Chapter 6

RECOMMENDATIONS FOR FUTURE WORK

The conclusion of this study suggest that concentration of NR latex by ultrafiltation is a viable option. A good preservation system and operating at low transmembrane pressure coupled with suitable crossflow velocity are important factors to consider. Concentration of NR latex by UF achieved so far was only 46.09% compared to the current method of concentration by centrifugation where it could reach as high as 60%. However, through choice of membrane complete rejection of latex particles occur.

The following areas of studies needs further investigations to increase the level of higher concentration within a shorter period of time and at the same time to have better cleaning procedures so as to improve flux recovery.

6.1 Membrane

From the results of the study on the concentration process it was calculated that an increase in concentration of 34.97% per square meter per hour ($m^{-1}hr^{1}$) occurred. Theoretically, if the membrane used is one meter square it was possible to get an increase of *ca.*35% in DRC in one hour. Future work thus must be focused on increasing membrane area which would require upgrading of diaphragm pump, feed tank piping and related network. Plate and frame type of UF system configuration could also be fabricated incorporating a heat exchanger in the UF system where it would be appropriate to maintain the temperature around 30°C, preventing destabilization of NR latex that would result in premature coagulation.

6.1.1 Membrane area

Cartwright, P. S., mentioned in his paper entitled "From Pilot to Production of System Design and Scale-up" [41] that the larger the membrane area in a system, the greater the permeate rate, everything else being equal. Greater permeate rate would hasten the concentration process, and the targeted concentration of 60% DRC would be achieved in a shorter period of time. Nambiar, J., [17] routinely achieved a DRC of 60% from an initial DRC of 30% for ENR latex, using larger membrane area with a plate and frame module configuration of UF system. CIP technique was employed to overcome gel layer interference. Increase in viscosity did not pose serious problems.

6.1.2 Membrane structure and surface modified membrane

Although the use of PVDF type membrane with 100kD MWCO was in this work satisfactory as it is inert for pH range of 1.5 – 11, it is still basically a hydrophobic material. Filtration efficiency would be further enhanced if a more hydrophilic membrane is used, as the feed is polar in nature.

Thin layers of negatively charged protein layer covers the individual latex particle thus a membrane which is modified to attract these negative charged latex particle would improve flux considerably. The surface chemistry of FP110 PVDF membrane can be modified by adding carboxylic acid functional group RCOOH (see section

2.12.1 of Chapter 2), which would become water wettable and with a critical wetting surface tension (CWST) of more than 70 dyne/cm. Liquids with surface tensions higher than the CWST will not be reliable for filter testing purposes, and may not give satisfactory process flow conditions. Special request would possibly be made to the membrane manufacturer to supply surface modified membrane for an improved flux performance. Surface modified membranes should be tested on their ability to form a physically and chemically stable structure with the requisite removal ability and good transmembrane flow and pressure drop characteristics [24].

6.2 Cleaning Protocol

A complete study of fouling of the membrane by high molecular weight protein and rubber particles should be systematically studied. The investigation should focus on identifying suitable cleaning regime (using chemicals or other methods) that would improve flux recovery without shortening membrane life. Cleaning membrane with two stage protocol at an higher temperature should be investigated to bring about a complete flux recovery of membrane used in concentration process of NR latex. Cleaning efficiency of water as well as other common cleaning solution should be investigated at temperatures 30, 40, 50 and 60 °C. Cleaning solutions at higher temperature would open up membrane pores and would facilitate flushing out of foulants easily.

Study by Shorrock, C. J. and Bird, M. R. [45] showed that cleaning efficiency of water at 40 °C reduced fouling resistance to over a 30 minutes period of cleaning and reached a minimum of only 15 and 10 minutes of cleaning at 50 °C and 60 °C respectively.

Two stage cleaning protocol should be investigated, especially, to remove the permanent fouling of the membrane by latex proteins and small sized rubber particles from plugging the membrane pores. The investigation should focus on identifying suitable cleaning regime such as cleaning with sodium hydroxide followed by nitric. Sodium hydroxide would hydrolyze the protein and subsequent cleaning with nitric acid would flush out the hydrolyzed protein by the dipole attraction of hydrogen bonding provided by nitric acid.

Nagata et. al [46] investigated two stage cleaning protocol using sodium hydroxide and nitric acid. When the membrane was first cleaned with 0.2 % sodium hydroxide for 30 minutes at 40 °C, and subsequently cleaned with 0.3 M of nitric acid for another 30 minutes it brought about a complete flux recovery.