CHARACTERIZING SODIUM DODECYL SULPHATE (SDS) IN AFFECTING THE PROPERTIES OF DEPROTEINIZED NATURAL RUBBER LATEX

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Abstract- Sodium dodecyl sulphate (SDS) is one of surfactant that has been extensively used in combination with chemical denaturing agent in acquiring deproteinized natural rubber latex. Though it has the ability to modify surface properties in latex and act as protein denaturants, excessive amount of SDS might contribute to foaming issues as reported in the previous studies; especially in combination with other type of anionic surfactant. In the present work, adsorption of SDS as a single surfactant on the deproteinized natural rubber latex was further scrutinized through particle size distribution, surface tension analysis, adsorption behavior and rheological measurement. Results showed that the average particle size of the deproteinized natural rubber latex did not portray marked differences. The experimental results of surface tension as a function of SDS concentration showed a break-point suggesting the maximum value before the critical micelle concentration (CMC) is reached. The data obtained was fitted to Langmuir equation and the plateau adsorption capacity was calculated to be approximately 0.0236 g_{SDS}/ g_{rubber}, corresponding to about 0.5 phr SDS. These findings were consistent with the viscoelastic rheograms of the deproteinized natural rubber latex that started to be viscous (G" > G') with highest value of phase angle beyond 1% strain. This high viscosity behavior may possibly contributed from the saturated adsorption of SDS on the surface of latex particles. The results described in this paper may suggest possibility of using merely SDS in deprotenizination of natural rubber latex.

Keywords- Sodium Dodecyl Sulphate (SDS), Deproteinized Natural Rubber Latex, Particle Size distribution, Surface Tension, Adsorption, Rheology

I. INTRODUCTION

Surfactant is a molecule that consist of hyrophobic and hydrophilic part that will adsorb onto interfaces (solid/liquid), subsequently lowering the surface tension and hence affecting the rheological behavior of such material. Excessive of these dual parts lead to self-association or micellization, where the surfactant molecules arrange themselves into an organized molecular assemblies known as micelles. The hydrophobic part forms the core of the micelle, while the hydrophilic parts position themselves at the micelle-water interphase in contact with a number of water molecules [1]. Depending on their chemical structure, surfactants are classified as anionic, cationic, zwitterionic or non-ionic, in which anionic-type of surfactant is the major class of the surfactants used in natural rubber latex (NRL).

Sodium dodecyl sulphate (SDS) $[CH_3(CH_2)_{11}OSO_3Na]$ is the most commonly use anionic surfactant in NRL. Besides easily dissolved in water, SDS that contain 11 carbon atoms has been reported amongst effective surfactants in enhancing stability of NRL [2]. For instance, SDS has been extensively utilized in producing deproteinized NRL. A great deal of research has been carried out to develop deproteinized NRL in order to address criticism pertaining latex protein allergy [3]-[14]. Although there exist few techniques, however in this study, only technique which involve with urea-denaturing process will be further scrutinized. In this process, urea was used to unfold the protein from the surface of the latex particles [15], [16] and the presence of SDS will further facilitate in protein denaturation process [17]. In addition to that, SDS will also generate kinetic balance in the latex system to maintain latex collidal stability.

Although SDS has been widely used in the deproteinized NRL, often another type of anionic surfactants were added into the system, which later on promote foaming issue [11]. As a whole, a lot of published works on the deproteinized NRL was focused either on the characteristics or performance of the latex and latex-based articles [4], [6], [8]-[9], [13], new process [3]-[7], [10] and alternative surfactant [11]-[12] . To the best of our knowledge, little published information was found provide a quantitative way in determining the best possible amount of surfactant to be utilized in the deproteinization of NRL, including work by S.F. Chen [18]. As his three decades approach emphasized more on the SDS characteristic in commercial NRL; this study however highlights more on the basis of the actual dispute of SDS in affecting the properties of the deproteinized NRL using current technologies on-hand.

Thus, in order to ascertain SDS as a single surfactant system for the deproteinized NRL, it is best to understand its physicochemical behavior, especially its adsorption characteristic in the deproteinized NRL. It is essential to identify maximum amount of SDS present on the surface of the deproteinized NRL particles; as beyond that, micelles will start to form

and foams will be likely generated. Further analysis on the deproteinized NRL rheological characteristic was also carried out to gain better understanding of the SDS behavior in the deproteinized NRL system.

