Livret des résumés des

19èmes Journées Scientifiques de la section Méditerrannée du GFP

les 20 au 21 mai 2026

à Toulon

Avec le soutien de :

Comité d'Organisation : Sophie Berlioz, Catherine Branger, Pascal Carriere

Conférenciers invités

<u>Mercredi 20 mai 2026</u>

13H45 : Pr Sébastien LIVI - *IMP, France*

Liquides ioniques : une plateforme pour la conception d'une nouvelle génération de réseaux époxy multifonctionnels et dégradables

<u>Jeudi 21 mai 2026</u>

08H45 : Dr Frédéric Peruch – *LCPO, Bordeaux, France*

Challenges in Ring-Opening Polymerization of lactones

Liquides ioniques : une plateforme pour la conception d'une nouvelle génération de réseaux époxy multifonctionnels et dégradables

S. Livi [a]
INSA – Lyon, CNRS, IMP, Lyon, France
email: sebastien.livi@insa-lyon.fr

Dans le domaine des polymères thermodurcissables, les liquides ioniques et leurs monomères offrent une réelle opportunité de concevoir de nouveaux matériaux polymères durables et multifonctionnels, aux propriétés améliorées telles que la stabilité thermique, les performances mécaniques, l'imperméabilité à l'eau et la résistance au feu. Récemment, notre laboratoire a développé une nouvelle génération de réseaux époxy-amine et époxy-anhydride plus respectueux de l'environnement, c'est-à-dire réutilisables et/ou dégradables, grâce à l'utilisation de liquides ioniques contenant des liaisons clivables. Plusieurs architectures ont ainsi été étudiées afin de mettre en évidence leur influence sur les propriétés physiques des réseaux [1-3]. Ici, des réseaux époxy avec des températures de transition vitreuse comprises entre 60 °C et 200 °C, combinant de bonnes propriétés thermomécaniques et mécaniques ainsi qu'un comportement hydrophobe, ont été développés.

.

Reférences:

[1] S *Livi*, C Chardin, LC Lins, N Halawani, S. Pruvost, J. Duchet-Rumeau, J-F. Gerard, J. Baudoux, From Ionic Liquid Epoxy Monomer to Tunable Epoxy-Amine Network: Reaction Mechanism and final properties, ACS Sustainable Chem. Eng., 7 (3), 3602-3613 (2019).
[2] S *Livi*, J Baudoux, J Duchet-Rumeau, JF Gérard, Ionic Liquids : A Versatile Platform for the Design of a Multifunctional Epoxy Networks 2.0 Generation, Progress in Polymer Science, 132, 101581 (2022).
[3] G. Perli, C.Y. Okada, J-F. Gerard, J. Duchet-Rumeau, S. *Livi*, Design for disassembly of composites and thermoset by using cleavable ionic liquid monomers as molecular building blocks, Composites Part B: Engineering, 264, 110899 (2023).

Challenges in Ring-Opening Polymerization of lactones

F. Peruch[a]
Université de Bordeaux, CNRS, Bordeaux INP, LCPO, Pessac, France
email: peruch@enscbp.fr

Over the last decades, the growing awareness of environmental concerns have raised the need to develop sustainable and degradable polymers. In this way, aliphatic (co)polyesters have emerged as serious candidates, and are already used in various applications thanks to their potential biodegradable and biocompatible properties. To achieve the synthesis of these polymers, the ring-opening (co)polymerization (ROP/ROCP) of cyclic esters (lactones and lactides), and more interestingly of biosourced ones, has been promoted as a powerful tool to design the structure and architecture of polymers. However, ROP of certain lactones faces thermodynamic challenges. For instance, γ-lactones were long considered as "non-polymerizable". Nevertheless, in recent years, high molar mass PγBL were successfully produced under specific reaction conditions [1]. Another strategy to overcome the thermodynamic difficulties is to perform the random copolymerization of γ-lactones with higher ring-strain energy lactones. For δ-lactones, the enthalpy is negative enough to enable the formation of the polymer. However, the presence of substituents disfavors the entropy of polymerization. Consequently, these lactones have a lower ceiling temperature, a higher equilibrium monomer concentration and thus a lower equilibrium monomer conversion [2]. The RO(C)P of both families of lactones will be discussed in this presentation. Among the γ-lactones, the ROCP of α-hydroxy-γ-butyrolactone (HBL), a bioderived monomer from glucose, and ε-CL or LA monomers has been investigated (Figure 1A), assessing the influence of several reaction parameters [3-5]. In a second study, ROP of biosourced n-alkyl δ-lactones was investigated. Poly(n-alkyl δ-lactone)s with different pendant chain lengths were obtained in mild conditions, with a molar mass ceiling of 40 kg/mol, whatever the experimental conditions (Figure 1B) [6]. Nevertheless, well-defined diblock copolymers could have been synthesized with a poly(lactide) block. The biodegradation of some of these (co)polymers was performed under the OECD 301F test guideline [7].

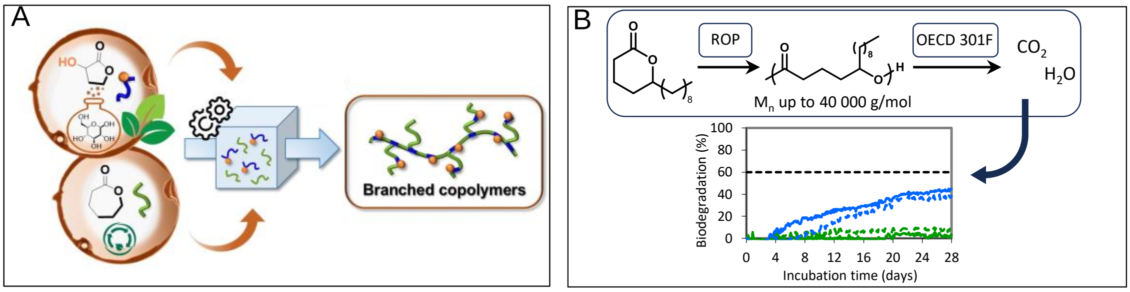

Figure 1 : *(A) copolymerization of HBL, (B) polymerization of alkyl-δ-lactones and their biodegradation.*

References:

[1] Q. Song, C. Pascouau, J. Zhao, G. Zhang, F. Peruch, S. Carlotti, Ring-opening polymerization of γ-lactones and copolymerization with other cyclic monomers, *Prog. Polym. Sci.*, 110, **2020**, 101309.

[2] P. McMichael, X. Schultze, H. Cramail, F. Peruch, Sourcing, thermodynamics, and ring-opening (co)polymerization of substituted δ-lactones: a review, *Polym. Chem.*, 14, **2023**, 3783.

[3] C. Pascouau, R. Mereau, E. Grau, A.-L. Wirotius, S. Carlotti, H. Cramail, F. Peruch, Ring-opening copolymerization of α-hydroxy-γ-butyrolactone and ε-caprolactone. Towards the metal-free synthesis of functional polyesters, *ACS Appl. Polym. Mater.*, 5, **2023**, 6685

[4] C. Pascouau, A.-L. Wirotius, S. Carlotti, H. Cramail, F. Peruch, *Eur. Polym. J.*, Functional polyesters via ring-opening copolymerization of α-hydroxy-γ-butyrolactone and ε-caprolactone: $La[N(SiMe_3)_2]_3$ as an efficient coordination-insertion catalyst, 185, **2023**, 111793.

[5] C. Pascouau, S. Carlotti, H. Cramail, F. Peruch, *Polym. Adv. Technol.*, Ring-opening polymerization of L-lactide in the presence of α-hydroxy-γ-butyrolactone, 35, **2024**, e6324

[6] P. McMichael, X. Schultze, H. Cramail, F. Peruch, *Eur. Polym. J.*, Investigation on the organocatalyzed ROP of δ-tetradecalactone: from polymerization to biodegradation, 208, **2024**, 112859.

[7] P. McMichael, X. Schultze, H. Cramail, F. Peruch, Block copolymers from δ-tetradecalactone and lactide: synthesis, self-assembly and ready biodegradation test, *Macromol. Chem. Phys.*, 227, **2026**, e00484.

Programme des 19èmes JS GFP Med 2026

20-mai-26		21-mai-26	
13h	Accueil	8h45-9h25	Frédéric Peruch
13h30-13h45	Ouverture des JS	9h25-9h45	Matalon Baptiste
13h45-14h25	Sébastien Livi	9h45-10h05	Zagoury Aaron
14h25-14h45	Erwan Ponsin	10h05-10h25	Kouider Sophia
14h45-15h05	Levron Agate	10h25-10h50	Pause / Posters
15h05-15h25	Arnould Nathan	10h50-11h10	Basbous Aya
15h25-15h45	Beaumel Sacha	11h10-11h30	Drahé Martin
15h45-16h10	Pause / Posters	11h30-11h50	Voicu Ana-Maria
16h10-16h30	Montassier Justine	11h50-12h10	Angelvin Noémie
16h30-16h50	Macarez Anne-Constance	12h10-14h	Repas
16h50-17h10	Vincent Carla	14h-14h20	Housseini Joulia
17h10-17h30	Stefan Ana-Roxana	14h20-14h40	Choulot Luna
17h30-17h50	Hamiach Houda	14h40-15h	Remise des prix - Clôture
17h50-18h10	Mama Lauran		
18h15-19h	Réunion du bureau étendu du GFP Méditerranée		
A partir de 19h30	Repas The Noon		

Résumés des Communications Orales

Development of New Alkaline Stable Polycations for Anion Exchange Membranes

E. Ponsin[a,b], D. Quemener[a], K. Aissou[a], P-A. Toulemonde[b]
[a]*Institut Européen des Membranes*
[b]*Michelin*
erwanponsin83@gmail.com

Anion Exchange Membranes (AEMs) are promising materials for hydrogen fuel cells and water electrolyzers. However, the commonly used organic cations in these systems have limited alkaline stability, leading to a decrease of the electrochemical performances with time. Thus, there is a critical need to develop alkaline stable polycations.
Several studies have shown that the nature of the cation and its close substituents have a huge impact on the alkaline stability [1,2]. Charge delocalization and steric hindrance are described as key factors to obtain highly stable cations. These results were obtained studying small organic cations but only few studies have tried to confirm this trend in polymeric materials.

A new imidazolium-based monomer has been designed to maximize steric hindrance and charge delocalization, according to structure-properties relationships shown in the literature. A multiple-steps synthesis path has been identified and studied to obtain the wanted monomer with good yield and high purity.
Polymerization of this new monomer have been conducted and poly(imidazoliums) were finally obtained and characterized by NMR, SEC, MALDI-ToF, TGA and DSC.
Key parameters for the study of polycations in AEM applications are: water uptake (WU), ionic conductivity and alkaline stability. Those were studied by means of DVS and EIS.

