Chapter 1

INTRODUCTION

Malaysia is one of the fastest developing countries in this part of the world, and at one time was fully dependent on foreign exchange earned from trading of raw rubber. With the onset of the industrialisation programme by the government since the late 1970s, the raw rubber was instead transformed into products for export.

Currently, Malaysia is the leading producer of examination gloves in the world, and facing stiff competition from neighbouring countries like Thailand and Indonesia for the number one producer status in the world. In order to safe guard this status and to maintain a competitive edge in manufacturing this product, all activities pertaining to glove making need to be reengineered and made environmentally and economically viable. One of the important concepts in this strategy is the processing of the raw material, namely, the concentration of natural rubber (NR) latex.

NR latex as an industrial raw material is supplied as concentrated latex, where the dry rubber content (DRC) is increased from *ca.* 30 % to *ca.* 60%. It serves as the main raw material for natural rubber latex product manufacturing factories that produce examination gloves, condoms and latex thread. Three methods of concentration currently used are centrifugation, creaming and evaporation. Centrifugation is the preferred method and accounts for some 95% of the total concentrate produced in Malaysia. Centrifugation produces skim latex as a by-product. Skim rubber processing involves the recovery of 4-5% of dry rubber by cheap grade sulphuric acid coagulation. Once the skim rubber is recovered the effluent consists of sulphuric acid contaminated serum with a high BOD discharged into the effluent ponds. Aerobic and anaerobic ponds situated next to the concentrate factory take the bulk of the effluent discharged from the processing activities. Microbial breakdown takes place below the scum layer in the anaerobic ponds, whereby the sulphate ion (SO_4^{2-}) from sulphuric is converted to poisonous, hydrogen sulphide gas (H_2S). This pungent acidic gas is released once the scum layer is disturbed due to heavy downpour, thus affecting the environment of the surrounding area and leading to a chain of unpleasant events such as malodour and ill health of the surrounding residents.

Thus an alternative method of concentrating field latex which could produce latex concentrate and a clear serum and not skim latex as by-product needs to be explored, in which case membrane separation technology seems to be a viable option. Aqueous phase make up 60% of NR latex by weight and rubber hydrocarbon comprises 35-38% with molecular weight distribution of latex particles ranging from 300,000 to about 10 million. The rest are non rubber solids. Thus a suitable membrane could separate the aqueous phase from the latex as a permeate which is known as serum leaving the bulk of latex as a concentrated retentate.

In fact, concentration of field latex by ultrafiltration has been suggested as a possible separation technique by engineers in this field. However, it is also recognized the major difficulties encountered in this endeavor were the instability of latex and non-availability of suitable membrane material capable of withstanding the highly alkaline feed.

The serum is the non rubber aqueous portion of latex which if properly separated from the latex, does not contain any latex particle as well as the milky appearance of the skim latex. Scientists at the Malaysian rubber Board (MRB) have identified that serum contains many useful bio-chemicals. The single largest component of latex serum (about 23% by weight of the total non-rubbers) is a water-soluble carbohydrate, i.e. quebrachitol, which is a chemical feedstock for the synthesis of a range of bioactive material. Researchers at the MRB have developed an economically feasible method for extracting this product from the serum. If all the serum from NRL processing could be exploited, the income from biochemical extraction may well exceed that from the sale of rubber.

This study would ascertain the possibility of concentrating latex by membrane separation technology, thus obtaining latex concentrate and latex free serum as a by-product. The latex concentrate goes to latex product manufacturing factory as a raw material and the serum subsequently could be utilized for useful biochemical extraction. This process does produce skim latex and subsequent acid coagulation. Since the whole latex, i.e. serum as well as latex concentrate, would be fully utilized by pharmaceutical and latex product manufacturing industry, this will lead to a zero discharge scenario.

