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The Optimization and production polyethersulfone ultra filtration flat sheet membranes using lithium chloride as additives

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Abstract—The polyethersulfone Ultra filtration flat sheet membranes are prepared by phase inversion process using PES as polymeric materials and DMF as solvent and lithium chloride as an additives. The additives lithium chloride concentration is varied from 1-5wt% in casting solution. The effect of lithium chloride concentration on performance of the membranes is evaluated in terms of percentage solute rejection and molecular weight cut off of the membrane, at 2wt% lithium chloride concentration, membranes found lower molecular weight cut off, after increased in concentration of lithium chloride beyond 2wt%, molecular weight cut off of the membranes increased. The minimum molecular weight cut off found at 2wt%lithium chloride concentration.

Keywords—Polyethersulfone, Ultra filtration, Phase inversion process, Membrane casting, additives.

I. INTRODUCTION

Membrane is an interface between two adjacent phases acting as selective barrier, regulating the transport of substances between two compartments. Today polymeric membranes are used for several applications in industries like ultra filtration, microfiltration, Reverse osmosis, pervaporation and gas and vapors separation, as well medical, Food etc membrane attracted the attention of chemist, chemical and biotechnological engineer due to their unique separation principle that is the selective transport and efficient separation in comparison with other unit operations. The separation with membranes performed isothermally at low temperatures with less energy consumption compared to other thermal separation process. Due to the unique properties of membranes, up scaling and downscaling of membrane separation processes and their integration with other separation or reaction processes are become easy.

Ultrafiltration, a novel and powerful pressure-driven separation technology, has been widely used in waste water treatment and food industry (1, 2) to concentrate or fractionate proteins and aqueous solutions. During Ultra filtration, the smaller suspended particle and dissolved molecules pass through the membranes (3), while the bigger molecules are mostly rejected. Some of the rejected molecules adsorbed or deposit on membrane surface causing considerable membrane fouling (4).

Polymer such as polysulfone, polyethersulfone, polycarbonate polyamide, cellulose acetate (5) etc, are widely used for preparations of membranes. Polyethersulfone is a favorable materials for membranes, it has properties like resistance to oxidation, acid and alkalis and excellent biocompatility.Polyethersulfone is an important engineering thermoplastic possess favorable mechanical properties and thermo oxidation stability, it is closely related derivatives of polysulfone which is totally devoid of aliphatic hydrocarbon groups and has a high glass transition temperature of 230^0c.It is an excellent ultra filtration membranes materials because of its membrane formed with high mechanical and chemical stability. It is commercially available and relatively inexpensive. It is one of the most widely used polymers for making ultra filtration membranes.

Membrane structure and performance depends on polymer concentration, choice, solvent and nonsolvent composition, evaporation time, elevation bath temperature, reaction time etc are among the parameters that play an important role to determine its final performance of the membrane In order to obtain membranes with special properties, additional additives can be dissolved in the casting solution (6). The role of these additives is to create a spongy membranes structure but prevents the formation of micro void, enhances pore formation, improve pore interconnectivity or induce hydrophilicity.Generally hydrophilic structure are obtained by addition polyvinylpyrrolidone.Other frequently used additives are glycerol,alcohol,water,polyethylene glycol and LiCl.(7,8,9).

In this study, the PES ultra filtration flat sheet membranes is prepared using DMF as solvent and Lithium chloride as an additives in dope solution, by phase inversion process. The additive lithium chloride percentage varied from 1-5wt%. The optimum concentration of lithium chloride is evaluated. The effect of lithium chloride additives on performance of the membranes evaluated in terms of molecular weight cut off and flux rate using different molecular weight cut off polyethylene glycol solutions.

II. EXPERIMENTAL

Materials used for casting membranes

Polyethersulfone (PES) was used as polymer for membrane casting. Analytical grade N_N dimethylformamide (DMF) was (M=73 g/mol) was purchased from Merck Germany. Inorganic salt additives Lithium chloride analytical grade, was purchases from BDH. Tap water was used as coagulant bath. The concentration of the LiCl was varied from 1-5 wt%. Polyethylene glycols (PEG) with different molecular weight ranging from 200 to 36,000 Daltons purchased from Fluka were used as solutes. Feed solutions were prepared using distilled water. Other chemicals used were sodium iodide (KI) purchased from SureChe Products Ltd, barium chloride ($BACl_2$) from Lab guard, iodine (I2) from Emory and hydrochloric acid (HCl) from Merck.

Membrane casting procedure.

Polyethersulfone was dried in an oven at a temperature of 80^0c for 24 hours to remove any moisture present in it. Dope solution was prepared by dissolving fixed 15 wt% of polyethersulfone in solvent N-N dimethylformamide with constant stirring for 7-8 hours. When the polymer was completely dissolved subsequently an additive was added, and solution temperature was maintained at 80^0c with continuous stirring for six hours until the additive was completely dissolved and homogeneous. The resultant polymer solution was filled in a glass bottle. The air bubbles in the resultant polymer solution were removed using ultrasonification process.

The dope solution was poured onto a clean glass plate at room temperature and casted on a glass plate using a casting knife. Immediately after casting, the glass plate with the casted film was dipped into R.O water at room temperature. After few minutes, a thin polymeric film separated out from the glass plate due to the phase inversion process. The membrane was washed with distilled water and transferred to another container ready to be tested. All flat sheet membranes were visually inspected for defects and only good areas were chosen for membrane evaluation.

