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Effect of Sodium Dodecyl Sulphate, Brij 35 on Natural Rubber Latex Properties

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Surfactants are normally added to the natural rubber latex system in order to maintain colloidal stability. Surfactants are generally anionic or nonionic in nature. Excessive addition of surfactants to the system will increase overall cost of production and cause problems in processing such as air bubbles contributing to pinhole formation in dried latex films. In this study, two types of surfactants having a chain length of twelve hydrocarbons were added to treated natural rubber latex (NRL). The NRL was partially purified through double centrifugation to remove low molecular weight non-rubber materials present in the latex. Removal of some of the nitrogenous material was indicated by intensity of the FTIR transmittance band at 3,280 cm^{-1} which diminished after the second centrifugation. Dynamic light scattering measurements showed that the partially purified latex particle size were narrowly poly-dispersed. Surface tension of the latex suspension as a function of increased concentration of SDS and Brij 35 were studied. The range of SDS concentration used was 0.2 – 2.0 mM and 0.002 – 0.011 mM for Brij 35. Surface tension of the latex suspension decreased with increasing surfactant concentration for both types of surfactants. In the same range of surfactant concentrations, the zeta potential magnitude increased in the presence of an anionic surfactant but decreased with the nonionic surfactant.

Keywords: Natural rubber latex; colloidal stability; surfactants; zeta potential; surface tension

Commercial natural rubber latex (NRL) is a natural polymer, obtained from the rubber tree, *Hevea brasiliensis*. It is a milky white liquid consisting of rubber hydrocarbon particles and nonrubbers such as proteins, carbohydrates, organic and inorganic constituents. Tapped *Hevea* latex contains about 20 to 30 % rubber solids. The pH of fresh latex is approximately 6.5 to 7. Rubber particles in NRL are narrowly poly-dispersed and range spherically in sizes from 0.005 to about 3 μm, though larger particles of 5 or 6 μm are found exceptionally. It is a high molecular weight polymer with a broad molecular weight distribution ranging from 10^5 to 10^6 Daltons[1].

The polyisoprene in NRL exists in particles stabilised by the adsorbed layer of hydrophilic proteins (84%) and phospholipids (16%)[2]. Charged proteins are found to be in control of the colloidal stability of the freshly tapped latex. When NRL leaves the tree, it gradually undergoes putrefaction leading to coagulation. In order to preserve and maintain

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stability of the latex for a considerable time before processing, ammonia, which acts as a bactericide and causes hydrolysis of phospholipids and proteins, is added[3].

NRL has been well established for use in medical gloves due to its durability, comfort, superior tensile strength, elasticity and barrier performance. Unfortunately, some individuals are sensitive to the proteins in NRL. One of the approaches to reduce allergy towards NRL is to use deproteinised NRL in latex products. As the stabilisation layer contributed by the proteins is removed during the deproteinisation process, surfactants are added during production to stabilise the latex. Among difficulties encountered during usage of the deproteinised NRL are excessive foaming and coagulation problems during the dipping process[4].

The typical manner to improve NRL stability is by addition of small amounts of water soluble fatty acid soap. Blackley *et al*. observe that optimum enhancement of mechanical stability is achieved when the alkyl chain of the soap contains approximately eleven carbon atoms[5]. Substantial enhancement of mechanical stability of NRL is due to strong adsorption of the added soap anions from an aqueous phase into the interface between the rubber particle and the aqueous phase. With increasing alkyl chain length, the fatty acid soap anions tend to be adsorbed at the rubber-water interface. However, longer alkyl chains tend to cohere in clusters and reduce the efficiency in conferring mechanical stability on rubber particles.

Adsorption of laurate soap and sodium dodecyl sulphate (SDS) on natural rubber latex particles were studied by Chen[6,7]. With increasing laurate soap concentration, the extent of adsorption increases rapidly and begins to plateau off when equilibrium concentration is reached, which approximates the critical micelle concentration of potassium laurate in water. Adsorption of SDS on latex particles increases rapidly with decreasing pH, which indicates that interfacial activity of the proteins and fatty acid soaps decreased with pH reduction.

While NRL requires to be stable throughout the storing period, control of destabilisation is important during latex film formation. Therefore, in this present investigation, two types of surfactants namely anionic SDS and a non-ionic under the trade name, Brij 35, were added into NRL individually, to assess their effect on NRL colloidal properties.

EXPERIMENTAL

Materials

Fresh natural rubber latex was collected at RRIM Experimental Field in Sungai Buloh, Selangor, Malaysia. The field latex was centrifuged using a Beckman Coulter centrifuge operating at 20,000 r.p.m. for 1 hour. The cream fraction, namely the rubber phase was re-dispersed in water and the re-dispersed latex was centrifuged again under same conditions. The rubber phase was recovered by re-dispersing again in water and kept as 0.05% (w/w) solid content. SDS and Brij 35 used were analytical grade.

