

## SCIENTIFIC AND TECHNICAL REPORT

**Program 2:** Increasing the competitiveness of the Romanian economy through research, development and innovation

**Subprogram 2.1.** Competitiveness through research, development and innovation

**Project type:** Experimental – demonstrative project – PED

**Project name:** Improved technologies for the development of membranes polysulfonic electrophiles integrated in an extracorporeal device applicable in renal failure

**Contract no:** 579PED/2022

**Project code:** PN-III-P2-2.1-PED-2021-2700

**Project acronym:** TechMembrEID

**Coordinator:** "Petru Poni" Institute of Macromolecular Chemistry, Iasi

**Partner:** Polytechnic University of Timisoara

**Project director:** Dr. Anca Filimon

**Stage 2 (2023) – Optimizing the surface properties of the FHMs membranes and evaluation of their functionality in medical applications by integration in the EID device**

**Reporting period:** January – December 2023

*Activity 2.1 - Obtaining of functionalized biocompatible fibrous membranes based on quaternized polysulfone (FHMs) by incorporation or immersion in anticoagulant solutions*

*Activity 2.2 - Controlling the hydrophobic/hydrophilic balance by studying the surface tension and hydration free energy*

*Activity 2.3 - Morphological and structural characterization of the obtained FHM membranes*

*Activity 2.4 - Membranes testing as biocide and establishing the inhibition mechanism against different types of bacteria*

*Activity 2.5 - In vitro screening of FHM membranes for biocompatibility evaluation*

*Activity 2.6 - Configuration and commissioning of the proposed innovative extracorporeal device*

*Activity 2.7 - Optimizing the operating parameters of the EID device*

*Activity 2.8 - Control of the dialysis process*

*Activity 2.9 - Dissemination*

## Summary of the stage

In accordance with the project implementation plan/activities schedule, the current stage, **Stage 2/2023**, includes research on obtaining through the electrospinning technique and property evaluation of new membranes based on quaternized polysulfone (FHMs) that will be integrated and used as separate media in an extracorporeal innovative device (EID), with the aim of being applicable in the renal failure treatment.

To remove/eliminate the harmful effect of the free radicals produced during the hemodialysis and to prevent inflammation associated with microaggregates and thrombus formation, in the current stage of the project, the preparation of bioactive fibrous membranes functionalized with antioxidants ( $\alpha$ -lipoic acid and  $\alpha$ -tocopherol incorporated directly into the solvent organic used for dissolving polymers - **Stage 1/2022, Act 1.3**) and anticoagulants (classic unfractionated heparin - **Stage 2/2023, Act 2.1**) was followed.

Taking into account the proposed goal and objectives, knowing the optimal parameters necessary for the formulation and obtaining of biocompatible functionalized fibrous membranes containing polysulfone with quaternary ammonium groups (PSFQ), cellulose acetate phthalate (CAP) and polyvinylidene fluoride (PVDF) with included antioxidants (optimal parameters established in **Stage 1/2022**), within the **activity 2.1** of experimental development type the solutions with different gravimetric ratios of the three polymers were prepared and subsequently electrospun in order to obtain the desired materials. Thus, the electrospinning processing technique of composite solutions based on quaternized polysulfone/antioxidants ( $\alpha$ -lipoic acid,  $\alpha$ -tocopherol) and anticoagulants (heparin) and the applied methodology (membrane activation by plasma treatment followed by heparin immobilization) led to the obtaining of fibrous membranes with improved properties, adapted to practical applications (uniform fibers, continuous, without "beads", with high flexibility and well-defined pores). The membranes obtained were characterized (**Act. 2.2 – 2.5**) from the structural (FTIR), morphological (SEM), transport properties (dynamic vapor sorption, diffusion coefficient) point of view, hydrophilicity (contact angle), biocompatibility and antimicrobial activity against relevant pathogens (*Escherichia coli* and *Staphylococcus aureus*).

The design/configuration of the extracorporeal innovative device (EID) (**Act 1.4**, partially realized in the previous stage) in which the bioactive fibrous membranes (FHMs) will be integrated (**Act 2.6, 2.7**) constituted one of the necessary premises for the experimentation of some HD processes in a extracorporeal device proposed within the project (**Act 2.8**), with the aim of determining the efficiency of the obtained membranes in the processes of insufficiency renal treating.

