WCCE11 - 11th WORLD CONGRESS OF CHEMICAL ENGINEERING
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Buenos Aires - Argentina - June 4-8, 2023
BUENOS AIRES 2023
JUNE 4 - 8
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# Lignin-Phenol-Formaldehyde Resol for High Pressure Decorative Laminates: Evaluation of Lignin Levels on Final Properties

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High pressure decorative laminates (HPDL) are composite materials made of core layers of Kraft papers impregnated with a resol type phenol-formaldehyde resin (PF) and a surface décor paper saturated with melamine-formaldehyde resin (MF). The set of saturated papers is cured by compression moulding at high pressure and high temperature.
In the aim of replacing non-renewable petroleum-based phenol (P), among biomass components, lignin (L) seems to be an attractive substitute owing to its structural similarity to PF resins. In this sense, hardwood *Eucalyptus* spp species are the main source of Kraft L in South America. However, the poor solubility and reactivity limit its exploitation in resol resins making necessary a previous chemical modification such as hydroxymethylation in alkaline conditions [1].
In this work, lignin-phenol-formaldehyde (LPF) resols were synthetised using different levels of P replacement (0 to 80 wt%) with a eucalyptus Kraft L chemically modified by hydroxymethylation. Resols were employed for Kraft-paper impregnation and HPDLs production. The impact of L levels on final properties was studied.
The synthesis of LPF resins was carried out in two stages. First, L was hydroxymethylated by reaction with formaline at pH 11, heated to 70 °C and held for 60 min. Then, P was added to the reaction vessel and pH was adjusted between 8.5-9.0. The condensation was carried out at reflux temperature until turbidity point was reached. The resins were cooled in an ice bath and splitting of phases was observed for the resin with 0 wt% P replacement. Water phase was discarded and the solid content of the resols was fixed to 45 wt% with ethanol.
Prepegs were prepared by the impregnation of Kraft-type paper with the resols and manually compression between 2 glass rods. The wet impregnated papers were dried at 105 °C for 10 min in an oven. Three phenolic prepegs and a white surface décor paper were stacked and pressed at 70 kg/cm$^2$ during 10 min at 150 °C. No changes in surface colour due to resin diffusion were observed.
Hydroxymethylated Ls and resols were characterized by chromatographic, spectroscopic and free formaldehyde (F) measurements. HPDLs performance was evaluated by thermo-mechanical techniques (DMTA) and the boiling water immersion resistance test.
Free F increased with L levels in resols being less than 2% for P replacements up to 60 wt%. The resistance to immersion in boiling water test exhibited higher increase in weight and thickness with higher L levels. Delamination and blister defects were observed for HPDLs with 70 and 80 wt% P replacement. Weight increments for HPDL with 0% and 60% P substitution were 5.66 (±0.37)% and 7.60 (±0.56)% meanwhile thickness increments were 8.97 (±1.60)% and 10.22 (±0.45)%, respectively. Gaining on weight and thickness comply the Australian/New Zealand Standard AS/NZS 2924.1:1998 specifications, thus demonstrating hardwood L as a high potential substitute for P in HPDLs manufacturing.

***References***

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