ABSTRACT

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Ultrafiltration is a pressure driven membrane separation process that uses molecular size differences to separate macro molecules and colloidal matter from solvents and smaller solutes. Ultrafiltration (UF) techniques have particular advantages for simultaneous purification, concentration and fractionation of macromolecules. UF is a separation process using membranes with pore sizes in the range of 0.1 to 0.001 micron. UF membranes can have extremely high fluxes but in most practical applications the flux varies between 50and 500 $lm^{-2} h^{-1}$ at an operating pressure of about 345 kPa.

UF depends on physical properties of the membrane, such as permeability, thickness, process and system variables like feed consumption, feed concentration, system pressure, velocity and temperature. UF has a wide range of applications such as oil emulsion waste treatment, concentration of biological macromolecules, electrocoat paint recovery, enzyme and pharmaceutical preparations, production of ultrapure water for electronics industry and macromolecular separations replacing the conventional change of phase methods.

Membrane separation process enjoys numerous industrial applications with the following advantages such as energy savings, environmentally benign, clean technology with operational ease and replaces the conventional processes like filtration, distillation, ion-exchange and chemical treatment systems.

The proper choice of a membrane should be determined by the specific application objective: particulate or dissolved solids removal, hardness reduction or ultra pure water production, removal of specific gases/chemicals etc.

The adaptability of membrane processes to a wide range of applications stems from the development of new polymers or modifications of the existing polymers. Although several methods are available for the preparation of ultrafiltration membranes, the phase inversion technique has been found to be versatile for making new types of modified ultrafiltration membranes, as the conditions of membrane formation can be varied widely to prepare membranes with desired morphology and pore structure.

Cellulose Acetate (CA) is one of the first polymer membranes that have been used for aqueous based separations. Cellulose acetate and its derivatives are suitable raw materials for membrane preparation, because of the advantages such as moderate flux, high salt rejection properties, cost effectiveness, relatively easy manufacture, renewable source of raw material and non-toxicity. However, CA possesses certain inherent deficiencies such as poor mechanical strength, low thermal and chemical resistance and susceptible to fouling by microorganisms. The performance of CA may be improved by either blending with other polymers or mixing it with appropriate additives to fulfill additional requirements and associated membrane properties

Another important membrane material, Polyethersulfone is an amorphous, brittle, high temperature engineering thermoplastic. It possesses high thermal stability, high heat resistance, and excellent high and low pH tolerance. PES membranes are hydrophilic and are instantly wettable without the addition of surfactants or wetting agents. It also has low surface charge, which lowers the binding capacity thus minimizing the propensity for fouling and prolongs membrane service life. PES polymers of practical interest as membrane materials for a wide variety of UF applications. PES due to their

ether linkages are more flexible than other polymers. To improve the performance of the membranes, additives can be added to PES.

In the present investigation, flat sheet ultrafiltration blend membranes based on cellulose acetate/aminated polyethersulfone(APES), cellulose acetate/carboxylated polyethersulfone (CPES) with a thickness of 0.20 ± 0.02mm were prepared by solution blending and phase inversion technique. The polymer compositions were varied from 100/0, 90/10, 80/20 and 70/30 wt% CA/APES, CA/CPES systems and the total polymer composition was optimized and maintained at 17.5 wt%. When the composition of APES/CPES exceeded 30% by weight phase separation was observed , indicating the incompatibility between the polymer components.

Membrane characterization such as compaction, pure water flux (PWF), water content, membrane hydraulic resistance, contact angle, percent protein rejection, molecular weight cut-off (MWCO) and morphological studies were done for both the systems. Also the present investigation applied to both the systems describes the rejection of proteins such as bovine serum albumin, egg albumin, pepsin and trypsin and rejection of metal ions such as copper, nickel, zinc and cadmium from aqueous streams.

Amination and carboxylation of PES was observed using FT-IR spectra. APES and CPES were characterized by ^{1}H NMR spectroscopy. The thermal stability of the APES and CPES was determined by TGA and DSC traces of the polymers were recorded up to 400°C. Morphology of the membranes were investigated using SEM.

The pure water flux of CA/APES and CA/CPES blend membranes decreases with increasing compaction time and remained constant after 5 h of compaction, indicating the completion of compaction.

Water content of the CA/APES, CA/CPES blend membranes is an indirect indication of the hydrophilicity and flux behavior of membranes. Membranes were thoroughly washed with distilled water before the estimation of water content. In CA/APES and CA/CPES blend membranes, as the APES and CPES content was increased, the water content also increased. Further, increase in the additive (PEG 600) in casting solution, also resulted in the membranes with increasing water content. Membrane hydraulic resistance, R_m, is an indication of tolerance of membrane towards hydraulic pressure. R_m was measured by subjecting the membranes to various pressures from 69 to 414 kPa and measuring the pure water flux. In CA/APES blend membranes, as the APES composition was increased, the hydraulic resistance decreased gradually. Further, increase in the additive (PEG 600) in casting solution, also resulted in the membranes with decreasing hydraulic resistance. CA/CPES system also behaved in the same manner.

The protein separation such as trypsin, pepsin, egg albumin and bovine serum albumin (BSA) in terms of permeate flux and percent rejection have been investigated at dilute concentrations, BSA was found to have the highest separation with lowest product rate of all membranes respectively. While trypsin showed least separation and highest flux. This variation has been accounted in view of the size of the molecules.

Heavy metal ions such as Cu^{2+}, Ni^{2+}, Zn^{2+} and Cd^{2+} were complexed with polyethyleneimine. The percent rejection of metal ions complex shows an higher separation but lower flux for Cu ion complex for both the systems owing to its higher size. This has paved solution to the emerging problem of pollution abatement by recycling of chemicals.