Study of Rubber Adhesive Compounds for Tire Retreading: Drying Rate and Adhesion Strength

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ABSTRACT

The scope of this article is to study the drying rate and the adhesion strength of rubber adhesive compounds that used three different tackifiers i.e. Coumaron Resin, Siongka, and Koresin. The rubber adhesive compounds were diluted in n-Hexane with the content of rubber adhesion compounds was 12 %, 13 %, 14 %, and 15 %. And then it was spread on the surface of 2.5 x 15 cm testpiece of the casing (worn tire) and retreading tire compounds. A time until the adhesive is slightly dry was used to determine the drying rate. The test piece of casing and retreading tire compounds was taped in one piece and pressed at 170°C. The adhesion strength was tested according to JIS K6301. The results show that the best rubber adhesive is an adhesive that uses Siongka as the tackifier with the solid content of 14%, adhesion strength 4.15 kg/cm, weight 13.653 mg/cm² and drying time 5 minutes.

Keywords: rubber adhesive, tackifier, motorcycle tires, retreading
INTRODUCTION

The adhesive is a material that is capable to stick fast to surface or object. There is a large number of adhesive types for various application. One of the applications of adhesive is in tire retreading (Kumar, 2016). Rubber to rubber bonding is common in tire industries. Bonding of vulcanized elastomers to themselves and to other materials is generally accomplished using an adhesive derived from an elastomer similar to the one being bonded. Natural rubber is one of the rubber-based materials that is used as adhesive (Ebnesajjad, 2011; Rippel & Galembeck, 2009).

The adhesive composition that is applied in tire retreading is a thermostet adhesive. Thermoset adhesive is crosslinked by polymeric resins that are cured using heat and/or heat and pressure. Rubber based adhesives may contain a wide variety of component materials such as elastomers, resins, tackifiers, fillers, plasticizers and softeners, antioxidants, curing agents, etc (Khan & Poh, 2011). The adhesive comprises a rubber composition containing a sulfur curative together with carbon black, processing oil, and tackifier resin (US Patent, 2000). Tackifiers are chemical compounds used in formulating adhesives to increase the tack, the stickiness of the surface of the adhesive. The tackifier acts as a diluent to develop the flowability of the and improves the peel strength (Sasaki et al., 2008). Tackifiers used are usually resins. Tackifying resin that was usually used can be divided in three groups: hydrocarbon resins, rosin resins, and phenolic resins. Coumarone-indene resin is one of hydrocarbon resins. Coumarone-indene resin was used as the tackifier of a natural rubber–based press-sensitive adhesive. The viscosity and tack of the adhesive is affected by resin content due to the concentration effect of tackifier resin (Poh & Chee, 2007). Hydrocarbon tackifier and rosin tackifier were applied in epoxidize natural rubber latex-based pressure sensitive adhesive. Hydrocarbon tackifier lower viscosity as a result of increased repulsion between particles as compared to rosin ester tackifier. The peel adhesion of adhesive containing hydrocarbon tackifier was greater than adhesive containing rosin ester tackifier (Rohani et al., 2013). Koresin is aphenolic resin that was applied to provide tack of rubber compounds during the building process of green tires until they are vulcanized(Durairaj, 2013).

This paper studied the properties of rubber adhesive compounds for tire retreading that used three different tackifiers i.e. Coumaron Resin, Siongka, and Koresin. Coumaron resin representative hydrocarbon tackifier resin, Siongka representative rosin tackifier resin from pine trees, and Koresin representative phenolic tackifier resin. The adhesive compounds were diluted in solvent for several concentration. The drying rate and the adhesion strength of rubber adhesive were investigated.
MATERIALS AND METHODS

Materials

Suitable worn tires were used in this study as the casing that is glued together with tire retreading compound. The polymer used in this study as an adhesive is Ribbed Smoked Sheet 1 (RSS1). The additives materials used were zinc oxide (ZnO) Indoxide, actiplast 8, stearic acid Aflux 42M, Carbon Black N660, insoluble sulfur, vulkanox HS, Coumaron Resin (C), Siongka (S), Koresin (K), Vulkacit DM/C, and n-hexane.

Methods

Compounding

Rubber adhesive compound’s preparation was made with the composition and formulation that are presented in Table 1.

