ABSTRACT

Membrane filtration is an attractive separation process, as it is usually performed under gentle conditions. Membrane processes have been applied in various types of industries such as the separation, concentration and purification in food technology, biotechnology and petrochemical processes, as well as water and wastewater treatment. Membrane based separation processes offer many advantages over conventional separation processes such as low operating cost due to less energy intensive, ease of operation under ambient temperature (no phase change is involved). Membrane separation technology, in its modern incarnation, is energy efficient and highly adaptive for a wide range of applications starting from the development of new polymers or modifications of the existing polymers as membrane material.

There are five major membrane developed processes such as reverse osmosis (RO), ultrafiltration (UF), microfiltration (MF), nanofiltration (NF) electrodialysis (ED), which cover a wide range of particle size. Of the various membrane separation processes, ultrafiltration has an dominating role in the industrial process for over three decades. The applicability of these systems can further be widened with development of new membrane materials with specific applications. With this objective in mind, membranes in the ultrafiltration range, based on cellulose acetate (CA), poly (ether imide) (PEI) and sulfonated poly (ether imide) (SPEI) have been prepared and
characterized. The applications of these membranes for the separation of proteins and metal-ions have also been investigated.

The experimental part of the thesis includes, the preparation of sulfonated poly (ether imide), blend membranes based on poly(ether imide), sulfonated poly (ether imide) and cellulose acetate both in absence and presence of additive poly (ethylene glycol) 600 at various concentrations (pore former) with NMP as solvent. The ultrafiltration experimental set up has also been described, along with the characterization of the membranes in terms of compaction, pure water flux, membrane resistance, water content, molecular weight cut off and application to proteins and toxic heavy metal ions separations from aqueous solutions.

The results and discussions part of the thesis describes about the effect of compaction time on pure water flux at 414 kPa, pure water flux at 345 kPa and the percent water content of the blend membranes. Pure water flux at 414 kPa was found to vary from 15.8 to 360.2 \( \text{lm}^2\text{h}^{-1} \) and 15.8 to 410.1 \( \text{lm}^2\text{h}^{-1} \) for CA/PEI and CA/SPEI blend membranes respectively. Pure water flux at 345 kPa was found to vary from 13.5 to 322.7 \( \text{lm}^2\text{h}^{-1} \) and 13.5 to 362.1 \( \text{lm}^2\text{h}^{-1} \) for CA/PEI and CA/SPEI blend membranes respectively. Water content of CA/PEI and CA/SPEI blend membranes ranges from 79.64 to 88.75% and 79.64 to 90.10% respectively. The membrane hydraulic resistance of all the blend membranes was also determined by finding flux at various pressures from 69 to 414 kPa and the results are discussed. Membrane hydraulic resistance was found to vary from 25.84 to 1.13 kPa / \( \text{lm}^2\text{h}^{-1} \) and 25.84 to 0.97 kPa / \( \text{lm}^2\text{h}^{-1} \) for CA/PEI and CA/SPEI blend membranes respectively.
Further, the pore statistics of the CA/PEI and CA/SPEI blend membranes in absence and presence of various PEG 600 concentrations were observed by scanning electron microscope with suitable magnifications and the observations have been discussed.

Based on the properties and performance study, few of the CA/PEI & CA/SPEI blend membranes were used to study the separation of proteins such as Bovine Serum Albumin (BSA), Egg Albumin (EA), Pepsin and Trypsin and the rejection and permeate flux results are discussed. Percentage rejection of BSA was found to reduce from 95 to 69% and 95 to 62% for CA/PEI and CA/SPEI blend membranes respectively. Similar trends were also observed for other proteins. Protein solution permeate flux of BSA was found to increase from 9.5 to 247.4 lm²-h⁻¹ and 9.5 to 299.6 lm²-h⁻¹ for CA/PEI and CA/SPEI blend membranes respectively. Similar trends were also observed for other proteins.

The membranes were also used for the study of rejection of toxic heavy metal ions such as Cu²⁺, Ni²⁺, Zn²⁺ and Cd²⁺ by complexing them with macromolecular chelating ligand, polyethyleneimine and the results are discussed. Percentage rejection of Cu²⁺ was found to reduce from 98.5 to 64.5% and 98.5 to 61.2% for CA/PEI and CA/SPEI blend membranes respectively. Similar trends were also observed for other metal ions. Metal ion solution permeate flux of Cu²⁺ was found to increase from 5.3 to 190.1 lm²-h⁻¹ and 5.3 to 240.2 lm²-h⁻¹ for CA/PEI and CA/SPEI blend membranes respectively. Similar trends were also observed for other metal ions. Further the membranes can also be applied for industrial applications and scaling-up can also be attempted.