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**Dedicated to the 75th anniversary of the**
**Petru Poni Institute of Macromolecular Chemistry**

# Book of Abstracts

**In memoriam Acad. Bogdan C. SIMIONESCU (1948-2024)**

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# Oral Communications

# OC1. LACCASE/ POLYSACCHARIDE HYBRID NANOSTRUCTURES FOR EFFICIENT DYE DEGRADATION

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## Introduction

The growing amount of harmful pollutants detected in water systems in the recent years emphasized the need for the development of efficient and sustainable water treatment methods. Due to their ability to effectively break down a wide range of pollutants, enzyme-based water purification technologies have become a viable alternative to conventional water cleaning methods [1, 2]. While enzyme-based water purification technologies offer greener solutions, their practical application faces significant challenges such as the denaturation of the enzyme and difficulties in recovery and reuse. Hybrid nanostructures, particularly enzyme-polysaccharide complexes, have gained attention for their capacity to enhance enzyme stability and activity, making them promising candidates for more efficient water purification methods. These hybrid nanostructures can easily be prepared based on electrostatic interactions between enzymes and oppositely charged compounds, such as polysaccharides, and are able to increase the stability of enzymes in environmental conditions. In this context, this study investigates the formation of hybrid nanostructures between laccase (LAC) and a custom-made copolymer, obtained by the grafting of poly(N-isopropylacrylamide) on chitosan (CHI-*g*-PNIPAM) and their potential use as catalysts for the degradation of water pollutants.

## Materials and methods

LAC from *Trametes versicolor* fungus and CHI-*g*-PNIPAM synthesized in our laboratory [3] were used for the preparation of hybrid nanostructures. The successful formation of the hybrid nanostructures was investigated using dynamic and electrophoretic light scattering and scanning transmission electron microscopy. The structural stability of the enzyme after the formation of the hybrid nanostructures was assessed using fluorescence spectroscopy and the preservation of the enzymatic activity was studied using the oxidation of ABTS as a model reaction. The capacity of the obtained nanostructures to catalyse pollutants degradation was investigated using indigo carmine (IC) and Congo red (CR) as model pollutants.

## Results and discussions

The formation of hybrid nanostructures based on CHI-*g*-PNIPAM and LAC was investigated at different mixing ratios between the two components. The successful interaction of LAC and CHI-*g*-PNIPAM was confirmed by the dynamic light scattering analyses which highlighted an increase in the scattered intensity of the hybrid nanostructured samples as compared to the initial CHI-*g*-PNIPAM and LAC solutions. Additionally, the formation of the hybrid nanostructures was confirmed by the STEM micrographs that show the formation of nanostructures with a well-organized internal structure. The preservation of the catalytic activity of the LAC embedded in the hybrid nanostructures was assessed using the oxidation of ABTS as a model reaction.

The obtained results evidenced a slightly enhancement on the enzymatic activity of the hybrid nanostructures, suggesting the electrostatic complexation between LAC and CHI-*g*-PNIPAM which can potentially modify the conformation of the enzyme, leading to an increased accessibility of the catalytic center.

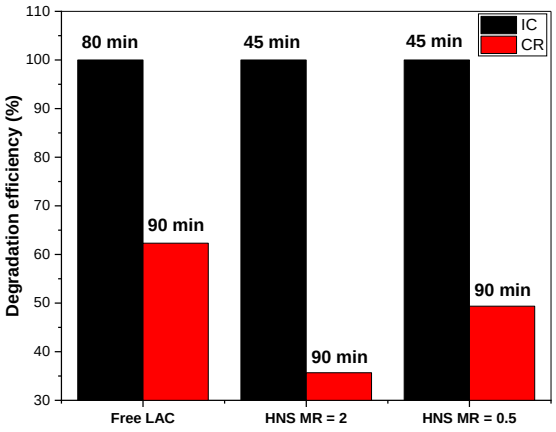


**Figure 1.** Maximum degradation efficiency of IC and CR achieved under the action of free LAC or of CHI-*g*-PNIPAM/LAC hybrid nanostructures.

The potential use of the hybrid nanostructures in water cleaning applications was assessed in the presence of IC and CR as target pollutants. The use of the hybrid nanostructures leads to the full degradation of the IC sample after only 45 minutes (**Figure 1**) and to the degradation of about 50% of CR after 90 minutes, demonstrating the capacity of the hybrid nanostructures to catalyse the degradation of the two dyes.

## Conclusions

This study demonstrates the feasibility of forming hybrid nanostructures between LAC and CHI-*g*-PNIPAM. By combining the catalytic activity of LAC with the stabilizing effects of the grafted copolymer, hybrid nanostructures were obtained which exhibited enhanced enzymatic activity in both model reactions (ABTS oxidation) and real interest catalytic applications such as the degradation of dyes. The obtained results suggest that the CHI-*g*-PNIPAM/LAC hybrid nanostructures could be a promising alternative to conventional water treatment methods, offering a green and efficient solution to face water pollution. Further research will focus on optimizing the preparation protocol and in demonstrating the potential of these hybrid nanostructures to catalyse the degradation of other types of pollutants.

## References

[1] F. Bucătariu, C. Teodosiu, I. Moroșanu, D. Fighir, R. Ciobanu, L.M. Petrila, M. Mihai, *Polymers* 2021, 13(22), 3963.
[2] A.R. Leontieș, A. Răducan, D.C. Culiță, E. Alexandrescu, A. Moroșan, D.E. Mihăiescu, L. Aricov, *Chem. Eng. J.*, 2022, 439, 135654.
[3] M.M. Zaharia, F. Bucatariu, M. Karayianni, E.D. Lotos, M. Mihai, S. Pispas, *Polymers* 2024, 16, 1315.

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# OC2. STRATEGIC SYNTHESIS OF MONO- AND BINUCLEAR COMPLEXES USING POLYDENTATE LIGANDS WITH EXTENDED π SYSTEMS

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This study focuses on the rational design and synthesis of mononuclear and binuclear complexes of 3d, 4d and 4f metals using Schiff base ligands with extended π-systems. Schiff bases, formed through the condensation of amines and aldehydes, are highly regarded in coordination chemistry due to their structural flexibility and ability to form stable metal complexes with a variety of applications [1]. The primary aim is to explore synthetic methodologies for these metal complexes and investigate their physicochemical properties, particularly for potential applications in the biomedical and materials science fields. The Schiff base ligands used in this research are polydentate, meaning they possess multiple coordination sites capable of binding metal ions. This, along with their extended π-systems, allows for the formation of stable metal-ligand frameworks.

The study emphasizes the synthesis of mononuclear complexes of 3d/4d metals like zinc (Zn) and palladium (Pd), as well as 4f metals like europium (Eu) and terbium (Tb). These complexes were synthesized by reacting Schiff base ligands with the appropriate metal salts, optimizing geometries and electronic properties for specific applications. Zinc triflate or perchlorate and palladium chloride were used for 3d or 4f metal complexes, resulting in tetrahedral or square-planar geometries. Schematic synthesis of Zn(II) complexes is presented in **Figure 1**. For the 4f metal complexes, the ligands were reacted with rare-earth hexafluoroacetylacetonates, $Ln(HFAc)_3 \cdot nH_2O$, yielding complexes with square-antiprismatic geometries. Single-crystal X-ray diffraction revealed intricate molecular architectures and provided insight into their coordination environments.

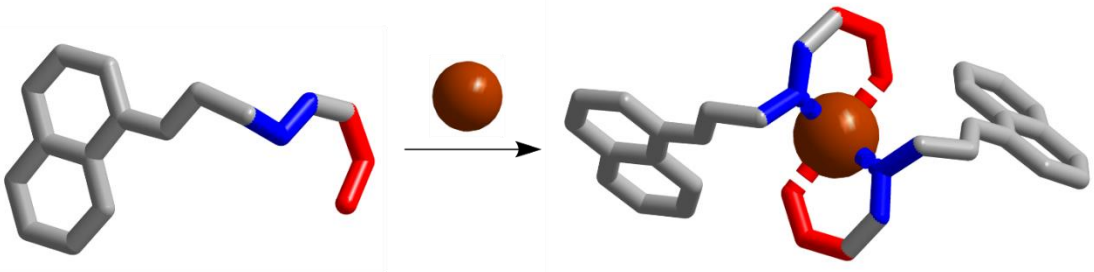

**Figure 1.** Schematic synthesis of 3d complexes using Schiff base ligands.

A significant focus of the study is on the luminescent properties of the synthesized complexes, particularly those involving europium (Eu) and terbium (Tb), known for their strong luminescence. Schiff base ligands not only stabilize these metal centres, but also can act as efficient antennas for energy transfer or enhancing luminescence.

These luminescent properties, especially in the visible and near-infrared regions, highlight their potential for applications in biomedical imaging, where the deep tissue penetration and minimal photodamage of near-infrared luminescence are highly desirable [2]. A key focus of this study is the sequential synthesis of heterometallic 3d-4f complexes, exploiting the distinct coordination preferences of transition metals and lanthanides with respect to the polydentate Schiff base ligand. The 3d metal ion, such as Zn(II), is first coordinated to the Schiff base, forming a stable scaffold, followed by the incorporation of the 4f metal ion. These heterometallic complexes, particularly those involving both Zn(II) and lanthanides, exhibit notable luminescence.

In addition to their luminescent properties, the potential of these metal complexes for DNA intercalation will be explored as a working hypothesis in this ongoing research. DNA intercalation involves the insertion of planar aromatic compounds between the base pairs of DNA, leading to biological effects such as the inhibition of DNA replication and transcription. This mechanism is of particular interest for developing anticancer agents, as DNA-intercalating compounds can selectively target rapidly dividing cancer cells. The Schiff base ligands in this study contain aromatic systems that may facilitate π-π stacking interactions with the nitrogenous bases of DNA [3]. When coordinated to metal centers like palladium (II), these complexes are hypothesized to exhibit enhanced binding affinity toward DNA, possibly acting as effective intercalators, as shown in **Figure 2.**

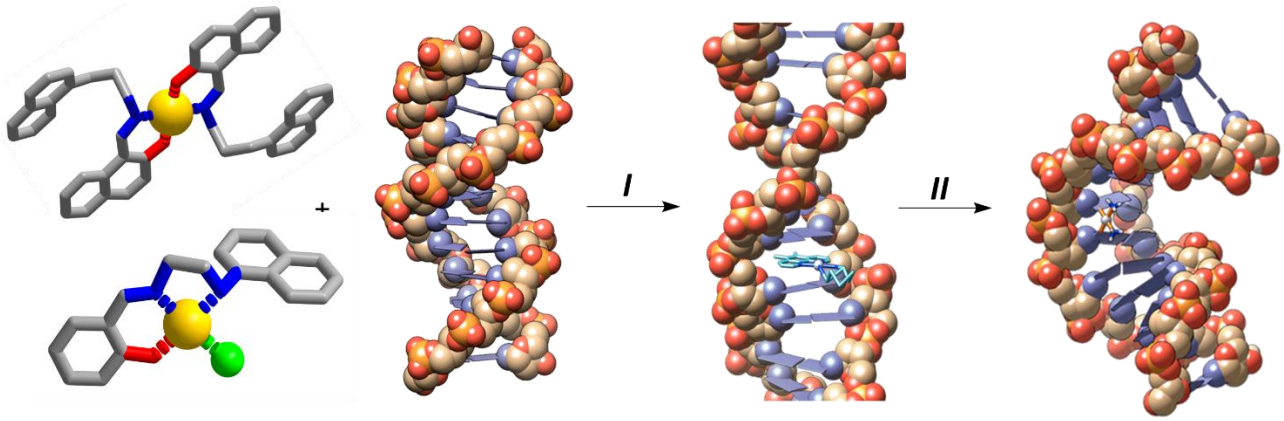


**Figure 2.** Proposed intercalation mechanisms and corresponding conformational changes; Intercalation (I) and covalent bonding (II).

## References

[1] M. Andruh, *Dalton Trans.* 2015, 44, 16633-16653.
[2] Y. Ning, M. Zhu, J.-L. Zhang, *Coord. Chem. Rev.* 2019, 399, 213028.
[3] S. N. Mbugua, N.R.S. Sibuyi, L.W. Njenga, *ACS Omega* 2020, 5, 14942-14954.

# OC3. EMERGING COMPOUNDS WITH CANCER INHIBITORY ACTIVITY TO WIDEN THE MEDICINAL CHEMISTRY FIELD

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Recent research in medicinal chemistry highlights the potential advantages of partially replacing carbon with silicon in the structure of certain drugs, resulting in improved metabolism and cellular absorption due to the increased lipophilicity imparted by silicon [1]. Additionally, silatranes, organosilicon compounds that contain a pentacoordinated silicon atom and a transannular dative bond between the Si and N atoms, are recognized for their biological properties, including antibacterial, antifungal, antiviral, anti-inflammatory, antioxidant, and antitumor activities (**Figure 1a**) [2]. The spherical shape and high dipole moment of these molecules facilitate their passage through cell membranes, while the apical radicals attached to the silicon atom allow for derivatization and for fine-tuning of biological activities [3].

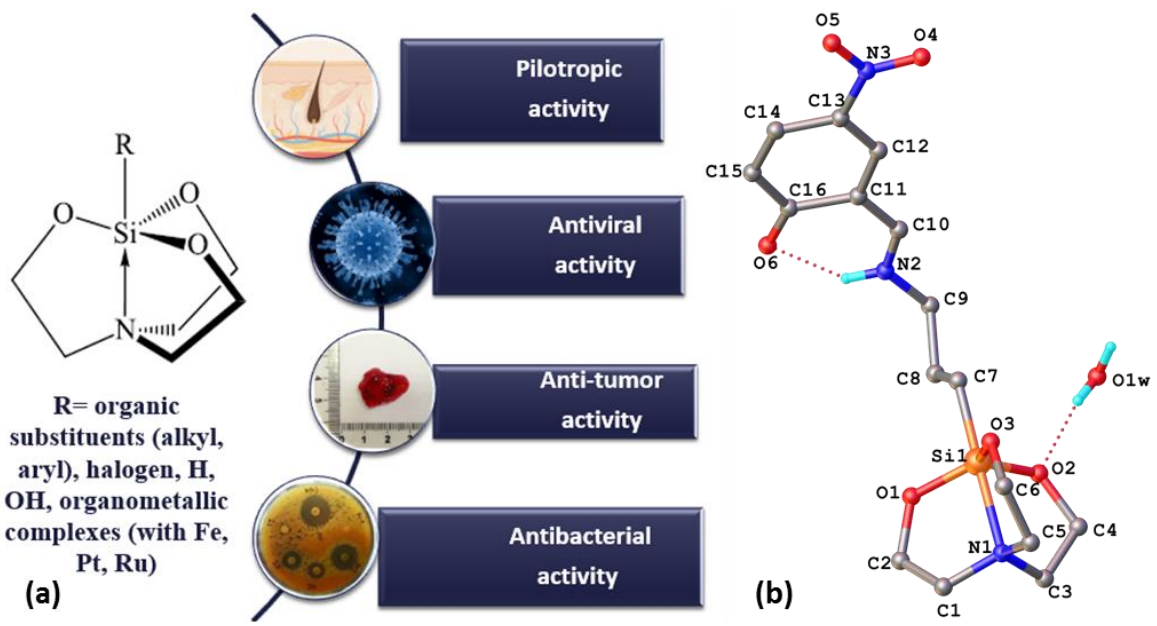


**Figure 1.** General structure and potential activity of silatranes (a); 1-(3-{[(2-hydroxy-5-nitrophenyl)methylidene]amino}propyl)silatrane (b).

Since in the design of new drugs, a convenient strategy is molecular hybridization - which integrates two or more pharmacophoric components in a single molecule, in this work a silatrane derivative was prepared and studied (**Figure 1b**), namely the Schiff base derived from 1-(3-aminopropyl)silatrane by condensing the latter with 5-nitro-salicylaldehyde, in a 1:1 ratio in a

mixture of acetonitrile/dichloromethane. Having in the structure two structural motifs of medicinal interest, silatranes and nitrosalicylaldimines, it became of interest to examine the *in vitro* effects of the compound on the development of harmful bacteria. It was found that it has stimulating effects at low concentrations and inhibitory effects at high concentrations. Also, the cytotoxicity of the silatrane derivative was studied at two concentrations on two cancer cell lines (hepatocarcinoma and breast adenocarcinoma), while cell viability was tested on a normal dermal fibroblast cell line, the compound showing viability even at high concentrations, compared to Cisplatin. The results obtained on cancer cell lines show that the silatrane-derived Schiff base has a pronounced cytotoxic effect, especially on the adenocarcinoma cell line (**Figure 2**) [4].