FTIR Spectroscopy

The spectra of latex films surface were obtained using a FTS 2000 Series FTIR spectrometer on an ATR flat top plate accessory.

Particle Size and Zeta Potential

The particle size and zeta potential of solutions were determined using a particle size

analyser *Nano ZS* of *Malvern Instruments*, UK. The instrument composed of a laser, particle size measurement system and zeta potential measurement system.

Surface Tension

Surface tension measurements were performed using Du Noüy Ring method using a Krüss K100 Tensiometer at 30 ± 0.1ºC. The platinum ring was cleaned with ethanol and washed thoroughly with distilled water and flame dried prior to measurement. The ring was hung above the solution surface and the force acting on a liquid film raised by the ring was measured.

RESULTS AND DISCUSSION

The FTIR spectra of field latex as well as the first and second centrifugation latex batches are shown in *Figure 1*. Vibration frequency at 3,280 cm^{-1} is characteristic bands of attached nitrogenous compounds in natural rubber[8]. The field latex showed a broad transmittance band at 3,280 cm^{-1}. The intensities of this band were significantly reduced after the first centrifugation. The band diminished after the second centrifugation, suggesting major reduction of proteins associated with the rubber and serum phases. In this study, the expected charged proteins thought to be responsible for colloidal stability of freshly tapped latex, were minimised by centrifugation. Thus, effects

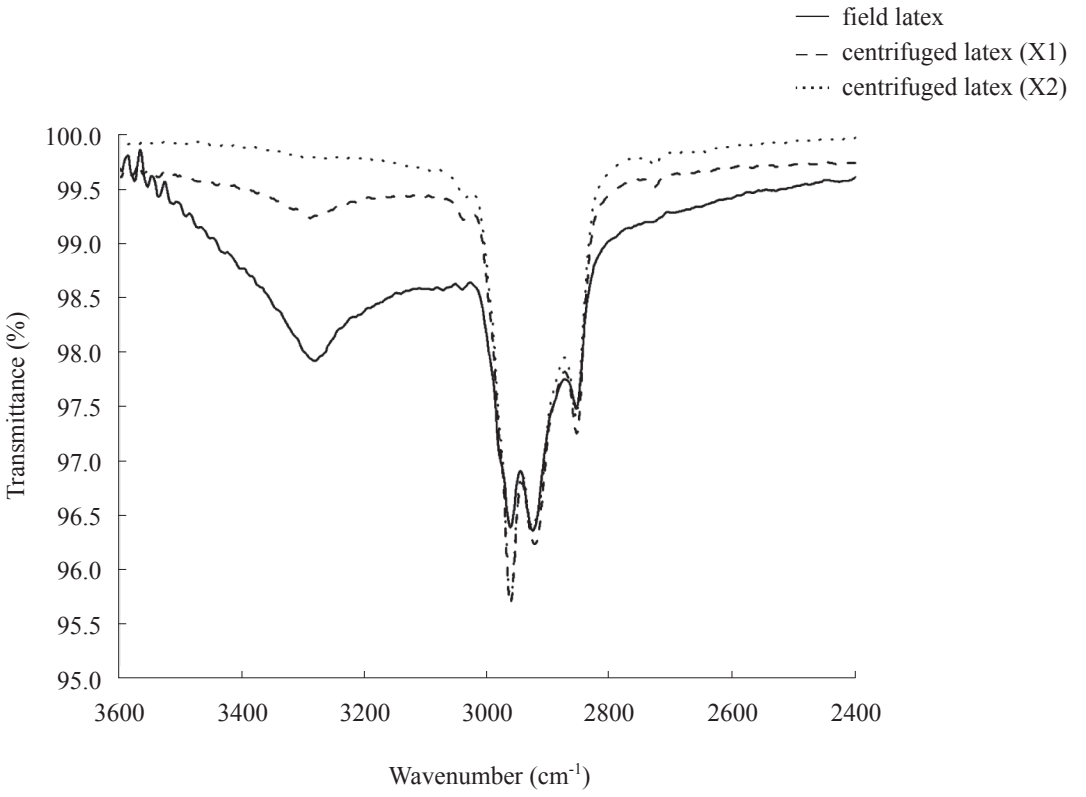

Figure 1. FTIR spectrum of field latex and centrifuged latex.

of individually added surfactant layer on the surface of the latex particles can be realised.

The centrifuged fraction of field latex contained a fairly narrow range of particle size and showed bimodal distribution (*Figure 2*). The *Z*-average of latex particles was 479.8 nm with a 0.54 polydispersity.