The main objective of the study is to adapt, modify and optimize the process of ultrafiltration of field latex especially with respect to the inherent nature and characteristic of the NR itself. Many factors need to be taken into consideration concerning the membrane, pore size, feed velocity, transmembrane pressure, fouling of membrane and the system. In terms of nature of feed, the latex emulsion must be stable for acceptable flux performance. However, the shear induced by pumping action required in an ultrafiltration system may deleteriously affect the normally stable latex. When the latex becomes unstable, coagulation of latex particles takes place and a compact foulant layer may develop on the membrane surface. Consequently, the flux will be reduced appreciably as the fouled layer offer higher hydraulic resistance to permeation. In severe cases of latex instability and membrane fouling, the entire flow passage in the membrane system may be plugged by coagulated latex. Thus there is a need to ensure latex stability during processing. This study would thus focus on finding suitable latex stabilizers and preservatives to be incorporated into the feed.

Although suitable membranes are the necessary basis for a successful application of a membrane technology, other aspects, especially the hydrodynamic and economical optimal membrane arrangement (module design) and the module arrangement (plant design) are of at least equal importance. Proper cleaning in-situ procedure needs to be explored since, it is absolutely vital to be able to clean and reuse a fouled membrane to save cost. The tenacious fouling layer, once formed on the membrane surface, may not be easily removed using ordinary cleaning techniques.

The early generation ultrafiltration membrane (cellulose acetate type) could not tolerate the harsh chemical environment necessary for effective membrane cleaning; consequently no significant progress was made in the commercialization of the ultrafiltration process for industrial latex streams until the emergence of improved ultrafiltration membranes. For latex concentration process membranes made from polyvinylidene fluoride (PVDF) and polysulphone (PS) could tolerate the harsh chemical environment necessary for effective membrane cleaning. This material can withstand a large pH range (1.5 - 12) and a maximum temperature of 80°C and has a good solvent resistance property.

Industrial latex generally refers to synthetic latex emulsion such as styrene butadiene rubber (SBR) and polyvinyl chloride (PVC). Presently there is was no reported major industrial concentration process employing membrane separation for concentrating NR field latex. An exception is in the case of concentrating epoxidised natural rubber (ENR) latex. ENR is modified NR latex with an addition of oxygen [O] in its structure. The presence of oxygen in the ENR structures increases the resistances to oil, chemical and environmental degradation (ozone, heat and water) when it is made into products such a rubber hose or car components. ENR 20,50 and 60 denotes the percentage of epoxidization from the original NR structure. Conventional latex concentration methods are not readily applicable to ENR latex. The difference in the specific gravity between the rubber and the serum phase in ENR is too small for the successful application of centrifuging and creaming methods, and sensitivity to heat precludes the use of evaporation as a possible technique. Thus ultrafiltration was found to be a workable alternative for concentrating ENR latex. This process was developed by RRIM in 1993 on small-scale commercial basis. Concentration levels between 60 and 65% could be routinely achieved from an initial DRC of 30%.

The case of NR field latex is quite different, as the concentration process is more complex than the more uniform ENR. Many factors affect latex stability as it is a natural product. Natural rubber latex has four major components and hundreds of minor components that can interact in myriad of ways with the membrane during the concentration process. To avoid fouling of membrane caused by premature coagulation and to minimize possible destabilization of latex when high mechanical shear stresses are encountered during passage through the membrane, several technical parameters need to be taken into consideration. The field latex needs to be treated with a composite preservation system and a mechanical stabilizer needs to be added into the latex before commencing the ultrafiltration process.

Thus the specific objectives of this investigation are:

i. To identify a suitable composite preservation system between two available options of Preservation system 1 [ammonia (1%), TMTD/ZnO (0.025% in the ratio of 1:1), and ammonium laurate (0.1%)] and Preservation system 2 [ammonia (0.5%) and teric® (3phr)]

ii. To study the effects of feed flow-rate and TMP on permeate flux during ultrafiltration of NR latex.

iii. To identify the optimum TMP for the concentration process

iv. To determine the degree of concentration achievable