II. MATERIALS AND METHODS

High-ammoniated natural rubber latex (HA-NRL) was purchased locally. Urea and sodium dodecyl sulphate (SDS) were products of Systerm Chemicals and the other materials were used as received.

Prior experiments, total solid content (TSC) of HA-NRL was adjusted to 30%, before urea was added as protein denaturant. Stock solution of 10% SDS (0.35M) was then added into the latex mixture at twelve varied concentration, ranging from 0 to 4 part per hundred rubber (phr). The latex mixture was stirred for about 2 hours before left overnight under room temperature.

On the following day, the deproteinized NRL was measured for its particle size distrubution using 90Plus/BI-MAS (Brookhaven Instruments Corporation). The technique employed photon correlation spectroscopy of quasi-elastically scattered light, which is based on correlating the fluctuation the average and scattered laser light intensity. Surface tension measurement was determined using pendant drop method by Kruss DSA 100 instrument on the serum fraction of the deproteinized NRL. The serum was collected after the latex has been centrifuged at 20,000 rpm for 1 hour. Meanwhile, adsorption behavior was generated by plotting the amount of SDS adsorbed as a function of equiblirium of SDS concentration. On the other hand, rheological analysis was performed by Discovery Hybrid Rheometer (DHR) from TA Instrument. The viscoelastic properties of the deproteinized latex were carried out at angular frequency = 10 rad/s with strain percentage set from 0.001 to 100%. All experiments were performed at 25°C by using a peltier concentric cylinderical geometry.

III. RESULTS AND DISCUSSION

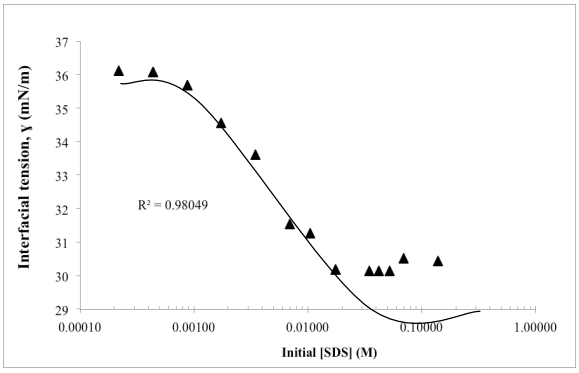
Results of effective diameter for the deprotenized NRL particles at varied phr of SDS were tabulated in Table 1. It was found that the deproteinized NRL particles did not show any substantial trend with increased of SDS contents, as the effective diameter were measured to be around 0.40 to 0.44 µm. Although it was first expected that higher SDS would affect particle size of the deproteinized NRL, however results obtained were contradictory. This may possibly suggest that saturated SDS in the latex system has generated crowding effect and subsequently delays the adsorption of the SDS onto the rubber particles surface. As the results obtained after overnight storage, further investigation on the effect of storing time should be executed before this initial hyphothesis could be confirmed .

Table 1. Effective diameter of deproteinized NRL at varied phr of SDS

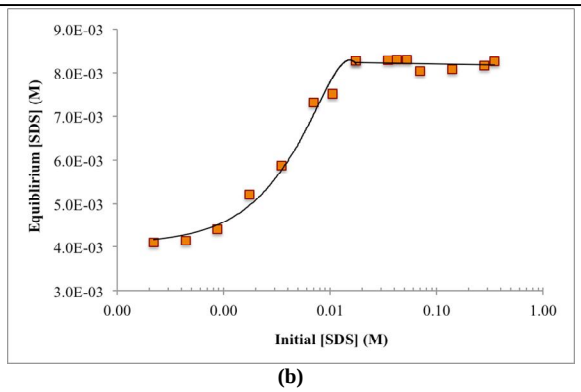
SDS amount (phr)	Effective diameter (µm)
0	0.43
0.0125	0.43
0.025	0.43
0.05	0.43
0.1	0.44
0.2	0.43
0.3	0.42
0.5	0.41
1.0	0.41
1.5	0.44
2.0	0.40
4.0	0.40

The measured interfacial tension of SDS in the serum fraction of the deprotenized NRL is shown in Figure 1a. Applying linear fitting to the two linear portions of the curve show a break point around 0.02M SDS with a correlation value of 0.98. The break point indicates the critical micelle concentration (CMC) of SDS in the latex serum.

