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Chitosan-Based Aerogel Membrane for Robust Oil-in-Water Emulsion Separation

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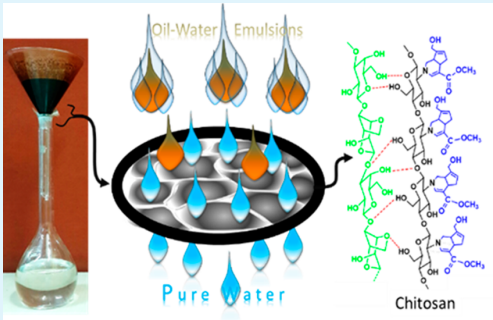
Supporting Information

ABSTRACT: Here, we demonstrate direct recovery of water from stable emulsion waste using aerogel membrane. Chitosan-based gel was transformed into highly porous aerogel membrane using bio-origin genipin as cross-linking agent. Aerogel membranes were characterized for their morphology using SEM, chemical composition by FTIR and solid-UV. Further, aerogel was tested for recovery of high quality water from oil spill sample collected from ship breaking yard. High quality (with >99% purity) water was recovered with a flux rate of >600 $L \cdot m^{-2} \cdot h^{-1} \cdot bar^{-1}$. After repeated use, aerogel membranes were tested for greener disposal possibilities by biodegrading membrane in soil.



KEYWORDS: *biopolymer, emulsion, wastewater, aerogel membrane, oil−water separation*

INTRODUCTION

Oil-in-water or water-in-oil emulsions are stable liquid/liquid systems which cause serious environmental problem in absence of proper separation techniques.[1−3] Oil−water emulsions are generally classified into 3 categories depending on their stability, namely, loose, medium, and tight emulsions. Loose and medium emulsions can be easily phase separated. However, a tight emulsion cause serious problems and requires proper demulsification agent or methods to break the emulsion. Large quantities of industrial emulsion wastes discharged to water bodies pose greater threat to aquatic life in particular causing rapid increase in the chemical oxygen demand (COD) and biological oxygen demand (BOD).[4] Demulsifiers have been popular choice among many to safely separate oil−water emulsions. But in the recent past, there have been several attempts made to selectively separate water from oil or oil from water using different materials.[5−7] Membrane based processes like reverse osmosis (RO) and ultrafiltration (UF) in combination with demulsifiers have been tested under different conditions for removal of oil from emulsion wastewater.[8−10] In the last two years, advanced materials have emerged in different forms like aerogels,[11,12] foam membranes,[13] polysaccharide agents,[14] surface modified fabrics and inorganic meshes for successful separation of oil/water mixtures.[15−17] Unique 3D network of hydrophilic aerogels preferably select water over oil. Similarly, transforming surface to hydrophobic leads to preferable selection of oil over water. These new class of materials have shown excellent separation properties because of their large surface area, high porosity and can be easily custom-made to fit the final application.[18] However, owing to their distinctive features like sustainability & biodegradability in addition to superhydrophilicity and high surface area, bio-based aerogels are a better choice for oil−water emulsion separation. Therefore, present study explores the use of highly porous polysaccharide chitosan based aerogel membrane for recovering water from oil-spill and stable emulsions. Macroporous aerogel was prepared using agarose and chitosan mixtures. Here, agarose is used as pore forming agent, as well as surface coating on highly cross-linked chitosan network. This unique feature helps in robust selection of water from stable emulsions. In our previous study,[13] we demonstrated gelatin as minor constituent for preparing superhydrophilic aerogel membrane, but for sustainable and large scale applications stable aerogel filter is vital.

Here highly cross-linked chitosan acts as support network along with inducing hydrophilicity to aerogel. As prepared membrane was tested for selective water separation from biodiesel/water emulsion, crude vegetable oil/water emulsion and highly contaminated oil spill wastewater. For sustainable applications, membranes were tested under crossflow filtration

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