Preliminary Study on Preparation of Unsaturated Polyester Resin/Natural Rubber Latex Blends in the Presence of Dispersion Aids

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ABSTRACT: The objective of this research was to study the possibility of blending unsaturated polyester resin (UPE resin) with 5, 10, and 15 parts per hundred resin (phr) natural rubber latex (NRL) in the presence of dispersion aids in order to improve the impact resistance of UPE resin. Three types of dispersion aids, sodium lauryl sulfate (SLS), toluene, and ammonia, were used in this study in amounts of 10, 15, 20 and 25 wt % of the NRL. These blended mixtures were cured at room temperature using methyl ethyl ketone peroxide (MEKPO) as an initiator and cobalt octoate as an accelerator. It was found that, regardless of the type of dispersion aid, the impact strength of blended UPE samples was higher than that of the pure UPE samples, and at 20 wt % toluene in 15-phr NRL, the sample had the highest impact strength. However, because of low elastic modulus, characteristic of NRL, the tensile strength and flexural strength of the blended samples decreased as the NRL content of the blends increased. © 2006 Wiley Periodicals, Inc. J Appl Polym Sci 101: 4238–4241, 2006

Key words: unsaturated polyester; rubber; dispersion; impact resistance; blends

INTRODUCTION

Unsaturated polyester resin (UPE resin) is widely used in many applications in the electronic equipment, container, automotive, and cultured marble industries, among others, because of its clarity, excellent chemical and corrosive resistance, and other characteristics. However, this polymer has the disadvantage of poor impact resistance. It has been found that the dispersion of rubber particles in the glassy matrix can improve impact strength because of energy absorption by these rubber particles.[1–7] Therefore, previous studies used both synthetic and natural rubbers as impact modifiers of UPE resin.[5–7] However, because of the difference in chemical structure between UPE resin and these rubbers, especially, natural rubber, the rubber component cannot be uniformly dispersed in the UPE resin matrix. In general, this dispersion can be improved by the use of many methods, such as modifying the chemical structure of one component of the polymer blends by grafting to it segments that can react or interact with other components.[8–10] However, this method always has complicated steps and sometimes has difficulty in handling. Therefore, an alternative route to the preparation of UPE/NRL blends by using chemicals that can promote dispersion of NRL molecules in the UPE matrix was preliminarily investigated in this study. Three chemicals, sodium lauryl sulfate (SLS), toluene, and liquid ammonia, were selected for use as dispersion aids in the system.

SLS, generally used as an emulsifier for emulsion polymerization of many polymers, has both hydrophobic and hydrophilic structures that can interact with NRL and UPE molecules, respectively. Toluene and liquid ammonia are common solvents for rubber and also for styrene monomer, a component of UPE resin. After being mixed with NRL and UPE resin, these two solvents would be expected to dissolve both rubber molecules and styrene monomers together. Because of their affinity for both materials, these three chemicals would be expected to create better dispersion of NRL molecules in a UPE matrix. Therefore, the potential to use these chemicals as dispersion aids in the system also was investigated on the basis of the mechanical properties of the blends compared to those of pure UPE resin.

EXPERIMENTAL

Materials

Analytical-grade sodium lauryl sulfate (SLS), toluene, and liquid ammonia were purchased from Aldrich Company (Singapore, Thailand).

Commercial-grade UPE resin (Polylite SMF-8111), methyl ethyl ketone peroxide (MEKPO), and cobalt

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TABLE I
Compositions of a Dispersion Aid in Blend Components

UPE (g)	NRL (g)	Dispersion aid in NRL (% w/w)
100	5	10
		15
		20
		25
	10	10
		15
		20
		25
	15	10
		15
		20
		25

octoate were donated from Siam Chemical Industries Company (Samutprakarn, Thailand).

Commercial-grade natural rubber latex (NRL) was obtained from Thai Rubber Latex Corp. (Thailand) Plc. (Samutprakarn, Thailand).

All materials were used as received without further purification.

