SUMMARY

Membrans are selective barrier technologies used in separation processes and controlled transport, and are widely employed in biomedical and water treatment applications. To address sustainability challenges associated with synthetic polymers as membran materials, biopolymer-based membrans offer a promising, innovative solution. This study develops a cross-linked chitosan (CS)-based modified membran with a vanilin (VAN) and gelatin (GEL) blend as a candidate hemodialysis membran with dual functions: a filter for creatinine and urea and a dye-capturing agent. This membran is designed to perform selective dialysis of metabolic toxins and adsorb dyes through chemical interactions within the biopolymer matrix, thereby enhancing the overall efficiency of the hemodialysis process. The study aims to produce a membran with optimal characteristics, dialysis performance, hemocompatibility, and adsorption capacity.

The research was divided into 6 stages, namely: 1) synthesis of chitosan/vanilin/gelatin (CS/GEL-VAN) membrans using the phase inversion method at varying vanilin concentrations (0.3; 0.5; 1%) for hemodialysis applications 2) synthesis of CS/GEL-VAN membrans with varying gelatin concentrations (0.5; 0.75; 1%) for dye adsorption applications 3) characterization of the membrans' physicochemical properties, including mass and thickness, porosity, degree of expansion, water absorption capacity, hydrophilicity, tensile strength, FTIR, SEM, XRD, and AFM; 4) testing the membran's transport capacity for creatinine and urea; 5) hemocompatibility testing; 6) testing the membran's adsorption capacity for crystal violet.

The results of the study demonstrate the successful synthesis of modified CS/GEL-VAN membrans as thin, yellowish films. FTIR analysis confirmed the formation of vanilin cross-links, evidenced by a C=N peak at 1576 cm^{-1} and a shift in the –OH group absorption from 3360–3350 cm^{-1} due to the addition of gelatin. Characterization of the modified membran indicates increased porosity, degree of expansion, water absorption capacity, and hydrophilicity. Dialysis performance showed increases of 23–30.12% in creatinine transport and 30.26–39.19% in urea transport compared with pure chitosan (CS) membrans, with the best performance obtained on the G3 membran (CS/GEL0.5-VAN1). Hemocompatibility testing showed that the membrans exhibited acceptable hemolysis levels (<5%) according to ISO 10993, suggesting that the CS/GEL-VAN membrans have potential as hemodialysis candidates. In adsorption applications, the CS/GEL-VAN membran removed 65.70–88.12% of crystal violet at 298 K, pH 6, an initial dye concentration of 3 ppm, and a contact time of 80 minutes, with the highest adsorption efficiency obtained on the G4 membran (CS/GEL0.75-VAN1). These results indicate that the CS/GEL-VAN membran also possesses adsorption capabilities.