Chapter 6: Conclusions

Investigations towards effects of membrane preparation parameters on the performance of resulting PAN based UF membranes led to an understanding towards use of adequate concentration, solvent, additive and support fabric to be used for obtaining a combination of good water flux and rejection performance. Protein rejection analysis revealed that PAN_{15} and PAN_{17} membranes exhibited MWCO of ~ 68 kDa. Increasing the PAN concentration in the dope solution to 23 wt. % (in case of PAN_{23} membrane) could lower the MWCO just upto 33 kDa. This indicated that merely increasing polymer concentration in the dope solution does not necessarily lead to lowering of the pore size.

The effect of solvents (DMF, DMAc, DMSO and NMP) was studied on membranes prepared using different polymer concentration (15, 18.5, 20.5 and 23%) in the dope solution. The membrane prepared by using DMF and DMAc as solvent exhibited similar fluxes at all PAN concentration and were lower as compared to that of membrane casted using DMSO and NMP as the solvent. The protein rejection analysis showed that membrane prepared with DMSO as a solvent showed poor control on its porosity. Among these solvents, the NMP emerged as better solvent as it offered high flux as well as appreciable rejection for all membranes prepared by varying polymer concentration.

Out of multicarboxylic acids studied as an additive in the dope solution, citric acid and tartaric acid based membranes offered ~ 2.5 times higher flux than that of $ZnCl_2$ based membranes, without any sacrifice in BSA rejection for two PAN concentrations studied (PAN_{15} and PAN_{13}). The supporting evidence for interactions between basic solvent and carboxylic acid additives was provided by FT-IR spectroscopy. The blue shift in >C=O, O–C–N stretching and –OH frequency was observed. The potential of these membranes for large scale applicability was assessed by preparing spiral modules. They exhibited not only the BSA rejection, but also a complete bacteria (*E.Coli*) rejection, as that of small size membrane coupons analyzed for these crucial characteristics; as far as application of drinking water purification is concerned.

Support fabric properties were found to play a crucial role in determining resulting membrane properties. Though material of construction of these supports was polyester, their properties like porosity and type (woven vs. nonwoven) was found to be crucial in governing properties of resulting membranes. Membranes casted on 3265 support showed higher water flux but wider BSA rejection than membranes casted on the H1006 support. The membrane casted with support 3324 though offered lower flux than that of 3265 based membranes, variation in its flux and rejection was smaller. The pore size distribution analysis showed that membranes prepared with 3265 and PES-111 supports exhibited wider pore size distribution and lower compaction pressure than the same for other cases.

Modification of PAN based membrane surface by different bases while varying treatment conditions (time, temperature, etc.) led to a maximum of 152% and 230% increase in water flux without sacrifice in rejection performance by dead end and cross flow mode of treatment, respectively, depicted potential of surface modification in improving membrane performance. A decrease in contact angle of modified membranes in comparison to the unmodified membrane due to increase in hydrophilicity by virtue of formation of amide and carboxylic group by the transformation of –CN functionality of PAN was confirmed by IR and ESCA analysis. A mechanism was proposed based on the swelling and deswelling of the pore caused by base and acid treatment, respectively.

It was thought to extend the potential of negative charge formation on the membrane surface by the base treatment for an application of As-V rejection by Donnan exclusion principle. The surface of the membrane with lowest possible porosity (PAN_{23}) was treated with NaOH in cross flow mode for 2.5 hour at 45 °C to obtain MWCO of 8 kDa and shown to offer quantitative As-V rejection from ppb to a ppm level. The feed conditions such as pH, temperature and concentration had their own effect in governing As-V rejection performance. In addition to FTIR-ATR and contact angle analysis for assessing effects of surface treatment, SEM and AFM analysis confirmed the pore swelling and smoothening, respectively.

Though PAN based membranes are known to sustain certain organic solvents, ABPBI based membranes were shown to be stable with almost all the organic solvents including DMF and DMAc. In addition, these membranes showed excellent stability to 2.5N NaOH and 25N H_2SO_4. These membranes showed excellent water flux at lower MWCO of ~ 6 kDa. The inability of these membranes to retain porosity when dried was resolved by glycerol treatment, which could be done repeatedly, without a large sacrifice in the flux of the membrane.