CHAPTER 7

SUMMARY AND SUGGESTIONS FOR FURTHER WORK

On the basis of the experiments performed and discussion of results following significant conclusions could be drawn:

- Nano-particles of TiO_2 (anatase phase) of average size 20-30 nm using extract of *Cajanus cajan* were successfully synthesized and characterized.
- Pure and composite polymeric membranes of PVDF and PVDF/TiO_2, respectively were prepared via the phase inversion technique.
- FTIR spectroscopic and XRD analysis results indicated proper and uniform embedding of TiO_2 particles within polymer matrix. The DRS results confirmed that PVDF matrix acted as support for electron transport during photo-catalytic activity.
- PVDF/TiO_2 membrane exhibited lower contact angle compared to PVDF membrane. Composite membrane (PVDF/TiO_2) also had better hydrophilicity compared to PVDF membrane.
- The higher porosity and pore size of PVDF/TiO_2 membranes resulted in improved flux.
- Kinetic and thermodynamic parameters indicated improved phase separation resulting in higher porosity and water flux with increasing TiO_2 loading.
- Better antifouling property of PVDF/TiO_2 membrane was due to lower surface roughness, improved hydrophilicity, and higher repulsion between the foulant and the membrane surface. The XDLVO theory confirmed these observations.
- Using BSA as the model foulant it was observed that the flux recovery remained up to 95% even after four cycles of use.

- Addition of small amount of TiO_2 (2%) reduced irreversible fouling and increased reversible fouling. Cake filtration and Hermia models indicate that fouling is physically reversible.
- PVDF/TiO_2 composite membranes exhibited good antibacterial activity.
- Flux, % rejection and % reduction exhibited an inverse relationship with particle size, pH and Cr(VI) concentration and were directly proportional to pressure and TiO_2 loading.
- Membrane with 2% TiO_2 nano-particles of size 20nm resulted in maximum reduction at pH 5 and 300 KPa for Cr(VI) concentration of 20 ppm.
- ANOVA indicated that pH and Cr(VI) concentration are more significant for both % rejection and % reduction and pressure only for % rejection.
- With synthetic Cr(VI) solution a % rejection of approximately 90% and % reduction greater than 87% was observed at optimum condition that is 2 wt% TiO_2 particle loading of size 20 nm, pH 5 and Cr(VI) concentration of 50 ppm. In case of tannery wastewater it was found to be 85% and there was no morphological change in membrane was observed even after five cycles of use.

7.1 Suggestions for Further Work

Due to various constraints and time limitation several aspects related to synthesis of nano-particles, their use as fillers in membranes, and performance of composite membranes in field conditions, particularly concentration polarization, fouling including microbial etc. could not be investigated thoroughly. Thus it would be interesting to carry out more investigations to resolve following issues:

i) Effect of agglomeration of nano-particles within membrane matrix and ways and means (such as surface modification) for its prevention,

ii) Use of other nano-materials and cost effective methods for their large scale preparation,

iii) Concentration polarization during use with actual wastewaters

iv) The stability of particle within the polymer matrix

v) A further study could include:

- ✓ Effect of different bio-extract on the synthesis of particle.
- ✓ Effect of particle size and shape on the membrane morphology and performance
- ✓ Optimization in the preparation technique of membrane by using different solvents
- ✓ Designing a filtration process that will integrate both rejection and reduction in single step.
- ✓ Exploring another NPs for enhancing the performance of PVDF and comparing it with this research.