Abstract

Firstly, the background knowledge of this work for better understanding of the types of membranes, membrane preparation techniques, functionalization, characterization, and applications are investigated. Membrane technology presents an attractive character comprising of easy manufacturing, modification, operation, and compactness. Several membrane preparation techniques are assessed and compared in detail. Moreover, the functionalization using physical blending and grafting methods for the modification of polymer and/or membrane are discussed. Finally, the possible applications of the membrane processes have been extensively discussed for water and wastewater treatments. Secondly, a detailed literature review about the preparation, modification and application of the polymeric membranes were discussed. A particular emphasises given to the phase inversion and electro-spinning techniques of membrane preparations. On the other hand, the functionalization and/or grafting effects on the resultant membrane structures were assessed regarding their specific applications. Moreover, the possible scopes for further enhancement on the preparation and modifications of the membranes are also identified. Furthermore, the specific objectives on the preparation, characterization, modification, and application of the polymeric membranes have been discussed extensively. Furthermore, valuable information on the chemicals used, methods of membrane preparation, and characterization techniques were provided. Detailed information on the preparation procedures, physicochemical and instrumental characterization techniques are also presented. An empirical investigation into the impacts of time duration, voltage supply, concentration, and flow rate on the membrane average fiber diameter and surface pore size distribution was done using response surface methodology (RSM) based on central compact design (CCD) are presented. Additionally, the effect of glutaraldehyde on membrane crosslinking was also assessed for further studies. Secondly, hybrid membranes from cellulose acetate (CA) and titanium oxide (TiO_2) nanoparticles (NPs) were fabricated using a novel electro-spinning technique and evaluated as an adsorbent for the elimination of lead and copper metal ions. The impact of TiO_2 NPs contents on the electro-spun membranes matrix was studied in detailed. The impacts of various adsorption parameters, namely, pH, the amount of TiO_2 nanoparticles, contact time, temperature, and kinetics of metal uptake were investigated using batch adsorption experiments. The model isotherms, such as Dubinin–Radushkevich (D-

R), Freundlich, and Langmuir were used to analyse the adsorption equilibrium data. Both pseudo first-order and pseudo second order were preferred for kinetic model study. An investigation on the effects of additives and solvents in the characteristics and performances of cellulose acetate (CA) ultrafiltration membranes was done. The effects of two different hydrophilic additives and two solvents on the membrane morphological structure, permeability property, and anti-fouling performances of cellulose acetate (CA) ultrafiltration membranes were also investigated. During the phase-inversion process cellulose acetate was selected as membrane forming polymer; polyethylene glycol (PEG) and polyvinyl pyrrolidone (PVP) were used as additives; acetone (Ac): N, N-Dimethylacetamide (DMAc) and N, N-Dimethylformamide (DMF) were used as solvents; and deionized (DI) water was used in the coagulation bath. All the prepared membranes were characterised in terms of hydraulic permeability (P_m), membrane resistance, average pore radius, and hydrophilicity. The top surface and cross-sectional view of the prepared membranes were also observed by using field emission scanning electron microscopy. Membrane fouling and rejection experimentations were done using a stirred batch-cell filtration set-up. The experimental studies of fouling/rinsing cycles, rejection, and permeate fluxes were used to investigate the effect of PEG and PVP additives and effect of the two solvents on the fabricated membranes using bovine serum albumin (BSA) as a model protein. Secondly, Modified cellulose acetate (CA) membranes were prepared by dissolving the polymers in a mixture of acetone (AC) and N, N- dimethylacetamide (DMAc) (70:30) solvent and deionized (DI) water were used in the coagulation bath. Effects of PEG additive and TiO_2 NPs on the preparation of phase-inverted CA ultrafiltration membrane were investigated in terms of morphology, equilibrium water content (EWC), pure water flux (PWF), hydraulic resistance, thermal stability, water contact angle (WCA) and anti-fouling performance. The anti-fouling performance and the flux recovery potential of the membranes were investigated using bovine serum albumin (BSA) protein. Thirdly, fouling resistant ultrafiltration membranes based on the blends of PVP, TiO_2 nanoparticles and cellulose acetate, CA-PVP-TiO_2 (CATP), for removal of bovine serum albumin (BSA) were prepared by using phase inversion process. The influences of PVP and TiO_2 on the preparation of phase inverted cellulose acetate (CA) ultrafiltration membrane were explored in terms of morphology study, equilibrium water content (EWC), hydraulic resistance, permeability performance, hydrophilicity, and thermal stability. BSA protein removal efficiency, anti-fouling performance, and recycling potential of the UF membranes were investigated.

Abstract

Moreover, TiO_2 nanoparticles (NPs) were modified using different amine groups, namely, ethylenediamine (EDA), hexamethylenetetramine (HMTA) and tetra ethylene pentamine (TEPA), using impregnation process. The prepared amine modified TiO_2 composite NPs were explored as an additive to fabricate ultrafiltration membranes with enhanced capacity towards the removal of chromium ions from aqueous solution. Membranes were prepared from cellulose acetate (CA) polymer blended with polyethylene glycol (PEG), and amine modified TiO_2 by using phase inversion technique. Fourier transform infrared spectroscopy (FTIR), zeta potential (ζ), thermo gravimetric analysis (TGA), field emission scanning electron microscopy (FESEM), water contact angle (WCA), and atomic absorption spectrophotometer (AAS) analysis were done to characterize the membranes in terms of chemical structure, electric charge, thermal stability, morphology, and hydrophilicity properties. Secondly, graft copolymerization of cellulose acetate (CA) and poly (methyl methacrylate) (PMMA) was synthesised through free radical polymerization with the presence of cerium sulfate (CS) as an initiator under the nitrogen atmosphere in an aqueous solution. During the grafting reactions, the effects of polymerization time and temperature on the grafting were investigated. Furthermore, functionalization of the synthesized product was done using amine group. The results from Nuclear Magnetic Resonance (^{1}H NMR) spectra and Attenuated total reflectance-Fourier-transform infrared spectroscopy (ATR-FTIR) confirmed the successful grafting of PMMA on the CA membrane surfaces. Zeta potential (ζ), field emission scanning electron microscopy (FESEM), and atomic absorption spectrophotometer (AAS) studies were done to characterise the membranes in terms of surface charge, morphology, and HA removal percentage, respectively. Finally, the overall conclusions and scope of the future work are presented precisely.

Keywords: *Electro-spinning; RSM; Crosslinking; PVA; Cellulose acetate; Adsorbent; Removal capacity; Kinetics; Modification; phase inversion; solubility parameter; ultrafiltration; additives; solvents**;** thermal stability; TiO_2 NPs; Polyethylene glycol; anti-fouling; Impregnation; amines; chromium ion; Graft copolymerization; amination; HA removal.*