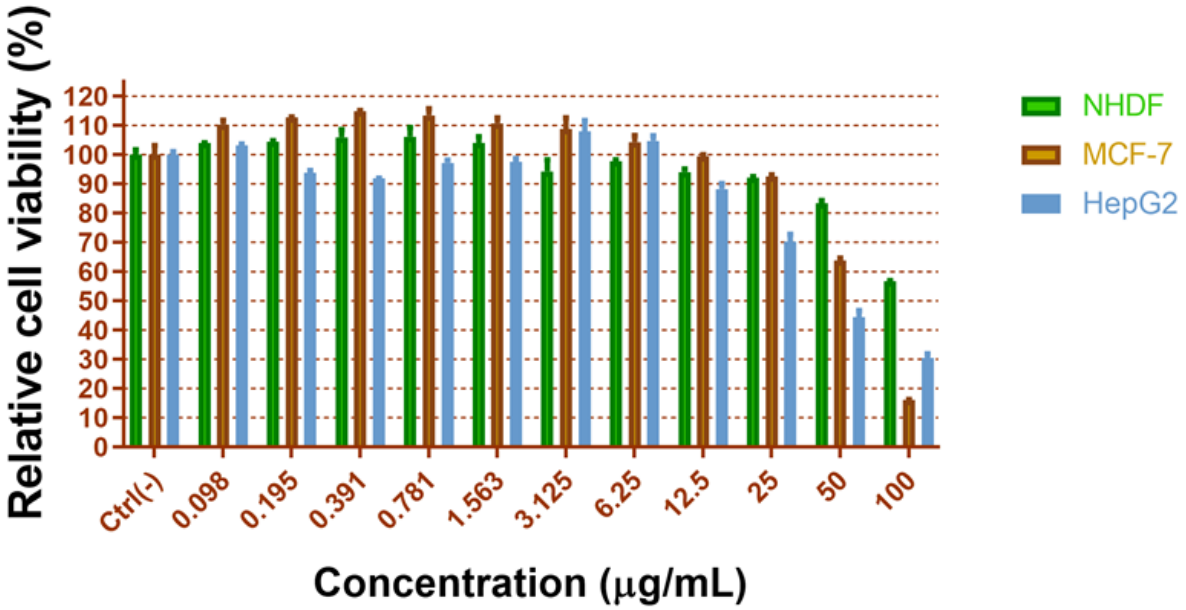


**Figure 2.** Effect of the silatrane derivative on studied cell lines, as a function of concentration.

Thus, it has been proven that silatrane derivatized as a Schiff base is a bioavailable drug-like compound with strong antibacterial and antiviral activity [4,5]. This approach has been successfully used to obtain and characterize novel silatrane hybrids suitable for biomedical applications, which will be discussed comparatively.

## References

[1] W. Bains, R. Tacke, *Curr Opin Drug Discov Devel*. 2003, 6(4), 526-543.
[2] S.N. Adamovich, E.K. Sadykov, I.A. Ushakov, E.N. Oborina, L.A. Belovezhets, *Mendeleev Commun.* 2021, 31, 204–206.
[3] J.G. Verkade, *Coord. Chem. Rev.* 1994, 137, 233-295.
[4] M.F. Zaltariov, M. Turtoi, D. Peptanariu, A.M. Macsim, L. Clima, C. Cojocaru, N. Vornicu, B.-I. Ciubotaru, A. Bargan, M. Calin, M. Cazacu, *Pharmaceutics*. 2022, 14(12), 2838.
[5] A. Bargan, M.F. Zaltariov, A. Vlad, M.C. Dumitriu, A. Soroceanu, A.M. Macsim, M. Dascalu, C.D. Varganici, M. Cazacu, S. Shova, *Arabian Journal of Chemistry.* 2020, 13(1), 3100-3111.

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# OC4. CHITOSAN-DEXTRAN MATRIX FOR DELIVERY OF CURCUMIN

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This study presents new materials consisting of chitosan (Chi) and dextran (Dex)/modified dextran (mDex) as matrices, with fillers such as lignin and curcumin. A comprehensive assessment of the physicochemical, mechanical, and morphological features of the materials was performed. Herein, both mechanical and biological (anti-inflammatory and antioxidant) properties, as well as the filler release kinetics are presented.

**Table 1.** Samples' formulation

| Component | Chitosan (g) | Dextran (g) | Modified dextran (g) | Lignin (g) | Curcumin (g) |
|---|---|---|---|---|---|
| *Chi-L* | *0.25* | | | *0.1* | |
| *Chi-Dex-L* | *0.25* | *0.1* | | *0.1* | |
| *Chi-mDex-L* | *0.25* | | *0.1* | *0.1* | |
| *Chi-L-Cu* | *0.25* | | | *0.1* | *0.1* |
| *Chi-Dex-L-Cu* | *0.25* | *0.1* | | *0.1* | *0.1* |
| *Chi-mDex-L-Cu* | *0.25* | | *0.1* | *0.1* | *0.1* |

According to **Figure 1**, Chi-Dex-L recorded the lowest value of diametral tensile stress (DTS), while Chi-mDex-L-Cu presented the highest value of DTS, followed by Chi-Dex-L-Cu material.

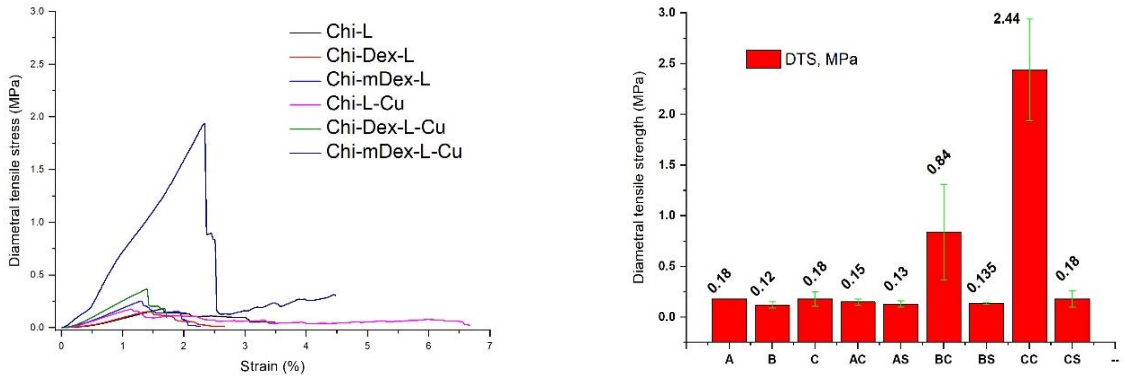


**Figure 1.** Diametral tensile stress *versus* strain (left) and DTS (right)

Thus, the interfacial interaction between the polymeric matrix and the added fillers is improved. More, curcumin's hydroxyl groups are prone to intermolecular interactions with the matrix polymers [1].

The antioxidant activity of materials, as evaluated using the ABTS assay, is shown in **Figure 2**. The presence of Dex into the matrix did not affect this biological property, whereas the replacement of Dex with mDex lightly decreased it. Our data show that Chi-L-Cu and Chi-L present very good antioxidant activity. This is due to the high content of phenolic hydroxyl groups in curcumin and lignin [2]. The inhibition degree of bovine albumin denaturation (**Figure 3**) of the studied materials has values between 11.9% (Chi-L) and 88% (Chi-Dex-L-Cu). The denaturation process involves alterations in electrostatic, hydrogen and hydrophobic bondings between the fillers and the matrix components.

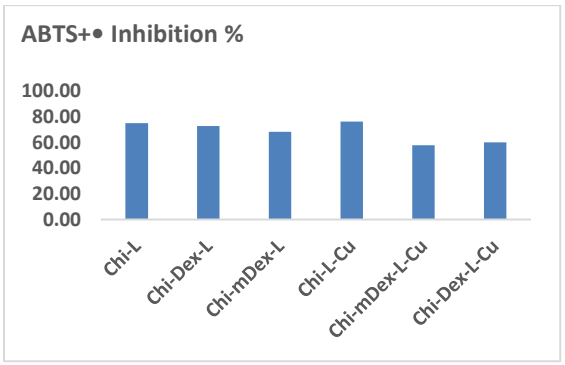


**Figure 2.** Antioxidant activity of the studied materials.

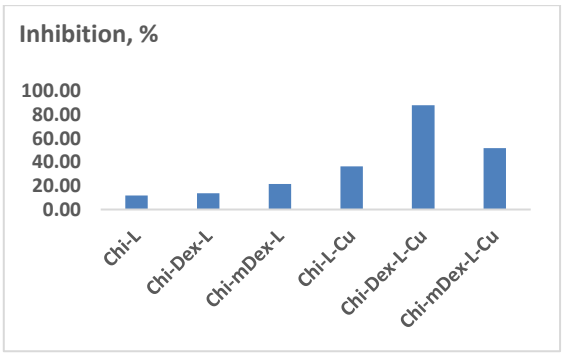


**Figure 3.** Anti-inflammatory activity of the studied materials.

*In vitro* curcumin release profiles (**Figure 4**) show that the Weibull model consistently provided the most accurate representation, with $R^2$ values ranging from 0.982 to 0.991. It means that the Cu attached to the materials' surface will be released quickly first, and the Cu contained in the material will be slowly released after the material swelling [3].

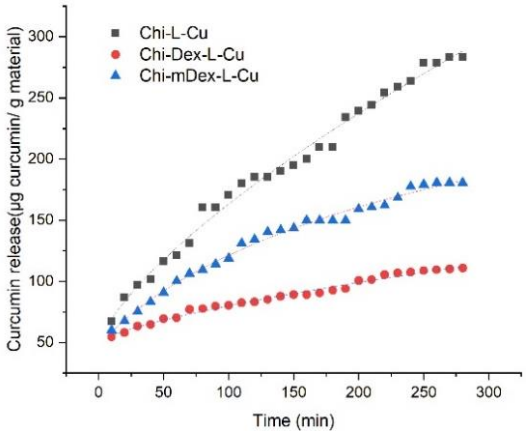


**Figure 4.** Curcumin release profile.

To conclude, the incorporation of Cu improved mechanical properties and also enhanced biological properties of developed materials. Consequently, the developed formulations have potential as carriers for hydrophobic drug delivery such as Cu.

## References

[1] M.G. Coscia, J. Bhardwaj, N. Singh, M.G. Santonicola, R. Richardson, V.K. Thakur, S. Rahatekar, *Ind. Crops Prod.* 2018, 111.
[2] H. Tang, Z. Han, C. Zhao, Q. Jiang, Y. Tang, Y. Li, Z. Cheng, *Prog. Org. Coat.* 2023, 177, 107445.
[3] G. Liu, S. Li, Y. Huang, H. Wang, Y. Jiang, *Chem. Eng. Sci.* 2016, 155, 405-414.

# OC5. SYNTHESIS, CHARACTERIZATION AND FLUORESCENT BEHAVIOR OF A CHEMOSENSOR BASED ON A DERIVATIVE OF PULLULAN AND BENZONITRILE

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The exopolysaccharide known as pullulan, is part of a class of polymers with many interesting attributes such as biocompatibility, biodegradability, film-forming capacity, antibacterial and antifungal activity, appropriate adhesion, antioxidant etc., widely used in a variety of applications. A key area of pullulan research has been its chemical modification by various methods (oxidation, sulfation, cationization, etherification, esterification, etc.) in order to improve its mechanical properties, antimicrobial properties, anticoagulant activity, pH sensitivity, solubility in solvents organic, as well as physico-chemical properties. These modifications expand pullulan's potential in areas like pharmaceutical and biomedical science, food industry, cosmetic industry, waste remediation [1]. There are currently two primary protocols used to selectively oxidize polysaccharides, one of which uses sodium periodate and the other the stable radical TEMPO in the presence of sodium hypochlorite and sodium bromide. In the case of the oxidation process of pullulan with sodium periodate ($NaIO_4$), a mild and selective reagent for oxidation, both ring opening and oxidation of specific C2 and C3 hydroxyl groups with the formation of two aldehyde groups on C2 and C3 are involved, which leads to polysaccharides with a controllable degree of oxidation and with valuable properties that allow expansion of application ranges. Pullulan oxidation with the TEMPO radical/NaBr/NaClO system leads to the formation of an acid type-derivative as the primary alcohol groups are turned into carboxyl groups. [2] It should be taken into account that there are situations where different ratios of certain oxidants and polysaccharides can lead to depolymerization [3].

The present paper reports the synthesis and characterization of a novel fluorescent pullulan derivative with superior characteristics, obtained by periodate oxidation of pullulan followed by a coupling reaction with an aromatic amine, 4-aminobenzonitrile (4-ABN). The obtained derivative was investigated by means of spectral analysis (FT-IR, $^1$H-NMR), thermal gravimetric analysis (TGA and DSC) and UV and fluorescence spectroscopies. The synthesized fluorescent compound was evaluated in detail as an efficient fluorescent chemosensor for various divalent and trivalent metal ions ($Na^+$, $Ag^+$, $Ca^{2+}$, $Pb^{2+}$, $Cr^{2+}$, $Mn^{2+}$, $Co^{2+}$, $Ni^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Cd^{2+}$, $Hg^{2+}$, $Al^{3+}$, $Fe^{3+}$) by the fluorescence technique. As could be seen in **Figure 1**, quenching experiments revealed a higher sensitivity, selectivity and binding ability for $Fe^{3+}$ ions (LOD = $0.996 \times 10^{-5}$ M) than for $Cu^{2+}$ ions (LOD= $1.791 \times 10^{-5}$ M). At a fixed ion concentration ($12 \times 10^{-5}$ M), best performance was achieved for $Fe^{3+}$ (fluorescence intensity was reduced by 95.97%), while for $Cu^{2+}$ the sensor performance was evaluated to be lower (75.93%) even with interference by high concentrations of other metal ions.

This behavior can be attributed to the formation of coordination compounds, more precisely to the electrostatic interaction between the lone pairs of electrons on the nitrogen atom of the end-on nitrile groups (–C≡N) in the polymer that can act as ligands in the interaction with the selected metal ions. In the presence of $Na^+$ ions, the response of the sensor was weakest (its fluorescence was quenched below 10%) and indicated a detection limit of 16.6 x $10^{-5}$ M. Fluorescence quenching occurred by both a dynamic process, following a linear Stern-Volmer relationship, and a simultaneous static and dynamic process.

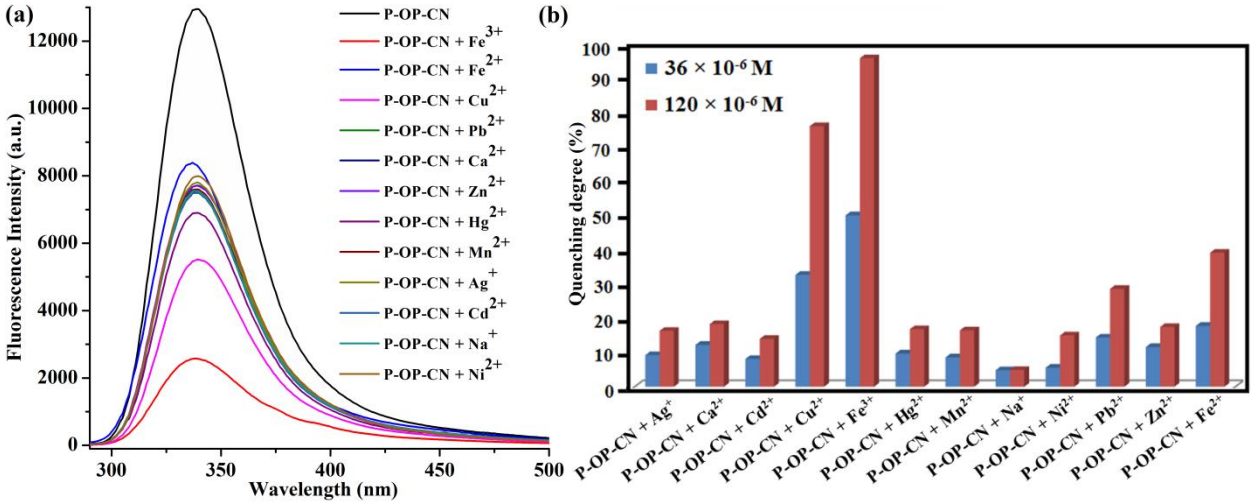


**Figure 1.** Quenching degree (%) of P-OP-CN+ metal ions solutions, at different concentrations.

The obtained results, along with simplicity of experimental procedures and biocompatibility of the sensor components, indicated that the derivative based on pullulan and benzonitrile could be recommended as highly sensitive chemosensor for $Fe^{3+}$ and $Cu^{2+}$ ions, capable to monitor delicate changes in varied environments.

## References

[1] C.K. de Souza, T. Ghosh, N. Lukhmana, S. Tahiliani, R. Priyadarshi, T.G. Hoffmann, S.D. Purohitf, S.S. Han, *Mater. Today Commun.* 2023, 36, 106477.

[2] G. Biliuta, S. Coseri, *Coord Chem Rev.* 2019, 383, 155-173.

[3] L. Münster, B. Hanulíková, M. Machovský, F. Latečka, I. Kuřitka, J. Vícha, *Carbohydr. Polym.* 2020, 229, 115503.

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# OC6. LUMINESCENT HYBRID LIQUID CRYSTALLINE SYSTEMS

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Nowadays, the research on luminescent hybrid liquid crystalline materials obtained by dispersion of different optical active nanomaterials into liquid crystalline (LC) phases have advanced greatly due to their synergistic properties with application in biomedicine [1,2] and LCDs [3]. The interest for these materials lies in understanding the interaction and chemical compatibility between the LC and nanomaterial and the way in which the liquid crystal guides the self-assembly of the nanomaterial, modulating the final proprieties of the composite/hybrid [4]. However, the studies involved various well-known commercially thermotropic and lyotropic organic liquid crystals that allowed a better understanding and an easier control of the changes induces (like nanomaterials orientation, molecular alignment of LC, photoluminescence etc.). To our knowledge, up to date, no research using metal containing liquid crystals (metallomesogens) was carried out. Taking this into consideration, we recently reported some materials composed by metallomesogens and carbon-based nanomaterials (CNT, graphene) as sensors for doxorubicin and bio-analytes detection [5-7]. Here, we present a luminescent hybrid system (**MIX**) composed by a room temperature metallomesogen (**Zn_MM**) based on a terpyridine type ligand and 3,4,5-trialkyl substituted gallate as co-ligands and N-doped carbon dots. The synthesis and characterization of **Zn_MM** was previously reported [8]. The hybrid material was obtained by ultrasonication of the components in 5:1 w/w ratio, in $CH_2Cl_2$, followed by evaporation of the solvent (**Figure 1**).