Thus, within the **activities 2.6 and 2.7** of experimental development type, the operating parameters of the EID device were optimized using the membranes obtained from PSFQ/CAP/PVDF and antioxidants/anticoagulants in experiments of permeation/dialysis processes realized by monitoring the main components in the simulated biological leachate (B<sub>12</sub>, lysozyme, urea, creatinine, uric acid, **Act 2.8**).

Within the **activity 2.9** of the support type, the scientific results were disseminated, concretizing in **4 ISI scientific papers (3 published and 1 sent for publication)** and **4 papers presented** at international conferences. In order to promote the project and to disseminate its results, a presentation was sustained during an event in the field of the project's theme, which was awarded (results visible on the project's web page (<https://icmpp.ro/techmembreid/>)).

All the activities provided in the implementation plan of the PN-III-P2-2.1-PED 2021-2700 project, financing contract no. 579PED/2022 for stage 2/2023 were realized.

### **ISI papers:**

1. Electrospun nanofibers based on polymer blends with tunable high-performance properties for innovative fire-resistant materials, D. Serbezeanu, C. Hamciuc, T. Vlad Bubulac, M.D. Onofrei, A. Bargan, D. Rusu, D.M. Suflet, G. Lisa, *Polymers* 2022, 14, 5501. <https://doi.org/10.3390/polym14245501>
2. Bioactive materials based on hydroxypropyl methylcellulose and silver nanoparticles: Structural-morphological characterization and antimicrobial testing, A. Filimon, M. D. Onofrei, A. Bargan, I. Stoica, S. Dunca, *Polymers* 2023, 15, 1625. <https://doi.org/10.3390/polym15071625>
3. Tailoring properties and applications of polysulfone membranes by chemical modification: Structure-properties-applications relationship, O. Dumbrava, A. Filimon, L. Marin, *Eur Polym J* 2023, 196, 112316. <https://doi.org/10.1016/j.eurpolymj.2023.112316>
4. Nanofibers membranes based on polysulfones with properties tailored for applications in biomedical field, A. Filimon, D. Serbezeanu, A.M. Dobos, M.D. Onofrei, A. Bargan, O. Dumbrava, D. Rusu, C.M. Rimbu, *Composite Structures* (send for publication)

### **Scientific manifestations**

1. Improved technologies for the development of electrospun polysulfone membranes integrated in an extracorporeal device applicable in renal failure, A. Filimon, L. Lupa, D. Serbezeanu, A. M. Doboş, O. Dumbravă, 27<sup>th</sup> International Exhibition of Inventions “INVENTICA 2023”, Iasi, Romania, June 21 – 23, 2023
2. Theoretical and experimental approaches applied in the formulation of polysulfone based materials: Solubility parameter and intrinsic viscosity, O. Dumbravă, A. Filimon, L. Marin, 21<sup>st</sup> International Balkan Workshop on Applied Physics and Materials Science-IBWAP, Constanta, Romania, July 11 – 14, 2023
3. Processing of quaternized polysulfone/cellulose acetate phthalate/polyvinylidene fluoride solutions by electrospinning to obtain bioactive fibrous membranes, A. Filimon, D. Serbezeanu, M. Onofrei, O. Dumbravă, D. Rusu, E. Miloş, L. Lupa, 17<sup>th</sup> International Conference of Physical Chemistry–ROMPHYSICHEM, Bucharest, Romania, September 25 – 27, 2023

4. New insights in the design of materials based on polysulfones with potential applications in biomedical field: structure–properties relationship, O. Dumbravă, D. Serbezeanu, I. Stoica, A. Bargan, A. Filimon, 17<sup>th</sup> International Conference of Physical Chemistry-ROMPHYSICHEM, Bucharest, Romania, September 25 – 27, 2023

### **Awards**

A. Filimon, L. Lupa, D. Serbezeanu, A.M. Doboş, O. Dumbrava Improved technologies for the development of electrospun polysulfone membranes integrated in an extracorporeal device applicable in renal failure, 27th International Exhibition of Inventions “INVENTICA 2023”, Iasi, Romania, June 21 – 23, 2023 (**Honorary degree, Gold Medal**)

Project manager,

Dr. Anca Filimon