The CMC was determined from a plot of equiblirium SDS concentration as a function of initial SDS concentration (Figure 1b). The CMC value obtained was 8mM, which correspond to 0.5 phr SDS. In our approximation, 0.5 phr SDS is the optimal concentration to be used for the deprotenization process of NRL, as beyond that SDS micelles will saturated the whole system.



(a)



(b)

Figure 1. Determination of CMC through (a) equiblirium interfacial tension and (b) equiblirium SDS at different SDS loadings

Figure 2 shows an adsorption isotherm of the amount of SDS adsorbed onto the surface of the deprotenized NRL particles after equilibrated with a wide range of SDS concentration, from below to above CMC. The results were fitted to the Langmuir isotherm, as desribed in [19]. Adsorption isotherm exhibits a pronounced sigmoidal shape, which the adsorption increased rapidly at low SDS concentration before reached plateau after the CMC value. A rapid increased implies that the SDS molecules were attracted to fill-up the empty spaces due to the protein removal in order to maintain latex colloidal stability. Apart from generating a stable electrostatic attraction, the SDS molecules also triggered the onset assosiation of the surfactant molecules onto the rubber surface. In other words, this region is termed as critical aggregation concentration (CAC) [20]. A plateau of the SDS adsorption isotherm indicated that the system is saturated with surfactants, after which the micelles begin to form. The adsorption value of the SDS at CMC point was found to be 0.0236 g_{SDS}/g_{rubber}. The value obtained is higher as compared to the value reported by Chen [18] considering that certain amount of the SDS molecules that were engaged to the free-site of the deproteinized NRL were calculated together with the SDS molecules that were adsorbed on the surface of the deproteinized NRL, due to the electrostatic attraction.

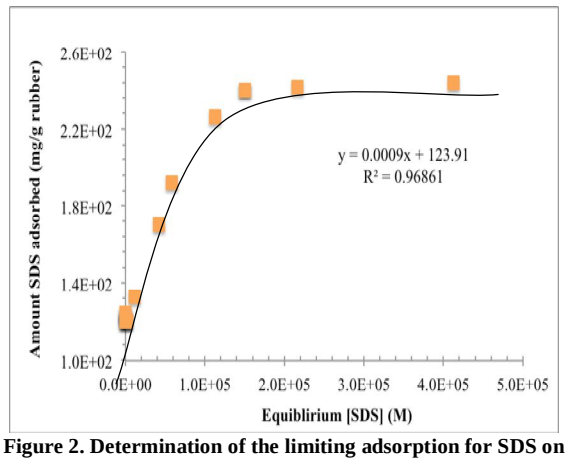


Figure 2. Determination of the limiting adsorption for SDS on the surface of the deproteinized NRL particles

In order to understand the overall viscoelastic properties of the deprotenized NRL, phase angle measurement was determined for all the latex systems, as illustrated in Figure 3. In this figure, the phase angle of all formulations was observed below 5° for strain in between 0.01% to 1%. It may indicate that at lower strain, presence of SDS molecules in the latex system minimized the attraction forces between the rubber particles. The values virtually remains at similar range up to 10% strain before increased rapidly beyond that. Thus, at higher deformation, regardless of the SDS content, the networking attributed to the rubber particles is completely broken, hence contributed to the abrupt change of the latex viscoelastic properties above this region [21].

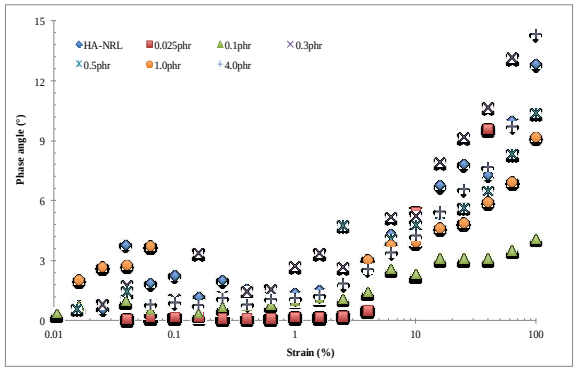
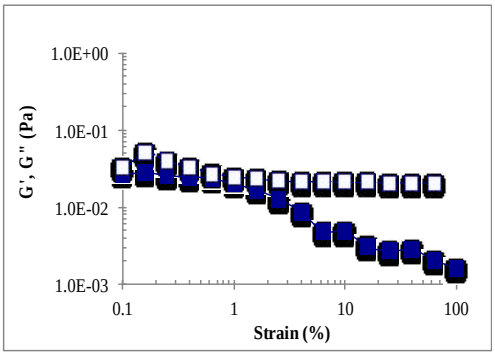