Ionic conductivity measurements were conducted first in bromide form and showed good results compared to commercial standards.
Bulky polycations in hydroxide form showed restricted water uptake, even highly functionalized ones. Stability tests were conducted in hydroxide form by varying the RH from very low to quite high, and comparing the WU upon cycles. This protocol simulates the fuel cell dry operating conditions. The very low WU of the bulky polycations strongly decrease their alkaline stability, as it has been showed that hydroxide reactivity is highly dependent on its solvatation state [3]. Thus, these polymers seem not adapted to fuel cell dry operating conditions. However, their behavior in electrolysis wet operating conditions should also be investigated. This requires to work on the film-forming ability of such polymers.

Références :

[1] J. Fan & al., Poly(bis-arylimidazoliums) possessing high hydroxyde ion exchange capacity and high alkaline stability. Nature (2019) 10:2306
[2] G. W. Coates & al., Imidazolium Cations with Exceptional Alkaline Stability: A Systematic Study of Structure−Stability Relationships. J. Am. Chem. Soc. 2015, 137, 8730−8737.
[3] D. R. Dekel & al., Effect of Water on the Stability of Quaternary Ammonium Groups for Anion Exchange Membrane Fuel Cell Applications. Chem. Mater. 2017, 29, 4425−4431.

N,O-acétal tertiaire fluoré : une plateforme d'échange sans catalyseur pour le design de CANs biosourcés.

Agate Levron[a], Sidonie Laviéville[a], Pierre Dellière[a], Rodolphe Sonnier[b], Sylvain Caillol[a], Camille Bakkali Hassani[a], Vincent Ladmiral[a], Eric Leclerc[a]

[a]Departments D1-D2, ICGM, CNRS, Montpellier, France

[b]IMT Mines Alès, Alès, France

agate.levron@etu.umontpellier.fr

Le recyclage des matériaux plastiques est une préoccupation majeure dans notre société. Une nouvelle génération de polymères, appelée Réseaux Covalents Adaptables (CANs), a été conçue comme l'une des solutions possibles à ce problème. Ces matériaux possèdent des liaisons échangeables qui leur permettent d'être recyclés et leur confèrent les propriétés de remise en forme des thermoplastiques, ainsi que les propriétés mécaniques et la résistance chimique élevées des thermodurcissables.

Afin de réduire l'impact environnemental et d'éviter la lixiviation des additifs, notre groupe s'est fortement impliqué dans la conception de CANs sans catalyseur, en incorporant des motifs fluorés qui activent les groupes fonctionnels et favorisent les réactions d'échange ou apportent une stabilité hydrolytique. Le développement de matériaux biosourcés constitue une étape supplémentaire dans cette direction. Récemment, nous avons conçu des CANs biosourcés fluorés à base de N,O-acétals tertiaires avec des taux de carbone biosourcés élevés (76 – 92 %C biosourcés) selon les diamines choisies, basés sur des réactions d'échange d'alcools (**Fig. 1**).[1] En raison de la structure du monomère de type A_2B_2, celui-ci peut s'homopolymériser, ce qui simplifie le procédé. Ces matériaux présentent des propriétés intéressantes selon leur structure qui leur donnent des propriétés mécaniques et dynamiques différentes. En revanche, ces matériaux possèdent malgré leur structure différente des temps de relaxation rapides, des énergies d'activation élevées et des conditions de remise en forme relativement douces, tout en étant exempts de catalyseur.

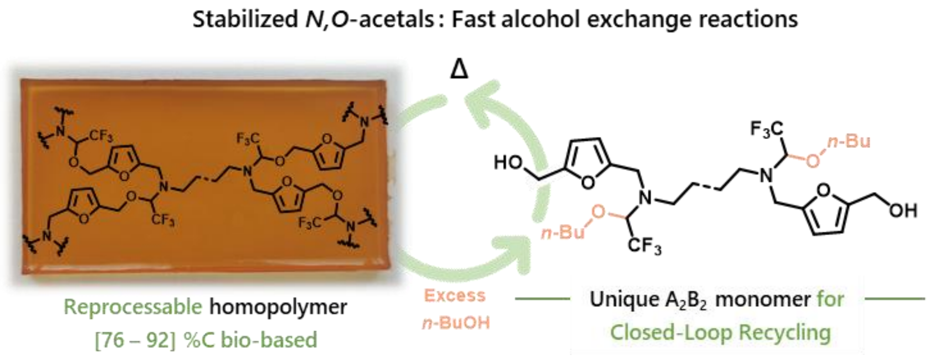

***Figure 1** : Schéma des voies de recyclages (mécanique et chimique) des CANs de type N,O-acétals stabilisés.*

Références :

[1] Laviéville, S.; Levron, A.; Caillol, S.; Bakkali-Hassani, C.; Ladmiral, V.; Leclerc, E. Stable *N* , *O* -Acetal Covalent Adaptable Networks: Bio-Based, Highly Dynamic and Fully Recyclable Materials. *J. Mater. Chem. A*, 14, **2026,** 3928-3937.

Interactions acide-base de Lewis réversibles : comment contrôler les propriétés rhéologiques des réseaux covalents adaptables de type uréthane vinylogue

N. Arnould[a], **A. Prieto**[a], **O. Giani**[a], **C. Bakkali-Hassani**[a]
[a] *ICGM, Univ Montpellier, CNRS, ENSCM, Montpellier, France*
nathan.arnould@umontpellier.fr

Les réseaux covalents adaptables (*Covalent Adaptable Networks* (CANs) en anglais) ont été popularisé en 2011 par l'équipe du Prof. L. Leibler.[1] Ces matériaux polymères possèdent la structure tri-dimensionnelle des thermodurcissables ainsi que leurs propriétés de résistance mécanique et chimique mais peuvent également s'écouler, une propriété caractéristique des thermoplastiques. Ce phénomène d'écoulement est permis par l'échange de liens covalents, à travers des réactions connues de la chimie moléculaire comme, parmi d'autre, la transamination d'uréthanes vinylogues (VU).[2] Les CANs utilisant cette plateforme d'échange (VU-CANs) sont connus pour leur dynamique rapide au-delà de 100 °C sans ajout de catalyseur externe. La présence de 5% d'amines primaires libre a été déterminé comme étant le meilleur compromis entre la vitesse d'échange et les propriétés thermomécaniques. La cinétique rapide d'échange des VUs permet une remise en forme efficace mais rend les matériaux sensibles au fluage sous contrainte. Cependant, il a été démontré que la formation dynamique de complexes acide/base de Brönsted favorisait/inhibait l'écoulement en fonction de la force et de l'encombrement stérique de l'acide par neutralisation réversible l'excès d'amine primaire. [3]

Les paires de Lewis classiques (LPs) sont des adduits entre un acide de Lewis (LA) et une base de Lewis (LB) liés par des liaisons covalentes de coordination, grâce au don d'une paire d'électrons libres de la LB à l'orbitale vacante en électrons du LA. Cette interaction réversible (couvrant une large gamme d'énergies de liaison allant de quelques dizaines de $kJ.mol^{-1}$ à plusieurs centaines de $kJ.mol^{-1}$) [4] a été utilisée pour générer des catalyseurs thermiquement latents et des liaisons physiques réversibles, mais n'a pas encore été explorée dans la chimie des CANs à ce jour.[5]

Dans ce travail, nous avons employé la formation réversible de paires de Lewis dans un VU-CAN comme un outil permettant de contrôler leurs propriétés rhéologiques grâce à la libération contrôlée d'amines primaires et de catalyseur. La formation de LP entre une amine primaire (RNH_2) et des acides de Lewis boré (de type BR_3 avec R=alkyl ou aryl), a été confirmée au niveau moléculaire par RMN ^{11}B et des calculs DFT. La RMN ^{11}B solide a été ensuite utilisée pour sonder au sein du réseau VU l'état et l'environnement du catalyseur. L'introduction de LP a permis de modifier drastiquement les propriétés rhéologiques des matériaux. D'une part, des vitesses d'échanges les plus élevées ont été obtenues grâce à l'introduction de tris-pentafluorophénylborane ($B(PhF_5)_3$), permettant d'obtenir des temps de relaxation de 20 secondes à 150 °C. D'autre part, une stabilité thermique accrue a été obtenue en utilisant le triphénylborane ($B(Ph)_3$) comme catalyseur. Ce dernier permet d'obtenir un matériau avec 2 régimes visco-élastiques, un premier à basse température avec des échanges lents (LP sous forme liée), suivi d'un second au-delà de 170 °C avec des échanges covalents très rapides par libération simultanée d'un catalyseur et de l'amine primaire (Figure 1).

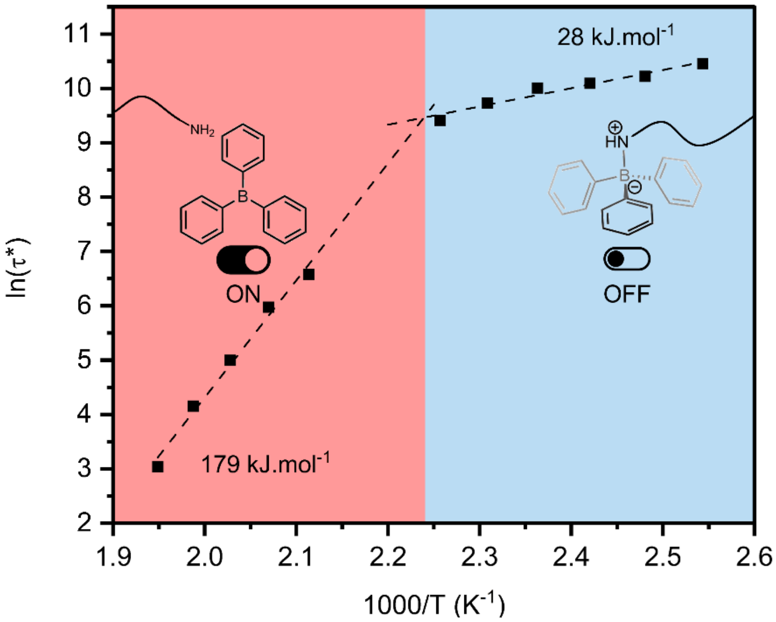

Figure 1 : *Temps caractéristique en fonction de l'inverse de la température montrant un double régime visco-élastique obtenu par l'introduction de B(Ph)$_3$ dans un VU-CAN.*

Références :

[1] D. Montarnal, M. Capelot, F. Tournilhac, L. Leibler, "Silica-Like Malleable Materials from Permanent Organic Networks" *Science* **2011**, *334*, 965–968.

[2] W. Denissen, G. Rivero, R. Nicolaÿ, L. Leibler, J. M. Winne, F. E. Du Prez, "Vinylogous Urethane Vitrimers" *Adv Funct Materials* **2015**, *25*, 2451–2457.