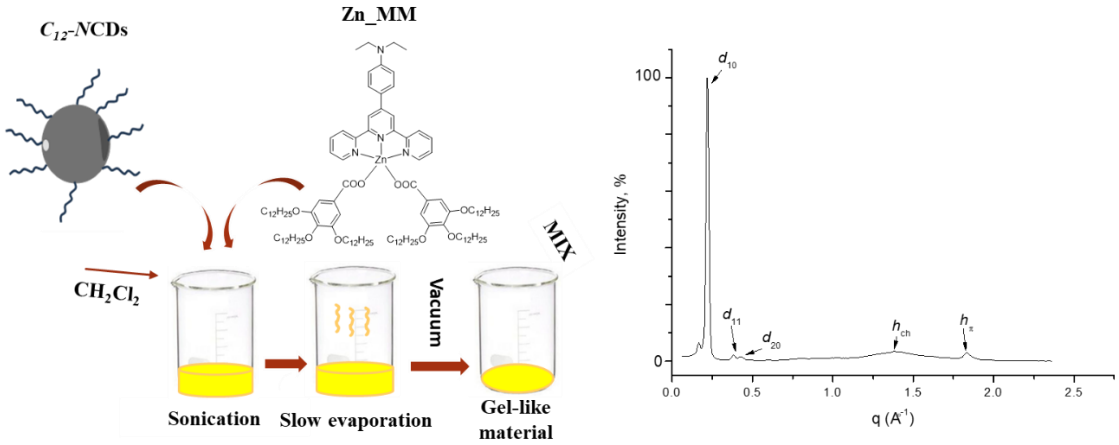


**Figure 1.** Schematic representation of the luminescent hybrid LC system (left) and S/WAX pattern of MIX at room temperature (right).

Using simple *N*CDs, the system obtained was not homogeneous, as observed by POM (polarized optical microscope) analysis. Therefore, we decorated the *N*CDs with long alkyl chains by amidation with dodecyl amine (***C12-N*CDs**), to ensure a better compatibility between the metallomesogen and carbon dots.

The precursors and the new material were characterized by FT-IR and $^{1}H$ and $^{13}C$ NMR and their mesomorphic and luminescent properties were investigated using POM with epifluorescence, DSC and S/WAXS studies. The thermal behavior of the hybrid material is different from its **Zn_MM** precursor (**Table 1**) and ***C$_{12}$-NCDs*** that is a white solid with a melting temperature of 107-109°C, supporting the formation of a new homogeneous hybrid material.

**Table 1.** DSC data of **Zn_MM** metallomesogen and **MIX** on second heating and cooling cycles.

| | Mesophases, transition temperatures (°C) and enthalpies (ΔH [J·mol-1]) |
|---|---|
| **Zn_MM** | $M_{hex}$ 182.5 [11.1] Iso / Iso 183.7 [10.2] $M_{hex}$ |
| **MIX** | Pristine waxy solid 41.7 [9.2] $Col_{x1}$ 65.3 [0.4] $Col_{x2}$ 99.4 [6.3] Iso / Iso 117.7 [0.6] $Col_{x3}$ 107.4 [5.4] $Col_{hex}$ |

S/WAXS studies evidenced that while **Zn_MM** organize into a 3D hexagonal columnar mesophase ($M_{hex}$) [8], the hybrid material **MIX** is organized into the common 2D columnar hexagonal phase ($Col_{hex}$) after one heating-cooling cycle.

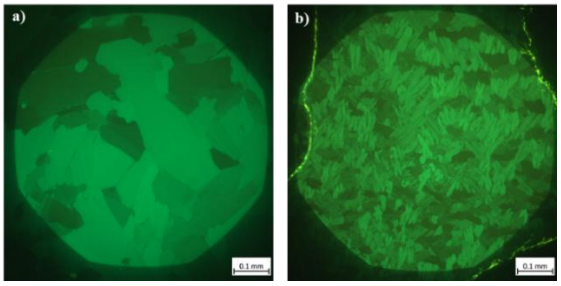


**Figure 2.** POM micrographs of a) **Zn_MM** and b) **MIX** at room temperature after the first heating and cooling cycle, magnification 20x, irradiated with 475 nm.

POM with epifluorescence observations (**Figure 2**) showed different textures with respect to **Zn_MM** and modified colour and luminescence intensities, respectively, that will be further discussed.

## References

[1] A. Bezrukov, A. Galeeva, A. Krupin, Y. Galyametdinov, *Int.J.Mol.Sci.* 2024, 25, 5520.
[2] A. Rastogi, F.P. Pandey, G. Hegde, R. Manohar, *J.Mol.Liq.* 2020, 304, 112773.
[3] Neha, G. Singh, S. Kumar, P. Malik, Supreet, *J.Mol.Liq.* 2023, 384, 122225.
[4] A. Roy, G. Pathak, J. Herman, S.R. Inamdar, A. Srivastava, R. Manohar, *Appl. Phys. A* 2018, 124(3), 273-280.
[5] S. Motoc Ilies, B. Schinteie, A. Pop, S. Negrea, C. Cretu, E.I. Szerb, F. Manea, *Nanomaterials* 2021, 11, 2788.
[6] S. Motoc, C. Cretu, O. Costisor, A. Baciu, F. Manea, E.I. Szerb, *Sensors* 2019, 19, 5353.
[7] S. Negrea, A.A. Andelescu, S. Ilies, C. Cretu, L. Cseh, M. Rastei, B. Donnio, E.I. Szerb, F. Manea, *Nanomaterials* 2022, 12, 4215.
[8] M. La Deda, G. Di Maio, A. Candreva, B. Heinrich, A.-A. Andelescu, E. Popa, E. Voirin, V. Badea, M. Amati, O. Costisor, B. Donnio, E.I. Szerb, *J. Mater. Chem. C* 2022, 10, 115–125.

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# OC8. COMPLEX POLYMERIC 3D STRUCTURES FOR DRUG RELEASE AND SKIN TISSUE REGENERATION

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**Introduction.** Wound healing, the physiological reaction to tissue injury, is a complex and dynamic biological process that activates the immune response to restore damaged tissue [1,2]. This process involves an intricate interaction among many cell types, cytokines, mediators, and the vascular system. In this regard, wound dressings are intended to enhance wound healing, encourage tissue development, and establish tissue regeneration without scarring. Over the past decade, regenerative medicine has concentrated on the obtaining of different scaffolds, such as 3D printed matrix, to improve skin wound healing [3]. 3D printing employs polymeric biomaterials, specifically natural polymers with high biocompatibility such as gelatin, alginate, xanthan gum or chitosan, or a blend of natural and synthetic polymers, along with crosslinking mechanisms to create a robust and viable structure tailored to the desired 3D scaffold architecture. GelMA (gelatin with methacryloyl side groups) has been extensively tested and characterized for its capacity to conduct covalent cross-linking under UV light, offering favorable cell stability and viability at low concentrations; nevertheless, it exhibits limited mechanical strength [4]. Additional modified biopolymers may be used to enhance the mechanical properties of the functionalized gelatin. This research presents the synthesis of three-dimensional complex polymeric structures utilizing functionalized biopolymers (such as gelatin, alginate, and xanthan gum) and bacterial nanofibrillar cellulose, designed for soft tissue healing, particularly in skin regeneration and the delivery of chemotherapeutic agents. Various ink formulations, comprising combinations of biopolymers and photo initiators, were printed or bioprinted utilizing an Inkredible$^+$ Cellink bioprinter on a nanofibrillar cellulose membrane.

**Methodology.** The biopolymers (gelatin, alginate) were modified using the approach outlined by Camci-Unal [5], with minor modifications of the protocol. In order to prepare inks, GelMA and AlMA (alginate with methacryloyl side groups) were combined in varying ratios, along with a specified quantity of LAP photoinitiator, according to the Table 1. The mixtures were then homogenized, printed using a Inkredible$^+$ Cellink bioprinter, on a nanofibrillar cellulose membrane and afterwards subjected to freeze-drying for further characterisation (54$^o$C; 0.07 mBar). Next, some of the polymer scaffolds were loaded with an active antitumoral principle, the model drug chosen being doxorubicin hydrochloride. This drug affects cell division because it possesses topoisomerase-II-inhibition properties and activity that determines the accumulation of oxygen-reactive species at levels that induce cellular damage.

Then, the scaffolds underwent to other several characterization methods to assess their morphology (stereoscopic and SEM microscopy), swelling behavior under two types of simulated physiological solutions (HBSS and DMEM), *in vitro* degradability, *in vitro* citocompatibility, wound healing capacity and drug release properties.

**Table 1.** 3D Printed Scaffolds Composition.

| Nr.Crt | Biopolymers | Polymer Ratio | Swelling degree (%) | |
|---|---|---|---|---|
| | | | HBSS | DMEM |
| **1.** | **GelMA** | 100 | solubilization | solubilization |
| **2.** | **GelMA_AlMA$_1$** | 25:75 | 322 ± 1.14 | 948 ± 0.64 |
| **3.** | **GelMA_AlMA$_2$** | 50:50 | 995± 1.30 | 1105 ± 1.24 |
| **4.** | **GelMA_AlMA$_3$** | 75:25 | 356 ± 1.02 | 830 ± 0.81 |

**Results and Conclusions.** Highly hydrophilic 3D double-layered structures, capable of swelling in biological simulation media and exhibiting bioadhesion to skin tissues, have been developed and biologically assessed. FT-IR spectroscopy demonstrates that methacrylic groups were covalently attached to the biopolymeric chains (gelatin, sodium alginate, and xanthan gum), which facilitate the polymers' crosslinking upon exposure to UV radiation. The fabricated 3D structures exhibit a progressively dispersed porosity and mechanical strength, demonstrating full form recovery in a hydrated condition post-compression, along with cytocompatibility when in contact with fibroblasts and keratinocytes. The Scratch Assay test shown a beneficial impact on the wound repair process, achieving complete closure after 48 hours of exposure, as observed in both fibroblast and keratinocyte cell cultures. The intricate scaffolds can load and regulate the release of chemotherapeutic agents (Doxorubicin). All this data supports the use of double-layered structures in cutaneous wound healing therapy.

## References

[1] R.Z. Murray, Z.E. West, A.J. Cowin, B.L. Farrugia, *Burns & Trauma*. 2019, 7, s41038-018-0139–7.
[2] H.A.Wallace, B.M.Basehore, P.M.Zito, Wound healing phases, *In:* StatPearls. StatPearls Publishing, Treasure Island (FL); 2023.
[3] K. Yu, X. Zhang, Y. Sun, Q. Gao, J. Fu, X. Cai, Y. He, *Bioactive Materials.* 2022, 11, 254–267.
[4] E.H.-P. De León, A.U. Valle-Pérez, Z.N. Khan, C.A.E. Hauser, *Current Opinion in Biomedical Engineering.* 2023, 26, 100450.
[5] G. Camci-Unal, D. Cuttica, N. Annabi, D. Demarchi, A. Khademhosseini, *Biomacromolecules*. 2013, 14, 1085–1092.

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# OC9. TOWARD A NEW INDOLO[2,3-*e*]BENZAZOCINE-BASED LIGAND AND ITS METAL COMPLEXES AS TUBULIN INHIBITORS

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Recently, a series of indole-containing analogues **2** of alkaloid latonduines 1 (**Figure 1**) have been reported as tubulin polymerization inhibitors, out of which 5,6,7,9-tetrahydro-8*H*-indolo[2,3-*e*]benzazocin-8-one (**2**, n = 2, R = H) was found to be the most potent compound, inhibiting the cell growth of several cancer cell lines in the lower nanomolar range [1]. Starting from this, our group has embarked in an ambitious project that aims investigating microtubule-destabilizing metal complexes based on such indolobenzazocines and analogues [2–5], which led to lead compound **3** (**Figure 1**) as the first reported transition metal complex to effectively bind to the tubulin–colchicine pocket.

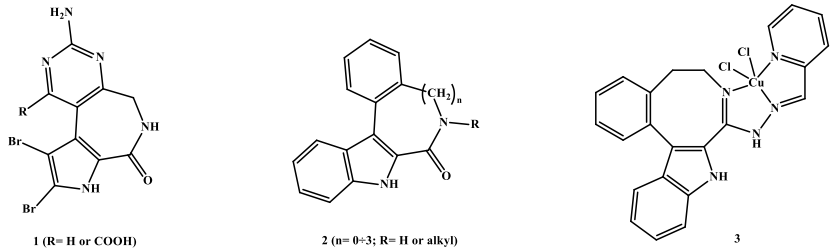


**Figure 1.** Structures of latonduines **1**, their indole-containing analogs **2** and lead compound **3.**

The design of new ligands for a second generation of complexes derived from indolobenzazocines began with a preliminary modelling that showed that placement of methoxy substituents either onto the indole fragment or onto the benzene ring would improve the biological activity of these complexes. The synthesis of one of these ligands up to the construction of the indolobenzazocine scaffold is presented in **Figure 2**. First, commercially available 3-methoxyphenylacetic acid **4** was iodinated in *ortho* position to the acetic acid side chain, the iodine-containing acid **5** was transformed into its ester **6**, which was reduced to the corresponding alcohol **7**. Next, conversion of alcohol **7** into its tosylate **8**, followed by one-pot replacement of the easily leaving tosyl group by azide and subsequent Staudinger-type reduction afforded amine **9**. At the same time, protection of the commercially available indole ester **10** with an methoxymethyls group gave intermediate **11**, which was hydrolysed to *N*-protected acid **12**. Coupling of amines **9** and acid **12** led to secondary amide **13**, whose substitution at the nitrogen atom with a *tert*-butoxy carbonyl (Boc) group yielded protected amide **14** as the intermediate for the benzoazocine ring closure as the key step in this reaction sequence. This transformation was accomplished *via* a Pd(0)-catalysed intramolecular Heck-type cyclization, and afforded indolobenzazocine **15** only with modest yields after repeated column chromatography separation.

Beside NMR spectroscopy, single crystal X-ray diffraction confirmed its structure. Simultaneous removal of both protecting groups under acidic conditions afforded indolobenzazocine **16**, whose further transformation (by thiolation, replacement of Sulphur with hydrazine, Schiff base formation) will produce the designed ligand after fourteen steps.

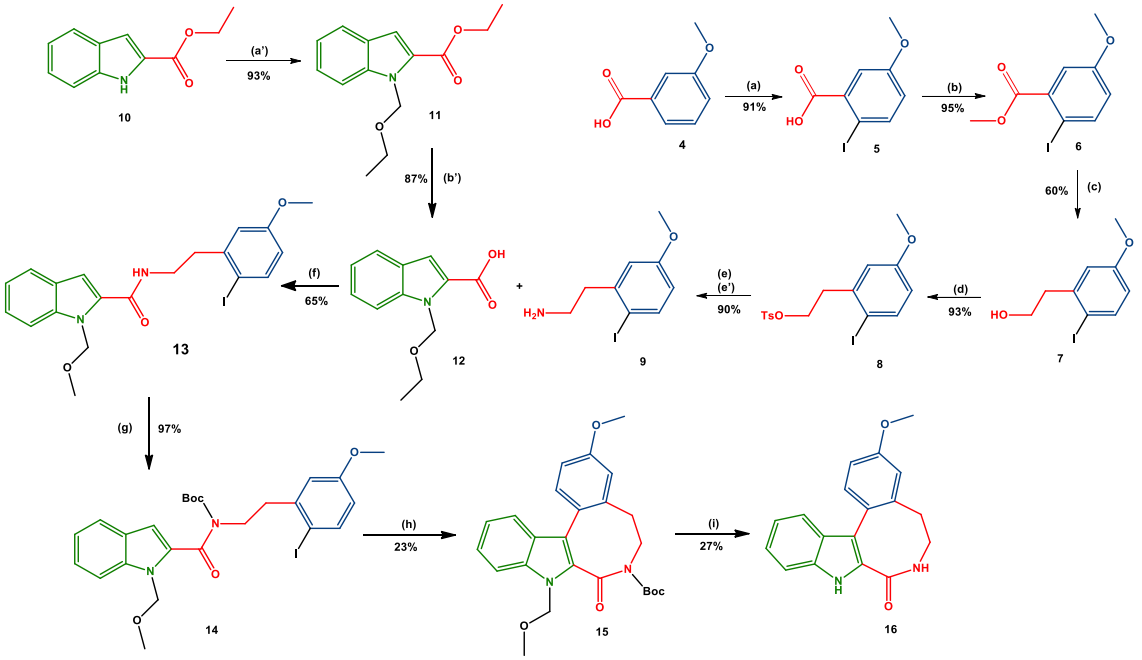

**Figure 2.** Synthetic pathway toward a new methoxy-substituted indolobenzazocine-based ligand. Reaction conditions: (a) *N*-iodosuccinimide, MeCN, TFA, dark, rt, 12 h; (b) $SOCl_2$, methanol, rt, 2 h, (c) $NaBH_4$, methanol–THF, reflux, 6 h, (d) 4-toluenesulfonyl chloride, $Et_3N$, DCM, rt, overnight; (e) $NaN_3$, NaI, DMF, 80 °C, overnight; (e′) $PPh_3$, diethyl ether, rt, overnight; (a′) chloromethyl ethyl ether, DMF, rt, overnight; (b′) $LiOH{\cdot}H_2O$, ethanol–water, reflux, 2 h; (f) DMAP, 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride, DCM, 0 °C, 4 h; (g) $Boc_2O$, 4-(dimethylamino)pyridine, MeCN, rt, 18 h; (h) $PPh_3$, $Ag_2CO_3$, $Pd(CH_3COO)_2$, DMF, argon atmosphere, 110 °C, 2 h, (i) HCl, dioxane, 80 °C, 2 h.

