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Colloidal and Rheological Properties of Natural Rubber Latex Concentrate

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Abstract:
Natural rubber latex concentrate (NRLC) is an important material used in manufacturing dipped products, yet thorough analysis of their colloidal and rheological properties are still lacking in these areas. In this work, the colloidal and rheological behaviour of the NRLC was studied. The NRLC particle size was in the range of 0.3 to 2 μm with narrow particle size distribution. The response of NRLC to an applied deformation was assessed through rheological experiments which include dynamic oscillation and steady state measurements. A change from liquid-like to solid-like behavior was observed as the volume fraction of the NRLC was increased above 0.48. The plastic viscosity and yield stress of the NRLC increased with increasing volume fraction according to the Bingham equation. The maximum packing volume fraction of the NRLC was found to be 0.75 with a diffused double layer thickness of 14 nm at ϕ =0.61.

Key words:
Natural rubber latex, latex concentrate, rheology, SEM, Bingham, diffused double layer

1 INTRODUCTION

Natural rubber latex (NRL) is harvested by tapping the bark of *Hevea brasiliensis*, the natural rubber is contained in the cells of tree which are formed by metabolic processes that occurred in plants. The rubber tree is originally found growing in the Amazon region of South America, however in the latter part of the 19th century it is grown extensively in plantation estate especially in South East Asia. The liquid of milky appearance that flows from the tree is a colloidal dispersion [1] of cis-1,4-polyisoprene particles in an aqueous medium. The latex comprises of two phases namely the disperse phase and dispersion medium. The disperse phase consists of large number of small particles which are polymeric in nature. The solid content of the latex is found to be between 30 to 40 % and the remainder being water. It consists of particles of rubber hydrocarbon and non rubbers [2] such as proteins, carbohydrates, phospholipids, amino acids, trace metals and mineral salts. The colloidal properties of NRL dispersion system are dependent on the composition at the interface between the disperse particles and the dispersion medium [3] and also the size of the disperse particles similar to other dispersion system. They are subjected to interfacial and kinetic phenomena such as Brownian motion, surface adsorption sedimentation and diffusion properties.

The NRL exhibit non-Newtonian flow, its viscosity varies with the shear rate and temperature. The material may exhibit shear-thinning, shear thickening, dilatancy, pseudoplastic, thixotropy or hysteresis. In daily manufacturing practice, the viscosity of NRL is obtained using a flow cup or Brookfield viscometer which provides a means of determining the presence and extends of structural viscosity and other rheological properties. The rubber particles in the field latex are envisaged by Blackley [4] to be surrounded by the double layer whereby an inner layer of phospholipids resides beneath a protein layer on the outside of a rubber hydrocarbon which is a body of very viscous liquid rubber. However recent research proposed a new model of natural rubber particle consisting of a mixed layer of proteins and phospholipids surrounding the latex particle with polyisoprene rubber as the hydrophobic core [5]. In this study, we hypothesized the NRL particles having a micellar structure (Figure 1). Whereby the NRL particles had a hydrophobic rubber core and mixed of lipids and protein at the surface of the NRL particles. As proteins could have dual characteristics similar to surfactants, it mae NRL or partly embedded on the rubber core. The colloidal properties namely particle size and

4 SUMMARY

The NRLC particles were predominantly small spheres with a few larger pear-shaped or elongated particles, having an average particle size of 0.98 μm. A change from liquid-like to solid-like behavior was observed when the volume fraction was increased from about 0.48 to 0.61 as there was a reduction in the elastic modulus value. The viscosity of the NRLC increased with increasing volume fraction was as expected. The yield stress and plastic viscosity of the NRLC increased with increasing volume fraction. The ϕ_p for NRLC was found to be 0.75, which corresponds to hexagonal packing. The NRLC also exhibited "elastic overshoot" behavior.

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