[3] F. Van Lijsebetten, S. Maes, J. M. Winne, F. E. Du Prez, "Thermoswitchable catalysis to inhibit and promote plastic flow in vitrimers" *Chem. Sci.* **2024**, *15*, 7061–7071.

[4] A. C. Mendes, E. T. Baran, R. L. Reis, H. S. Azevedo, "Self-assembly in nature: using the principles of nature to create complex nanobiomaterials" *WIREs Nanomed Nanobiotechnol* **2013**, *5*, 582–612.

[5] F. Vidal, J. Gomezcoello, R. A. Lalancette, F. Jäkle, "Lewis Pairs as Highly Tunable Dynamic Cross-Links in Transient Polymer Networks" *J. Am. Chem. Soc.* **2019**, *141*, 15963–15971.

Thermally conductive composites based on polyethylene and hexagonal boron nitride, with low environmental impacts

Sacha BEAUMEL [a], Aurélie TAGUET [a], Joana BEIGBEDER [b], Christian GARNIER [c], France CHABERT [c]
[a] Polymères et Composites Hybrides (PCH), IMT Mines Ales, Ales, France
[b] IPREM, IMT Mines Ales, Université de Pau Et Des Pays de L'Adour, CNRS, E2S UPPA, Pau, France
[c] Université de Toulouse, UTTOP, LGP, Tarbes, France
sacha.beaumel@mines-ales.fr

In the context of electrification of uses, the development of polymer-based thermally conductive materials with low environmental impact represents a strategic challenge for efficient heat dissipation in several electronic devices such as heat sinks (Thermal Interface Materials, TIMs) [1]. This work is part of an eco-design approach aimed at formulating model composites based on a low-density polyethylene (LDPE) matrix, both recycled (rLDPE) and virgin filled hexagonal boron nitride (h-BN) fillers.

Two types of boron nitride fillers were investigated: hexagonal boron nitride platelets (h-BN) and agglomerates of h-BN platelets exhibiting different particle size and geometry. Composites based on 6, 19, 27 and 47wt% of h-BN platelets and agglomerates were prepared by melt mixing. The in-plane and through-plane thermal conductivity of the composites were measured. The results show that at high filler content (47%m), the recycled matrix composite loaded with h-BN exhibits a significantly higher in-plane thermal conductivity than that of virgin LDPE, largely exceeding the values required for TIM applications (> 4 $W \cdot m^{-1} \cdot K^{-1}$). However, the through plane thermal conductivity remained very low (< 0.5 $W \cdot m^{-1} \cdot K^{-1}$) due to a final anisotropic microstructure of the composites.

In parallel, within the eco-design framework, the environmental impacts of h-BN and recycled polymer production were assessed using the Life Cycle Assessment method. It was shown that the use of recycled polymer does not significantly reduce the environmental burden associated with composite raw materials production, highlighting the predominant environmental impact of h-BN.

These results emphasize the need to explore alternative thermally conductive fillers with lower environmental impacts (Al_2O_3, AlN, MgO) but comparable thermal performance, in order to jointly optimize the performance and the sustainability of thermal interface materials.

Références :

[1] Q. Chen, K. Yang, Recent advances in thermal-conductive insulating polymer composites with various fillers, *Composites Part A*, 178, **2024**, 107998.

Synthesis and optimization of functional star-shaped PEG-PLA copolymers for colorectal tissue engineering

Justine Montassier[1], Coline Pinese[1,2], Giovanni Vozzi[3], Benjamin Nottelet[1,2]

[1]Polymers for Health and Biomaterials, IBMM, ENSCM, University of Montpellier, CNRS, Montpellier, France; [2]Department of Pharmacy, Nîmes University Hospital, Nîmes, France; [3] Department of Information Engineering, Università di Pisa, Pisa, Italy
Justine.montassier@enscm.fr

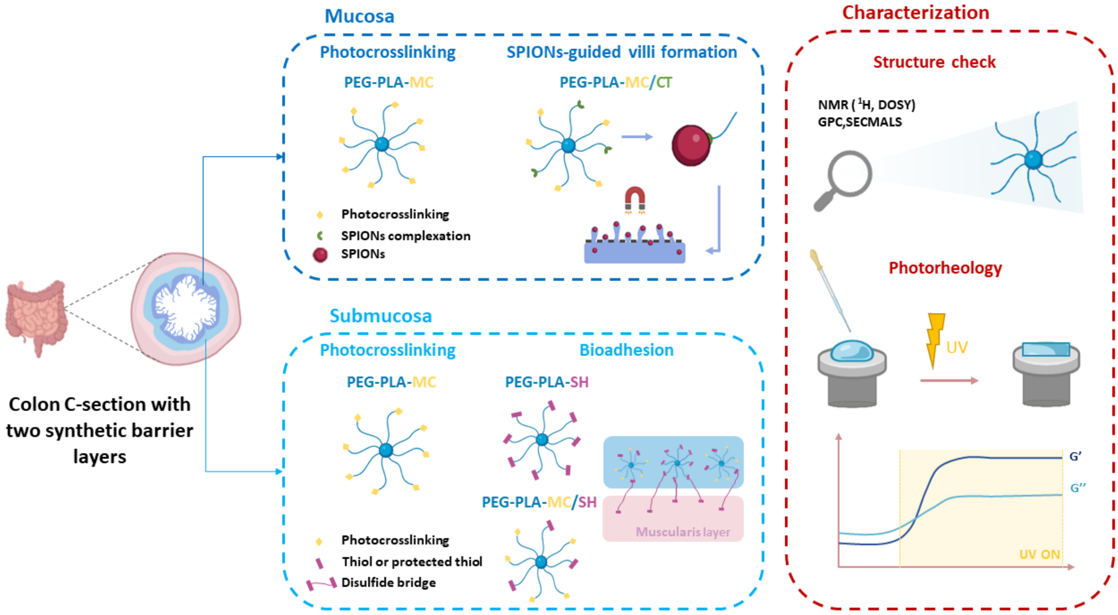

Figure 1: Overview of the project

Surgical treatment of colorectal diseases can lead to loss of colonic tissue. The Daedalus European project addresses this by developing synthetic bilayered materials to replace the mucosa and submucosa with distinct mechanical/functional properties. Both layers require photopolymerizable crosslinking functionalities, mucosal surface structuration for villi-like topography (SPIONs-responsive), and submucosal bioadhesion to underlying tissues. This contribution illustrates the first steps taken to provide star-block copolymer families able to meet these demanding objectives.

Multifunctional 8-arm star-shaped PEG-PLA copolymers were synthesized via ring-opening polymerization and post-polymerization modification. Mucosal methacrylate/catechol star (PEG-PLA-MC/CT) was prepared to enable SPIONs complexation and magnetic field-responsive patterning. Submucosal formulations combined methacrylated (PEG-PLA-MC), thiolated (PEG-PLA-SH), and MC/SH bifunctional stars for crosslinking density/disulfide bioadhesion control. NMR spectroscopy (^{1}H, DOSY) and GPC analysis confirmed composition, functionalization degrees, and molecular weight. Rheological analysis of PEG-PLA-MC and PEG-PLA-MC/CT precursor solutions showed concentration-dependent viscoelastic behavior suitable for 3D printing. Photorheology demonstrated rapid gelation upon UV exposure: PEG-PLA-MC formulation exhibited G′/G″ crossover within seconds, with final G′ increasing from 0.1 kPa to 1 kPa, confirming robust network formation. PEG-PLA-MC/CT system showed comparable crosslinking kinetics. This methacrylate star platform validates the development of both the mucosal and submucosal layers. Ongoing work evaluates MC/CT and MC/SH ratio to optimize layer-specific mechanical profiles. These multifunctional stars provide a versatile framework combining SPION-pattering for villi-like topography and disulfide-mediated bioadhesion, enabling bilayered materials tuned for post-surgical colorectal tissue regeneration.

This project is funded by the European Union (DAEDALUS G.A.101178568).

Ecofriendly antibacterial patches prepared from carboxymethyl cellulose and zinc oxide

Anne-Constance Macarez*[a], Samia Essabaoui [a], Pelagie Kamgang-Syapnjeu [a], Laurence Soussan [a], Hana Maalej [b], Camille Bakkali-Hassani [c], Céline Pochat-Bohatier [a], Suming Li[a]

[a] *Institut Européen des Membrane, IEM, UMR-5635, Univ Montpellier, ENSCM, CNRS, 34095 Montpellier, France*

[b] *University of Gabes, Laboratory of Biodiversity and Valorization of Arid Area Bioresources (BVBAA), LR16ES36, Faculty of Science, Erriadh 6072, Gabes, Tunisia*

[c] *Institut Charles Gerhardt de Montpellier, ICGM, Univ Montpellier, CNRS, ENSCM, 34293 Montpellier, France*

* anne-constance.macarez@umontpellier.fr

Biopolymer-based wound healing patches have attracted growing interest as they combine biocompatibility and biodegradability. Among the various biomass resources, olive stones (OS), an abundant agro-industrial by-product rich in cellulose, hemicellulose, and lignin [1], offer an interesting but underexploited raw material for developing new biomaterials. This work focuses on the valorization of OS as a sustainable source for the manufacture of an antibacterial wound healing patch.

Carboxymethyl cellulose (CMC) was synthesized by a alkylation-etherification process using cellulose extracted from olive stones, yielding a good degree of substitution (~ 1.1) and a molecular weight ranging from 244 to 676 kDa. The chemical structure of CMC was determined using FTIR and NMR, in comparison with a commercial CMC. The spectra revealed the presence of characteristic peaks of CMC. TGA and DSC analyses showed profiles similar to commercial CMC. These findings confirmed that CMC was successfully synthesized, making it suitable for various biomedical applications.

The second part of the study focused on the manufacture of CMC:ZnO hybrid hydrogels by adding zinc nitrate hexahydrate, which provides Zn^{2+} ions for physical crosslinking, and zinc hydroxide ($Zn(OH)_2$) as a precursor for zinc oxides (ZnO) formation. Good physical cross-linking was obtained, with a gel content up to 88%. SEM showed a highly porous structure with a uniform pore distribution, and EDX evidenced the presence of Zn in the whole matrix. The release of ZnO was monitored by UV measurements [2]. A cumulative release up to 0.57 mg was obtained. Antibacterial tests were carried out in comparison with positive and negative controls. The CMC/ZnO patches exhibited excellent antibacterial activity against *S. epidermidis* bacteria, as shown in Figure 1. This study highlights the great potential of CMC:ZnO hydrogel patches derived from OS as sustainable and effective wound healing material with antimicrobial and biocompatible properties.