Figure 3 shows surface tension of the latex suspension in the presence of SDS as a function of increasing SDS concentration. Surface tension indicates activity of the emulsifier in solution. Equal surface tensions indicate equal emulsifier activities[9]. Surface tension of the latex suspension dropped appreciably with each increment of SDS. While some of the SDS adsorbed on to the surface of latex particles, the unabsorbed SDS molecules were expected to remain in the bulk solution which might cause a reduction in surface tension.

Surface tension of the latex suspension in the presence of Brij 35 is shown in *Figure 4*. The reduction in surface tension was achieved at a much lower concentration of surfactant compared with SDS. The similar decrease in surface tension of the Brij 35 solution was also due to free surfactant molecules concentrated at the air-water interface in accordance to the Du Noüy Ring method.

Particles in a colloidal dispersion contain charges at their surface, these charges are contributed by ions that have a high affinity to the surface of particles and may be taken as part of the surface. Zeta potential is potential at the shear plane within the electrical double layer and is crucial in determining stability of a colloidal suspension. The zeta potential of partially purified NRL was found to be -52 mV. The high value of zeta potential suggested that there was still a substantial amount of

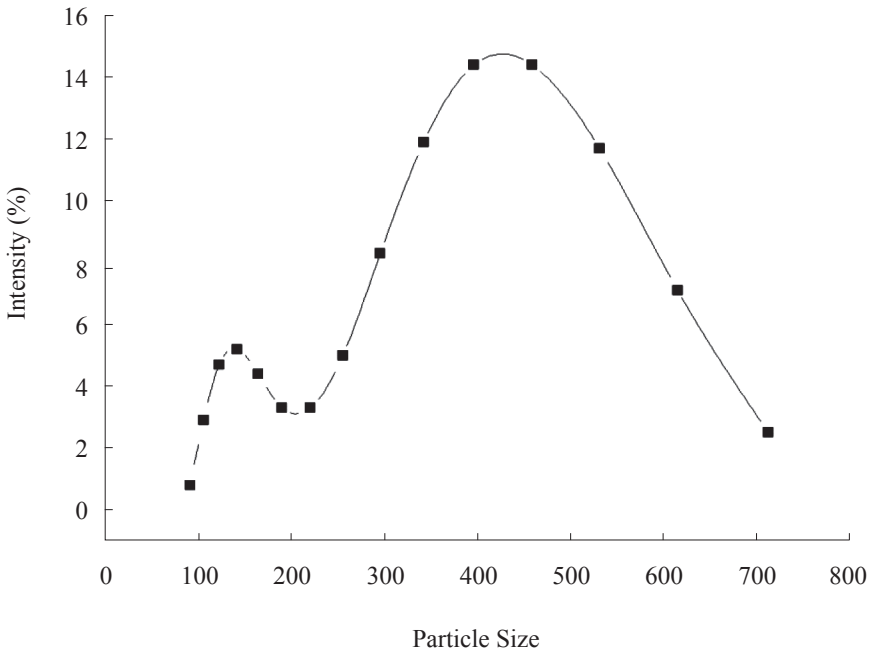

Figure 2. Particle size histogram for double centrifuged latex.

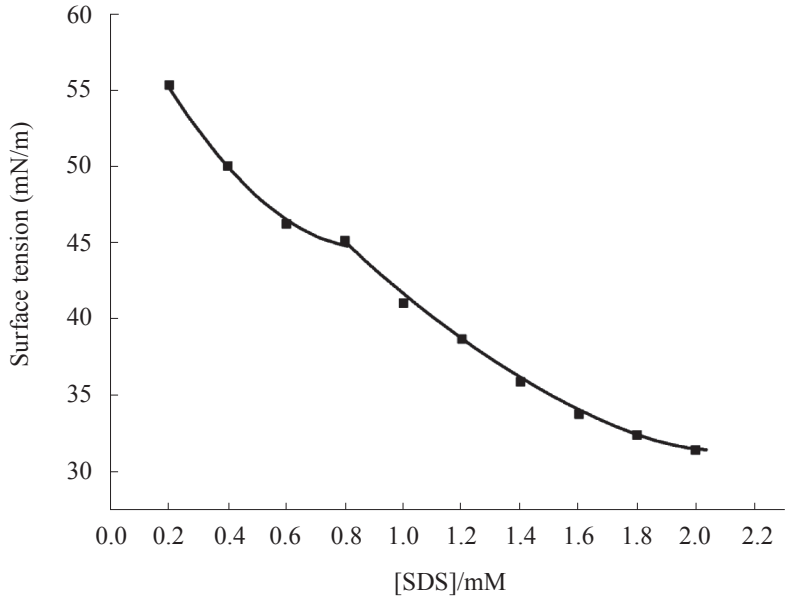

Figure 3. Surface tension of latex suspension in the presence of SDS as a function of concentration at 30ºC.