Methods

NRL and each dispersion aid were mixed in the proportions indicated in Table I. Then they were poured into UPE resin containing MEKPO and cobalt octoate (UPE resin:cobalt octoate:MEKPO = 100:0.5:0.5). The mixture was stirred, poured into silicone rubber molds, and maintained at room temperature until it hardened. Then the tensile strength (ASTM D638 with a Universal tensile testing machine), flexural strength (ASTM D790M with a LLOYD 500), and impact strength (ASTM D356-93A with an impact testing machine) of the samples were determined.

RESULTS AND DISCUSSION

From Figures 1 and 2, it can be seen that, regardless of the type of dispersion aid, the flexural strength and tensile strength of the blended samples were lower than those of the pure UPE resin and that as the NRL content of the blends increased, these two properties decreased. Because NRL is a material that characteristically has a low elastic modulus, it would be expected that decreases in both tensile strength and flexural strength would occur when NRL was added to UPE resin, as was observed. Furthermore, it also was observed that when tensile and flexural loads were applied, the sample broke at the interface between NRL and UPE resin. This indicates no strong interaction between these two components, suggesting the interfaces were the defects of the samples.

Figure 3 shows that the addition of NRL to UPE resin in the presence of dispersion aids tended to improve the impact strength of the UPE resin. When considering the chemical structure of UPE resin, as shown as follows, the crosslinked UPE resin was hard and brittle. Therefore, it was easy to break when the impact load was applied. When flexible NRL molecules were added to this glassy UPE resin, they were able to dissipate and absorb the impact load. Therefore, as the amount of NRL increased, the impact strength of the blend samples increased. However, without dispersion aids, NRL molecules aggregated and did not uniformly disperse in the UPE matrix. This created the defects in the samples and resulted in the blends having low impact

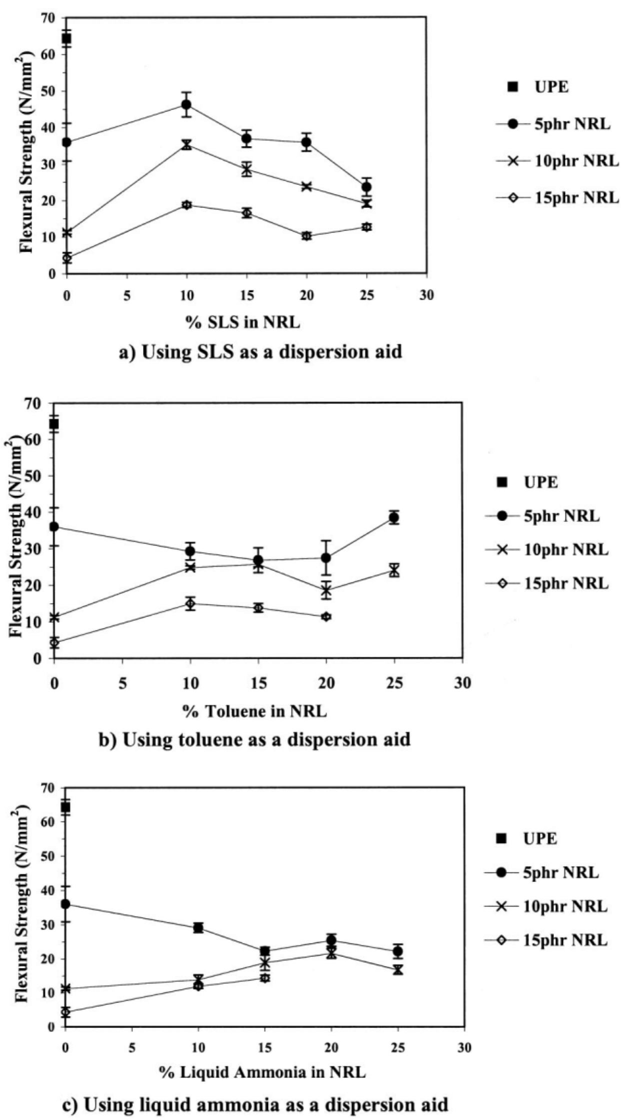


Figure 1 Flexural strength of pure UPE resin and UPE/NRL blends using different dispersion aids.

