Synthesis of Lignin-Based Thermoplastic Copolyester Using Kraft Lignin as a Macromonomer

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Abstract  
Lignin-based thermoplastic copolyester was synthesized for eco-friendly polymers and composite applications using lignin as a macromonomer to form a high molecular weight polymer. Kraft lignin was polymerized with sebacoyl chloride in the presence of triethylamine in N,N-dimethylacetamide (DMAc), and the molecular weight of the synthesized polymer was controlled by the polymerization temperatures and \([\text{COCl}] / [\text{OH}]\) ratios providing up to 39 000 corresponding to 4–5 repeating units of lignin macromonomers. The glass transition temperature of the synthesized polymer was difficult to measure due to the random distribution of functional groups and irregular configurational or conformational arrangement of natural lignin. Therefore, the complex electric modulus (CEM) technique was used to determine the glass transition of the synthesized polymer to give around 70°C measured by the peak of the imaginary part of CEM. The synthesized lignin-copolyester exhibited good thermal stability up to 200°C in TGA analysis and, thus, it was possible to shape the synthesized polymer using the solvent casting or hot-melt processing techniques at 120°C–140°C without generating odor, fume or irritation. Although the molecular weight should further be increased in the future, the developed methodology may help to exploit new applications for eco-friendly sustainable materials in various fields.  
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Keywords  
Copolyester, lignin, biodegradable polymer, thermoplastics, eco-friendly materials

1. Introduction  
Lignin is the second most abundant natural renewable polymer after cellulose [1]. The chemical structure of lignin is a three-dimensional phenylpropanoid polymer where phenylpropane units are joined mainly by ether links. The concentration of...