## References

[1] A. Putey, F. Popowycz, Q.-T. Do, P. Bernard, S.K. Talapatra, F. Kozielski, C.M. Galmarini, B. Joseph, *J. Med. Chem.* 2009, 52, 5916–5925.
[2] C. Wittmann, A.S. Sivchenko, F. Bacher K.K.H. Tong, N. Guru, T. Wilson, J. Gonzales, H. Rauch, S. Kossatz, T. Reiner, M.V. Babak, V.B. Arion, *Inorg. Chem.* 2022, 61, 1456–1470.
[3] C. Wittmann, F. Bacher, E.A. Enyedy, O. Dömötör, G. Spengler, C. Madejski, J. Reynisson, V.B. Arion, *J. Med. Chem.* 2022, 65, 2238–2261.
[4] I. Kuznetcova, M. Ostojić, N. Gligorijević, S. Aranđelović, V.B. Arion, *Inorg. Chem.* 2022, 61, 20445–20460.
[5] C. Wittmann, O. Dömötör, I. Kuznetcova, G. Spengler, J. Reynisson, L. Holder, G.J. Miller, E.A. Enyedy, R. Bai, E. Hamele, V.B. Arion, *Dalton Trans.* 2023, 52, 9964–9982.

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# OC10. POLYSACCHARIDE MATRICES FOR SKIN APPLICATIONS

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Polysaccharides-based materials are attracting attention due to their biodegradability, biocompatibility and low toxicity, making them ideal for biomedical and cosmetic uses [1,2]. This research was focussed on the obtaining of materials derived from guar (GU) and sulfate dextran (DexS) as matrix. Lignin (Li), lignin aspartate (LiAs) and *Rosa canina* (RC) extract, with potential applications in topical drug delivery were added. The resulted materials (Gu/DexS, Gu/DexS/RC, Gu/DexS/Li, Gu/DexS/Li/RC, Gu/DexS/LiAs, Gu/DexS/LiAs/RC) were obtained by casting method. The aqueous extract of RC used in this study contains 9% phenolic compounds, of which 7.5% are flavonoids. Tensile properties of the obtained materials were evaluated. It was found that (**Table 1**) the addition of LiAs increased the rigidity of the obtained materials. Thus, Gu/DexS/LiAs and Gu/DexS/LiAs/RC presented low values of elongation at break and breaking length due to the electrostatic interaction between aspartate group of lignin ester and polymeric matrix. The experimental data also revealed that presence of RC increases the Young's modulus values, which is a proof of existence of intra- or intermolecular interaction between the polymeric matrix and the extract.

**Table 1.** Tensile tests values of the obtained materials.

| Material | Mechanical Parameters | | |
|---|---|---|---|
| | **Elongation at break (mm)** | **Breaking length (MPa)** | **Young Modulus (MPa)** |
| *Gu/DexS* | *34.88±7.29* | *0.85±0.26* | *1.42±0.15* |
| *Gu/DexS/RC* | *25.19±9.80* | *1.27±0.10* | *3.18±0.96* |
| *Gu/DexS/Li* | *28.51±9.13* | *0.75±0.16* | *1.64±0.44* |
| *Gu/DexS/Li/RC* | *26.44±3.02* | *1.26±0.05* | *2.83±0.19* |
| *Gu/DexS/LiAs* | *20.34±1.09* | *0.67±0.32* | *2.00±0.86* |
| *Gu/DexS/LiAs/RC* | *23.78±3.11* | *1.49±0.17* | *3.74±0.08* |

The anti-inflammatory activity of the materials was investigated by the albumin denaturation assay method. According to the obtained data (**Figure 1**), Gu/DexS/RC, Gu/DexS/Li and Gu/DexS/Li/RC presented the highest percent of inhibition of egg albumin denaturation (61.58 %, 54.36 % and 48.70 %, respectively).

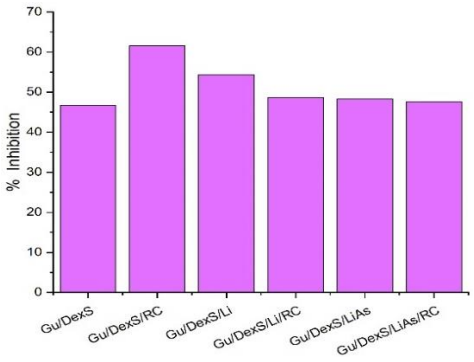


**Figure 1.** Anti-inflammatory activity.

Release kinetics of RC revealed that the Korsmeyer-Peppas model is adequate for fitting the experimental data ($R^2$ values of 0.962, 0.941 and 0.965 respectively) (**Figure 2**).

This one is commonly used to describe drug release kinetics from polymeric systems. The diffusion coefficient n, which indicates the transport of active principle, was less than 0.5 (0.47 and 0.31, respectively) for Gu/DexS/LiAs/RC and Gu/DexS/RC materials, suggesting quasi-Fickian diffusion. Gu/DexS/Li/RC material had n=0.74, indicating non-Fickian transport. This is attributed to several factors, including the intricate interactions between the diffusing molecules, as well as structural heterogeneity [4].

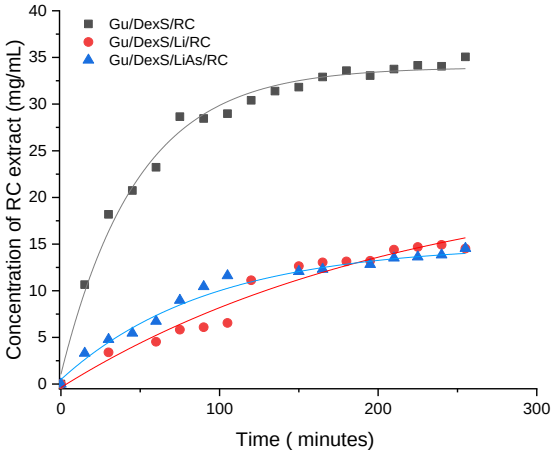


**Figure 2.** Korsmeyer-Peppas release kinetic graphs.

The presence of Li or LiAs causes a delay in the release of the RC from the polymeric matrices. This can be attributed to the formation of intramolecular interactions, such as hydrogen bonding or van der Waals forces, between RC molecules and the material components, which hinder the diffusion process.

Additionally, the irregular pore structures can restrict the movement of the active principle, further slowing its release. According to the experimental data, the presence of Li, LiAs and RC into materials composition increased their rigidity and improved anti-inflammatory activity. The RC release kinetics fitted well the Korsmeyer-Peppas model, with non-Fickian and quasi-Fickian diffusion, depending on the composition of materials. Additionally, the Gu/DexS/Li/RC and Gu/DexS/LiAs/RC materials exhibited a slower rate of RC release, making them advantageous by minimising the need for frequent applications on the skin.

## References

[1] B. Posocco, E. Dreussi, J. De Santa, G. Toffoli, M. Abrami, F. Musiani, M. Grassi, R. Farra, F. Tonon, G. Grassi, B. Dapas, *Materials.* 2015, 8(5), 2569-2615.
[2] D.B. Portes, L.W. Abeldt, C dos Santos Giuberti, D.C. Endriger, E.F. Pimentel, *In vitro toxicol.* 2024, 97, 105791.
[3] V. Průša, L. Trnka, *Appl. Eng. Sci.* 2023, 14, 100126.
[4] M.P. Paarakh, P.A. Jose, C. Setty, G.V.P. Christopher, *Int. J. Pharm. Res.* 2018, 10, 12-20.

# OC11. TWO-DIMENSIONAL COORDINATION POLYMER SENSITIVE TO ORGANIC SOLVENT VAPORS

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Volatile organic compounds (VOCs) are among the most harmful air pollutants, being ubiquitous in industrial and urban environments. These compounds readily evaporate into the atmosphere at room temperature and atmospheric pressure, being associated with severe negative effects on human health. Major sources of VOCs emissions include industrial solvents, construction materials, and the chemical industries, and the main classes of such compounds are: ketones, aldehydes, alcohols, phenols, ethers, and esters. Due to the large surface area of exposure, two-dimensional (2D) materials have stood out in a wide range of applications, from gas separation and storage to inert coatings and catalysis and high-performance sensors [1,2]. Their high sensitivity to even minimal surface chemical interactions generate remarkable changes in the electronic state of the material [3-5]. From the class of 2D materials, two-dimensional coordination compounds have the additional advantage to vary the composition through the constituent ligands and metal ions, while their layered structure allows easy access to the active centers.
In this work, a 2D coordination polymer, P1, was synthesized by the reaction of 1,3-bis(cyanopropyl)tetramethyldisiloxane (Cy) and $Co(SCN)_2$ in ethanol (**Figure 1**).

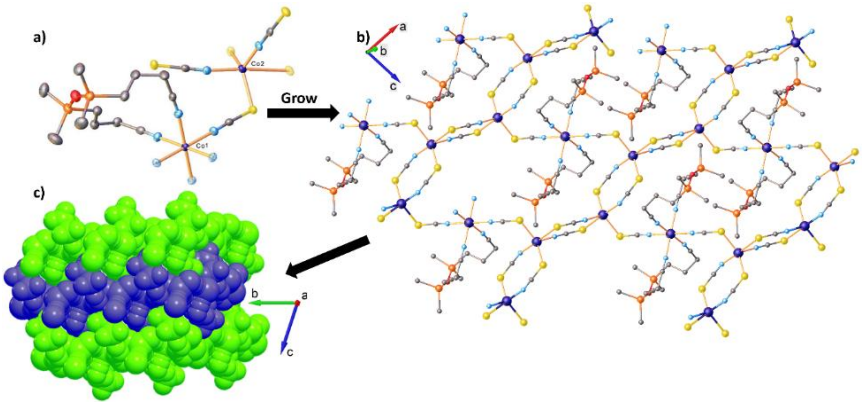


**Figure 1.** (a) Asymmetric unit of the coordination polymer P1, with hydrogen atoms removed for clarity; (b) 2D structure of the coordination polymer P1; (c) Supramolecular interactions in the crystal structure of polymer P1.

The SC-XRD analysis of the polymer P1 reveals the asymmetric unit consisting in a Cy ligand (in its *cisoid* form), two Co atoms, and three thiocyanate groups. The Co1 atom occupies a special position coinciding with the inversion center and exhibit an octahedral geometry. The Co2 atom occupies a general position, and it has a tetrahedral geometry. The Cy ligand coordinates to the Co1 atom, occupying the equatorial positions, while the thiocyanate counterion occupies the apical positions. The interaction between the Co1 and Co2 atoms is achieved through a thiocyanate bridge. Self-assembly of the asymmetric unit leads to a 2D structure. The presence of cobalt metal centers, fulfilling different functions, creates the prerequisites for this compound to present optical properties.

Depending on the solvent used, *i.e*, methanol, ethanol, THF, acetone, ACN, solutions of varying colors, ranging from pink to blue-green, are obtained (**Figure 2a**). These solvents were chosen due to their volatility, toxicity as well as their frequency of use in practice. UV-Vis measurements revealed acetonitrile to exhibit one of the highest molar extinction coefficients. By titrating the acetonitrile solution with different solvents, the color change occurs. In the case of titration with MeOH, a general hypochromic effect was observed. Moreover, the band at 562 nm disappears in the early stages of the titration, while the band at 649 nm underwent a hypsochromic shift up to 640 nm (**Figure 2b**). At the end of the titration, the solution changed its color from intense blue-green to pink. The colors for each titration step are illustrated in **Figure 2c**.

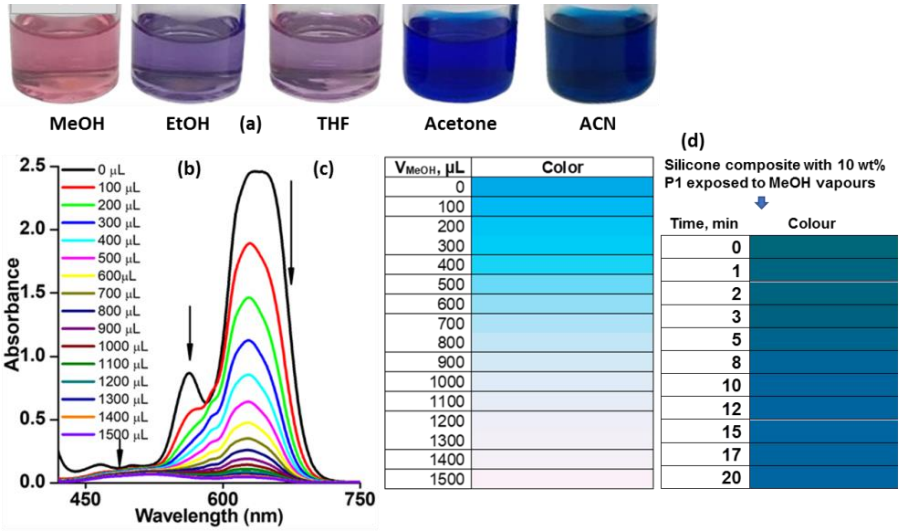


**Figure 2.** Solutions of the same concentration ($10^{-2}$ M P1) in different solvents, exhibiting various colors (a); titration of a P1 solution in ACN with MeOH: change in the UV-Vis spectrum (b) and corresponding color (c); MeOH vapor sensing by color change of silicone composite incorporating 10 wt P1 (d).

Coordination compounds of this type have proven to play the role of active elements in organic solvent vapor sensors. For efficiency and easier handling, they can be incorporated, in minimum quantities, in compatible polymer matrices, silicones being ideal (**Figure 2d**).

## References

[1] R. Mas-Balleste, C. Gomez-Navarro, J. Gomez-Herrero, F. Zamora, *Nanoscale*. 2011, 3, 20–30.
[2] W. Wang, W. Zhao, H. Xu, S. Liu, W. Huang, Q. Zhao, *Coord. Chem. Rev*. 2021, 429, 213616.
[3] M. Donarelli, L. Ottaviano, *Sensors*. 2018, 18, 3638.
[4] Y. Zhou, H. Yin, S. Ai, *Coord. Chem. Rev.* 2021, 447, 214156.
[5] Y. Ravi Kumar, Kalim Deshmukh, Tomáš Kovárík, S.K. Khadheer Pasha, *Coord. Chem. Rev.* 2022, 461, 214502.

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# Posters

# PP1. ENHANCING BIOPOLYMER BIODEGRADABILITY FOR FOOD PACKAGING APPLICATIONS THROUGH IRRADIATION AND NATURAL EXTRACTS INCORPORATION

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The growing environmental concern over plastic waste has intensified the search for sustainable alternatives to conventional petroleum-based plastics in various industries, especially food packaging. Biopolymers, derived from renewable resources such as cornstarch, cellulose, and polylactic acid (PLA), offer a viable solution as they are designed to degrade over time in natural environments [1]. However, their slow degradation rates, particularly in anaerobic environments like landfills, present a significant barrier to their widespread use [2]. Furthermore, as food packaging, biopolymers must meet multiple functional requirements: mechanical strength, barrier properties against moisture and gases, and often antimicrobial activity to ensure food safety and freshness. To address these needs while enhancing biodegradability, recent research has focused on modifying biopolymer structures through irradiation and incorporating natural extracts with bioactive properties [3,4]. The main objective of the present work was to present a comprehensive analysis of various methods used for enhancing the biodegradability and functionality of biopolymer-based food packaging through the incorporation of natural extracts and irradiation. By investigating the preparation and screening of bioactive medicinal plant extracts, this study aimed to determine how these natural additives could be used to improve the environmental breakdown and protective qualities of biopolymer materials. Additionally, the research focused on the role of irradiation as a tool to modify the polymer structure, making it more susceptible to microbial degradation and enhancing its compatibility with sustainable packaging applications. Irradiation is a physical process that involves exposing materials to ionizing radiation, such as gamma rays, electron beams, or X-rays. This technique can induce significant molecular changes in biopolymers, primarily through chain scission, which breaks long polymer chains into smaller, lower-molecular-weight segments. These changes increase the material's surface area and porosity, making it more susceptible to microbial and enzymatic degradation [5,6]. The ionizing radiation interacts with the polymer chains, creating free radicals that initiate chain scission. The extent of degradation depends on the irradiation dose, polymer type, and environmental conditions. Lower doses may only slightly affect molecular weight, while higher doses lead to more pronounced degradation. Selecting an optimal dose is critical to balance biodegradability with the material's structural integrity. Studies have demonstrated that irradiated biopolymers decompose faster in composting and soil environments, showing a marked improvement over non-irradiated materials [6]. When applying irradiation to food packaging, maintaining safety is essential. The treatment must not produce harmful degradation byproducts that could leach into food. Natural extracts such as rosemary, green tea, caffeine, curcumin, garlic, and clove, have been widely studied for their bioactive properties, including antimicrobial and antioxidant effects.

These extracts are particularly valuable in food packaging, where preventing spoilage and extending shelf life are primary goals. Incorporating them into biopolymer matrices provides a means to enhance functionality and promote biodegradability [7]. Essential oils and extracts from plants contain active phenolic compounds, which can inhibit the growth of bacteria and fungi. When embedded in biopolymers, these compounds create an antimicrobial surface that reduces the growth of pathogens, potentially extending the shelf life of perishable foods. This "active packaging" feature could be beneficial in reducing food waste and enhancing food safety. Natural extracts are also rich in antioxidants, which can prevent oxidative spoilage in foods. This activity could help delay the degradation of packaged foods by protecting against the adverse effects of oxygen and light exposure, providing a dual benefit by enhancing both food stability and packaging performance. Studies suggest that natural extracts may also contribute to faster degradation rates [8]. Certain compounds in these extracts attract microbial activity, promoting breakdown when disposed of in soil or compost. The degradation-promoting properties may vary based on extract concentration, type of biopolymer, and environmental conditions, highlighting the need for tailored formulations for specific applications. The combination of irradiation and natural extracts offers a synergistic effect, enhancing both the degradability and functional properties of biopolymers. Irradiation generates free radicals and active sites in the polymer chains, which allows natural extracts to interact at a molecular level, intensifying their effect on degradation rates. Additionally, the physical changes caused by irradiation, such as increased porosity, allow for greater exposure of the embedded bioactive compounds, enhancing their antimicrobial and antioxidant efficacy. This synergy ensures a quicker breakdown of packaging in the environment while maintaining the packaging's protective qualities during use. This balance between enhanced degradability and functionality is ideal for single-use food packaging. Both, the irradiation and natural extract incorporation in biopolymer-based packaging represent a promising path toward developing sustainable materials for food packaging. This dual approach addresses two major challenges: enhancing biodegradability for environmental benefit and adding functional properties that support food preservation. Irradiation effectively modifies the polymer matrix, reducing molecular weight and creating structural changes that make the material more susceptible to microbial attack. Simultaneously, incorporating natural extracts introduces bioactive properties, such as antimicrobial and antioxidant activity, which can extend the shelf life of packaged foods and reduce spoilage.

