-9356.
[5] Pawlowska et. al. *Sci Rep*. **2024**, *14*, 13148.

P2-056

A Facile and Accurate Empirical Scheme for Detonation Properties Prediction of Heterocyclic Energetic Materials

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Nitrogen-rich heterocyclic energetic materials form the main synthetic trend in the field for the last few decades.[1] This is primarily due to a better general performance in terms of detonation velocity (*D*, m/s) and pressure (*P*, GPa), sensitivity and environmental safety.[1] The *D* and *P* values are usually calculated by the benchmark thermochemical code EXPLO5.[2] Meanwhile, because of the commercial availability of the latter, various empirical schemes are still developing to provide an alternative. Recently, an accurate approach (the MWP method) was proposed and it was concluded to be similar in quality to the EXPLO5 code.[3]

In this work, we have used Kamlet-Jacobs empirical scheme, which was modified as shown schematically in Figure 1. We have performed variation of the nonlinear parameters in 3D space followed by a regression analysis using genetic function approximation (GFA). This was done for a wide range of heterocyclic compounds, which was divided into training (532 entries) and test (137 entries) subsets.

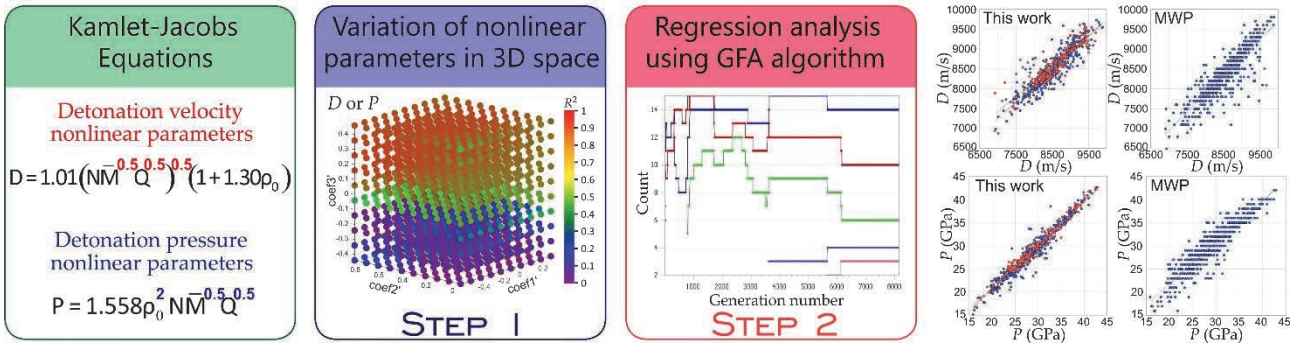

Figure 1. Key workflow steps applied for developing of our empirical models and their performance.

As a result, we have developed an approach including three different empirical schemes for three groups of energetic material divided according to their intrinsic oxidability (oxygen balance), namely, “high+moderate”, “low” and “low_1”. The latter group means no oxygen atoms are present in the molecule. This group is especially important, since a lot of nitrogen-rich compounds fall into this category. Thus, we have obtained results for the test dataset, which outperform the recently proposed method MWP (Table 1). Thus, our empirical approach can be considered as one of the most accurate methods for detonation properties prediction of heterocyclic energetic materials.

Table 1. Accuracy of the presented approach compared to the recently reported MWP method [3]

Estimate	R^2 (*D*)	R^2 (*P*)	*RMSE* (*D*)	*RMSE* (*P*)	*MAE* (*D*)	*MAE* (*P*)
This work	0.81	0.97	257 m/s	0.97 GPa	173 m/s	0.77 GPa
MWP	0.76	0.86	282 m/s	1.90 GPa	231 m/s	1.61 GPa

References

[1] H. Gao, Q. Zhang, J. M. Shreeve, *J. Mater. Chem. A*, **2020**, *8*, 4193-4216.
[2] M. Sućeska, *Mater. Sci. Forum*, **2004**, *465-466*, 325-330.
[3] N. V. Muravyev, D. R. Wozniak, D. G. Piercey, *J. Mater. Chem. A*, **2022**, *10*, 11054-11073.

List of posters

No.	Presenting Author	Poster Title
		Poster Session 1 (Thursday, 21) P1
P1-001	Stępniak Weronika	*Synthesis of Morpholino Nucleoside Thiomonophosphates and Dithiomonophosphates via an Oxathiaphospholane Approach*
P1-002	Salah Ahmed	*Comprehensive analysis of the effect of renewable energy on the stability of the environment*
P1-003	Tsygankov Alexander	*Synthesis of morpholine-2,5-dione by tandem multicomponent isocyanide reactions Azido-Ugi and Ugi*
P1-004	Singh Hemant Kumar	*Paramagnetic helicenes: π-Curved Blatter radicals through photo-Smiles rearrangement*
P1-005	Ríos Gutiérrez Mar	*Why is phenyl azide so unreactive in [3+2] cycloaddition reactions? Demystifying Sustmann's paradigmatic parabola*
P1-006	El Ouedghiri-Idrissi Ismail	*Luminescence properties of 2,4,5-Triphenyl Imidazole*
P1-007	Łagiewka Jakub	*Ionically crosslinked composite based on chitosan and cyclodextrin polymer as a novel adsorbent for removal of organic dyes*
P1-008	Kawka Anna	*Steroid-pyrimidine hybrids as potential agents with high biological activity*
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P1-010	Świętczak Eliza	*The phenomenon of mechanochromism observed under a microscope*
P1-011	Malinowska Marta	*Can 2′-methylthiamine act as an anti-vitamin of thiamine?*
P1-012	Staś-Bobis Monika	*Exploring the Potential of Tetrazole and Triazole as trans-Amide Bond Isosteres in Amino Acid Residues via DFT*
P1-013	Mucha Wiktor	*4-Chloro- and 5-Chloro-7-Azaindole-3-Carbaldehydes: Structural Insights, Vibrational Spectroscopy, and DFT Calculations*
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P1-016	Sahoo Abhishek	*Axially chiral stable radicals: a promising class of functional materials*
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P1-021	Stelmaszyk Julia	*Diastereoselective synthesis of novel fluorine-containing α-aminophosphonates as potential urokinase inhibitors*
P1-022	Skrobek Maja	*Synthesis and analysis of film-forming properties of imine derivatives of salicylaldehyde*

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P2-003	Bosak Natalia	*Sonochemical synthesis of 1,3,5-aminotriazines in the light of the Principles of Green Chemistry*
P2-004	Sowa Sylwia	*Versatile reactivity of benzo[b]phosph-3-yl triflates*
P2-005	Sowa Sylwia	*Effect of 3-aryl substituent on the fluorescent properties of benzo[b]phosphole oxides*
P2-006	Jasiński Radomir	*The Au(III) catalytic effect on the molecular mechanism of the [3+2] cycloaddition reaction between (Z)-C,N-diphenylnitrone and nitroethene: MEDT computational study*

P2-007	Kącka-Zych Agnieszka	*Stability of acyclic nitronic acids*
P2-008	Łapczuk Agnieszka	*Selected [4+2] cycloadditions with the participation of methylcyclopentadiene: DFT study*
P2-009	Kula Karolina	*The key structural and electronic properties of (1E,3E)-1,4-dinitro-1,3-butadiene*
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P2-017	Nowak Ewelina	*Regioselective protection of tylosin functional groups*
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