Figure 3. Variation of phase angle as a function of % strain for different SDS content

Figures 4b-4f are distinctive behavior in strain sweep rheograms for the deprotenized NRL with different SDS contents as compared to that of HA-NRL (Figure 4a). A noticeable change was observed on their G' and G" curve, especially for 0.0025 phr SDS at 5% strain. At this critical strain, besides portraying a G'>G" curve, this latex formulation illustrated a broad gap between these parameters as compared to the rest suggesting the more elastic behaviour [22]. It is perceived that as the SDS concentration increased, the gap begin to diminish and the G' curve slowly approaching G" curve indicating structural breakdown. Taking the critical strain at 1% for 0.3, 0.5, 1.0 and 4.0 phr SDS, it was observed that the G" is greater than the G' starting from 0.5 phr SDS. This result may suggest that the deproteinized NRL started to lose its solid-like characteristic.



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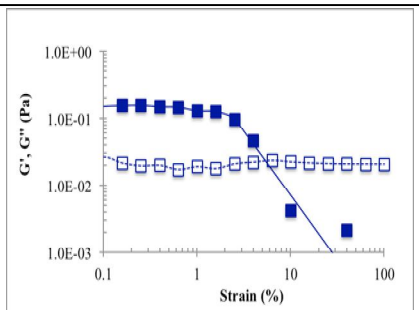

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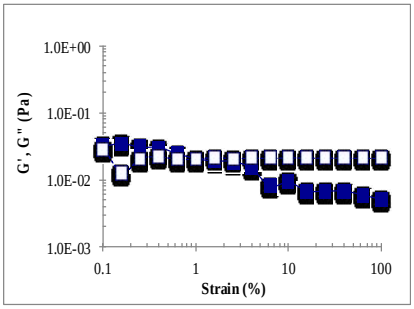

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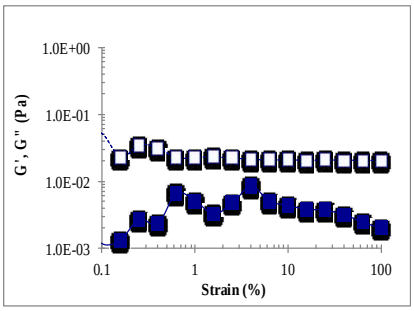

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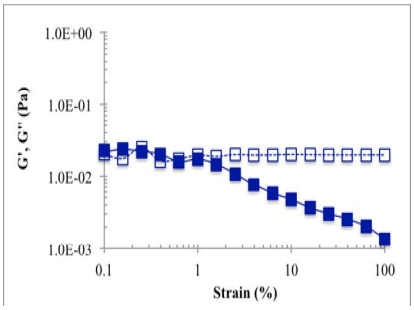

(e)

Figure 4. Strain sweeps of deproteinized NRL, where ■ = G' and □ = G" at various SDS content (phr): (a) HA-NRL, (b) 0.025, (c) 0.1, (d) 0.3, (e) 0.5 and (f) 4.0

CONCLUSION

In this study, SDS was evaluated for its potential as a single surfactant system in the deproteinized NRL. It was found that from varied concentration of SDS present in the latex system, there was no significant difference observed in the particle size diameter. Strong adsorption of SDS onto the surface of the deprotenized NRL was obtained with an adsorption value of 0.0236 g_{SDS}/g_{rubber}, corresponding to 0.5 phr SDS, in which consistent with the break point for the plateau region of the adsorption isotherm. From the linear viscoelastic domain, which strain is less than 1%, it was noticed that G">G' particularly after 0.3 phr SDS; while at 4.0 phr SDS, the latex system was observed saturated with SDS micelles. Thus, with the aim of eliminating foaming issues pertaining to the earlier generation of the deprotenized NRL, it is presumed that SDS could be used as a single surfactant in the NRL deproteinization process at an optimum concentration of 0.5 phr SDS. The particle size and latex viscosity seemed well besides macroscopically homogeneous by our experimental results. Nevertheless, these findings might open up new perspectives in preparing a more stable, controllable and commercializable deprotenized NRL.

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