## References

[1] W. Ali, H. Ali, S. Gillani, P. Zinck, S. Souissi, *Environ. Chem. Lett.*, 2023, 21, 1761–1786.
[2] M. M. Reddy, S. Vivekanandhan, M. Msra, S. K. Bhatia, A. K. Mohanty, *Prog. Polym. Sci.*, 2013, 38(10-11), 1653-1689.
[3] P. Ezti, A. Khan, R. Priyadarshi, T. Bhattacharya, S. K. Tammina, J.-W. Rhim, *Food Hydrocol.*, 2023, 142, 108771.
[4] D. Dutta, N. Sit, *J. Food Sci. Technol*., 2023, 60(7),1888-1902.
[5] E. C. Grosvenor, J. C. Hughes, C. W. Stanfield, R. L. Blanchard, A. C. Fox, O. L. Mihok, K. Lee, J. R. Brodsky, A. Hoy, A. Uniyal, M. et al. *Appl. Sci.*, 2022, 12(4), 1819.
[6] I. Parveen, M. I. Mahmud, S. C. Das, R. A. Khan, H. M. Cho, *Mater. Circ. Econ.* 2024, 6, 47.
[7] A. M. Musuc, M. Badea-Doni, L. Jecu, A. Rusu, V. T. Popa *J.Therm.Anal.Calorim.* 2013, 144, 169-177.
[8] S. Sheibani, S. Jafarzadeh, Z. Qazanfarzadeh, M.M. J. O. Wijekoon, N. H. M. Rozalli, A. M. Nafchi, *Int.J.Biol.Macromol.* 2024, 267, 131537.

# PP2. HYBRID CRYOGELS AS DERMAL DRUG DELIVERY SYSTEMS

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Cryogels have received tremendous attention in applications targeting the controlled release of active principles and tissue engineering of the skin, considering their large pore size, increased elasticity, and heightened strength attributed to the presence of crystalline regions [1]. Poly(vinyl alcohol) (PVA) is one of the most investigated water-soluble synthetic polymers for obtaining cryogels, with applications as a drug carrier, in wound dressings due to its biocompatibility and non-toxicity [2,3]. The use of pure PVA-based cryogels as a biomaterial is limited by the absence of bioactivity and inertia in the healing process of skin wounds [4]. To overcome these limitations, combining them with other materials or compounds with antimicrobial properties and/or stimulatory effects on growth factors is a promising approach for wound healing [5]. The present study aims to obtain PVA/poly(ethylene brassylate-co-squaric acid) (PEBSA)/dextran (Dex) cryogels incorporated with amoxicillin (Amx) inclusion compounds as wound dressings and controlled delivery of antimicrobial agents.

The preparation of hybrid cryogels based on PVA_PEBSA_Dex_Amx was carried out in stages, with the first stage focused on obtaining the PEBSA_Dex_Amx network. This was achieved by individually preparing the PEBSA solution (0.016 g/mL in 1,4-dioxane) with Amx, respectively the Dex solution (10%, w/v) and mixing in a PEBSA: polysaccharide volumetric ratio of 1:3. The multicomponent hybrid systems were formed by adding the PVA solution (4%, w/v) and subjecting to multiple freeze-thaw cycles to create the second network (**Figure 1a**). The physicochemical properties of the cryogels, in terms of their chemical composition, network morphology, enzymatic degradability, and release profiles of Amx in simulated physiological conditions, were studied. The antimicrobial activity screening of the samples was investigated against four different reference strains: *Staphylococcus aureus* ATCC® 25923 (*S. aureus*), *Escherichia coli* ATCC® 25922 (*E. coli*), *Klebsiella pneumoniae* ATCC® 10031 (*K. pneumoniae*), and *Enterococcus faecalis* ATCC® 29212 (*E. faecalis*).

The FT-IR spectroscopy data confirm the blend preparation and the presence of intermolecular hydrogen bonds. SEM images of the freeze-dried cryogels showed that the three-dimensional networks consist of porous structures with interconnected pores. SEM analysis also confirmed the encapsulation of Amx within the polymer network, attributed to the hydrophobic affinity between the PEBSA amphiphilic copolymer and the antibiotic. A gradual degradation rate was observed, extending over a period of twenty-eight days. The potential of PVA_PEBSA_Dex matrices to encapsulate and release Amx through diffusion in a controlled manner under *in vitro* conditions has been demonstrated (**Figure 1b**).

The PVA_PEBSA_Dex_Amx systems exhibited antimicrobial activity against *S. aureus*, *E. coli*, and *K. pneumoniae* (**Figure 1c**). The significant potential of the investigated systems needs to be extensively evaluated by additional studies, *in vitro* and *in vivo*, with a focus on possible toxicity concerns and their applicability in the management of skin wounds.

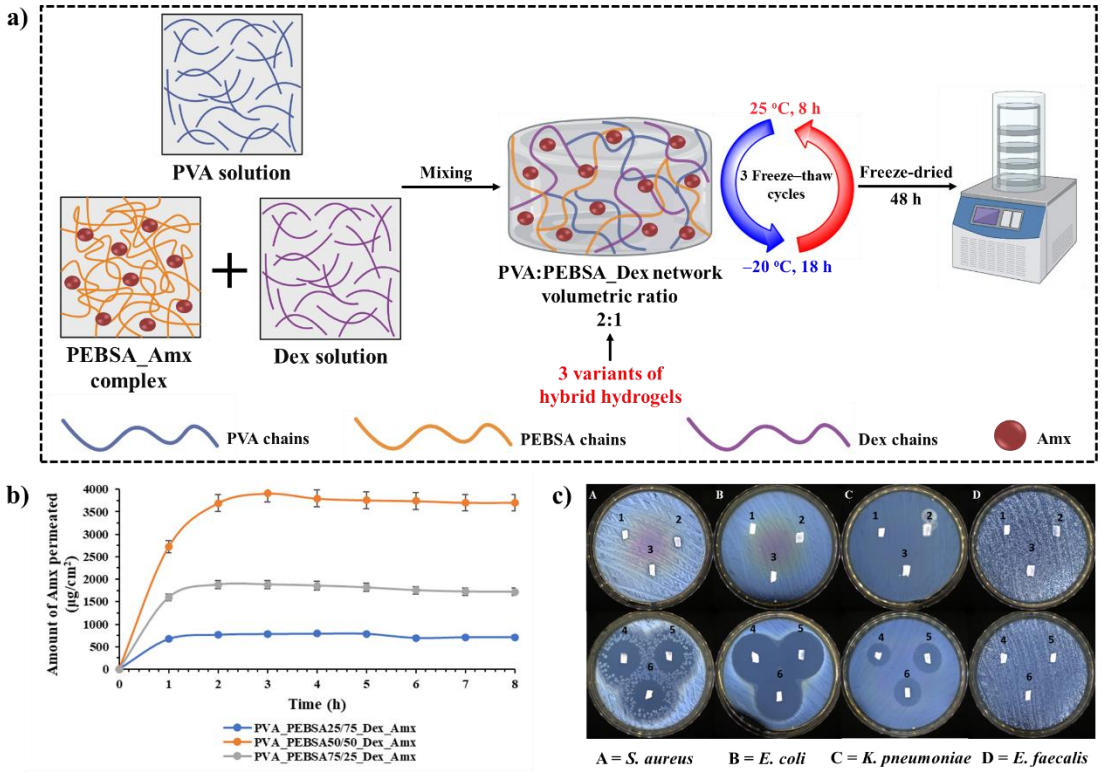


**Figure 1.** a) Schematic illustration of the preparation of hybrid cryogels by F-T method; b) *in vitro* drug release; c) antimicrobial activity of the tested samples: (1) PVA_PEBSA$_{25/75}$_Dex, (2) PVA_PEBSA$_{50/50}$_Dex, (3) PVA_PEBSA$_{75/25}$_Dex, (4) PVA_PEBSA$_{25/75}$_Dex_Amx, (5) PVA_PEBSA$_{50/50}$_Dex_Amx, (6) PVA_PEBSA$_{75/25}$_Dex_Amx against *S. aureus*, *E. coli*, *K. pneumoniae*, and *E. faecalis*.

## References

[1] A. Haleem, S.-Q. Chen, M. Ullah, M. Siddiq, W.-D. He, *J. Environ. Chem. Eng.* 2021, 9, 106510.
[2] A. Aslanli, N. Stepanov, T. Razheva, E.A. Podorozhko, I. Lyagin, V.I. Lozinsky, E. Efremenko, *Materials* 2019, 12, 3619.
[3] M. Wang, J. Bai, K. Shao, W. Tang, X. Zhao, D. Lin, S. Huang, C. Chen, Z. Ding, J. Ye, *Int. J. Polym. Sci.* 2021, e2225426.
[4] L.E. Nita, B.-E.-B. Cretu, A.-M. Serban, A.G. Rusu, I. Rosca, D. Pamfil, A.P. Chiriac, *React. Funct. Polym.* 2023, 182, 105461.
[5] Z. Pan, H. Ye, D. Wu, *APL Bioeng.* 2021, 5, 011504.

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# PP3. POLY(VINYL ALCOHOL)/POLYURETHANE-BASED HYDROGELS FOR THIAMINE RELEASE

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Hydrogels are versatile materials constituted of physical or chemical crosslinked polymer chains into a three-dimensional (3D) network structure, able to absorb and retain a high amount of water or other fluids (up to 99.9%). Their porous network structure, non-toxicity, and good biocompatibility make the hydrogels appropriate for various biomedical applications, such as drug carriers, wound dressings, tissue engineering, and regenerative medicine [1,2].

Poly(vinyl alcohol) (PVA), as one of the most important water-soluble polymers, is of great interest for many applications. Due to the large number of hydroxyl groups in each repeating unit of its structure, PVA can form either chemically or physically crosslinked gels with a stable structure and good mechanical strength. On the other hand, water-soluble polyurethane (PU) hydrogels are very attractive hemocompatible and biocompatible materials, but they present poor hydrophilicity and poor mechanical properties [3].

In the present work, composite hydrogels were prepared by using PVA and two polyurethane structures (PU): one includes lysine-di-isocyanate (PU1) and the other uses hexamethylene di-isocyanate (PU2) as the NCO component. Two sets of hydrogels were formulated by varying the ratio between PVA and PU, from 0-100%. The obtained hydrogels were characterized from the morphological, structural, and rheological point of view. Also, the swelling behavior and the release of thiamine in simulated physiological conditions at 37°C were monitored. Amplitude sweep tests were carried out to determine the upper strain amplitude values ($\gamma_L$) limiting the linear domain of viscoelasticity. In the linear range of viscoelasticity, G′ and G″ were independent of the applied strain ($\gamma$), as shown in **Figure 1** for PVA, PU1, and PU2 samples.

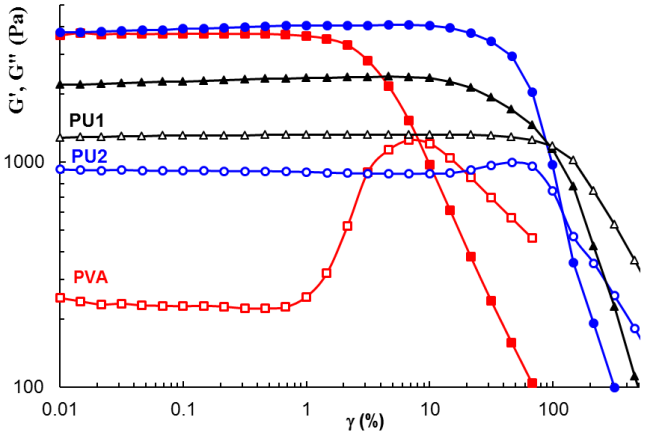


**Figure 1.** The viscoelastic moduli as a function of strain for PVA and PU hydrogels (37°C).

**Figure 2** presents the data obtained for PVA/PU1 hydrogel (50/50 wt.) in the oscillatory step strains experiments (for ω = 10 rad/s), when the strain values were successively switched each 300 s from a low amplitude (γ = 1%, in the linear range of viscoelasticity) to a high amplitude value and again to a low γ value of 1%. The viscoelastic parameters (G′, G″, and tanδ) were registered as a function of time in order to monitor the ability of each sample to restore their structure after applying high deformations. The following strains were chosen in the nonlinear viscoelastic regime: 50%, 100%, 300%, 500%, and 1000%, and in these conditions, a liquid-like behavior was registered (G′ became lower than G″ and tanδ > 1). The sample showed nearly complete recovery after applying high deformations, and the time required for structure recovery was very short (on the order of a few seconds).

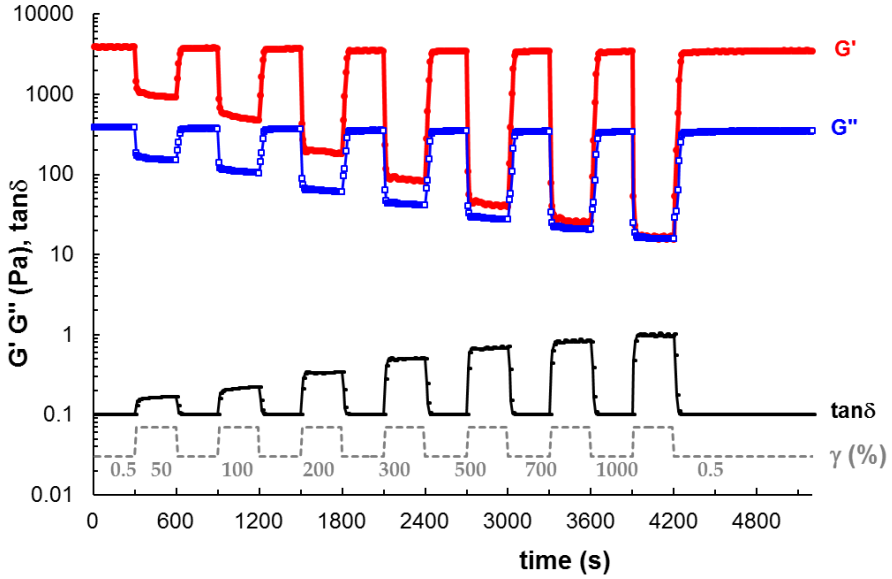


**Figure 2.** Illustration of self-healing behavior of PVA/PU1 composite hydrogel at 37°C.

The PVA/PU hydrogels were loaded with thiamine and the release of active compound from the polymeric matrix was investigated in PBS buffer solution (pH = 7.4). The composite hydrogels appear as promising materials for wound dressing applications.

## References

[1] H. Xu, Y. Zhang, J. Ma, H. Miao, S. Chen, S. Gao, H. Rong, L. Deng, J. Zhang, A. Dong, S. L, *Acta Biomater*. 2024, 181, 235–248.

[2] I. Carayon, P. Szarlej, P. Gnatowski, E. Piłat, M. Sienkiewicz, M. Glinka, J. Karczewski, J. Kucinska-Lipka, *Adv. Med. Sci.* 2022, 67, 269–282.

[3] M. Mandru, M. Bercea, L.M. Gradinaru, C. Ciobanu, M. Drobota, S. Vlad, R. Albulescu, *Eur. Polym. J.* 2019, 118, 137–145.

# PP5. DESIGN, SYNTHESIS, AND ANTICANCER POTENTIAL OF NOVEL FUSED HETEROCYCLIC COMPOUNDS

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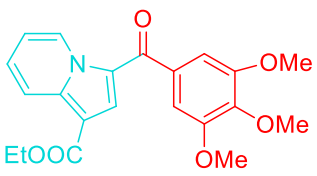
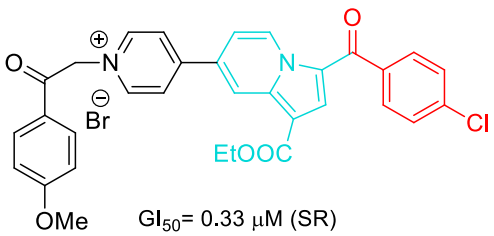
Among a large number of microtubule-targeting agents with diverse scaffolds investigated during the last decades, Phenstatin stands out as one of the simplest molecules that significantly inhibit tubulin polymerization by binding to the colchicine site of tubulin. Phenstatin is also known for its outstanding antitumor activities on a wide variety of human cancer cells. In the process of drug discovery, these kinds of compounds are lead scaffolds for the development of improved bioactive analogues, and Phenstatin continues to be a source of inspiration for researchers in designing new potential anticancer drugs.

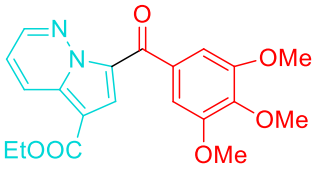
At the same time, fused heterocyclic structures are fundamental in pharmaceutical chemistry because they form the backbone of many bioactive compounds. Their rigidity and complexity often lead to increased binding affinity with biological targets, which is why they are highly investigated for drug design. Indolizines, in particular, are bicyclic heteroaromatic compounds where a five-membered pyrrole ring is fused to a six-membered pyridine ring. This fusion gives indolizinic derivatives with unique electronic properties that make them versatile scaffolds in medicinal chemistry. Thus, indolizines and other fused heterocycles were used by our group to replace the cycle A of Phenstatin (**Figure 2**), and the synthesized analogues proved a broad spectrum of growth inhibitory activity against cancer cell lines and good inhibitory properties of tubulin polymerization (**Figure 1**) [1-2].




