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Assessment of Cationic Lignin as a Chloride Ion Scavenging Additive in Cement.

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Chloride-induced corrosion of steel reinforcement is a major factor adversely influencing the durability of reinforced concrete structures. The main objective of this preliminary study was to explore the use of waste residues generated during the bioethanol processing of sugar cane bagasse as a source of high value products, primarily lignin that can be functionalized to scavenge chloride ions in cement and therefore increase the service life of concrete structures. Lignin is next to cellulose the most abundant biopolymer on earth. Lignin coats cellulose micro-fibrils and other components in the cell wall preventing collapse and providing support to the cell walls in biomass. Being a renewable energy source, biomass is a common feedstock for biopolymers, paper and biofuel production. Being a significant portion of biomass (up to 25%), lignin left over from the production of biofuel, is often burned to generate heat for the distillation of alcoholic fuels from the fermentation liquor. With ever-increasing demand of sustainable energy sources, we are exploring the recovery and modification of lignin to reduce costs of biofuel production using it as concrete admixture to scavenge chloride ions. Thus, the hypothesis of this preliminary study is that functionalized lignin (cationic lignin) can "trap" chloride ions in cement mixtures and serve as an additive to hinder the diffusion of chloride ions in concrete structures.

Pre-treated lignin was provided by the University of Florida Ethanol Pilot Plant and The Stan Mayfield Biorefinery. Lignin is isolated from biomass using a two-step hydrolysis in phosphoric acid followed by enzymatic hydrolysis that removes polysaccharides. This process solubilizes approximately 80-90% of the hemicellulose, leaving the cellulose and lignin largely intact as polymers. The Mannich reaction (Fig. 1) was used to increase the nitrogen content in lignin, and thereby increase its electron-donating capacity. Tests were conducted with mixtures of cationic lignin and NaCl, as well as with mixtures including cement. The results indicate (Figs. 2 and 3) that cationic lignin is effective in retaining Chloride ions and reducing their concentration in solution as compared to the un-reacted Lignin. Accelerated diffusion experiments in cement and concrete samples are being planned to assess the slowdown of the diffusion of Chloride ions in solid samples. The results of the analysis using a technique for large scale qualitative and quantitative elemental maps in concrete samples using EDS and WDS will be presented. Diffusion coefficients calculated from this data will be presented and compared with control samples without cationic lignin.

References:

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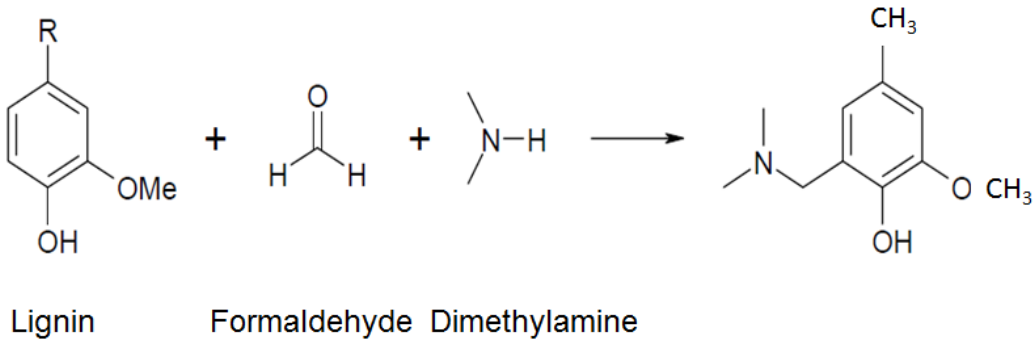

Fig.1 The Mannich reaction.

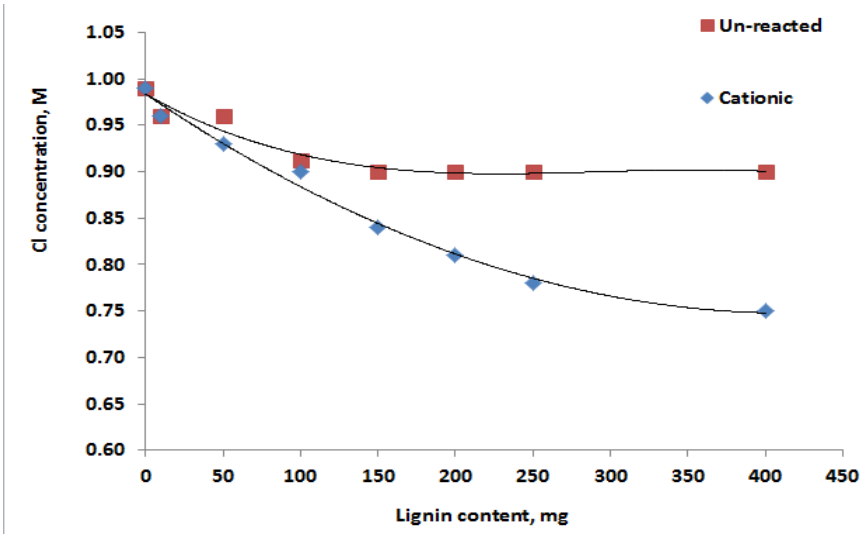

Fig. 2 Effect of lignin on Cl concentration (NaCl no cement).

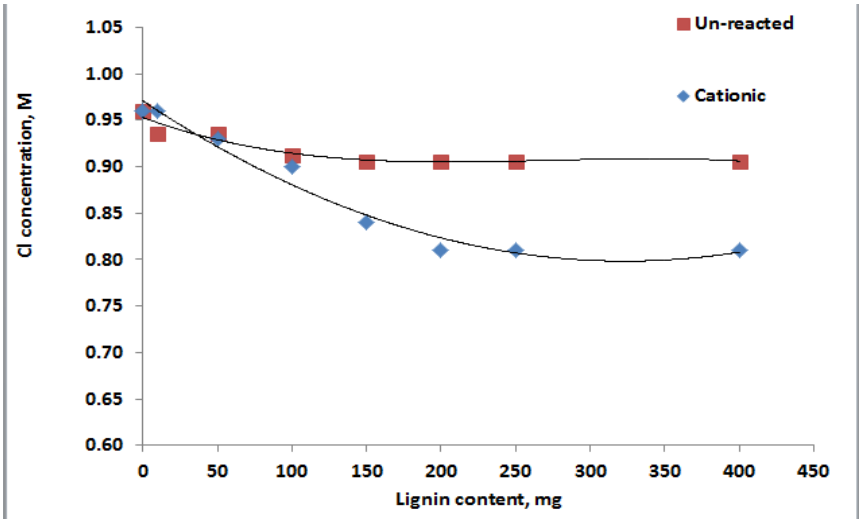

Fig. 3 Effect of lignin on Cl concentration (with cement).

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