MDI-bonded hardwood composites: some indications of the impact of MDI on formaldehyde and VOC emissions.

INTRODUCTION

Formaldehyde and VOC emissions from wood and wood-based articles is an issue that increasingly arouses concerns, and regulatory controls and restrictions. It is commonly accepted that the main source of formaldehyde from wood composite panels produced with formaldehyde-based phenolic adhesive resins comes from the resin itself. For this reason producers are devoting resources to limiting and controlling resin-originated formaldehyde and VOC emissions. MDI-based resins do not easily decompose. The question is whether MDI resins impact positively, negatively or indifferently on wood originat ed formaldehyde and VOC compounds.

OBJECTIVE

The purpose of this project was twofold: to achieve a better understanding of the chemistry of interaction between isocyanates and wood as related to VOCs in general, and formaldehyde in particular; and to design isocyanate resins promoting interactions that prevent and hinder VOCs.

MATERIALS AND METHODS

Materials

Heartwood from 80 cm long / 30 to 40 cm diameter softwood (Pinus Sylvestris) trunks (ex-Poland) was ground down to flour. Polymeric MDI was supplied by Huntsman.

Formaldehyde and VOC emissions

Materials were heated by thermogravimetric analyzer (TGA) in two steps from room temperature to 230°C (at 20°C / min) in an air atmosphere. The eluted gasses were collected in a Tenax tube and a 2,4-dinitrophenyl hydrazine (DNPH) sorbent tube placed in series. Absorbed material in the Tenax tube was thermally desorbed and analyzed by gas chromatography mass spectrometry (GC-MS). Aldehydes (including formaldehyde) absorbed in the 2,4-DNPH tubes were analyzed by high performance liquid chromatography (HPLC).

RESULTS AND DISCUSSION

Emissions of wood origin formaldehyde and VOC compounds were normalized to the wood content of the composites. NB: All data should be interpreted in a comparative sense.

1. Formaldehyde emissions

Thermally treated wood exhibited similar formaldehyde (HCHO) emissions compared to neat wood. Overall, the addition of MDI did not aggravate but made the release of HCHO slightly decrease (with the exception of the composite made with 20 wt% MDI). The authors speculate that the emission data of the latter composite represents a non-resinated fraction of the wood sample. Indeed, when modest amounts of MDI were added, rapid absorption and/or penetration into the wood leads to difficulties in uniform resin distribution, yielding highly resinated and non-resinated regions.

In general, emission tests indicate that HCHO is scavenged or blocked by the MDI binding agent to a small extent.

2. VOC emissions

2.1. Quantitative analysis

A differentiation was made between wood and resin origin VOCs. Their total amount is plotted below as a function of MDI loading.

VOCs, which are predominantly derived from wood, are significantly reduced as the amount of MDI is increased. Incomplete curing was observed when MDI loadings exceeded 20 wt%.

2.2. Qualitative analysis

All VOCs were characterized and could be grouped in four major classes (both in their unaltered and degraded / rearranged forms).

A significant drop in emissions was observed for all classes upon curing with MDI, especially for lignin-polyphenols and terpene origin VOCs at low MDI loadings. The most abundant compounds are summarized below.

CONCLUSIONS

1. The amount of wood origin VOCs decreases with increased MDI loadings.

2. Four major classes of VOCs were determined (lignin, polysaccharides, lipids and terpenes) and/or degradation products, which were quantified and analyzed.

3. Non / semi crystalline cell wall components (lignin and hemicelluloses) have a higher affinity for MDI through the formation of primary and secondary bond interactions.

4. The penetration of MDI into the cell wall was observed by x-ray spectroscopy and confirmed by the decrease of lignin-polyphenols and terpene origin VOCs.

5. MDI does not aggravate wood origin HCHO emissions and may even slightly lower the wood background emissions.

6. Distribution and quality of resination are crucial parameters in controlling formaldehyde and VOC emissions of MDI based composites.

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