$GI_{50}$ < 10 nM (MDA-MB-435)
$GI_{50}$= 23 nM (SR)
$GI_{50}$= 27 nM (A498)




$GI_{50}$= 0.33 μM (SR)
$GI_{50}$= 1.38 μM (SW-620)
$GI_{50}$= 1.40 nM (RXF-393)
$GI_{50}$= 1.40 nM (MCF7)




$GI_{50}$= 31 nM (MDA-MB-435)
$GI_{50}$= 46 nM (SR)
$GI_{50}$= 47 nM (A498)

**Figure 1.** Reported anticancer fused heterocycles Phenstatin analogues

The research involving azaindoles is particularly exciting due to their diverse pharmacological activities, including anticancer, anti-inflammatory, and CNS-related effects. Their ability to modulate key biological targets makes them promising candidates for the development of new drugs, particularly in areas like oncology and neurology [3-4]. In this context, our study centered on the design and synthesis of new Phenstatin analogues having the 3'-hydroxy-4'-methoxyphenyl ring replaced with a pyrroloindolizine skeleton as it is shown in **Figure 2**.

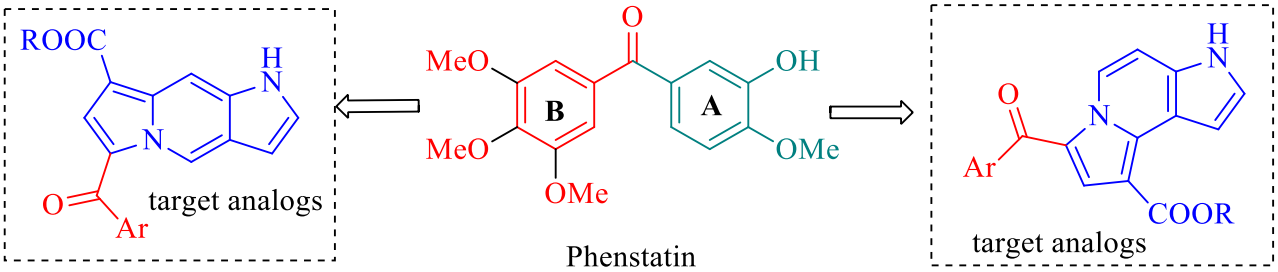



**Figure 2.** Target azaindolizine analogues of Phenstatin

Using a [3+2] cycloaddition approach as the key step, we generated a series of pyrroloindolizine structures starting from quaternary salts derived from 5-azaindole, aiming to explore their anticancer potential. The structures of the new compounds were confirmed using spectral methods (NMR, IR). The new intermediate quaternary pyridinium salts have already been tested for their anticancer activity at the National Cancer Institute (NCI, US) against a panel of 60 human tumor cell lines and the results are discussed herein.

## References

[1] L. Popovici, R.M. Amarandi, I.I. Mangalagiu, V. Mangalagiu, R. Danac, Synthesis molecular modelling and anticancer evaluation of new pyrrolo[1,2-b]pyridine and pyrrolo[2,1-a]phthalazine derivatives, *J. Enz. Inhib.* 2019, 34 (1), 230-243.

[2] M.C. Sardaru, A.M. Craciun, C.M. Al Matarneh, I.A. Sandu, R.M. Amarandi, L. Popovici, C.I. Ciobanu, D. Peptanariu, M. Pinteala, I.I. Mangalagiu, R. Danac, Cytotoxic substituted indolizines as new colchicine site tubulin polymerisation inhibitors, *J. Enz. Inhib.* 2020, 35(1), 1581-1595.

[3] D. Amariucai-Mantu, V. Antoci, M.C. Sardaru, C.M. Al Matarneh, I.I. Mangalagiu, R. Danac, *Phys. Sci. Rev.* 2023, 8(9), 2583-2645.

[4] N. Ramalakshmi, S. Amuthalakshmi, R. Yamuna, A. Smith, S. Arunkumar, *Der. Pharma. Chem.* 2021, 13(2), 60-69.

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# PP6. FERRITE/PVDF COMPOSITE MEMBRANES WITH HIGH PHOTOCATALYTIC PROPERTIES

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Water stands as one of the most vital resources on our planet. Despite its importance, the quality of drinking water has been deteriorated in recent decades due to human activities and global climate change. Numerous hazardous substances, including pathogens, inorganic and organic pollutants, radioactive materials, and more, are directly discharged into water bodies [1]. The development of new hybrid photocatalytic nanomaterials for purification and environmental protection technologies represents one of the most attractive scientific domains in water purification. However, polymer-based membranes commonly used for such applications lack photoactive elements. Ongoing research aims to develop hybrid composite membranes that offer stability, flexibility, high mechanical strength, and recyclability while incorporating photocatalytic nanoparticles [2]. Poly(vinylidene fluoride) (PVDF) is a prominent hydrophobic polymer support in wastewater treatment due to its outstanding thermal stability, mechanical durability, chemical resistance, and selective permeability [3]. Recent studies highlight multiple nanostructured material synthesis methods. Electrospinning stands out for creating hybrid materials with high surface area, aspect ratio, low density, and high pore volume, enhancing electrode and electrolyte materials in membrane systems [2, 4].

In this regard, the remarkable photocatalytic characteristics $ZnAlFe_{0.94}Sm_{0.06}O_4$ (ZFAS) were demonstrated [5] and the nanoparticles were used as filler for the preparation of PVDF-based composite membranes (ZFAS/PVDF). The composite membranes with filler concentrations of 10 and 20% were produced utilizing the electrospinning technique. The materials were characterized by different techniques, such as X-ray diffraction, transmission electron microscopy, dynamic vapor sorption method, vibrating sample magnetometry, and standardized mechanical tests. To determine the photocatalytic properties of the prepared materials, typical photocatalytic tests were performed by using a model pollutant (methylene blue). The kinetic analysis assessed the performance of catalytic composite membranes at various ratios for MB dye photodegradation under visible light. A simple photolysis test of MB was conducted for comparative purposes. The experimental data were fitted to the pseudo-first-order (PFO) kinetic model via nonlinear regression. The kinetic model (PFO) parameters, shown in **Table 1**, identify 10ZFAS/PVDF as the optimal composite membrane when used at a ratio of 0.50% w/v. This setup yielded the highest rate constant value.

**Table 1.** The kinetic data of PVDF-based materials

| Sample | Material Dose (% w/v) | $k$ (min$^{-1}$) | $\varepsilon^2$ |
|---|---|---|---|
| - | Photolysis test | $6.689 \times 10^{-4}$ | 0.021 |
| *10ZFAS/PVDF* | 0.25 | $2.402 \times 10^{-3}$ | 0.301 |
| *10ZFAS/PVDF* | 0.50 | $5.413 \times 10^{-3}$ | 0.872 |
| *20ZFAS/PVDF* | 0.25 | $3.428 \times 10^{-3}$ | 0.403 |
| *20ZFAS/PVDF* | 0.50 | $4.267 \times 10^{-3}$ | 0.438 |

Understanding the mechanism of photocatalysis is essential for optimizing reaction efficiency [6, 7]. By applying chemical scavengers in trapping studies, the mechanisms of photodegradation in organic pollutants are clarified (**Figure 1**). The results indicated that the main active species in the photodegradation of MB dye was the superoxide radical ($\bullet O_2^-$).

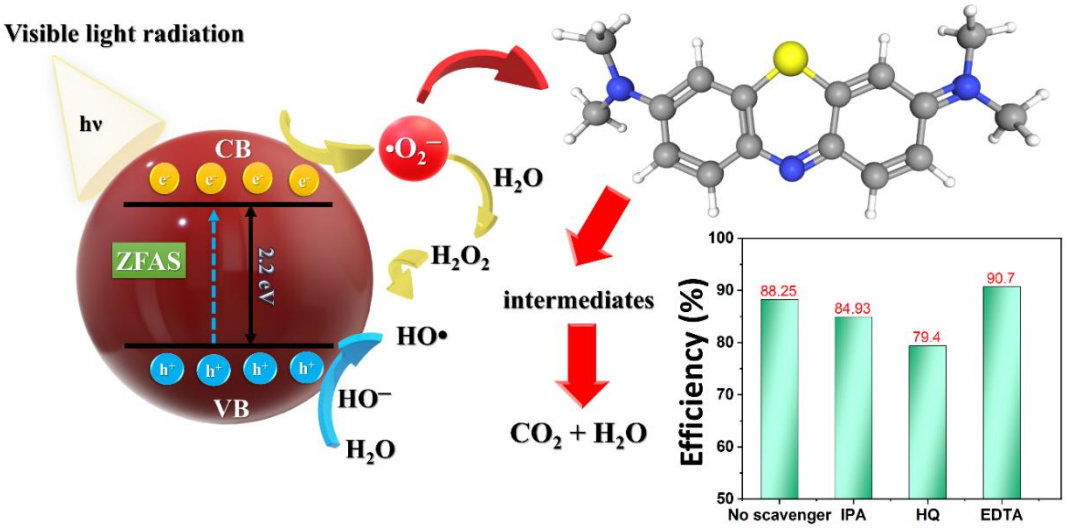


**Figure 1.** Schematic representation of the potential mechanism for MB dye photodegradation using a ZFAS catalyst attached to PVDF fiber, illustrating the impact of various scavengers.

## References

[1] A.-C. Enache, I. Grecu, P. Samoilă, C. Cojocaru, V. Harabagiu, *Gels* 2023, 9(5), 358.
[2] P. Pascariu, C. Cojocaru, P. Samoilă, N. Olaru, A. Bele, A. Airinei, *Mater. Res. Bull.* 2021, 141, 111376.
[3] P. Pascariu, C. Cojocaru, M. Homocianu, P. Samoilă, I. Grecu, A. Bele, *Surf. Interfaces* 2022, 34, 102382.
[4] P. Pascariu, M. Homocianu,. *Ceram. Int.* 2019, 45(9), 11158-11173.
[5] I. Grecu, P. Samoilă, P. Pascariu, C. Cojocaru, I.A. Dascălu, V. Harabagiu, *Catalysts* 2023, 13, 266.
[6] F. Mohamadpour, A.M. Amani, *RSC Advances* 2024, 14(29), 20609-20645.
[7] I. Grecu, A.-C. Enache, P. Pascariu, A. Bele, P. Samoilă, C. Cojocaru, V. Harabagiu, *Surf. Interfaces* 2024, 51, 104536.

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# PP8. MODIFIED CHITOSAN NANOFIBERS FOR BIOABSORBABLE WOUNDS DRESSING

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## Introduction

It is known that the skin is the largest organ with a sensory role for the protection and thermoregulation of the human body [1]. That's why it is important to treat skin wounds using efficient dressings which favor a rapid healing and low side effects. Among the materials investigated for this purpose are chitosan nanofibers (CS) because they mimic the extracellular matrix of the body, being easily applied and removed from wounds, thus avoiding the traumatic debridement [2]. By encapsulation of antimicrobial compounds in this type of material its properties are improved, assuring the prevention of invasive infections [3]. Of major importance is the control of the release rate of the antimicrobial compound and the monitoring of its bioavailability at the infected site. To this end, this study proposed the functionalization of chitosan nanofibers by imination with a mixture of two aldehydes, 2-formylphenylboronic acid (2-FPBA) and citral (CI). Their choice was done anticipating a synergistic relationship between them, as CI has the ability to potentiate the antimicrobial activity of 2-FPBA by improving intracellular reactive oxygen species (ROS) and cell permeability [4]. It was expected that the reversible imine bond will stimulate the release of both aldehydes in a humid environment, under the control of their consuming during the process of pathogens' inactivation.

## Results and discussion

As can be seen in **Figure 1**, a series of five chitosan fibers mats were prepared by imination of neat chitosan fibers with a mixture of two aldehydes, 2-FPBA and CI, by keeping a constant molar ratio of glucosamine units of chitosan / aldehyde groups, while varying 2-FPBA/CI ratio. Two of five samples were prepared using only one aldehyde, in order to create references for the understanding of characterization data and properties of the mixed samples. The neat chitosan nanofibers were prior prepared by electrospinning of a chitosan/PEO mixture followed by PEO washing.

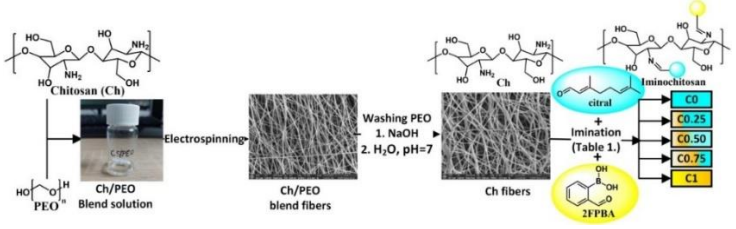
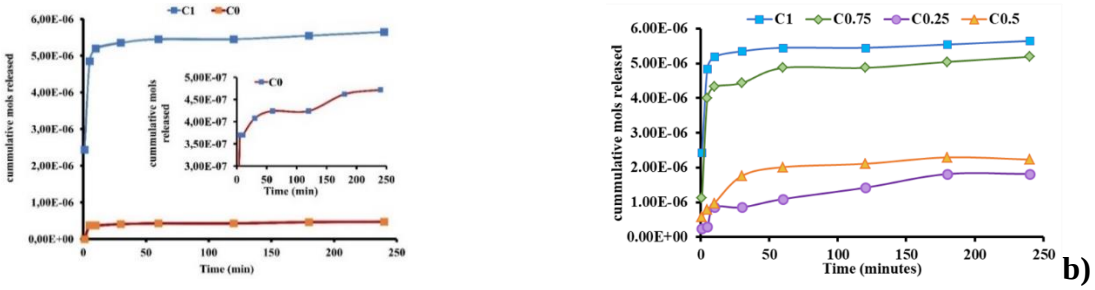



**Figure 1.** Representation of the preparation of functionalized chitosan fibers.

Structural characterization by FTIR and $^{1}$H-NMR confirmed the presence of imine bonds yielded by each aldehyde, reaching a maximum conversion degree of amine units into imines of 56%. UV-vis analysis revealed the dynamic nature of the imine bonds, 2-FPBA being released much faster than CI in a PBS solution. This behavior was attributed to the hydrophilic character of 2-FPBA compared to the hydrophobic one of CI (**Figure 2**).




**a)** **b)**

**Figure 2.** a) Cumulative aldehyde release in 24 hours (inset: cumulative citral release from C0). b) Cumulative 2-FPBA release in 24 hours. For a proper comparison, the amount of aldehyde released was expressed in mols

The same cause influenced the diffusion of aldehydes into fibers during the imination reaction and consequently the site where the reaction took place: CI preponderantly reacted at the fibers' surface while 2-FPBA inside them. The fibers had the diameter less than 200 nm and exhibited birefringence under POM indicating the alignment of chitosan chains during the electrospinning. From the swelling kinetics, it was observed that the mass equilibrium swelling value of the functionalized fibers was lower than that corresponding to neat chitosan fibers, the swelling being influenced both by the reversibility of the imine bond and hydrophilic/hydrophobic nature of the two aldehydes. The enzymatic biodegradation in the presence of lysozyme was also correlated with the hydrophilic/hydrophobic nature of the two aldehydes, a more intense biodegradation being recorded for the samples with higher amount of 2FPBA and less intense in the case of those in which CI predominated. The investigation of the biocompatibility showed that the fiber mats presented fibroblasts viability higher than 80%, in line with the safety standards for biomedical devices, ISO 10993-5:2009(E). Antimicrobial tests have shown antifungal activity against *C. albicans* and *A. brasiliensis*, especially for the samples with a high 2-FPBA content. All these confirmed that the double imination of chitosan nanofibers is an efficient method for obtaining biomaterials with suitable properties for wound dressing.

## References

[1] McKnight, G., Shah, J., Hargest, R., *Surgery* 2022, 40, 8-12.
[2] K.J.B. Kus, E.S. Ruiz, *Curr. Dermatol. Rep.* 2020, 9, 298–308.
[3] R. Castro-Muñoz, M.S. Kharazmi, S.M. Jafari, *Intern. J. Biol. Macromol.* 2023, 245, 125424.
[4] P. Gupta, D.K. Patel, V.K. Gupta, A. Pal, S. Tandon, M.P. Darokar, *Phytomedicine* 2017, 34, 85-96.

## Acknowledgments:

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# PP9. CO-ASSEMBLY OF CHITOSAN-*g*-POLY(*N*-ISOPROPYLACRYLAMIDE) COPOLYMER WITH DNAs

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## Introduction

Chitosan is derived from the acetylation of chitin, a biopolymer that ranks among the most abundant in nature. Its favorable characteristics, such as biocompatibility, biodegradability, low toxicity, and proven antimicrobial and mucoadhesive properties, make it a popular choice for various bioapplications, particularly in drug and gene delivery systems [1,2]. Chemical modification of chitosan, such as grafting with monomers and polymers, is a widely recognized method for addressing its limitations and enhancing the performance of chitosan carriers. By selecting suitable grafted copolymers, it is possible to add extra capabilities, such as response to external stimuli, which is one of the most exciting possibilities of chitosan grafting [3,4]. A notable example is the widely studied temperature-responsive poly(*N*-isopropylacrylamide) (PNIPAM), which is characterized by its water solubility at room temperature [5].

## Materials and methods

Here, we examine the electrostatic interaction between two DNA macromolecules of different lengths, roughly equivalent to 50 and 2000 bp, and a chitosan grafted with PNIPAM side chains, namely Chit-*g*-PNIPAM. The objectives of this study were to create stable polyplexes that could demonstrate the copolymer's potential to be used in gene delivery systems and to thoroughly examine their physicochemical properties. Dynamic and electrophoretic light scattering (DLS and ELS) were used to examine the physicochemical characteristics of the resultant polyplexes, while scanning-transmission electron microscopy (STEM) was used to examine their morphology.