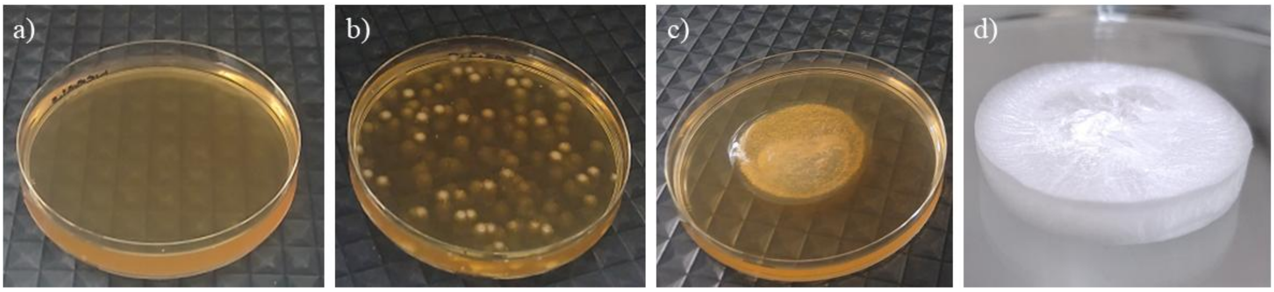

Figure 1 : *Antibacterial activity of the CMC:ZnO network: a) negative control, b) positive control, c) CMC/ZnO network from olive stones, and d) dry CMC/ZnO patch (before bacterial exposure).*

References :

[1] G. Rodríguez ; A. Lama ; R. Rodríguez ; A. Jiménez ; R. Guillén ; J. Fernández-Bolaños, *Bioresource Technology*, 2008, **volume 99**, pages 5261-5269

[2] R. Priyadarshi ; B. Kumar ; JW. Rhim, *International Journal of Biological Macromolecules*, 2020, **volume 162**, pages 229-235

Hofmeister-driven reinforcement of gelatin–dextran hydrogels for controlled biomolecule release

C. Vincent[a], E. Hachem[a], S.J. Buwalda[a]

[a]MINES Paris, PSL Research University, Center for Materials Forming (CEMEF), UMR CNRS 7635, Sophia Antipolis, France

carla.vincent@minesparis.psl.eu

Introduction

Gelatin and dextran are widely used biopolymers for biomedical applications due to their biocompatibility and biodegradability. Gelatin and aldehyde-functionalized dextran crosslinked via Schiff base formation yield hydrogels which are stable at physiological temperature but with limited mechanical strength. The Hofmeister effect provides a simple means to reinforce polymer networks via polymer- and ion-specific interactions [1]. In this study, we explore its role as a secondary crosslink technique in gelatin–dextran hydrogels, focusing on structural reinforcement and biomolecule release.

Material and Methods

Gelatin was crosslinked with aldehyde-functionalized dextran via Schiff base formation to form single-crosslinked hydrogels, which were characterized for gelation time, crosslinking degree, and structural properties. Secondary crosslinking was introduced by immersing the hydrogels in 10–30 % w/w sodium citrate solutions. Single- and double-crosslinked hydrogels were compared in terms of structure, protein loading, and release using FITC-labeled bovine serum albumin (BSA-FITC).

Results

Secondary crosslinking of gelatin–dextran hydrogels with sodium citrate reduced the network mesh size from 11 nm to 4–6 nm, demonstrating that a kosmotropic salt can reinforce the hydrogel structure via specific interactions. FT-IR confirmed additional gelatin–gelatin and gelatin–citrate interactions contributing to network stabilization. BSA-FITC was released in a sustained manner (~20 % over one month), and double-crosslinking did not significantly alter the release profile, showing that Hofmeister-driven reinforcement can enhance structural integrity without compromising controlled biomolecule delivery.

Conclusion

Gelatin–dextran hydrogels with tunable structural properties were successfully prepared by controlling polymer concentration and introducing a secondary crosslinking step with citrate ions. This straightforward salt treatment strengthened the hydrogel network, as confirmed by FT-IR analysis and swelling studies. Both single- and double-crosslinked hydrogels allowed sustained protein release over several weeks. Overall, these results demonstrate the potential of Hofmeister-reinforced gelatin–dextran hydrogels for controlled protein delivery, supporting applications such as wound healing and tissue regeneration (Figure 1).

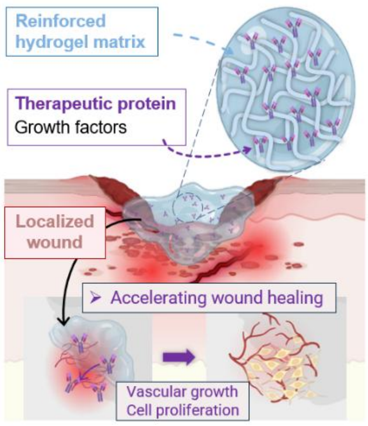

Figure 1: Hofmeister-reinforced gelatin-dextran hydrogels for wound healing.

References:

[1] M. Jaspers, A.E. Rowan, Tuning Hydrogel Mechanics Using the Hofmeister Effect, *Adv Funct. Mater.,* 25, **2015** 6503–6510.

BIOPOLYMER-BASED HYDROGEL BEADS AS FUNCTIONAL ADSORBENTS FOR DYE REMOVAL APPLICATIONS

Ana-Roxana Ştefan [1,2], Ana-Maria Voicu[1,2], Isabelle Martin[1], Horia Iovu[2], François-Xavier Perrin[1*]

[1]*Université de Toulon, Laboratoire Matériaux Polymères Interfaces et Environnement Marin-MAPIEM EA 4323 SeaTech-Ecole d'ingénieurs, BP 20132, 83957, La Garde Cedex, France*

[2]*Advanced Polymer Materials Group, University Politehnica of Bucharest, 1-7 Gheorghe Polizu St., 011061, Bucharest, Romania*

*francois-xavier.perrin@univ-tln.fr

Although water is essential for life, a large part of the global population still lacks access to safe drinking water. Rapid industrialization, population growth, and urban expansion have caused severe contamination of water resources with various pollutants, including pesticides, heavy metals, pharmaceuticals, dyes, and surfactants. Among these, synthetic dyes are of particular concern due to their toxicity, potential carcinogenic effects, poor biodegradability, and harmful impact on aquatic ecosystems even at low concentrations. Several wastewater treatment technologies have been developed. However, adsorption stands out as one of the most effective and widely used methods because of its high efficiency, simplicity, low cost, and versatility in removing various contaminants [1].

This work focuses on the development of bio-based adsorption materials for the efficient removal of cationic and anionic dyes from aqueous systems, combining high adsorption capacity, fast kinetics, and good regeneration potential. Biopolymer-derived adsorbents have attracted increasing interest due to their renewable nature, low toxicity, and tunable functionality. Sodium alginate was selected for its biocompatibility, biodegradability, and ability to form stable hydrogels via ionic crosslinking with Ca^{2+}. [2]. However, its limited mechanical strength and poor affinity toward anionic dyes were addressed by blending with carboxymethyl chitosan, which introduces additional functional groups ($–COO^-$, $–NH_2$, –OH) acting as active binding sites for both cationic and anionic dyes [3].

Hydrogel beads based on sodium alginate (SA) with different contents of carboxymethyl chitosan (CMC) were fabricated using ionic crosslinking with calcium chloride ($CaCl_2$) and the impact of the CMC content on the adsorption properties was evaluated. Adsorption studies using methylene blue and Congo red as model cationic and anionic dyes were carried out under different pH values, temperatures, contact times, and adsorbent dosages. Adsorption mechanisms were analyzed using kinetic and isotherm models, and the reusability of the hydrogel beads was assessed through repeated adsorption–desorption cycles.

References

[1] Z. Zhang *et al.* "Smart superabsorbent alginate/carboxymethyl chitosan composite hydrogel beads as efficient biosorbents for methylene blue dye removal," *J Mater Sci Technol*, 159, 81–90, 2023.

[2] H. Jing *et al.* "Facile synthesis of pH-responsive sodium alginate/carboxymethyl chitosan hydrogel beads promoted by hydrogen bond," *Carbohydr Polym*, 278, 118993, 2022.

[3] X. Li *et al.* "Precisely controlled electrostatically sprayed sodium alginate/carboxymethyl chitosan hydrogel microbeads as super-adsorbent for adsorption of cationic dye," *Int J Biol Macromol*, 283, 2024.

Physically Crosslinked Hydrogel Coatings for Tunable Phosphorus Release and Enhanced Wheat Growth

Houda Hamiach [a b], Saida Tayibi [c], Saloua Fertahi [c], Salima Atlas[d], Mustapha Raihane [a e], Abdellatif Barakat [b c] **

[a] IMED Lab. Faculty of Sciences and Techniques, Cadi Ayyad University (UCA), Morocco
[b] UMR IATE, Montpellier University, INRAE, Montpellier Agro Institut, 2, Place Pierre Viala, 34060 Montpellier, France
[c] College for Sustainable Agriculture and Environmental Sciences, Mohammed VI Polytechnic University, Hay Moulay Rachid, 43150 Ben Guerir, Morocco
[d] ERSIC, Polydisciplinary Faculty - Sultan Moulay Sliman University, Mghila P.O. BOX: 592, 23000 Beni-Mellal, Morocco
[e] Applied Chemistry and Engineering Research Centre of Excellence (ACER CoE), Mohammed VI Polytechnic University, Lot 660, Hay Moulay Rachid Ben Guerir, 43150, Morocco
Email: houdahamiach16@gmail.com

Abstract

In the context of sustainable agriculture and resource-efficient bioprocessing, the valorization of industrial by-products through eco-designed materials represents a key strategy to improve nutrient management and soil functionality. In this study, a cost-effective and environmentally friendly hydrogel coating was developed through a physical crosslinking approach, integrating principles of biorefinery and green processing, to enhance water retention and enable slow phosphorus release from triple superphosphate (TSP) fertilizer.
The proposed system is based on the valorization of lignosulfonate, a lignin-derived byproduct, combined with chitosan and polyvinyl alcohol to form sustainable hydrogel coatings via hydrogen bonding and electrostatic interactions, without the use of chemical crosslinkers. Several formulations with varying lignosulfonate contents were prepared and comprehensively characterized in terms of structural, morphological, thermal, and mechanical properties.
The hydrogel-coated TSP fertilizers exhibited a significant reduction in phosphorus release compared to uncoated TSP, with release values reduced by up to two-fold after 3h in water. In soil conditions, nutrient release was further slowed, with the most crosslinked formulation (TSP@CPL50) showing a decrease in phosphorus release from 80.74 ± 2.16% at 6 days to 47.15 ± at 28 days. The swelling behavior and retention capacity of the hydrogels were strongly influenced by lignosulfonate content, with soil water retention improving by approximately 8% in hydrogel-amended soils over 20 days. Biodegradation studies demonstrated that incorporating lignosulfonate modulated degradation rates while preserving the coating's barrier function.
Finally, agronomic evaluation revealed that the coated fertilizers positively influenced wheat growth, physiological performance, and phosphorus availability. Overall, this work highlights the potential of lignin-based by-product valorization through sustainable bioprocesses to develop functional agricultural inputs that improve fertilizer efficiency, reduce nutrient losses, and contribute to more resilient and resource-efficient agroecosystems.