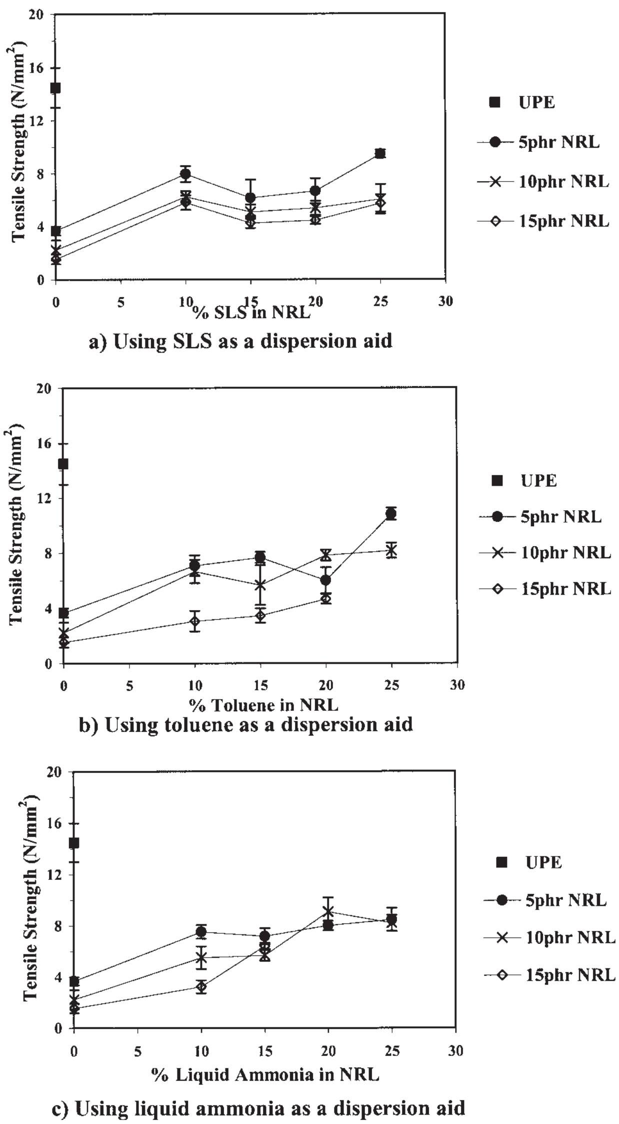
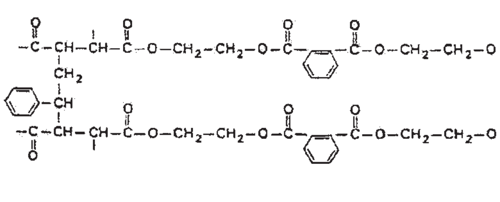


Figure 2 Tensile strength of pure UPE resin and UPE/NRL blends using different dispersion aids.

strength, as shown in Figure 3. In contrast, the blend samples prepared in the presence of the dispersion aids exhibited higher impact strength than did pure UPE resin because better dispersion of the NRL molecules in the UPE matrix was achieved.



UPE resin structure

However, it can be seen that when SLS and liquid ammonia were used as dispersion aids, the impact strength of the blended samples was comparable to that of the pure resin. In contrast, the use of toluene had a greater effect on the impact strength of the blended samples. It was found that at 20 wt % of toluene in 15 parts per hundred resin (phr) NRL, the blend sample exhibited the highest impact strength.