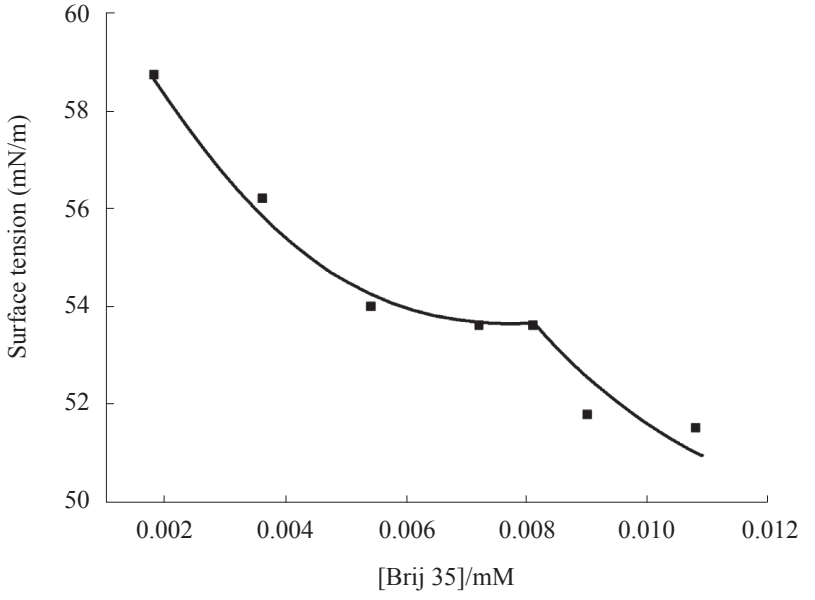

Figure 4. Surface tension of latex suspension in the presence of Brij 35 as a function of concentration at 30ºC.

proteins in the NRL after purification through centrifugation.

However, stabilisation of the latex suspensions at pH 7 was significantly affected by the adsorption of SDS and Brij 35 as shown in *Figure 5*. The magnitude of the zeta potential increased as concentration of SDS increased. The deflection point of the zeta potential magnitude was observed at approximately 0.8 mM, this was in agreement with the deflection point of the suspension's surface tension, suggesting that a greater covering of the surfactant had taken place on the latex particles surface.

The zeta potential magnitude of the latex suspension with Brij 35 decreased as the surfactant concentration increased. The deflection point of the zeta potential magnitude corresponded with surface tension at approximately 0.009 mM. This may be due to the bulky ethylene oxide group of the nonionic surfactant that caused the shear plane to be extended further away from the surface of the latex particles. It is known that the nonionic surfactant contributes towards steric stabilisation rather than electrostatic stabilisation and needs to be taken into account in colloidal stability.

CONCLUSIONS

The NRL was purified through double centrifugations; some of the proteins were removed as indicated by the FTIR spectrum. The centrifuged fraction contained a narrow range of particle sizes. The surface tension of latex suspension with SDS and Brij 35 surfactants decreased as the concentration of surfactant increased. The magnitude of zeta

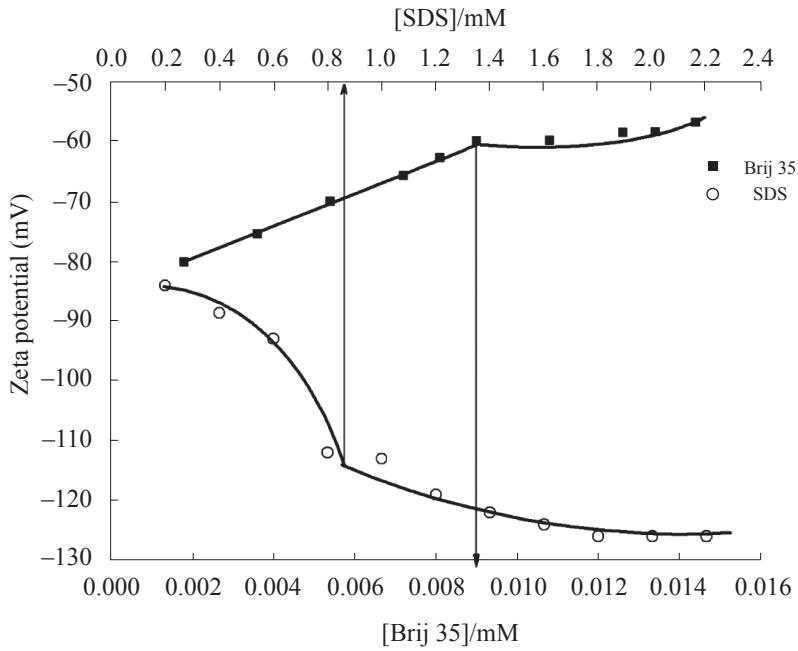

Figure 5. Zeta potential of latex suspension in the presence of SDS and Brij 35 as a function of surfactant concentration.

potential increased for the SDS system but decreased for the Brij 35 system which might be due to the ethylene oxide group.

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