Fabrication of high-flux asymmetric polyimide membrane from water-soluble poly(amic acid) precursors via an Aqueous Route

Lauran MAMA[a], Irshad KAMMAKAKAM[a], Damien QUEMENER[a*]
[a] Institut Européen des Membranes, IEM-UMR 5635, Univ Montpellier, ENSCM, CNRS,34090 Montpellier, France
email : lauran.mama@umontpellier.fr

Polymer membranes play a key role in water treatment technologies due to their energy efficiency and modularity. Among the materials used, polyimides (PI) stand out for their thermal and mechanical stability, which explains their use in demanding separation applications [1]. However, conventional polyimide membrane fabrication relies heavily on dipolar aprotic solvents, which increasingly conflict with environmental, safety, and large-scale manufacturing constraints [2]. Here, we report a fully aqueous and scalable route to high-performance Kapton® polyimide ultrafiltration membranes based on poly(amic acid) salt PAAS precursors. The PAAS membrane is processed entirely from water via monovalent salt (NaCl) induced phase inversion, followed by a glycerol-assisted thermal imidization step that preserves a highly asymmetric polyimide membrane (PI) morphology. The resulting membranes consist of a thin dense top layer supported by a microvoid-rich porous sublayer, yielding an overall porosity of approximately 70%. The PI membranes combine high mechanical robustness with excellent transport performance, exhibiting a tensile strength close to 50 MPa and a pure water permeance of ~ 400 $L \cdot m^{-2} \cdot h^{-1} \cdot bar^{-1}$ at room temperature. A comparative life cycle assessment focused on the membrane fabrication step shows that replacing conventional NMP based processing (7.18 kg CO_2-eq.m^{-2}) with the proposed aqueous PAAS based process via the aqueous PAAS based process (6.6 kg CO_2-eq.m^{-2}) reduces the global warming potential, while maintaining comparable membrane performance. This work demonstrates that aqueous PAAS-based phase inversion enables the fabrication of mechanically robust, high flux Kapton® polyimide ultrafiltration supports, offering a sustainable relevant alternative to solvent-intensive polyimide membrane processing.

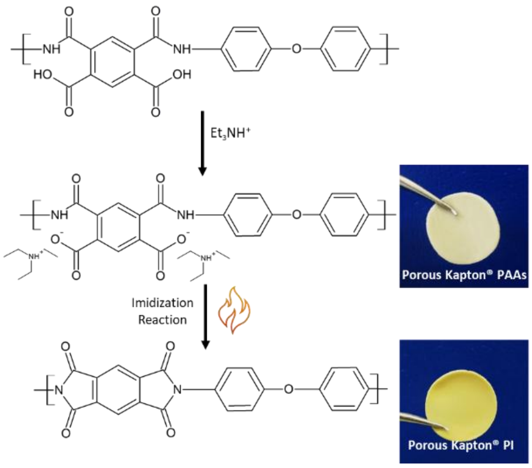

Figure 1: *Synthesis of poly(pyromellitoyl-oxydianiline amic acid) triethylammonium salt (PAAS) and the corresponding polyimide (PI) obtained by thermal imidization.*

References:

[1] Y. Ding, B. Bikson, and J. K. Nelson, "Polyimide Membranes Derived from Poly(amic acid) Salt Precursor Polymers. 1. Synthesis and Characterization," *Macromolecules*, vol. 35, no. 3, pp. 905–911, Jan. 2002, doi: 10.1021/ma0116102.

[2] P. Yadav, N. Ismail, M. Essalhi, M. Tysklind, D. Athanassiadis, and N. Tavajohi, "Assessment of the environmental impact of polymeric membrane production," *Journal of Membrane Science*, vol. 622, p. 118987, Mar. 2021, doi: 10.1016/j.memsci.2020.118987.

Amphiphilic copolymers for silicone-based antifouling coatings

Baptiste Matalon[*,1], **Farah Ibrahim**[1] **and Christine Bressy**[1]

[1] Laboratoire MAPIEM, Université de Toulon, La Garde, France

*baptiste-matalon@etud.univ-tln.fr

Silicone-based fouling release coatings (FRC) is one of the strategies to tackle colonisation issues by marine organisms on ship hulls [1]. Although there is no doubt about their efficiency under dynamic conditions, long-time static conditions without irreversible damages remain challenging. To overcome this problem, amphiphilic copolymers (e.g. silicone polyethers) introduced as additives in FRC is a widespread method [2,3]. In fact, diffusion of these additives across silicone elastomer in presence of water generate ambiguous surface which inhibit settlement of microorganisms and macroorganisms. Thus, a new type of amphiphilic copolymers poly(ethylene glycol methyl ether methacrylate)-*ran*-poly(polydimethylsiloxane methacrylate)-*ran*-poly(trialkylsilylmethacrylate) (PEGMEMA-*r*-PDMSMA-*r*-TASiMA) were synthesized by reversible addition-fragmentation chain transfer (RAFT) polymerization. Different macromolecules compositions were tested according to a predefined hydrophilic-hydrophobic balance (HLB) which has already shown good marine antifouling properties [3]. Compared to conventional silicone-polyether surfactants, adding TASiMA as hydrolysable co-monomer should ensure an evolution of surface chemistry over time during immersion. Copolymers with high conversions and a good control of molar mass and dispersity were obtained (i.e Đ<1.3). These amphiphilic copolymers were incorporated at fixed weight percentage (wt%) in silicone elastomer networks using polydimethylsiloxane (PDMS) sol-gel precursors. Different commercial PDMS precursors and various sol-gel catalysts have been examined for PDMS condensation curing films at room temperature. Dynamic wetting measurements of these silicone coatings enable to emphasize additives diffusion and reorganisation at the coating surface in presence of water [3]. Indeed, notable differences in decay of water contact angle may be most likely attributed in part to network topology disparities [4]. Moreover, long time field immersion tests in Toulon harbour confirm the antifouling performance of such amphiphilic PDMS films in static conditions. Correlation of additives diffusion velocity, surface and bulk coatings chemistry, as well as antifouling performances ranked amphiphilic copolymers mainly according to their composition and microstructure [2]. This strategy could be further investigated to bring additional chemical functions, such as nitroxide, with a contact activity against specific foulers [5].

[1] M. Lejars, A. Margaillan, C. Bressy, "Fouling Release Coatings: A Nontoxic Alternative to Biocidal Antifouling Coatings" *Chem. Rev.* **2012**, *112*, 4347–4390.
[2] A. Camós Noguer, S. M. Olsen, S. Hvilsted, S. Kiil, "Diffusion of surface-active amphiphiles in silicone-based fouling-release coatings" *Progress in Organic Coatings* **2017**, *106*, 77–86.
[3] Y. Soriano-Jerez, E. Gourlaouen, O. Zeriouh, M. D. C. Cerón-García, F. M. Arrabal-Campos, C. Ruiz-Martínez, I. Fernández, J. J. Gallardo-Rodríguez, F. García-Camacho, E. Molina-Grima, C. Bressy, "Role of dynamic surface tension of silicone polyether surfactant-based silicone coatings on protein adsorption: An insight on the 'ambiguous' interfacial properties of Fouling Release Coatings" *Progress in Organic Coatings* **2024**, *186*, 108079.
[4] T. Raemaekers, B. Erich, N. Esmaeili, H. Li, A. Børve, J. Aarts, O. Adan, "The impact of solvent content and curing conditions on drying and network properties of condensation curing PDMS films" *Materials Today Communications* **2025**, *46*, 112861.
[5] R. Medhi, A. Cintora, E. Guazzelli, N. Narayan, A. K. Leonardi, G. Galli, M. Oliva, C. Pretti, J. A. Finlay, A. S. Clare, E. Martinelli, C. K. Ober, "Nitroxide-Containing Amphiphilic Random Terpolymers for Marine Antifouling and Fouling-Release Coatings" *ACS Appl. Mater. Interfaces* **2023**, *15*, 11150–11162.

* Funded by ANR Projet-ANR-23-CE04-0001

Development of nanoporous polymer electrolytes for lithium metal batteries

A. ZAGOURY[a,b], A-A. KA[c], K. AISSOU[c], J-M. ZANOTTI[b], D. GIGMES[a], T. PHAN[a]

[a]Aix Marseille Univ, CNRS, Institut de Chimie Radicalaire UMR 7273, Marseille, France
[b]Laboratoire Leon Brillouin, CEA Saclay Universite Paris-Saclay, CNRS, Saclay, France
[c]Institut Européen des Membranes, Université de Montpellier, CNRS-ENSCM, Montpellier, france
aaron.zagoury@univ-amu.fr

Separators used in lithium batteries (LiBs) physically separate the electrodes to prevent short circuits, while allowing lithium ions (Li^+) to move freely through the pores of the separators. As a critical component of LiBs, separators directly impact battery performance. Macroporous polyolefin-based membranes have been widely used as separators in LiBs due to their mechanical strength and adequate electrochemical stability. However, these separators suffer from inherent limitations, such as poor wettability, low liquid electrolyte loading as well as low thermal stability. Poor electrolytes wettability and absorption hinder Li^+ transport, degrading battery performance during charge and discharge cycles. In addition, the low thermal stability of polyolefin separators increases the risk of internal short circuits at high temperatures, raising significant safety concerns [1].
On the other hand, confining liquid electrolytes or poly(ethhylene oxide)/Li salt electrolytes within nanoporous membranes enhanced both ionic conductivity and cycling performance [2.3]. However, the pore wall chemistry and the pores density of the reported nanoporous membranes cannot be easily modulated. In the present work, we propose an innovative approach based on the self-assembly of block copolymers (BCPs) to fabricate porous polymer electrolyte membranes with oriented nanometric cylindrical pores perpendicular to the electrodes.
This approach provides a versatile platform for tailoring the size and geometry of nanopores at large-scale as well as enabling selective functionalization of voided channels. The BCPs used in this work consist of a sacrificial block – polyethylene oxide (PEO) – and a matrix block, that is a random copolymer of styrene and isoprene: poly(styrene-r-isoprene) (PSI) (Fig. 1A). These BCPs were synthesized via nitroxide-mediated polymerization to achieve low dispersity (Đ<1.3).