The above results suggest that the type of the dispersion aid had a significant effect on the overall uniformity of the impact strength of the blend samples. This was because of the chemical structure and the unique characteristics of each dispersion aid. When liquid ammonia and toluene were used, they dissolved the rubber molecules and the styrene monomers in UPE resin together. Because they are volatile solvents, after curing, they evaporated out of the samples. Therefore, rubber and UPE molecules can directly interact. However, because of the faster evaporation rate at room temperature of liquid ammonia, it evaporated before it completely helped NRL to uniformly disperse in UPE matrix. In contrast, toluene

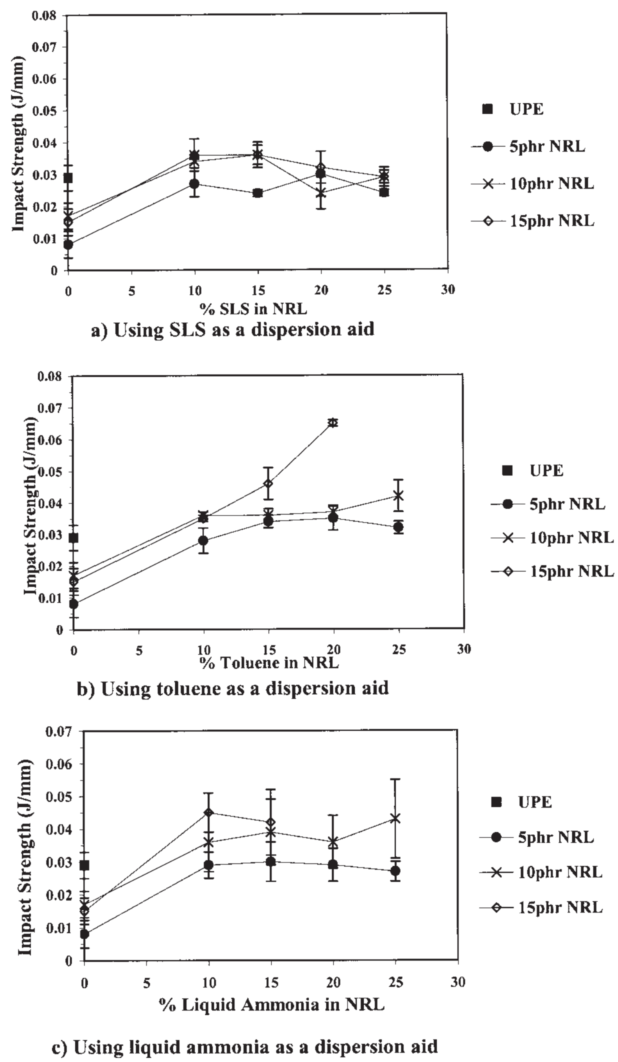


Figure 3 Impact strength of pure UPE resin and UPE/NRL blends using different dispersion aids.

has a lower evaporation rate at room temperature and is a good solvent for both NRL and UPE resin, as a consequence of which NRL was better dispersed in the UPE matrix. Therefore, the blended samples prepared in the presence of toluene exhibited better mechanical properties than did those prepared in the presence of liquid ammonia.

Polar and nonpolar groups make up the molecular composition of SLS, a common anionic surfactant; consequently, it can interact with both UPE resin and NRL. Although its hydrophobic sites interacted with rubber molecules, its hydrophilic sites interacted with UPE molecules. This helped the NRL molecules to uniformly disperse in the UPE matrix. However, after curing of the resin had finished, the SLS molecules could not evaporate, so they remained in the samples. This created an interface between the rubber and UPE molecules, resulting in less interaction between these molecules compared to in the samples prepared in the presence of toluene and liquid ammonia, where they could interact directly. Therefore, the mechanical properties of the blended samples prepared in the presence of toluene and liquid ammonia tended to be higher than those of the blended samples prepared in the presence of SLS. All these results suggest that in this study toluene was the most suitable chemical for use as a dispersion aid in the blending of UPE resin with NRL.

CONCLUSIONS

The incorporation of NRL using a dispersion aid was effective in improving the impact resistance of UPE resin, depending on the type of dispersion aid used. Of the three chemicals used in this research, only toluene exhibited a significant improvement in impact strength, especially at 20 wt % toluene in UPE with 15-phr NRL.

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