SOFTWOOD KRAFT LIGNIN CHARACTERIZATION AND COMPOSITION WITH THERMOPLASTICS

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Abstract

Lignin is one of the key structural polymers found within the cell walls of wood, alongside cellulose and hemicellulose. This makes it one of the most abundant natural polymers on Earth, and due to its monomers containing phenol groups it is also a major source of aromatic carbon. Traditionally used as an inexpensive secondary fuel in Kraft pulping plants, in the form of black liquor, various attempts have been made recently to valorise it, for instance as a precursor to carbon fibre.

Because it is inexpensive, and a renewable resource, especially in comparison to traditional fossil fuel derivative precursors (pitch and PAN), lignin by itself isn’t generally processable into filament form without the aid of a plasticizer or other means. In addition, the properties obtained with lignin-based carbon fibre are generally much lower than their petroleum-based precursors.

In this study, a purified Kraft lignin was obtained and dried before being characterized and processed. The lignin thermal characterization was performed by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) in inert and oxidative atmospheres. Fourier Transform Infrared Spectroscopy (FTIR) and elemental analysis represent the reported chemical characterization.

DSC results provide the glass transition temperature and onset of thermal degradation, which were verified experimentally to be the temperature limits for the processing temperature for this lignin, and limiting the plasticizing thermoplastic selection. TGA results showed the potential of this lignin as carbon fibre precursor with a residual mass over 40 % wt. relative to the initial mass, under inert atmosphere, at 800 ºC.

FTIR and elemental analysis showed expected lignin chemical structure and composition. Comparing to the theoretical estimate, it was concluded that the studied lignin was of softwood origin.

Blending and extrusion was carried out on batches of 10 g in a micro-compounder/extruder in various-weight ratios of lignin: thermoplastic of 50:50, 75:25, 85:15 and 95:5. The polymers tested were poly(lactic acid) (PLA) and acrylonitrile-butadiene-styrene (ABS).

Both thermoplastic polymers mixed successfully with lignin. However only PLA formed fine uniform continuous filaments, and ABS required reprocessing of the first obtained filament to acquire equivalent extrusion behaviour to PLA. Reducing the weight ratio of thermoplastic generally resulted in a rougher filament surface and increased overall brittleness.

Samples of the obtained filaments of 50:50 of both materials were characterized by DSC to verify the impact of the introduction of lignin upon the composite thermal behaviour, to differentiate them and select only one of the blends for the thermosetting step. Finally, they were tested by TGA to evaluate their potential as carbon fibre precursors.

Keywords: Carbon fibre, Extrusion, Lignin, Polymer blends, Thermoplastic polymers.