FIRE PERFORMANCE AND LEACH RESISTANCE OF PINE WOOD IMPREGNATED WITH GUANYL-UREA PHOSPHATE (GUP)/BORIC ACID (BA) AND MELAMINE-FORMALDEHYDE (MF) RESIN

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Background

Fire retardant treated (FRT) timber can be produced by impregnation under high pressure with aqueous guanyl-urea phosphate (GUP) and BA (Gao *et al.*, 2006). However, neither GUP nor BA is strongly attached to the wood polymers and normally leach out during weathering; thus, wood loses its fire retarding property (Mantanis, 2002). Wood modified with melamine-formaldehyde (MF) resin can provide an increased dimensional stability (Inoue *et al.*, 1993), thermal stability (Deka *et al.*, 2002) and to some extent improve fire performance (Xie *et al.*, 2016). Blending MF resin and the conventional fire retardant (FR) for decreasing leaching from the FRT timber has been poorly researched, up to date. The aim of this work was to evaluate the leachability of the FR by treating pine wood with MF resin/GUP/BA, and followed by an analysis of the fire behaviour of the treated material. The cured MF resin is thus expected to form a hydrophobic polymeric network and incorporate the FR within the wood cell wall.

Experimental

Scots pine (*Pinus Sylvestris* L.) sapwood specimens measuring 10x10x150 mm (TxRxL) were impregnated (30 min vacuum followed by 15 bar pressure for 1 h) with GUP/BA solution. The impregnated specimens (10 replicates) were dried in an oven at 103^{o}C for 2 days, followed by conditioning at 20^{o}C/65% RH for one week. Leaching tests were performed on 5 replicates, according to EN 84, replacing water 10 times during the 14-day leaching period. Fire tests were carried out on 5 replicates, using the limited oxygen index (LOI) method according to ISO 4589. Preparation of the FR solution was done by dissolving GUP/BA (weight ratio 7:3) in deionised water, before mixing it with the MF resin solution. The resin was provided by NTL Chemical Consulting (MF polymer: 50%; melamine content: <15%). Different amounts of MF resin in the GUP/BA solution were applied. For description of the treatments see Fig. 1 a.

Results and Discussion

Limiting oxygen index (LOI) is the minimum concentration of oxygen (expressed as a percentage) that will support combustion of a polymer, e.g. wood. It is typically measured by

passing a mixture of oxygen and nitrogen over burning wood specimen until a critical level is reached which corresponds to LOI value (White, 1979). A higher LOI value indicates enhanced fire retarding performance. The flammability of FR treated wood was obtained as a single numerical value. To simulate the FR performance after weathering, LOI values before and after leaching in water, according to standard EN 84, was determined. Wood treated with 10 wt% of FR only had similar LOI after leaching as the untreated wood, since the FR itself was not fixed within the wood structure (Fig. 1). Lower weight percentage gain (WPG) loss and higher fire retardant performance of treated wood (after EN 84) was attained after introduction of 10 to 30 wt% of MF resin into the GUP/BA solution. The possibility of incorporating this FR is supported by the fact that the MF/GUP/BA treated wood specimens exhibited superior FR performance, even after water leaching (EN 84), as compared with results with the samples treated only with MF resin (0-30MF). In addition, the presence of the MF resin in the FR system showed no significant influence on the FR performance of the wood samples; even when 10 to 30 wt% of resin was added in the FR solutions (Fig. 1c). To investigate which chemicals were leached out from the wood impregnated with the MF/GUP/BA, leached water fraction was evaporated, and the solid residue was analysed using ATR-FTIR. The material from 4-days leaching fraction of 10-30MF was mainly composed of BA (Fig. 1d). Similar spectra were observed in other dried fractions. Consequently, it was concluded that GUP (but not BA) had been efficiently trapped in the cell wall, by the cured MF resin network.

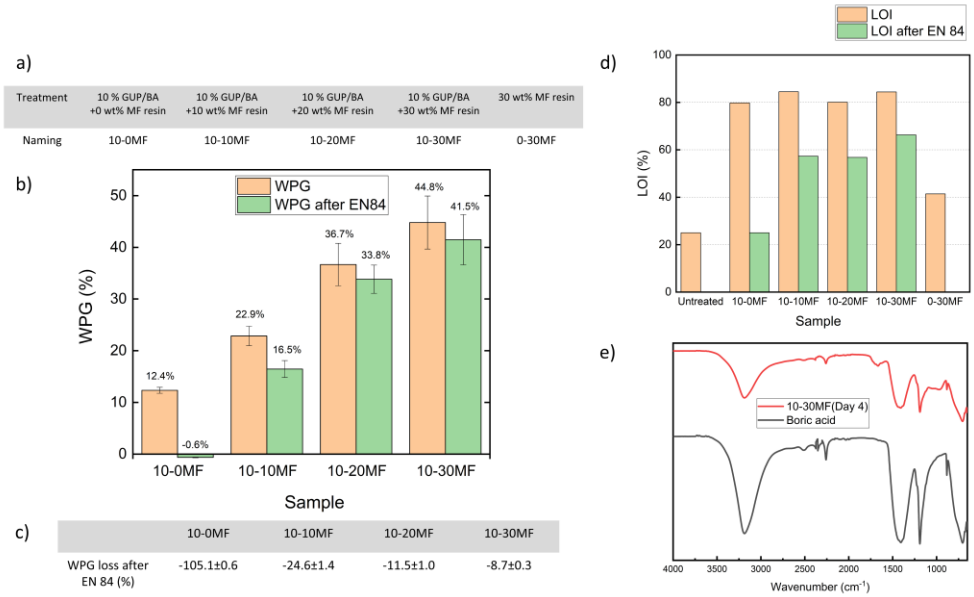

Figure 1. Test results: a) The naming of the treatments, b) Weight percentage gain (WPG), c) WPG loss, d) limiting oxygen index (LOI) before and after leaching (EN 84) and, e) FTIR spectrum of leached water of the 10-30MF treated wood (after 4 days), as compared to pure BA.

Conclusions

The resistance to leaching of Scots pine wood treated with GUP/BA can be improved, while maintaining a high fire retarding performance, by the incorporation of MF resin. A reduction of the WPG loss, following water leaching according to EN 84, up to 90 wt% was achieved, in presence of 30 wt% MF in the solution, probably by enclosing the FR in the cured polymeric MF network. Overall, we suggest that such treatment could be a good methodology for producing exterior-use FRT pine wood.

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