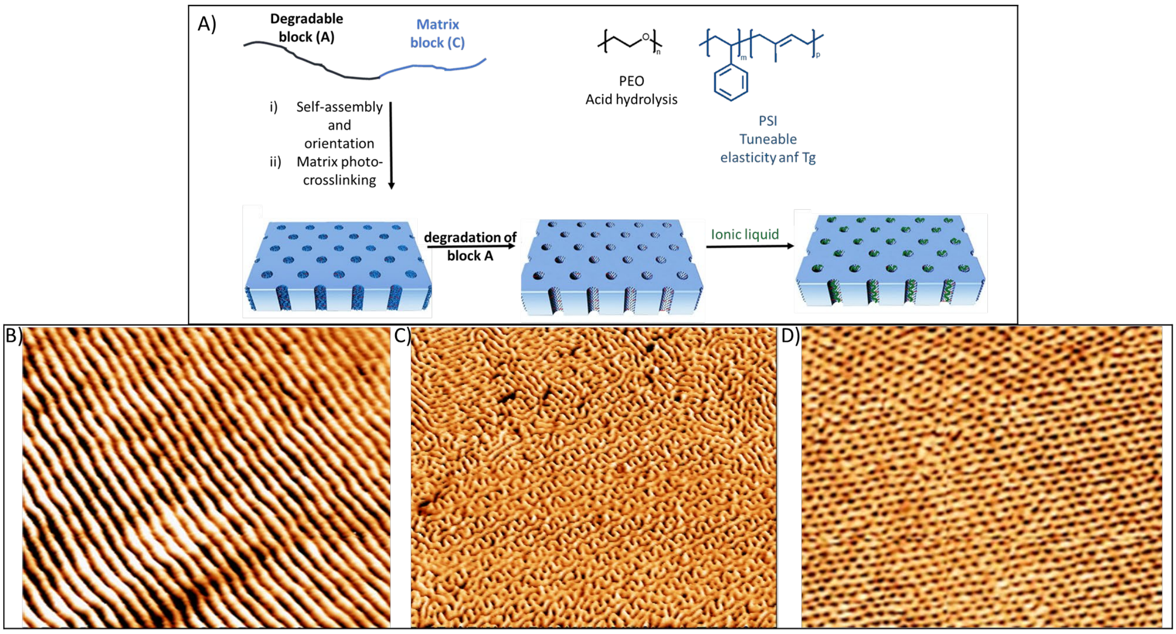

Figure 1: A) Schematic illustration of the process route to manufacture nanoporous polymers electrolyte. B) AFM phase image of the surface of one of our polymer with a lamellar morphology. C) AFM phase image of the surface of one of our polymer with a gyroid morphology. D) AFM phase image of the surface of one of our polymer with a cylinder morphology.

The pore size was directly controlled by the length of the PEO block (ranging from 5 to 20 kg/mol), while the mechanical properties of the membranes were conferred by the cross-linked PSI matrix. Thin films, approximatively tens of micrometers thick, exhibited excellent nanostructuration in various morphologies depending on the BCP composition (Fig. 1B-D). The PEO block was subsequently removed from the UV-cross-linked films via acid hydrolysis, resulting in nanoporous membranes. Extensive chemical and physical

characterization were performed using a combination of techniques (AFM, SEM, SAXS ,SANS,…) to fully characterize our membranes, both empty and filled with non-flammable liquid electrolytes.
This communication will feature on synthesis, self-assembly and characterization of our BCPs.

Références :

[1] Yang, H.; Shi, X.; Chu, S.; Shao, Z.; Wang, Y. Design of Block-Copolymer Nanoporous Membranes for Robust and Safer Lithium-Ion Battery Separators. *Adv. Sci.* **2021**, *8* (7), 2003096. https://doi.org/10.1002/advs.202003096.

[2] Modesto, N.; Pinchart, C.; Abdel Sater, M.; Appel, M.; Fouquet, P.; Tengattini, A.; Russina, M.; Grzimek, V.; Günther, G.; Jouneau, P.-H.; Coasne, B.; Lairez, D.; Judeinstein, P.; Ramos, R.; Gigmes, D.; Phan, T. N. T.; Berrod, Q.; Zanotti, J.-M. 1D Nanoporous Membrane Boosts the Ionic Conductivity of Electrolytes. *Energy Storage Mater.* **2025**, *75*, 104045. https://doi.org/10.1016/j.ensm.2025.104045.

[3] Wan, J.; Xie, J.; Kong, X.; Liu, Z.; Liu, K.; Shi, F.; Pei, A.; Chen, H.; Chen, W.; Chen, J.; Zhang, X.; Zong, L.; Wang, J.; Chen, L.-Q.; Qin, J.; Cui, Y. Ultrathin, Flexible, Solid Polymer Composite Electrolyte Enabled with Aligned Nanoporous Host for Lithium Batteries. *Nat. Nanotechnol.* **2019**, *14* (7), 705–711. https://doi.org/10.1038/s41565-019-0465-3.

GFP-Med.

Thermodurcissables autodéconstructibles compatibles avec l'impression 3D via rROP et bases thermolatentes

S.Kouider[a], L.Charles[a], C.Lefay[a], Y.Guillaneuf[a]
[a]Aix-Marseille Université, CNRS, Institut de Chimie Radicalaire UMR 7273, 13397 Marseille, France
kouidersophia@icloud.com

Les polymères thermodurcissables sont largement utilisés dans des secteurs exigeants comme l'aéronautique, l'automobile ou encore l'électronique, en raison de leurs excellentes propriétés mécaniques et de leur résistance chimique et thermique. Cependant, leur structure réticulée permanente empêche tout recyclage ou dégradation en fin de vie, constituant un enjeu majeur en termes de durabilité.

Dans ce contexte, différentes stratégies ont été développées pour introduire des liaisons clivables au sein des réseaux, notamment via l'incorporation de comonomères dégradables en polymérisation radicalaire par ouverture de cycle. Parmi ces systèmes, les thionolactones[1] ou les lipoates[2] permettent d'intégrer des fonctions labiles telles que des thioesters ou des disulfures dans l'architecture du polymère.

Dans ce travail, nous explorons une approche synergique combinant l'incorporation de comonomères dégradables, en particulier le DOT, avec des bases thermolatentes de type TBD [3](***Figure 1***). Cette stratégie permet d'obtenir des réseaux thermodurcissables stables lors de l'usage, mais capables de se dégrader de manière contrôlée après activation thermique ou photoactivation.

Les résultats montrent que la dégradation peut être déclenchée à des températures modérées, avec une diminution significative des masses molaires observée par SEC, ainsi qu'une altération des propriétés mécaniques confirmée par DMA.

Cette approche est compatible avec des procédés industriels tels que l'impression 3D[4]., et permet également d'envisager des stratégies de recyclage ou de revalorisation des matériaux, notamment par incorporation en tant que charges dans de nouveaux matériaux.

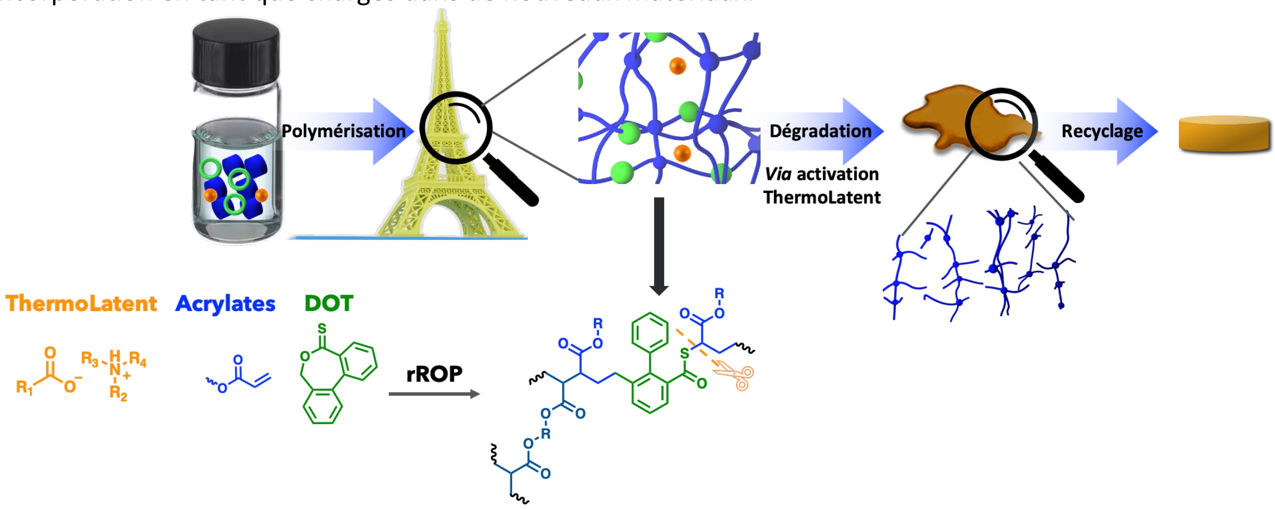

Figure 1*. Thermodurcissables autodéconstructibles compatibles avec l'impression 3D via rROP et bases thermolatentes.*

Références :

[1] H.Elliss, F.Dawson, Q.un Nisa, N.M. Bingham, P.J. Roth, and M.Kopeć, Fully Degradable Polyacrylate Networks from Conventional Radical Polymerization Enabled by Thionolactone Addition, *Macromolecules*, **2022**, 55 (15), 6695-6702

[2]K.R. Albanese, Y.Okayama, P.T.Morris, M.Gerst, R.Gupta, J.C. Speros, C.J.Hawker, C.Choi, J.Read de Alaniz, C.M.Bates, Building Tunable Degradation into High-Performance Poly(acrylate) Pressure-Sensitive Adhesives*, ACS Macro Letters*, 2023, 12 (6), 787-793.

[3] D.Reisinger, M.U.Kriehuber, M.Bender, D.Bautista-Anguís, B. Rieger, S.Schlögl, Thermally Latent Bases in Dynamic Covalent Polymer Networks and their Emerging Applications, *Adv. Mater*, **2023**, 35: 2300830.

[4]N.Gil, C.Thomas, R.Mhanna, J.Mauriello, R.Maury, B.Leuschel, J.-P.Malval, J.-L.Clément, D.Gigmes, C.Lefay, O.Soppera, Y.Guillaneuf, Thionolactone as a Resin Additive to Prepare (Bio)degradable 3D Objects via VAT Photopolymerization, *Angew. Chem. Int. Ed.***2022**, 61.

Titre : Identification, caractérisation et transformation des protéines issus des sous-produits de l'arganier en vue d'applications alimentaires et fourragères.

Résumé : Les enjeux actuels liés à la durabilité des systèmes alimentaires et à la diversification des sources protéiques encouragent la valorisation des coproduits agro-industriels encore peu exploités. Dans ce contexte, cette étude s'intéresse à la valorisation des protéines issues des sous-produits de l'arganier, en particulier les tourteaux d'argane, riches en protéines (>40 %). L'objectif est d'identifier, de caractériser et de transformer ces ressources à fort potentiel, encore peu exploitées et valorisées, en ingrédients protéiques à haute valeur ajoutée, destinés à des applications alimentaires et non alimentaires.

