Bio-based membrane surfaces with tunable properties for water-borne impurities removal

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Water-borne impurities and pathogens such as microplastics, viruses, nutrients, pharmaceuticals, hormones, industrial chemicals and many others affect human lives all over the world and are linked to numerous health issues. Pressure-driven membrane filtration technologies are one of the most energy-efficient pathways for water purification. However, conventional membrane structures are fabricated from relatively expensive and synthetic materials, and therefore are often non-sustainable. On that note, there has been several efforts to use plant-based building blocks in the preparation of water purification systems.

Bio-based membranes can be fabricated, for example, using nanocellulose, a material directly obtained from plants and produced by disintegrating biomass-sourced fibers, therefore it is biodegradable and renewable. The combination of high strength, chemical inertness, high density of hydroxyl groups offering numerous opportunities for further functionalization, hydrophilicity and high surface area makes (nano)cellulose a promising material for high-performance membranes and filters to capture various chemical species, where the removal selectivity relates to both microstructure and chemistry of the membrane material.

We conducted a systematic study to investigate the structure-property relationship of plant-derived membranes to fulfill the specifications and final application requirements relevant for wastewater treatment to capture pollutants and recover valuable elements. The approach was based on fine-tuning the structure of nanocellulosic networks towards addressing porosity, flux, and rejection rates while simultaneously assuring required mechanical performance. Moreover, proposed routes were designed to enable large-scale production and roll-to-roll processing. Developed nanocellulose-based membranes had tunable pure water permeances in the range of 3-60 L m^{-2} h^{-1} MPa^{-1} and could reject nearly 90% of nanoplastics and 80% of BSA.

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