## Results and discussion

As shown in **Figure 1a**, the mass of the polyplexes formed between the Chit-*g*-PNIPAM and either the short or the long DNA reaches its maximum values at N/P ratios below 1, which is the estimated charge neutralization point. Apparently, at low N/P values the interaction between the two components is very strong, leading to the formation of massive polyplexes/aggregates. Figure 1b shows that as the N/P ratio decreases or in other words the DNA content increases, the zeta potential of the polyplexes gradually decreases. This is in direct correlation to the occurring charge neutralization due to the electrostatic interaction of the two components. Concerning the size of the formed polyplexes, the size distribution functions presented in **Figures 1c** and **1d** display multiple peaks. The pure Chit-*g*-PNIPAM solution and the two DNA samples exhibit two peaks corresponding to two scattering populations in solution, and thus indicating some degree of self-assembly. In the case of the short DNA polyplexes, at high N/P values (specifically 2 and 4), the size distribution functions resemble that of the pure copolymer.

This suggests that the sizes of the two polyplex populations are influenced by the corresponding populations of the graft copolymer which is in excess. For the long DNA systems, the size distribution functions reveal a single population, corresponding to smaller sizes across all three stable dispersions.

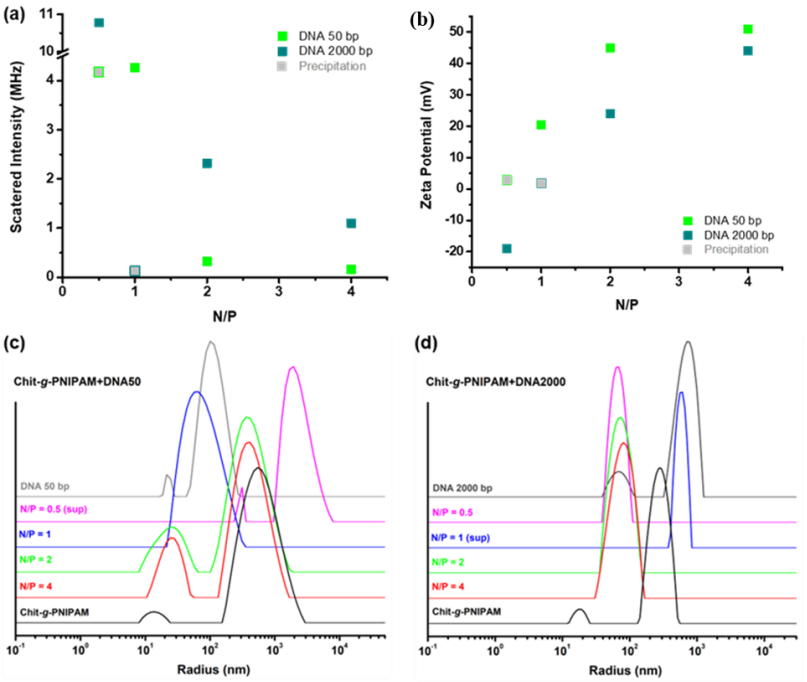


**Figure 1.** DLS and ELS results in regard to (a) the scattered intensity, (b) the zeta potential values (c, d) size distribution functions, for the polyplexes of the two Chit-*g*-PNIPAM+DNA50/2000 systems, as a function of the N/P ratio.

## Conclusions

The overall physicochemical properties of the formed polyplexes, including their mass, size, charge, structure, and stability, demonstrated a complex interplay between the ratio of the two macromolecular components, the length of the DNA molecule, and the inherent conformation of the Chit-*g*-PNIPAM copolymer. The PNIPAM side chains impart thermoresponsive properties to the polyplexes, enabling enhanced functionality. As the temperature rises above 35 °C, the polyplexes undergo a fully reversible structural change towards more dense/compact structures. STEM imaging revealed spherical, homogeneous nanostructures of varying sizes, with a rather loose conformation, and an urchin-like morphology.

## References

[1] A. Haider, S. Khan, D.N. Iqbal, M. Shrahili, S. Haider, K. Mohammad, A. Mohammad, M. Rizwan, Q. Kanwal, G. Mustafa, *Eur. Polym. J.* 2024, 210, 112983.
[2] M. Karayianni, T. Sentoukas, A. Skandalis, N. Pippa, S. Pispas, *Pharmaceutics* 2023, 15, 1849.
[3] Y. Iqbal, I. Ahmed, M.F. Irfan, S.A.S. Chatha, M. Zubair, A. Ullah, *Carbohydr. Polym.* 2023, 321, 121318.
[4] Y. Guo, D. Qiao, S. Zhao, P. Liu, F. Xie, B. Zhang, *Mater. Sci. Eng. R Reports* 2024, 159, 100775.
[5] S. Lanzalaco, E. Armelin, *Gels* 2017, 3, 36.

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# PP10. TARGETING CANCER: THE ROLE OF PYRROLO-FUSED HETEROCYCLES

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Cancer remains a leading global cause of death, despite significant advances in drug development and the emergence of combination therapies that have transformed the landscape of cancer treatment. The complexity of cancer biology, characterized by genetic mutations, heterogeneity, and the ability of cancer cells to adapt and develop resistance to therapies, presents substantial challenges in effectively eradicating the disease [1].

As our understanding of cancer mechanisms deepens, it has become increasingly clear that a one-size-fits-all approach to treatment is inadequate. Tumors exhibit diverse genetic and phenotypic profiles, resulting in varied responses to standard treatments such as chemotherapy, radiation, and targeted therapies. Consequently, some patients may experience limited therapeutic benefits or endure severe side effects, while others may achieve remission. This variability underscores the urgent need for personalized medicine approaches that tailor therapies to the specific characteristics of an individual's cancer [2].

The rise of drug resistance further complicates cancer treatment. Over time, cancer cells can adapt to therapies through various mechanisms, including mutations that alter drug targets, enhanced drug efflux, and the activation of alternative signaling pathways. This resistance compromises the effectiveness of existing treatments and limits options for subsequent lines of therapy. As a result, there is a critical demand for innovative therapeutic strategies that can circumvent or delay the development of resistance.

In response to these challenges, researchers are exploring a range of new treatment modalities, including immunotherapy, gene therapy, and novel small molecules targeting specific oncogenic pathways. Among the promising candidates in drug discovery are fused polyazaheterocyclic derivatives, essential structural motifs commonly found in various natural products, and bioactive agents. Fused polyazaheterocycles possess a unique molecular framework characterized by multiple nitrogen atoms within the heterocyclic core, allowing them to interact with diverse biological targets, making them highly versatile in medicinal chemistry. These compounds exhibit a broad spectrum of biological activities, including antimicrobial, antiviral, anti-inflammatory, and anticancer properties. Their structural complexity and functional diversity have positioned them as one of the most important classes of organic compounds in the pharmaceutical industry [3].

Researchers frequently employ these derivatives in the design and development of new therapeutic agents aimed at modulating complex biological pathways such as enzyme inhibition, receptor binding, and signal transduction. The ability to fine-tune their chemical properties by introducing different substituents and modifying their heterocyclic core further enhances their potential as lead compounds in drug discovery. In particular, the anticancer potential of fused polyazaheterocycles has drawn significant attention due to their ability to inhibit key enzymes and disrupt cancer cell growth pathways. Continued research into these compounds expands our understanding of their biological mechanisms and opens new avenues for creating more selective and potent drugs in the fight against cancer. Their design often utilizes combinatorial methods aimed at assembling different pharmacophores within the same molecular framework, resulting in a wide variety of molecules showing promising biological activities.

At the same time, the pyridine ring, prevalent in numerous natural products and integral to the structure of genetic material, has garnered significant attention for its role in various biological processes. Pyridine and its derivatives are involved in crucial biochemical pathways, including neurotransmission, cellular respiration, and metabolism. Moreover, the pyridine ring has been implicated in cancer pathogenesis, participating in modulating signaling pathways essential for cell proliferation, apoptosis, and angiogenesis [4].

Due to these multifaceted roles, pyridine has emerged as a privileged scaffold in anticancer agent discovery. Its properties, such as the ability to form hydrogen bonds and engage in electron transfer processes, make it attractive for rational drug design. Researchers leverage these attributes to develop novel pyridine-based compounds that exhibit selective cytotoxicity against cancer cells while minimizing potential side effects.

Taking all the presented facts, we present herein the synthesis of novel 2,2'-bipyridyl scaffold derivatives via [3+2] cycloaddition reactions. The strategy to build the desired series consisted of two main synthetic steps, starting from the N-heterocycle – 2,2’ bipyridyl to be fused to the pyrrole ring. Four monoquaternary salts were synthesized in the first step. The second step consisted of the *in situ* generation of the cycloimmonium ylides from the corresponding salts under triethylamine treatment. The *in situ*-formed ylides acted as 1,3-dipoles when reacted with ethyl propiolate or fumaronitrile, following a Huisgen [3 + 2] cycloaddition. Initially, formed unstable intermediates undergo an aromatization process under the current reaction conditions, leading to target compounds in good yields. The structures of all synthesized compounds were fully confirmed using NMR, IR, and MS analysis. Their antitumor activity and cytotoxicity were assessed through tests on cancer cell lines and normal fibroblasts respectively.

## References

[1] L. Oniciuc, D. Amăriucăi-Mantu, D. Diaconu, V. Mangalagiu, R. Danac, V. Antoci, I. I. Mangalagiu, *Int. J. Mol. Sci.* 2023, 24, 8124.
[2] C.T. Supuran, *Pharmacol. Rev.* 2024, PHARMREV-AR-2023-001125.
[3] M.C. Al-Matarneh, R.-M. Amărandi, I.I. Mangalagiu, R. Danac, *Molecules* 2021, 26, 2066–2085.
[4] M.C. Sardaru, A. M. Craciun, C.M. Al Matarneh, I.A. Sandu, R.M. Amarandi, L. Popovici, C.I. Ciobanu, D. Peptanariu, M. Pinteala, I.I. Mangalagiu, R. Danac, *J. Enzyme Inhib. Med. Chem*. 2020, 35, 1581–1595.

# PP11. A NEW APPROACH FOR OBTAINING MATERIALS BASED ON FORMYLATED POLYSULFONE AND CHITOSAN LINKED BY IMINE OR AMINE UNITS

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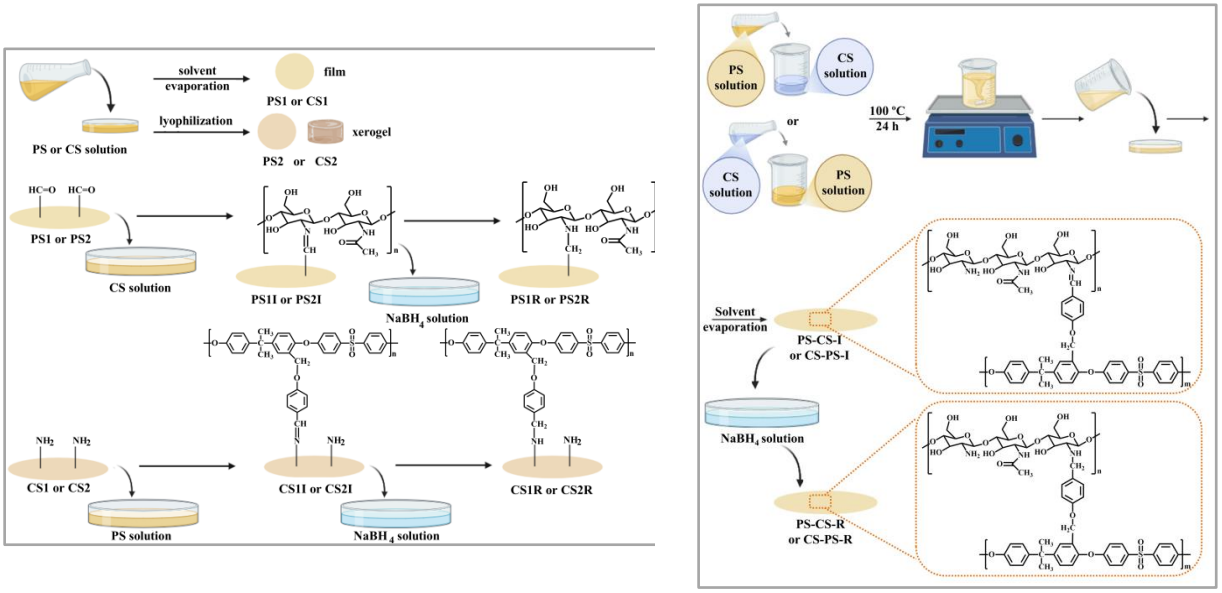
Polysulfone-based membranes are widely used in separation processes due to their thermal stability, mechanical strength, and chemical resistance. However, their hydrophobic nature affects their permeability. In order to overcome this drawback, researchers have explored various modification techniques, including blending, bulk modification, and surface grafting [1].

Chitosan is a naturally originated biopolymer, which exhibits hydrophilicity, biocompatibility, and biodegradability, as well as film-forming properties. Chitosan membranes are used in various separation processes, including nanofiltration, ultrafiltration, pervaporation, and reverse osmosis. Literature data reports a promising method to improve the hydrophilicity, flux, and antifouling properties of polysulfone membrane by using chitosan or modified chitosan and the composite membranes have shown superior removal of dyes, salts, and heavy metals from water [2].

In this line of thought, the aim of this study was to develop a new approach to obtain polysulfone and chitosan-based materials by imination or amination reactions at the surface of the material or *via* bulk condensation, respectively. Therefore, in order to achieve this goal, different modification techniques were applied, such as chemical modification of polysulfone structure through chloromethylation and Williamson etherification, immobilization of chitosan on the surface of materials based on formylated polysulfone or immobilization of formylated polysulfone on the surface of materials based on chitosan *via* imine or amine units (**Figure 1 (a)**) and bulk synthesis of formylated polysulfone-graft-chitosan *via* imine or amine units (**Figure 1 (b**)).

The structural characterization by FTIR spectroscopy of the materials based on formylated polysulfone and chitosan revealed the formation of imine bonds between the amine groups of chitosan and the aldehyde group of formylated polysulfone, as well as the occurrence of reductive amination reaction of the imine bond upon the treatment of the investigated materials with $NaBH_4$ solution. The thermogravimetric analysis indicated the increase in the thermal stability of the materials, following the functionalization, and the SEM microscopy highlighted the obtaining of irregular and porous structures. All iminated and aminated samples were characterized in terms of supramolecular organization and their XRD diffractograms indicated a profile characteristic of semicrystalline phase.

The materials based on chitosan and formylated polysulfone were evaluated in terms of dynamic water vapor sorption capacity. Among these, the PS-CS-R sample demonstrated superior performance in terms of water sorption capacity, while PS-CS-I, CS-PS-I, and CS-PS-R exhibited a stronger affinity for water vapor compared to formylated polysulfone-based materials functionalized at the surface with chitosan. This suggests that the bulk condensation reaction between the polymers led to materials with enhanced hydrophilicity and increased water sorption capacity.




**(a)** **(b)**

**Figure 1. (a)** Immobilization of chitosan on the surface of materials based on formylated polysulfone or immobilization of formylated polysulfone on the surface of materials based on chitosan *via* imine or amine units and **(b)** and bulk synthesis of formylated polysulfone-graft-chitosan *via* imine or amine units.

By monitoring the rate at which water vapor permeates chitosan and/or formylated polysulfone-based materials over 14 days, it was observed that their water transport capacity decreased as a result of their swelling in the presence of water, and the best results were recorded for samples with imine units in their structure/surface. This increased permeability can be attributed to the dynamic nature of the imine bond, which in the presence of water, can undergo hydrolysis, resulting in the formation of micropores or defects within the polymer matrix. These structural irregularities facilitate the diffusion of water molecules through the material.

The evaluation of the antioxidant activity in the solid state revealed slight scavenging activity, which can be influenced by the method of obtaining the material or by its chemical structure. The best antioxidant activity was observed in the case of samples CS-PS-I and PS-CS-I, around 20 %.

## References

[1] M. Z. Zailani, A. F. Ismail, P. S. Goh, S. H. S. A. Kadir, M. H. D. Othman, H. Hasbullah, M. S. Abdullah, B. C. Ng, F. Kamal, R. Mustafar, *J. Environ. Chem. Eng.* 2021, 9, 106878
[2] R. Kumar, A. M. Isloor, A. F. Ismail, S. A. Rashid, T. Matsuura, *RSC Adv.* 2013, 3, 7855-7861

# PP12. GRAFT COPOLYMERIZATION OF POLY(*N*-ISOPROPYLACRYLAMIDE) ONTO AMYLOPECTIN

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**Introduction**: Natural polymers like polysaccharides have attracted considerable attention in the past few decades in a wide range of fields, due to the fact that are biocompatible, biodegradable, nontoxic and inexpensive [1]. Amylopectin (AMP) is a natural biopolymer with a highly branched structure, which is composed of α-D-glucopyranose residues linked together by α-(1,4) and α-(1,6)-glycosidic bond. AMP is one of the major components found in starch granules (75–85%) with a higher molecular weight and due to its high biocompatibility and biodegradability is widely used in various applications [2,3]. Due to society's need for durable biomaterials with adapted functionalities, the most effective approach is to combine polysaccharides with synthetic polymers to create hybrid molecules that integrate their properties and functionalities. Over the years, stimuli-responsive polymers have been grafted onto different polysaccharides for the development of suitable materials for wastewaters treatment and biomedical applications. Poly(*N*-isopropylacrylamide) (PNIPAM) is a water-soluble and thermoresponsive synthetic polymer with a low critical solution temperature (LCST) in the range of 31 - 33°C. The change of its hydrophilic interactions takes place between the room temperature and body temperature, making it a promising polymer for the medical field [4,5].