Les travaux reposent sur des procédés d'extraction et de fractionnement éco-compatibles des protéines des tourteaux d'arganier, combinant des approches de voie sèche et des traitements enzymatiques. Les protéines obtenues sont caractérisées selon différentes approches biochimiques, physico-chimiques, structurales et techno-fonctionnelles, à l'aide de techniques analytiques avancées (CLHP, CG, MEB, DSC, FTIR, Raman, DLS, SDS-PAGE, fluorescence, etc.).

Les fractions protéiques obtenues (farines, concentrés, isolats et hydrolysats) seront ensuite intégrées dans la formulation de produits innovants solides et liquides, tels que pains, pâtes, barres protéinées et boissons végétales. Ces formulations s'appuient sur des procédés technologiques modernes, notamment l'extrusion à froid, l'émulsification et la gélification, afin d'optimiser les propriétés nutritionnelles, fonctionnelles et technologiques de ces ingrédients protéiques.

Mots-clés : Arganier, Tourteaux d'argane, protéines, valorisation, applications alimentaires

Bibliographie : L'auteure possède une expertise en sciences des aliments et une passion pour la valorisation des protéines d'origine végétale dans les applications alimentaires. Ses recherches portent sur l'utilisation des protéines du tourteau d'argan pour leur formulation et leur application dans l'industrie agroalimentaire. Elle a obtenu son master en sciences des aliments à l'Université de Lorraine, en France, et poursuit actuellement un double doctorat en Sciences, Techniques et Ingénierie à l'UMR, IATE et INRAE à Montpellier, et à l'UM6P au Maroc.

Etalement maximal d'une goutte d'alginate impactant une plaque solide

M. Drahé[a], N. Nazzal[a], L. Jorgensen[b], E. Peuvrel-Disdier[a], A. Pereira[a]

[a] *Mines Paris, PSL University, Centre for material forming (CEMEF), UMR CNRS 7635, rue Claude Daunesse, 06904 Sophia-Antipolis, France*

[b] *Sciences et Ingénierie de la Matière Molle (SIMM), ESPCI Paris, Université PSL, UMR CNRS 7615, Sorbonne Université, Paris, France*

martin.drahe@minesparis.psl.eu

Les biopolymères comme l'alginate de sodium sont de plus en plus utilisés dans divers procédés nécessitant le contrôle du dépôt et de la forme de la matière. Ils sont employés pour diverses applications, telles que l'encapsulation de fluides, d'actifs ou de cellules d'intérêt [1], la production de billes céramiques [2] pour la texturation de surface ou la bio-impression 3D de tissus mous ou d'organes [3]. Un enjeu majeur est la compréhension du comportement physique de ces fluides, soumis à des sollicitations extrêmes lors de ces procédés. Nous présentons ici une étude basée sur une approche mixte expérimentale-numérique consacrée à l'étalement d'une goutte millimétrique d'alginate impactant une plaque solide de verre (figure 1). La déformation de la goutte en fonction du temps est suivie à l'aide d'une caméra rapide et prédite numériquement en couplant les équations de conservation de la masse et de quantité de mouvement avec des lois de comportement viscoélastiques. Cette approche nous permet de démontrer que l'étalement de la goutte est dominé par une compétition entre les contraintes inertielles (motrices), visqueuses, élastiques et capillaires. Enfin, l'étalement maximal de la goutte est prédit à la lumière des contraintes pilotant l'écoulement.

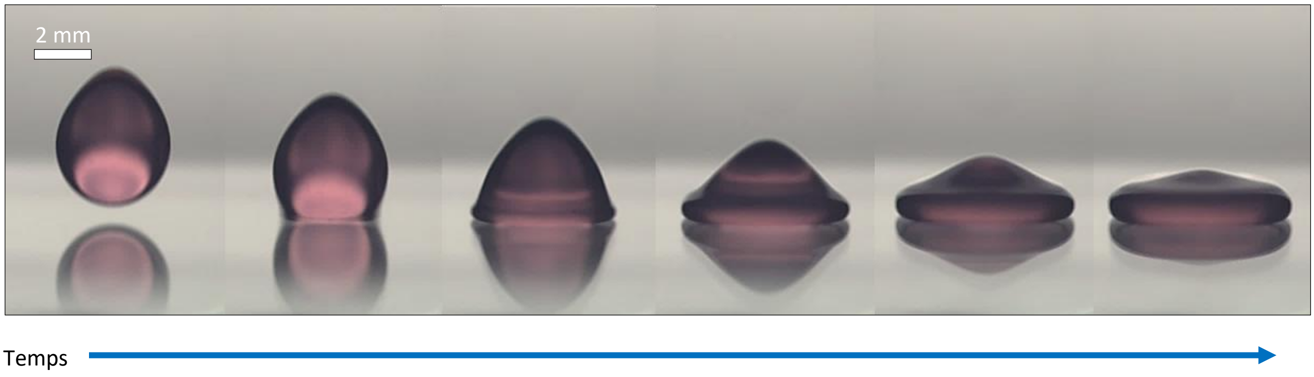

***Figure 1** : Impact d'une goutte de solution d'alginate de sodium sur une plaque de verre.*

Références :

[1] M. Bochenek *et al.* Alginate encapsulation as long-term immune protection of allogeneic pancreatic islet cells transplanted into the omental bursa of macaques. Nature Biomedical Engineering, 2(11):810–821, **2018**.

[2] C. Santos *et al.* A forming technique to produce spherical ceramic beads using sodium alginate as a precursor binder phase. Journal of the American Ceramic Society, 96(11):3379–3388, **2013**.

[3] S. Murphy, A. Atala, 3D bioprinting of tissues and organs. Nature Biotechnology, 32(8):773–785, **2014**.

Nanocellulose–alginate hydrogel beads with tunable porosity for organic dye removal

Ana-Maria VOICU[1,2], Ana-Roxana ȘTEFAN[1,2], Isabelle MARTIN[1], Horia IOVU[2], François-Xavier PERRIN[1*]
[1]Université de Toulon, Laboratoire Matériaux Polymères Interfaces et Environnement Marin-MAPIEM EA 4323 SeaTech-Ecole d'ingénieurs, BP 20132, 83957, La Garde Cedex, France
[2]Advanced Polymer Materials Group, National University of Science and Technology Politehnica Bucharest, 1-7 Gheorghe Polizu St., 011061, Bucharest, Romania
*Corresponding Author E-mail: perrin@univ-tln.fr

The increasing presence of organic dyes and heavy metals in wastewater represents a significant environmental challenge due to their toxicity and bioaccumulation potential. Conventional remediation technologies including adsorption, membrane filtration, and chemical precipitation often present limitations such as high operational cost, low selectivity, toxic sludge generation, or poor recyclability [1]. As one of the most promising methods for handling wastewater, the adsorption method has been widely used since it is more economical and environmentally benign than the other approaches. Despite extensive research on a variety of adsorbents with carbon, silica, polymers, and natural adsorbents has been done, research is still ongoing on unique and extremely effective adsorbents for wastewater treatment.
Bio-based materials have gained significant attention as sustainable and high-performance sorbents [2]. Among them, cellulose nanofibers (CNF), especially in their TEMPO-oxidized form (TOCNF), provide high surface area, abundant functional groups, and excellent colloidal stability, making them ideal candidates for the design of next-generation sorbents [3]. This study presents the development and evaluation of innovative ionically crosslinked hydrogel beads composed of sodium alginate (SA) blended with a CNF slurry incorporating in situ–grown $CaCO_3$ nanoparticles as sacrificial porogens to enhance internal porosity and improve sorption capacity.
The synthesized material was analyzed for its thermal stability using TGA. The surface morphologies and distribution of elements in the samples were determined using scanning electron microscopy and EDX, the presence of various functional groups in samples was identified by FTIR, the crystallinity and crystal form assessed through XRD. The porosity of the beads was measured using the liquid displacement method. The effect of CNF content and $CaCO_3$ porogen on the adsorption performance toward organic dyes was thoroughly analysed.

Keywords: water treatment; cellulose nanofibers; porogenic agents; adsorption.

Bibliography:

[1] Z. Zhang, K. Li, W. Dong, Z. Wang, X. Zhang, and J. Wang, "An ingenious construction of porous sodium alginate/TEMPO-oxidized cellulose composite aerogels for efficient adsorption of crystal violet dyes in wastewater," *J. Solgel Sci. Technol.*, vol. 110, no. 2, pp. 391–405, May 2024, doi: 10.1007/s10971-023-06299-0.

[2] Y. Chen *et al.*, "Porous sodium alginate/cellulose nanofiber composite hydrogel microspheres for heavy metal removal in wastewater," *Int. J. Biol. Macromol.*, vol. 278, Oct. 2024, doi: 10.1016/j.ijbiomac.2024.135000.

[3] T. S. Hamidon, R. Adnan, M. K. M. Haafiz, and M. H. Hussin, "Cellulose-based beads for the adsorptive removal of wastewater effluents: a review," Jun. 01, 2022, *Springer Science and Business Media Deutschland GmbH*. doi: 10.1007/s10311-022-01401-4.

3D printing and functionalization to create a hemoperfusion cartridge

N. ANGELVIN[a], M. MARESCA[b], Y. GUILLANEUF[a], C. LEFAY[a]
[a] *Institut de Chimie Radicalaire, Aix Marseille Univ., CNRS, UMR 7273, Marseille, France*
[b] *Institut des Sciences Moléculaires de Marseille, Aix Marseille Univ., CNRS, UMR 7313, Marseille, France*

noemie.angelvin@univ-amu.fr

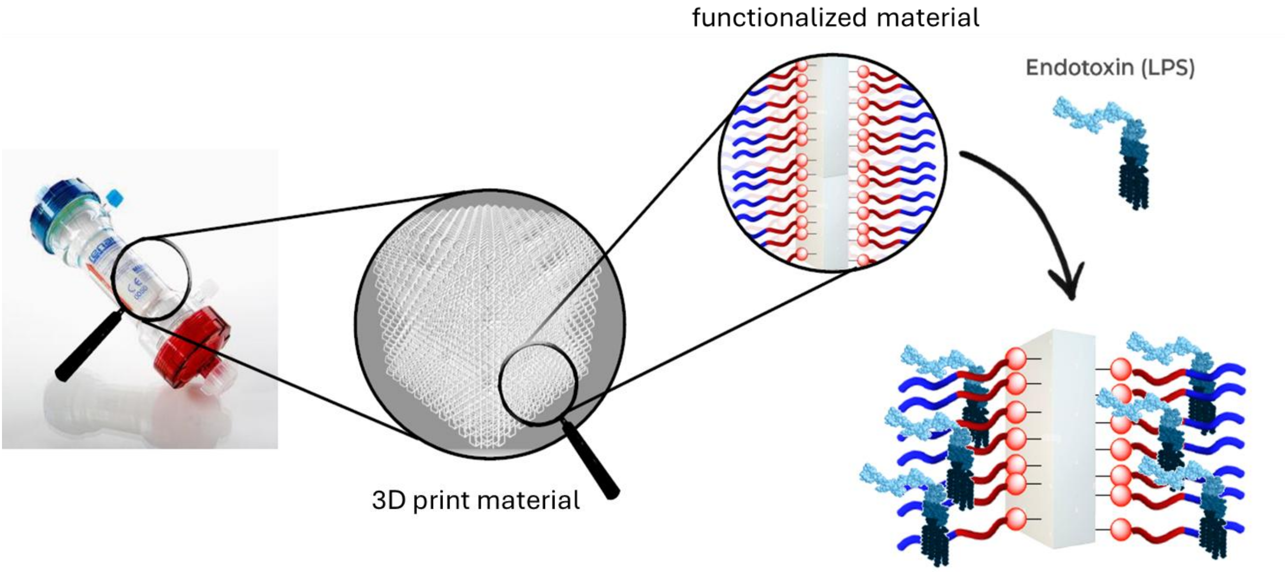

***Figure 1**: Thesis project*

Every year, sepsis causes more than 11 million deaths. It can occur unpredictably during any infection, most often bacterial. It results from a dysregulation of the immune response to infection, usually causing excessive inflammation that disrupts organ function. One solution for treating this infection is hemoperfusion.