<table>
<thead>
<tr>
<th>Materials</th>
<th>C</th>
<th>S</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoked sheets</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Actiplast 8</td>
<td>0,5</td>
<td>0,5</td>
<td>0,5</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>0,5</td>
<td>0,5</td>
<td>0,5</td>
</tr>
<tr>
<td>Vulkanox HS</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>N 660 (GPF) black</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Vulkacit DM/C</td>
<td>1,2</td>
<td>1,2</td>
<td>1,2</td>
</tr>
<tr>
<td>Sulphur (insoluble)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Coumaron Resin</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Siongka</td>
<td>-</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Koresin</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
</tbody>
</table>

Preparation of Rubber Adhesive

Rubber adhesive compound was diluted in n-hexane with the content of compound are presented in Table 2.

<table>
<thead>
<tr>
<th>Rubber Adhesive Compound</th>
<th>C12</th>
<th>C13</th>
<th>C14</th>
<th>C15</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
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</tbody>
</table>
Bonding Process

Rubber adhesive compounds were diluted in n-hexane. Then, the rubber adhesive was spread on the surface of 2.5 x 15 cm testpiece of casing and tire retreading compound. Allow the spreading of rubber adhesive a few moment until the rubber adhesive is slightly dry. Record the drying time and the amount of the rubber adhesive that is spreaded on the surface of the testpiece.

Adhesion Testing

The testpiece of casing and tire retreading compounds which have been spreaded with rubber adhesive was taped in one piece and pressed in hot vulcanizing press at 170°C. Then, the testpiece placed in the conditioning room for 24 hours. Adhesion testing of testpiece according to JIS K6301.

RESULT AND DISCUSSION

Figure 1. shows the drying time of rubber adhesive solution that spread on casing and tire retreading compound.

![Drying time vs Adhesive compound content](image)

Figure 1. The drying time of rubber adhesive

The drying time of rubber adhesive is affected by the amount of rubber adhesive content in the solvent. Figure 1 shows that the greater adhesive compound content, the faster the drying time. This is because the greater adhesive compound content has less amount of solvent so that it takes less time to evaporate. In tire retreading manufacturing, drying time of rubber adhesive is related to the efficiency process.
Figure 2 shows the weight of rubber adhesive dilution per unit area of casing and tire retreading compound.

![Graph showing weight per unit area vs adhesive compound content.](image)

**Figure 2.** The weight of rubber adhesive per unit area

Figure 2 shows that each type of tackifier shows tendency that the greater of solids, the greater the weight of rubber adhesive per unit area. The weight of rubber adhesive per unit area is related to adhesive viscosity. In tire retreading process, the solvent is use to reduce the viscosity of rubber adhesive so that they can be applied in the tire smoothly and spreads uniformly (Kumar, 2016). The thick rubber adhesive is difficult to spread on the surface of casing and tire retreading compound. So, the rubber adhesive does not spread evenly on the surface. Rubber adhesive that is too thick is easy to peel because rubber adhesive is only bonded to one side (casing or tire retreading compound). Otherwise, rubber adhesive that is too thin contains a small rubber adhesive compound, so the adhesion strength is small.

![Graph showing adhesion strength vs adhesive compound content.](image)

**Figure 3.** Adhesion strength of rubber adhesive
Figure 3 shows the adhesion strength of rubber adhesive that bond casing and tire retreading compound. Figure 3 shows that tackifier and adhesive compound content give effect in adhesion strength. Siongka as tackifier at various adhesive content has a relatively higher in adhesion strength than Coumarone Resin and Koresin. This is probably because Siongka as a natural tackifier is more compatible with natural rubber as the raw material of adhesive compound. It is similar to the natural resins isolated from the coagulated latex of E. caducifolia, that improving tack strength properties in the filled NR compound comparable to CI resin at equal loading.

CONCLUSION

Coumaron resin, Siongka, and Koresin were used as the tackifier in rubber adhesive compounds. The drying time of rubber adhesive is affected by the amount of rubber adhesive content in the solvent. The adhesion strength is affected by adhesive compound content and tackifier that used in rubber adhesive compounds. Siongka as tackifier has a relatively higher adhesion strength than Coumarone resin and Koresin. This is probably because Siongka as a natural tackifier is more compatible with natural rubber adhesive.

ACKNOWLEDGEMENTS

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REFERENCES


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