**Materials and methods**: The aim of this study was the synthesis and characterization of the new amphiphilic copolymer AMP-*g*-PNIPAM applying the *"grafting to*" technique which is based on the chain end anchoring of synthetic homopolymer macromolecular chains to polysaccharides via covalent bonding, where potassium persulphate was used as initiator (**Figure 1**). The obtained copolymer was purified by extensive dialysis and freeze-drying. PNIPAM was obtained in our laboratory via reversible addition-fragmentation chain transfer (RAFT) polymerization which is a versatile radical polymerization method used for the generation of molecular weight-controlled polymers. For the molecular characterization of PNIPAM and AMP-*g*-PNIPAM, FTIR and $^{1}$H-NMR spectroscopy were performed. For a better understanding of the self-assembly of the graft copolymer in aqueous solution, the AMP-*g*-PNIPAM size distribution and diameter as a function of time (at 1, 2, 3 and 6 days) were measured using dynamic light scattering (DLS). Also, the charges as a function of pH (from pH=3 to pH=1), were studied using electrophoretic light scattering (ELS).

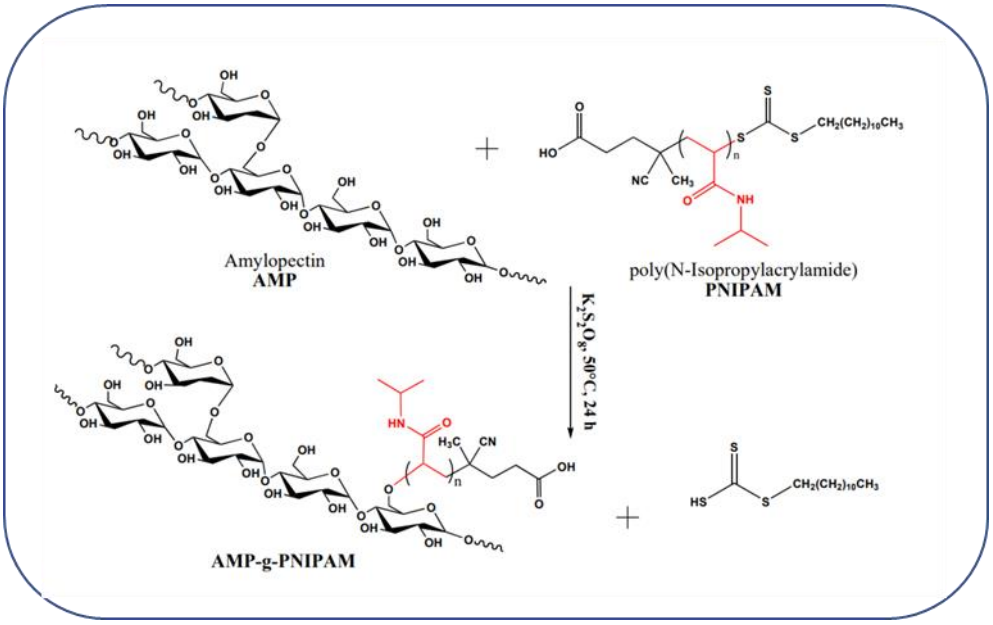


**Figure 1**. Synthesis reaction of Amylopectin-*graft*-poly(N-isopropylacrylamide)

**Results**: Based on the FTIR and $^1$H NMR characterization results, the structure of the AMP–*g*–PNIPAM copolymer was confirmed. By studying the behavior of the copolymer in aqueous solution we observed that the size distribution remained stable during the 6 days, with sizes between 100 and 400 nm. The ELS measurements confirmed the negative charging of the copolymer with an isoelectric point around pH=4.

**Conclusions**: The results obtained suggest that the grafting of PNIPAM chains onto amylopectin was successfully achieved resulting in amphiphilic graft copolymer. Also, the copolymer shows interesting self-assembly behaviour in aqueous solutions.

**Perspectives:** Utilization of the graft copolymer for the development of materials/hydrogels suitable for different applications, including drug nanocarriers and sorbents of different species.

## References

[1] O. Garcia-Valdez, P. Champagne, M.F. Cunningham, *Prog. Polym. Sci.* 2018, 76, 151.
[2] Y. Fan, N. Boulif, F.Picchioni, *Int. J. Mol. Sci*. 2021, 22(17), 9606 .
[3] P.V. Lemos, L.S. Barbosa, I.G. Ramos, R. E.Coelho, J.I. Druzian, *Int. J. Biol. Macromol.* 2019, 132, 32–42.
[4] B. Bazoubandi, J.B.P. Soares. *Miner. Eng.* 2020, 148, 106.
[5] M.M. Zaharia, F. Bucatariu, M. Karayianni, S. Pispas, M. Mihai, *Polymers* 2024, 16(10), 1315.

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# PP14. ASSESSING THE ANTICANCER POTENTIAL OF COBALT COMPLEXES THROUGH THEORETICAL AND EXPERIMENTAL APPROACHES

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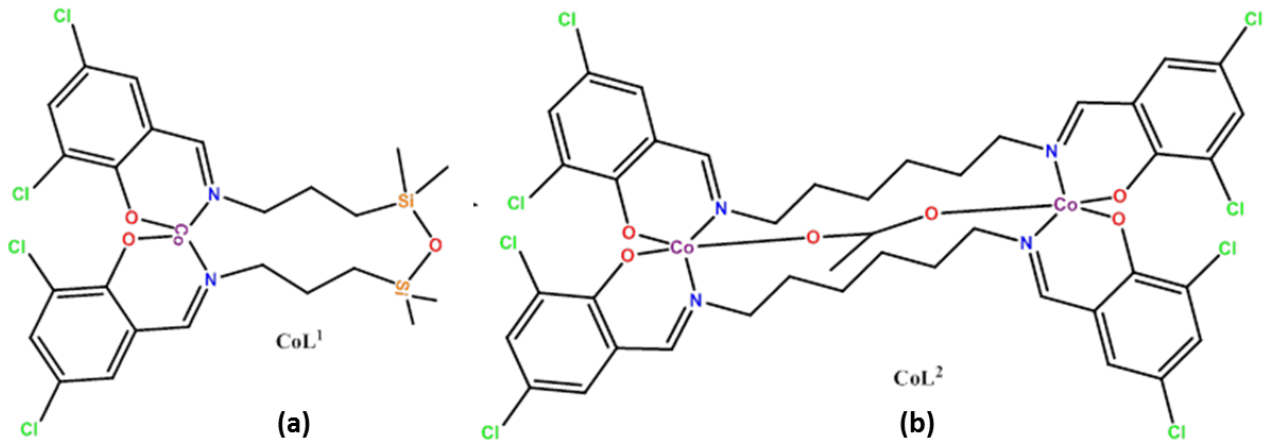
Medicinal coordination chemistry has emerged as a pivotal area of research, with metal-based complexes playing a significant role in developing therapeutic agents. Among these, cobalt complexes have garnered substantial attention due to their promising biological activities, including anticancer, antimicrobial, and antiviral properties. The medicinal potential of these complexes stems from cobalt's ability to exist in multiple oxidation states, allowing it to engage in redox reactions and interact dynamically with biological systems [1,2]. Therefore, cobalt complexes seem to become an alternative in chemotherapy to those of platinum, whose use has become more restrictive due to toxicity and drug-resistant properties. Cobalt has been found to be less dangerous to the human body than platinum. A distinct class of cobalt complexes is that with Schiff base ligands derived from the condensation of primary amines and carbonyl compounds. These Schiff base ligands provide a versatile platform for tuning the electronic and steric properties of the central cobalt ion. A Co(III) complex with a Schiff base called Doxovir is even in an advanced antiviral clinical testing phase [3].

In this work, it was studied from the perspective of the biological activity of a cobalt complex of a siloxane-spaced salen-type Schiff base recently obtained by us [4] (**Figure 1a**), in comparison with a cobalt complex of a somewhat similar but having an alkyl bridge (**Figure 1b**).




**Scheme 1.** Structure of the cobalt complexes of siloxane-, $CoL^1$, (a) and alkyl-, $CoL^2$, (b)–spaced Schiff bases.

The compounds were docked into 13 protein structures (PDB IDs: 1N8Z, 2W3L, 4GV1, 4HJO, 5DS3, 5VAM, 3CP9, 5FDO, 6GQO, 1FDW, 5GWK, 1P20, and 5O1H). The structures were selected according to the literature, being characteristic of HeLa and MCF-7 cell lines. From **Figure 1**, it can be observed that the $CoL^2$ molecule is larger and fits more efficiently into the pockets. Additionally, the overlap with the co-crystallized ligand is greater for $CoL^2$, except for protein 4GV1, for which docking could not be carried out. For MCF-7 the studied proteins, the pockets where the co-ligands are located are smaller, compared to the previous case, favoring the access of smaller molecules. Molecular docking calculations showed good accommodation of $CoL^1$ within the pockets, while $CoL^2$ was only partially located inside the pocket, with part of the molecule remaining in the aqueous phase.

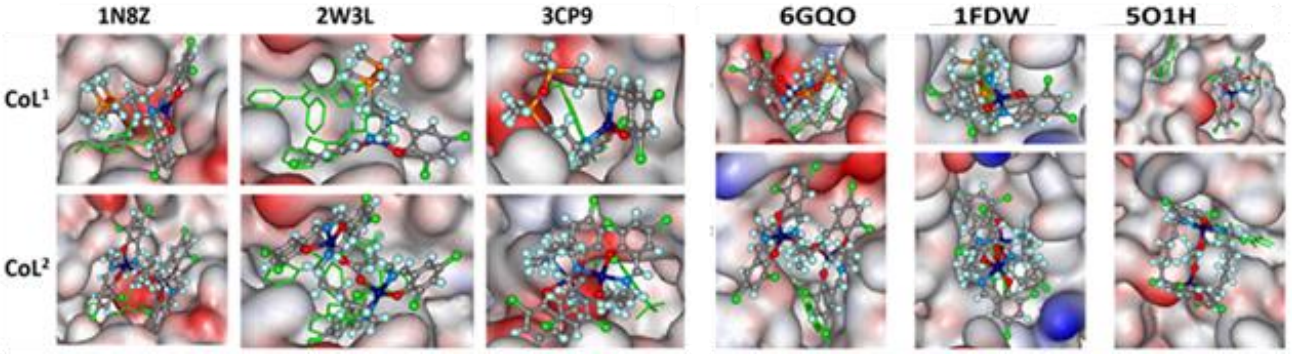



**Figure 1.** The docked pose of studied compounds (ball-and-stick) in different protein binding sites, the co-crystalized ligand is shown in line format (green).

Experimental studies consisting of measuring the viability of normal cells (human gingival fibroblast, HGF) and two cancerous cell lines (MCF7 and HeLa) demonstrated significantly higher activity for the siloxane-containing complex compared to its full organic ligand-based counterpart.

## References

[1] M. J.Carter, D. P. Rillema, F. Basolo, *Journal of the American Chemical Society*, 1974, 96, 392–400.
[2] B. T. Huie, R. M. Leyden, W. P. Schaefer, *Inorganic Chemistry*, 1979, 18, 125–129.
[3] K. Kanisha, G. Diya, K. Bikash, C. Chandra, *Polyhedron*, 2022, 222, 115890.
[4] M. Damoc, A.-C. Stoica, M. Dascalu, M. Asandulesa, S. Shova, M. Cazacu, *Dalton Trans.*, 2021, 50, 13841-13858.

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# PP15. NEW CHIMERIC AZAHETROCYCLIC COMPOUNDS WITH PYRROLO[1,2-*a*]QUINOLINE STRUCTURE

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Pyrrolo[1,2-*a*]quinolines are a class of heterocyclic compounds formed by the fusion of quinoline and pyrrole rings [1]. In terms of biological activity, pyrrolo-quinolines are considered "chimeric compounds", a term that reflects the integration of the pharmacophoric activity of two distinct components, in this case quinoline and pyrrole, into a single structure. This integration aims to enhance the biological efficacy beyond what each component could achieve individually, resulting in a compound with superior therapeutic potential [2]. Numerous studies support this perspective by examining in particular the anticancer and antimicrobial activities of pyrrolo[1,2-*a*]quinolines, demonstrating their promising potential in these therapeutic areas [3],[4]. Apart from the biological activity, pyrrolo-quinolines are also studied in the field of materials science due to the photoelectronic properties, but also for their corrosion inhibitory activity [5], [6]. These chimeric compounds can be synthesized through various methods; however, in this study, the [3+2] dipolar Huisgen cycloaddition is employed. This type of intermolecular cyclization is chosen due to its well-studied reaction mechanism.

In this respect, this study presents the synthesis and characterization of novel pyrrolo[1,2-*a*] quinoline derivatives. The synthetic route is efficient and involves two steps: the quaternization of nitrogen heterocycle, followed by [3+2] dipolar cycloaddition reaction. In the second step, quinolinium *N*-ylide is generated *in situ* from the quaternary salt and subsequently undergoes a [3+2] dipolar cycloaddition with a variety of activated symmetrical and non-symmetrical substituted acetylenic and olefinic dipolarophiles. The reaction conditions were optimized to maximize yields by adjusting the type of the base/solvent system or by introducing an oxidizing agent. These reactions successfully led to the desired compounds, with yields varying based on the stability and reactivity of the *N*-ylide in the base/solvent system, as well as the nature of the dipolarophile involved. The structure of compounds was proven by spectral analysis using NMR experiments: $^{1}$H-NMR, $^{13}$C-NMR and 2D correlations homonuclear ($^{1}$H-$^{1}$H)-COSY and heteronuclear ($^{1}$H-$^{13}$C)-HMQC and HMBC. The analyses validated the proposed molecular structures.

In **Figure 1** is presented an overlay of spectra recorded for the quaternary salt alongside the cycloadducts formed with the olefinic dipolarophiles 1,4-naphthoquinone (a symmetrically activated dipolarophile) and benzoquinone (an unsubstituted dipolarophile). The proposed structure of the quaternary salt is confirmed by a singlet at 6.09 ppm, attributed to the two hydrogen atoms of the methylene group (2x$H_9$). Additionally, the highly shielded singlet at 1.43 ppm corresponds to the three methyl groups within the *tert*-butyl moiety, further supporting the structural assignment. To confirm the structure of the cycloadduct obtained from the reaction with naphthoquinone, it is essential to discuss the signals corresponding to the protons marked as $H_{13}$, $H_{14}$, $H_{15}$, and $H_{16}$, from the naphthoquinone structure. A similar analysis can be applied to confirm the structure of the cycloadduct formed with benzoquinone, where the most significant signals correspond to the protons labeled as $H_{13}$ and $H_{14}$. Another evidence that supports the closure of the five-membered ring and the formation of a thermodynamically more stable aromatized adduct is the absence of the protons $H_9$ (singlet at 6.09 ppm) and $H_2$ (doublet at 9.57 ppm) in the spectra of the cycloadducts, which are only present in the spectrum of the quaternary salt. Thus, the analysis of the NMR spectra indicates that, despite the use of two different base/solvent systems, the reaction consistently yields to the same compound.

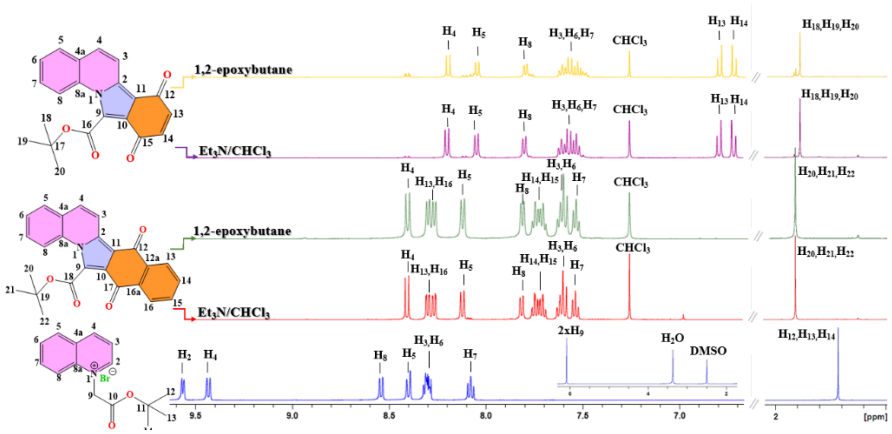


**Figure 1.** Overlay of $^1$H-NMR spectra of the quaternary salt and cycloadducts obtained with olefinic dipolarophiles

## References

[1] P. Králová, M. Soural, *Eur. J. Med. Chem.* 2024, 269, 116287–116287.
[2] C. Borsari, D.J. Trader, A. Tait, M.P. Costi, *J. Med. Chem.* 2020, 63, 1908–1928.
[3] R.-M. Amărandi, M.-C. Al-Matarneh, L. Popovici, C. I. Ciobanu, A. Neamțu, I.I. Mangalagiu, R. Danac, *Pharmaceuticals* 2023, 16, 865–865.
[4] A. Hazra, S. Mondal, A. Maity, S. Naskar, P. Saha, R. Paira, K.B. Sahu, P. Paira, S. Ghosh, C. Sinha, A. Samanta, S. Banerjee, N.B. Mondal, *Eur. J. Med. Chem.* 2011, 46, 2132–2140.
[5] D.Wu, L. Chen, S. Ma, H. Luo, J. Cao, R. Chen, Z. Duan, F. Mathey, *Org. Lett.* 2018, 20, 4103–4106.
[6] X. Zhang, Y. Su, Y. Zhang, S. Guan, X. Wang, Y. *J. Mol. Struct.* 2023, 1290, 135914–135914.

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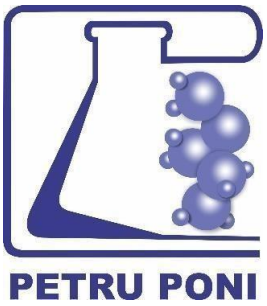
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