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Influence of lignin on thermo-mechanical behavior of modified novolac resins

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Abstract – Phenolic resins are considered an attractive area for commercial lignin applications because of its chemical reactivity. Lignin is available, less toxic and less expensive raw material than phenol. In this study, two unmodified novolac resins and three lignin modified resins were analyzed. The influence of type of lignin on the curing process and thermo-mechanical behavior of modified novolac-resins were studied. According with FTIR analysis of curing processes, reductions on the final conversion were registered of modified resins respect to unmodified resins. Overall, this same trend was present in the thermal and mechanical behavior between these two groups of resins.

Phenol – formaldehyde (PF) resins have been studied for decades to find modifiers, additives, and even economically and environmentally applicable substitutive raw materials for phenol. Raw materials such as lignin offer interesting possibilities as substitutes for phenol [1]. After cellulose, lignin is the second abundant organic polymer in the plant world. Lignin content depends on plant species (roughly 15–30%) [2]. Lignin can be defined as an amorphous, polyphenolic material arising from the copolymerization of three phenylpropanoid monomers, namely, coniferyl, sinapyl, and *p*-coumaryl alcohol. The structures are complex and heterogeneous. Their heterogeneity depends on the species of plant or the pulping processes [3].

In this work, phenolic resins were modified, keeping the molar ratio phenol/formaldehyde constant and making a mass substitution of the phenol. Two unmodified novolac resin (PF and PFB) and three types of lignin were used: alkali lignin isolated at pH4 (PFLpH4), alkali lignin isolated at pH2 (PFLpH2), and ammonium lignosulfonate (PFLVIII). Samples were cured at two different concentrations of hexamethylentetraamine (HTMA), (8.5 y 10 wt%). Fourier transform infrared spectroscopy (FT-IR) analysis were recorded for solid samples in KBr tablets to determine the degree of conversion during curing. Thermogravimetric analysis (TGA) was used to follow the thermal degradation. And dynamic mechanical analysis was used to investigate the curing properties of these materials.

According with FTIR analysis of curing processes, reductions on the final conversion were registered on modified resins respect to unmodified resins. In figures 1 and 2 are showed TG y DTG curves of two of the most relevant cases, where modified resins exhibit a lower thermal stability with respect to the unmodified resin. Finally, this same trend was present in the dynamic mechanical analysis between these two groups of resins.

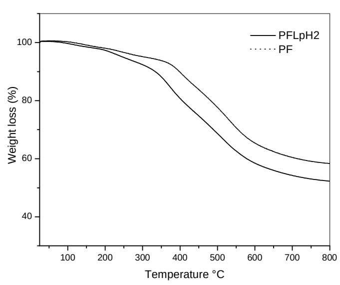

Figure 1. TG curves of PFLpH2 and PF

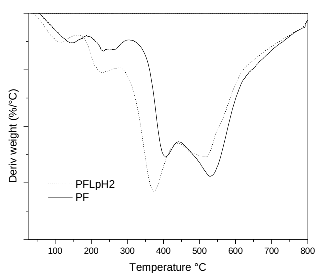

Figure 2. DTG curves of PFLpH2 and PF

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