Preliminary Investigation of Waste Cooking Oil-Based Bio-asphalt and Reinforcement with Lignin-Based Epoxy

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Introduction

This research optimizes the production of Kraft lignin (KL)-based epoxy and waste cooking oil (WCO)-based bio-asphalt to achieve a comparable alternative to the commercial asphalt.

Methods and Materials

**Synthesis of Bio-asphalt:**

Waste cooking oil (0.2 wt % iodine, 24 wt % Maleic anhydride) → Bio-asphalt

**Synthesis of KL based epoxy monomer:**

Kraft lignin → Glycidation

KL-epoxy

**Reinforcement of bio-asphalt with KL-epoxy:**

KL-epoxy + Bio-asphalt → KL-epoxy modified bio-asphalt

**Characterization of Rutting Resistance & Viscoelasticity**

- Studies performed using Parallel Plate geometry:
  1. Effect of reaction time of Bio-Asphalt: 12 hours vs 24 hours
  2. Effect of KL-epoxy contents: 2.5%, 5%, 7.5% or 10% by weight

Results

**Table 1:** The molar ratios of each reagent for the glycidylation reaction of KL were as follows:

<table>
<thead>
<tr>
<th>Hydroxyls of KL</th>
<th>Epichlorohydrin</th>
<th>NaOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>KL-epoxy-1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>KL-epoxy-2</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>KL-epoxy-3</td>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>

**Figure 1:** FTIR spectra of KL and different KL-based epoxies.

- Production of epoxy rings
- Decrease of hydroxyl groups
- KL-epoxy-3: highest production of epoxy groups

**Figure 2:** ³¹P NMR spectra for KL and KL-based epoxy

**Figure 3:** Rheological properties of neat asphalt, neat bio-asphalt and KL-epoxy modified bio-asphalt samples

**Figure 4:** Rheological properties of neat asphalt, neat bio-asphalt and KL-epoxy modified bio-asphalt samples

The temperature at which G*/sin(δ) = 1 KPa is the maximum temperature for effective asphalt performance.

Conclusion

- Addition of KL-epoxy has improved the high temperature performance and viscoelasticity of the bio-asphalt.
- The properties increased with the increase of the KL-epoxy contents.
- By varying the KL-epoxy content, rheological properties of the modified bio-asphalt can be greatly regulated.

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