The aim of this study is to create blood filtration cartridges for hemoperfusion, grafted with polymers capable of removing bacteria and toxins from the blood in cases of bacteremia or even sepsis. We have chosen to take an innovative approach combining 3D printing and the synthesis of methacrylate-type polymers. To study the structure-activity relationship of these polymers, we synthesized copolymers of varying molar masses and compositions with amphiphilic properties, containing a hydrophobic monomer and a cationic monomer. We determined the antibacterial properties of these free copolymers in solution on Gram-negative (E. coli) and Gram-positive (S. aureus) bacteria, as well as their hemolytic activities. Tests on their anti-inflammatory properties were also conducted. The next step in the project is to functionalize a 3D-printed support with the copolymer exhibiting the best properties.

Impact of Contaminants on the Structural, Thermo-Mechanical, and Processability Characteristics of Recycled PET for Bottle Applications

J. Housseini [a], C. Combeaud [a], J-L. Bouvard [a], M. Derrien [b], X. Monnier [b]
[a] Mines paris, CEMEF, Sophia antipolis, France
[b] Sidel, Octeville-sur-Mer, France
jouliahousseini@gmail.com

The recycling of polyethylene terephthalate (PET) bottles represents a critical challenge for the packaging industry, particularly in light of increasingly stringent European regulations mandating higher collection and incorporation of recycled PET (rPET) in bottle production [1]. However, the presence of contaminants such as polypropylene (PP) and various ink residues can significantly alter the physicochemical and mechanical properties of rPET, thereby affecting its processability and the overall performance of recycled bottles [2]. This project, conducted in collaboration with CEMEF-Mines Paris and SIDEL, aims to systematically investigate the impact of polyolefin and ink contaminants on the structural, thermo-mechanical, and processability characteristics of rPET. The study focuses on assessing how these impurities influence the microstructure, crystallization behavior, and stretchability of rPET. To achieve this, several rPET formulations containing controlled levels of contaminants are prepared and characterized through a comprehensive experimental approach. Structural and microstructural analyses, including X-ray diffraction (XRD), and differential scanning calorimetry (DSC), are performed to evaluate changes in microstructural organization. Thermo-mechanical behavior and stretchability are examined using dynamic mechanical analysis (DMA) and uniaxial tensile tests in the rubbery-like state ***(Figure 1)***. The results of this research will provide critical insights into the mechanisms by which contaminants influence rPET behavior throughout the recycling processes. Ultimately, this work aims to optimize processing conditions and establish guidelines for improving the compatibility of recycled PET with existing industrial equipment, thereby enhancing the circularity, performance, and sustainability of PET bottle production.

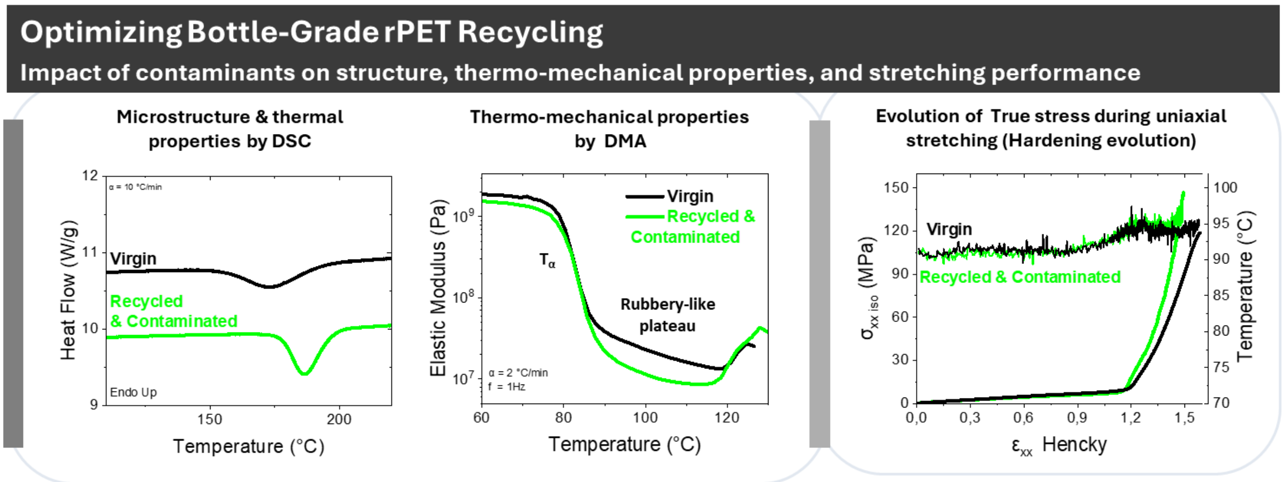

Figure 1 : *Thermal and thermo-mechanical behavior (DSC and DMA), along with stress evolution during uniaxial stretching, for virgin PET (black) and recycled PET with contamination (green), illustrating the relationship between material properties and processability.*

Références

[1] Directive (EU) 2019/904, On the reduction of the impact of certain plastic products on the environment, Journal officiel de l'Union européenne, n° L155, 2019, p. 1–19.

[2] E. M. Aizenshtein, Bottle Wastes – to Textile Yarns, Fibre Chemistry, vol. 47, n° 5, 2016, p. 343–347.

New platform for rROP: Cyclic Allylic Sulfides enabling fully degradable water-soluble polymers

Luna CHOULOT[a], Guillaume MICHAUD[b], Jean-Jacques FLAT[c], Catherine LEFAY[a], Yohann GULLANEUF[a]

[a] Aix-Marseille University CNRS, Institut de Chimie Radicalaire, UMR 7273, F-13397 Marseille, France.

[b] Coatex SAS, F-69370 Genay, France

[c] ARKEMA, Ctr Etud Rech & Dev, F-27170 Serquigny, France.

Luna.choulot@univ-amu.fr

The development of degradable vinyl polymers remains a major challenge, particularly for water-soluble systems that are difficult to recover and rarely undergo efficient end-of-life degradation. Radical ring-opening polymerization (rROP) offers a promising route to introduce cleavable units into vinyl backbones, but is often limited by incomplete ring-opening and restricted monomer scope.[1-4]

Herein, we report a novel cyclic allylic sulfide monomer that overcomes these limitations. It undergoes quantitative ring-opening via a thiyl radical-mediated mechanism, enabling the efficient incorporation of cleavable units without competition from ring-retaining pathways. This ensures a well-defined distribution of degradable motifs along the polymer backbone.

The monomer is readily synthesized and copolymerized with a wide range of vinyl monomers under conventional free-radical conditions. Despite the non-controlled nature of the polymerization, degradable units are efficiently incorporated, yielding materials with tunable degradation profiles.

Notably, copolymerization with acrylic acid provides access to degradable water-soluble polymers, addressing a key limitation in the field. Degradation can be triggered under various mild conditions, including fluoride (TBAF), acidic or basic media, and metal-mediated pathways ($FeCl_3$/MeOH), highlighting the versatility of this system.

This work introduces a new monomer platform for rROP based on cyclic allylic sulfides and opens new perspectives for the design of environmentally relevant degradable vinyl polymers, including highly challenging water-soluble systems.

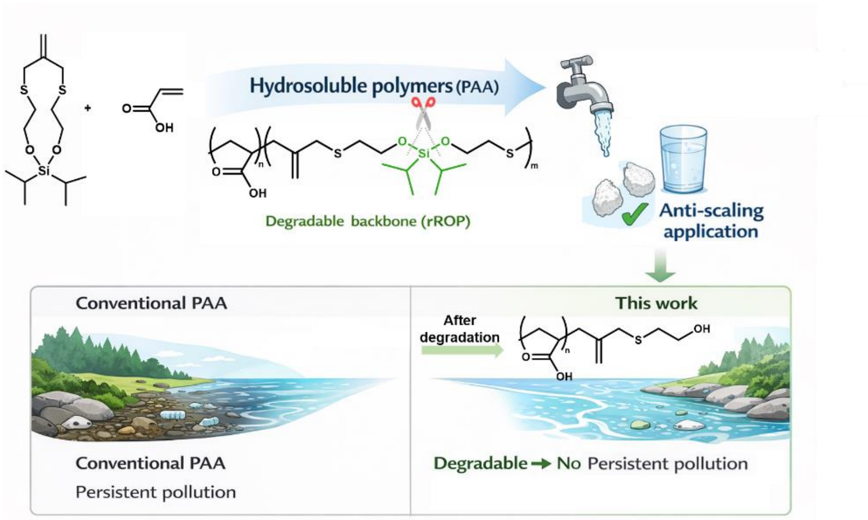

Figure 1:Degradable water-soluble vinyl polymers via rROP of a cyclic allylic sulfide monomer

Références :

[1] Tardy, A., Nicolas, J., Gigmes, D., Lefay, C. & Guillaneuf, Y. Radical Ring-Opening Polymerization: Scope, Limitations, and Application to (Bio)Degradable Materials. *Chem. Rev.* **117**, 1319–1406 (2017).

[2] Seema Agarwal. Chemistry, chances and limitations of the radical ring-opening polymerization of cyclic ketene acetals for the synthesis of degradable polyesters. *Polym Chem* **1**, 953–964 (2010).

[3] Bingham, N. M. & Roth, P. J. Degradable vinyl copolymers through thiocarbonyl addition–ring-opening (TARO) polymerization. *Chem. Commun.* **55**, 55–58 (2019).

[4] Smith, R. A., Fu, G. Y., McAteer, O., Xu, M. Z. & Gutekunst, W. R. Radical Approach to Thioester-Containing Polymers. *J. Am. Chem. Soc.* **141**, 1446–1451 (2019).