III. RESULT AND DISCUSSION

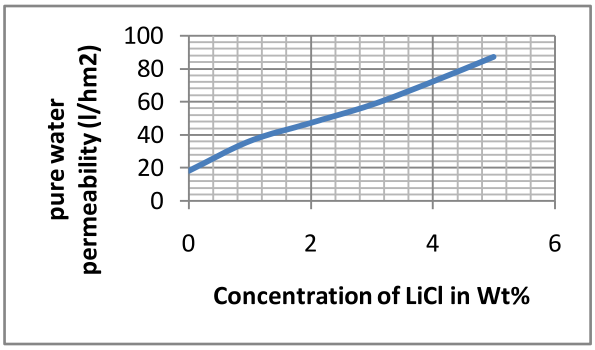

Fig.1.1.

The figure 1.1. showed the effect of different concentration of LiCl on pure water permeability of the membranes.It showed that pure water permeability with addition of additive LiCl in dope solution three fold time more than the without additive LiCl membranes.The pure water permability increased with increased in the lithium chloride concentration in dope solution.The highest PWP found at 5% lithium concentration. The nucleophilic substitution properties of chloride ions in DMF is highest than other halide groups(Miller et. Al,1999).due to higher nucleophilic tendency of lithium chloride in DMF, higher hydrophilic PES membranes produced.

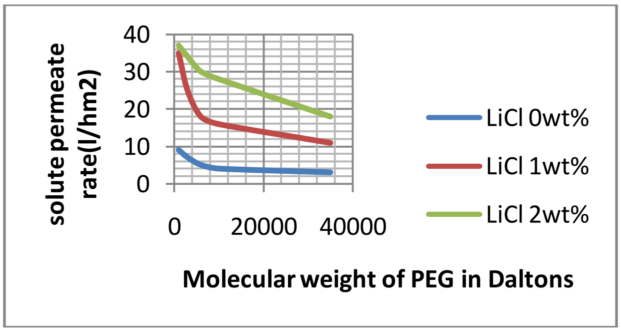

Fig.1.2.

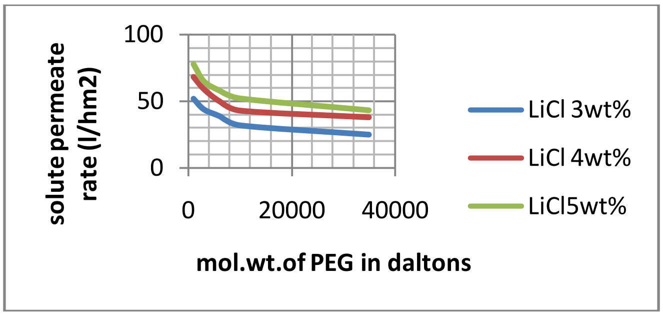

Fig1.3

Figure1.2,and 1.3. showed the solute permeation rate increased with increased in the concentration of lithium chloride,highest permeation rate found at 5wt% lithium chloride concentration.The presence of LiCl was increased the permeation rate many fold compared to PES/DMF membranes without LiCl. The result clearly showed that, LiCl when used as additives enhanced the hydrophilic properties of the membranes and this showed by increased in PWP and permeation rate of the membranes.The formation of LiCl and DMF complex in dope solution create hydration effect and coused swelling in polymer gel .similarly reported by Kesting in his study for cellulose acetate membrane,significantly increased the permeation rate when salt added in casting solution.

Molecular weight cut off.

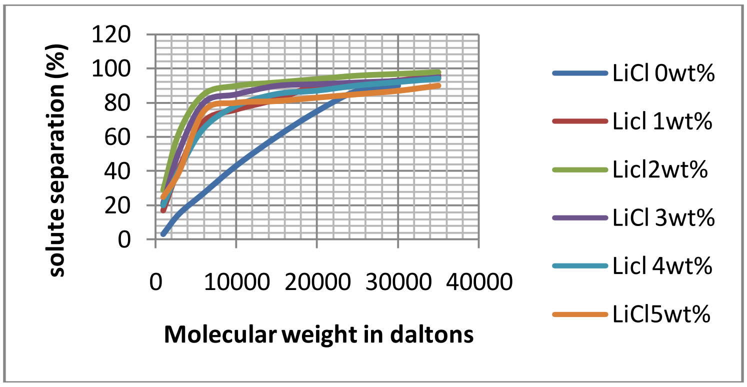

Fig.1.4.

Molecular weight cut off is molecular weight of solute at which 90% of solute rejected by membrane .Fig.1.4. Shows that increasing in concentration of lithium chloride from 1to 5wt% effect on percentage solute separation of the membranes. The concentration of LiCl up to 2wt% increased the rejection rate of the membrane, beyond that rejection rate of the membrane start decreasing. The optimum concentration of lithium chloride obtained at 2wt% LiCl concentration, with molecular weight cut off at 10KDa and permeate rate of 37 L/hm$^{2.}$.It is found that increasing lithium chloride concentration beyond 2wt%, solute rejection rate of the membranes decreased. Further increased in lithium chloride concentration beyond 2wt% it was not improve the membranes percentage rejection rate but its permeation rate increased whereas the solute rejection rate without LiCl membrane found lower and MWCO found at 30KDa.

IV. CONCLUSION

The PES membranes prepared using PES/DMF/LiCl solution, with increased in lithium chloride concentration from 1-5wt%.The results showed that increased in lithium chloride concentration pure water permeability and permeate rate of the membranes increased. At 2 wt% lithium chloride concentration, percentage of solute separation found maximum, and with beyond 2 wt% LiCl concentration, percentage of solute separation decreased. The molecular weight cut off of the membranes at 2wt% lithium chloride found 10KD.The optimum concentration of lithium chloride found at 2wt% concentration.

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