Wood Adhesives Made with Pyrolysis Oil

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ADHESIVES RESEARCH INSTITUTE (A.R.I.) Ltd., based in Thessaloniki, Greece, is a member of the **A.C.M. Wood Chemicals plc** group, which is involved in the development and manufacturing of formaldehyde-based resins and resin additives for the production of wood-based panels. A.R.I., the research and development centre of the group, is specialised in the wood and adhesives chemistry and its aim is to

- develop new products and processes for the wood panel industry
- test and verify the performance and effectiveness of products and technologies already in use
- carry out quality control by following the most stringent international regulations
- offer training in a continually updated know-how.

Phenol-formaldehyde resins represent an important type of adhesives employed in the production of wood-based panels of superior water resistance (exterior use products). They are mainly the products of the reaction between phenol and formaldehyde, which is catalyzed by alkali to provide a thermosetting polymer called a resole. Other phenolic compounds (e.g. resorcinol) can also react with formaldehyde to provide polymers of the same type.

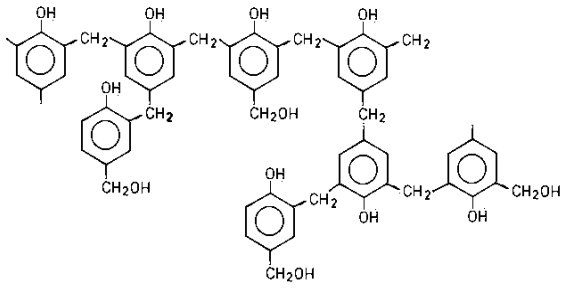

Figure 1: Resole structure.

Phenol is a petrochemical toxic substance and the increased oil prices together with the need of reducing the demand on fossil fuels and promoting environmentally friendly products have encouraged the development of alternative resin feedstocks derived from renewable resources. Efforts in this field have accelerated in the latest two decades.

The research group of A.R.I. in this respect has studied the potential use of pyrolysis oil (bio-oil), a portion of which comprises of phenolic compounds, for replacing part of the phenol needed in the formula of a phenol-formaldehyde resin. A successful phenol substitute should be:

- less toxic than phenol
- of considerably lower cost than petroleum-derived phenol
- able to provide resins with the same or enhanced quality than the ones conventionally synthesized.

The first two requirements are fulfilled by fast pyrolysis oil (bio-oil). The scope of this work was to evaluate, whether the third requirement can also be fulfilled by pyrolysis oil. Preliminary results presented in PyNe Newsletter, issue 6 of September 1998, by Mr. P. Nakos of SAPEMUS CHEMIE GmbH, also a member of the A.C.M. Wood Chemicals plc group, showed that an up to 30% phenol substitution by pyrolysis oil was possible. However, the resin efficiency was negatively affected, most importantly for substitution levels over 20%. These results were considered promising and worthy of further investigation, of which results are presented herebelow.

METHODOLOGY AND RESULTS

Phenol-formaldehyde resins were successfully produced by substituting up to 50% of the phenol needed in the formula with bio-oil, using slight modification of the commercial synthesis Know How. The resins were intended for use in two different applications: production of either Oriented Strandboard (OSB) or plywood (PW) panels. This difference in resin application requires a different approach in resin production sequence. However, the use of bio-oil in both cases provided phenolic adhesives with reactivity (curing time) and performance equal to the ones of the conventional resin.

Industrial scale production of plywood was realized by employing the bio-oil modified phenolic resin. Representative results from testing of the board properties are given in Figure 2. The board samples were tested according to the requirements of bond type WBP (Weather and Boil Proof, 72h boil pretreatment) of British Standard 6566, using the

knife test for assessing the bond quality. Two different types of wood veneers were employed for forming of the panels: poplar (hardwood) and okoume (tropical) veneers. The bond quality of the modified resin was compared with that of the conventional resin (control) and the value of plant control. The panel bond performance, however, is highly dependent not only on the resin type but also on the type of wood veneers. The results show that the bond quality of the bio-oil modified resin is equal or even better than that of the conventional resin and higher than the plant control value.

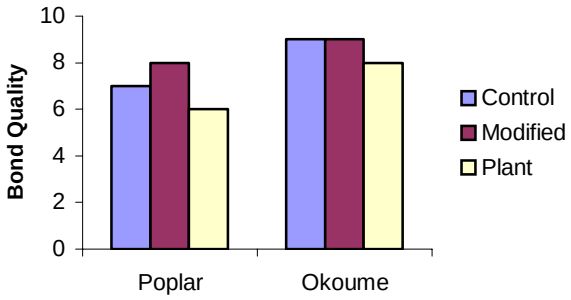

Figure 2: Bond quality of industrial plywood produced with bio-oil modified PF resin.

Furthermore, pilot scale production of OSB was carried out, by employing bio-oil modified resin. In Figure 3, the values of tensile strength (IB), bending strength (MOR), thickness swelling after immersion in water for 24h (TS) and bonding durability (BD, MOR after 2h boiling of the board samples) are provided in comparison with the conventional phenolic resin and the standard requirements (CSA 0437). It is obvious that the resin performance was not negatively affected by the incorporation of bio-oil. These results will be verified in industrial scale tests planned.

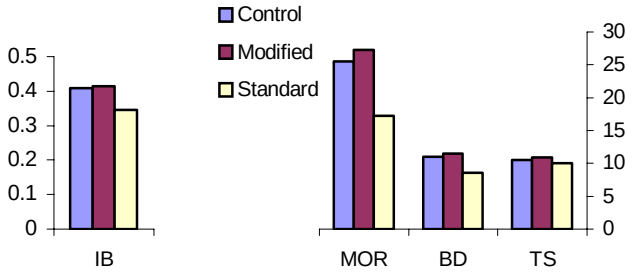

Figure 3: Tensile (IB) and bending (MOR) strength, 24h thickness swelling (TS) and bonding durability (BD) of pilot scale OSB produced with bio-oil modified PF resin.

CONCLUSIONS

The pyrolysis oil can be used in the manufacture of phenolic resins for various panel types with positive results. An up to 50% phenol substitution was realized already and further increase in the substitution level is envisaged. To provide significant savings for the resin manufacturer the phenol substitution level should be above 40% and the price of the pyrolysis oil should be maximum 50% of the phenol price. Its lower toxicity as compared to phenol and its conformity with the EU directive for sustainable development (it is produced from renewable resources) make it attractive for further investigation.

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