Effect of type of phenolic resin in preparation of an adhesive from phenol-formaldehyde resin

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Abstract

Adhesion between the interface of yarn and rubber is achieved by coating cords with resorcinol formaldehyde-latex (RFL) adhesive. In this study, phenolic adhesive synthesis has been studied from different perspectives. In order to produce this adhesive, we compare two modes of adhesive preparation of two monomers including 1, 3-dihydroxybenzene (resorcinol) and 1, 4-dihydroxybenzene (hydroquinone) and also of two phenolic oligomers including resol and novalac. It was only observed that the adhesive obtained from the condensation polymerization of formaldehyde with resorcinol was produced as a single-phase adhesive. After selecting resorcinol to produce phenolic resin, Latex content was optimized to improve rubber adhesion. 30% latex has the best adhesion.

Keywords: adhesive, resorcinol, hydroquinone, oligomer, resol, novalac, yarn.

Introduction

Many elastomer types are too weak to be used without some reinforcing system. There are two main possible reinforcing principles: either the elastomer matrix is compounded with reinforcing fillers or the product is provided with some fiber consisting components applied in the product assembly phases [1,2].

Before the fibers can be used for elastomer reinforcement some treatments are often needed. Last stage in textile manufacturing is combined heat-setting and adhesive treatment [1,3].

The adhesion between the interface of yarn and rubber is achieved by coating the surface of synthetic cords with resorcinol formaldehyde-latex (RFL) adhesive [4,5]. There are two basic RFL formulations. One is based on an alkali catalyzed resole resin and the other on an acid catalyzed pre-condensed novolak resin. The novolak is a linear where the resole resin is more fully cross linked and additional formaldehyde is required to give the high degree of cross-linking [1,6].

The single stage method has a further advantage in that as the resin is formed in the presence of the latex comprising up to six resorcinol units giving a much-improved dispersion of the resin. This improved dispersion also occurs with the novolak system, as the cross linking of the linear pre-condensate occurs in the presence of the latex [1,7]. Ammonia or sodium hydroxide as the alkali catalyst is used for the condensation reactions [1,8].

Experimental

Materials

The materials for RFL preparation and H-adhesion test were prepared as follow:

Styrene-Butadiene Latex was obtained from the Minko Co., Malaysia. Resorcinol, Sodium hydroxide and Ammonium hydroxide were obtained from the Kian Chemistry., Iran. Formaldehyde was obtained from the Samed Chemicals Industrial Co., Iran. Rubbers obtained from Baspar Sazeh Co., Iran were used to preparation Specimens for H-adhesion test.

The thickness of the rubber stock was 3.7-3.9 mm

RFL preparation

The RFL adhesive is shown in Table I. After mixing, it was allowed to mature for 20 h at room temperature before use. The yarn was fixed on one side and immersed in the previous step solution for 6 seconds with a weight of 50 g on the other side. cure for 2 minutes at 170 ° C.

Evaluation of H-adhesion

The H-adhesion test was measured according to ASTM 4776. A dipped sample was sandwiched in "H" shape arrangement between two layers of rubber compound test stock to be subsequently placed in a heated mould to cure. Figure 1 shows mould loading schematic used in this study. The H-shaped sample according to Figure 2 was placed in the tensile tester grips. The maximum force obtained was the H-test adhesion force. Several samples were used for each test and the average value is reported with its standard error calculation.

Results and discussion

Effect of phenolic resin type on the prepared adhesive

Table 1 presents a comparison of two modes of adhesive preparation of two monomers including 1,3 dihydroxybenzene (resorcinol) and 1,4 dihydroxybenzene (hydroquinone) and also of two phenolic oligomers including resol and novalac.

It was observed that the adhesive obtained from formaldehyde condensation polymerization with resorcinol produced the resulting adhesive in single phase. The reason for this is that the single stage method has a further advantage in that as the resin is formed in the presence of the latex comprising up to six resorcinol units giving a much-improved dispersion of the resin. This improved dispersion also occurs with the novolak system, as the cross linking of the linear pre-condensate occurs in the presence of the latex [1].

Table 1. Effect of phenolic resin type on the prepared adhesive

Materials	Monomer		Oligomer	
	Resorcinol	Hydroquinone	Novalac	Resol
phenolic resin	2.34	2.34	3.2	3.2
Methanol	----	----	11.5	11.5
water	82.15	82.15	45.6	45.6
Sodium hydroxide	1.13	1.13	0.7	0.7
Ammonium hydroxide	1.51	1.51	0.9	0.9
Formaldehyde (42%)	2.77	2.77	1.7	1.7
Latex SBR	10.1	10.1	36.4	36.4
Total	**100**	**100**	**100**	**100**
peeling	**61<**	**not**	**71**	**75**
Morphology	**Single phase**	**Double phase**	**Double phase**	**Double phase**

Effect of latex on adhesion

A latex component is nowadays replaced with resorcinol/formaldehyde resins giving improved adhesion and more reproducible results. In the RFL adhesive, the latex component causes the yarn to adhere to the rubber and the phenol-formaldehyde part is responsible for the adhesion to the yarn. When the production processes for yarns improved, it was found that the SBR latex/resin adhesives with 10 %w latex did not give adhesion good enough to realize the improved strengths of these yarns. To improve this, latex component was increased. Latex content was optimized to improve adhesion to rubber. 30% latex has the best adhesion(Table 2).

Table 2. Effect of SBR latex on adhesion

Materials	RFL 10 %wt.	RFL 20 %wt.	RFL 30 %wt.
resorcinol	2.5	2.5	2.5
water	82	72	62
Sodium hydroxide	1.1	1.1	1.1
Ammonium hydroxide	1.5	1.5	1.5
Formaldehyde (42%)	2.8	2.8	2.8
Latex SBR	10.1	20.1	30.1
Total	100	100	100
peeling	51	54	>61

Conclusions

Many elastomer types are too weak to be used without some reinforcing system. This means that most practical rubber products include the concept of reinforcing the elastomer matrix with some reinforcing agent. Adhesion between the interface of yarn and rubber is achieved by coating cords with resorcinol formaldehyde-latex (RFL) adhesive. In this study, phenolic adhesive synthesis has been studied from different perspectives. In order to produce this adhesive, we compare two modes of adhesive preparation of two monomers including 1, 3-dihydroxybenzene (resorcinol) and 1, 4-dihydroxybenzene (hydroquinone) and also of two phenolic oligomers including resol and novalac. It was only observed that the adhesive obtained from the condensation polymerization of formaldehyde with resorcinol was produced as a single-phase adhesive. After selecting resorcinol to produce phenolic resin, Latex content was optimized to improve rubber adhesion. 30% latex has the best adhesion.

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