Improving the water resistance of phenol-formaldehyde resin using biophenols obtained from liquid pyrolysis products of wood waste

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According to some researchers, about 35.5 million m³ of wood waste is generated annually in the Russian Federation.

These waste lignocellulosic biomass can serve as a source of energy and chemical components.
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**Phenol in plants**

**An example of a possible structure of lignin**

Phenolic compounds are produced by plants and microorganisms, and during growth they accumulate in cell vacuoles or polymerize into lignin.
Title

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Keywords: Phenol-formaldehyde resin, Resol resin, Wood pyrolysis, Pyrolysis liquid, Bio-oil, Phenol substitution, Biophenol, Water resistance coefficient

Fast ablative pyrolysis
Title

Improving the water resistance of phenol-formaldehyde resin using biophenols obtained from liquid pyrolysis products of wood waste


<table>
<thead>
<tr>
<th>Yield of pyrolysis products at the FPP02 production complex, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Charcoal</td>
</tr>
<tr>
<td>2. Pyrolysis liquid</td>
</tr>
<tr>
<td>3. Gas</td>
</tr>
</tbody>
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1. Charcoal
2. Pyrolysis liquid
3. Gas
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**Title**

**Separation of the phenol-substituting fraction**

Pyrolysis liquid PL → PL-2 → phenol replacement fraction / PRF

- distillation
- water extraction

acids → hot water → sugar + water
Title

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Yield of fractionation products (PL-2, PRF) from the pyrolysis liquid

<table>
<thead>
<tr>
<th>Yield, %</th>
<th>Pyrolysis liquid (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate obtained during distillation</td>
<td>55,08</td>
</tr>
<tr>
<td>PL-2</td>
<td>40,43</td>
</tr>
<tr>
<td>PRF</td>
<td>14,77</td>
</tr>
</tbody>
</table>

Yield of the phenol replacement fraction (PRF) from dry wood

<table>
<thead>
<tr>
<th>Yield, %</th>
<th>Weight of absolutely dry wood (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRF</td>
<td>8,27</td>
</tr>
</tbody>
</table>
Laboratory plant for the synthesis of phenol-formaldehyde resins:

**photo**

**scheme**

Resin with PRF

1 - three-necked flask; 2 - reflux condenser; 3 - tripod; 4 - mechanical mixer; 5 - shutter; 6.7 - thermometer; 8 - water bath; 9 - thermostat
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<table>
<thead>
<tr>
<th></th>
<th>Modified resin with</th>
<th>Control resin without</th>
</tr>
</thead>
<tbody>
<tr>
<td>color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smell</td>
<td>Distinct smoke odor characteristic of pyrolysis liquid</td>
<td>Weak, sweet taste</td>
</tr>
<tr>
<td>consistency</td>
<td>Heterogeneous with small inclusions</td>
<td>Homogeneous</td>
</tr>
</tbody>
</table>

Distinct smoke odor characteristic of pyrolysis liquid.
Weak, sweet taste.
Samples for testing shear strength

Before the break

After the break
Dependence of the resin strength on the degree of substitution of phenol with pyrolysis liquid

The ultimate strength when chipping on the adhesive layer according to the state standard 20907-2016 is not less than 1.47 MPa
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Treatment of modified resin with PRF solvents

Two solvents were used for extraction: benzene and n-hexane

Stirring for 1 hour

Settling in the dividing funnel for 3 hours

benzene  

hexane
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**Shear strength before and after boiling and water resistance coefficients**

1-control resin without PRF, 2-resin modified with PRF, 3-resin with PRF and cleaned with benzene, 4-resin with PRF and cleaned with hexane.
Conclusions
- The results of the study indicate a significant influence of neutral substances in the composition of liquid products of rapid pyrolysis on the quality indicators of the resol phenol-formaldehyde resin.
- The release of neutral substances increased the water resistance coefficient for the resin with PRF purified hexane to 0.91 MPa, for the resin purified with benzene to 1.04 MPa.
- Benzene as an organic solvent copes more efficiently, the mass content of substances dissolved in benzene is 3.2%, in hexane 2.5%. The strength values of the resin purified with benzene remain stable before and after boiling (3.17 MPa before boiling, 3.31 MPa after boiling), and the water resistance coefficient is comparable to the water resistance coefficients of the control sample.

References

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Thank you for your attention!

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