GLYMO FUNCTIONALIZED SILICON NANOPOROUS MEMBRANE (SNM) FOR NON-INFLAMMATORY, NON-IMMUNOGENIC HEMODIALYSIS APPLICATIONS AND METHOD THEREOF

IITM Technology Available for Licensing

Problem Statement

- **Hemodialysis membranes** help in uremic toxin clearance **for kidney treatment**.
- **Conventional polymer-based** membranes are thick, inconsistent, and **prone to fouling**, leading to **inefficient toxin clearance** and potential **blood protein loss**.
- Further, traditional **silicon-based membranes** with PEG coating suffer from **high costs**, **instability** under blood exposure, and **inadequate precise pore size** control.
- There is a **need for thin, stable and reusable membrane** that **minimizes fouling** while ensuring **toxin clearance** and **protein retention.**

Intellectual Property

- IITM IDF Ref 2553
- **IN 559892 Patent Granted**

TRL (Technology Readiness Level)

TRL 4 Technology validated in Lab

Technology Category/ Market

Category- Drugs and Pharmaceutical Engineering

Industry Classification:

Healthcare and Medical Devices Industry; Nanotechnology and Advanced Materials; Advanced membrane and filtration technologies

Applications:

Hemodialysis devices; Blood purification systems; Modular and scalable dialysis apparatuses

Market report:

The global hemodialysis membrane market was valued at USD 9.16 billion in 2024 and is projected to grow to USD 12.93 billion by 2031, with a CAGR of 5.1%

Research Lab

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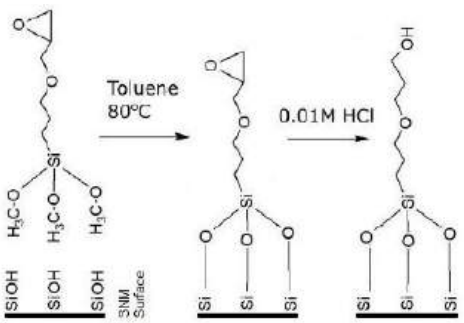

Figure: Surface functionalization of SNM with GLYMO. This procedure completely reduced the surface interaction with major uremic toxins, particularly urea, and proteins.

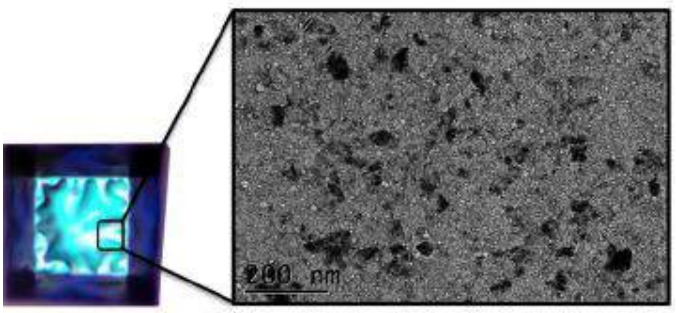

Figure: Optical image of single SNM (left) and magnified TEM image of SNM (right). The small pore-size and high porosity helps in efficient clearance of small and medium sized biomolecules (MW< 65 kDa) at a faster rate, while retaining the higher MW proteins in blood

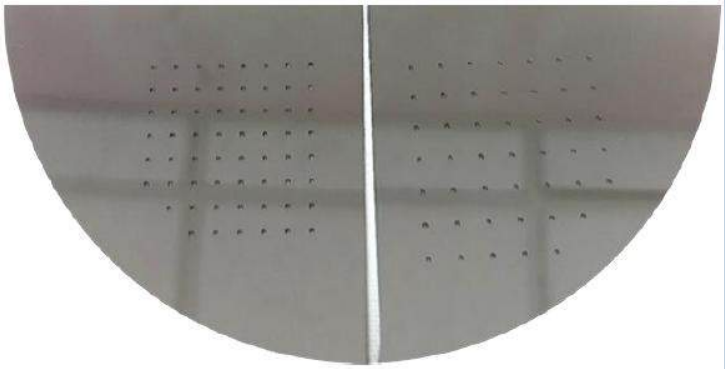

Figure: SNM array: 6x6 array (left) and 5x5 array (right). This greatly improved the exchange area and surface area to volume ratio for dialysis, thereby reducing the clearance time for higher volumes

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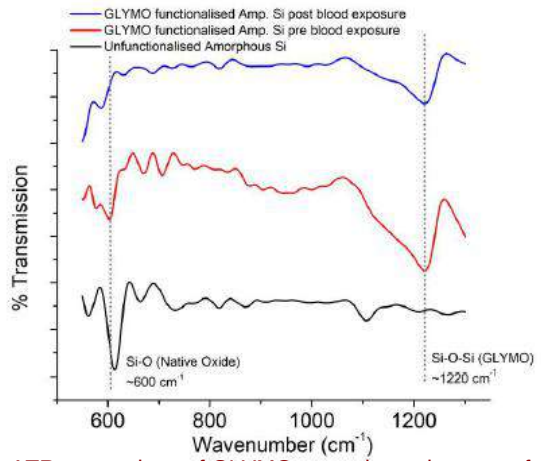

Figure: ATR comparison of GLYMO treated membrane surface before and after the exposure to the human blood. The stability was checked by the presence of Si-O-Si peak at ~1200 cm^{-1} in FTIR, which is the characteristic indication of silane ether bond formed after functionalization. Histological blood slides were prepared with the blood sample after the test and screened under a microscope. The cells were intact indicating that there was no chemical effect or shear stress of the functionalized membranes on the blood cells.

Figure: Irritability, pyrogenicity and systemic toxicity of the GLYMO treated Silicon membranes were tested in Lister mice. As per standard procedure, the animals were kept for 7 days in quarantine before testing. In test animal, a cut was made on the skin, empty space was created under the skin and 2 cm^2 area of functionalized silicon membranes was inserted. The histological analysis of the surrounding tissue and the organ tissue showed no inflammatory or sensitization response

Technology

- The invention is a GLYMO-functionalized Silicon Nanoporous Membrane (SNM) designed for hemodialysis, ensuring efficient uremic toxin clearance while retaining vital blood proteins.
- **Fabricated via ICP-CVD and rapid thermal processing, the SNM is 15 nm thick with ~10 nm pore diameters, offering high precision and scalability.**
- GLYMO silanization converts surface groups to stable Si-O-Si bonds, minimizing biofouling and enhancing long-term stability under blood exposure.
- The membrane clears 50% of uremic toxins in 15 minutes, meets ISO 10993-4:2017(E) standards, and demonstrates excellent hemocompatibility with minimal cytotoxicity.
- Targeted for advanced hemodialysis devices, the technology offers reusability, durability, and a compact design, providing a safer and more efficient solution for kidney failure treatment.

Key Features / Value Proposition

- The invention uses a 15 nm-thin SNM with ~10 nm pores, ensuring faster uremic toxin clearance and reduced clogging compared to conventional polymer membranes that are thicker and less uniform.
- GLYMO functionalization minimizes biofouling by stabilizing the surface with Si–O–Si bonds, enhancing biocompatibility and reducing adverse blood interactions.
- Compare to conventional polymer or PEG-coated membranes, the invention efficiently retains vital blood proteins while clearing toxins, lowering risks like sepsis and hemolysis.
- The fabrication process in the invention using ICP-CVD and rapid thermal processing is scalable and more cost-effective than expensive, complex nanolithography techniques.
- Rigorous in vitro tests confirm the invented membrane's non-inflammatory, non-immunogenic performance, demonstrating superior durability and reusability for safe, long-term hemodialysis applications.

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