Bio-based Composites from Soybean Oil Thermosets and Natural Fibers

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ABSTRACT

In order to reduce over-dependency on fossil fuels and to create an environment that is free of non-degradable plastics, and most importantly to reduce greenhouse gas emission, bio-based products are being developed from renewable resources through intense research to substitute conventional petrochemical-based plastics with renewable alternatives and to replace synthetic fibers with natural fibers.

Many authors have done quite a lot of work on synthesizing polymers from renewable origin. Polylactic acid (PLA) has been developed and characterized, and it was found that it has enormous potential and can serve as an alternative to conventional thermoplastics in many applications. Modification of the plant oil triglycerides has been discussed by many authors, and research is still going on in this area. The challenge is how to make these renewable polymers more competitive in the market, and if possible to make them 100% bio-based. There is also a major disadvantage to using a bio-based polymer from plant oils because of the high viscosity, which makes impregnation of fibers difficult. Although natural fibers are hydrophilic in nature, the problem of compatibility with the hydrophobic matrix must be solved; however, the viscosity of the bio-based resin from plant oils will complicate the situation even more. This is why many authors have reported blending of the renewable thermoset resin with styrene.

In the process of solving one problem, i.e reducing the viscosity of the renewable thermoset resin by blending with reactive diluents such as styrene, another problem which we intended to solve at the initial stage is invariably being created by using a volatile organic solvent like styrene. The solution to this cycle of problems is to synthesize a thermoset resin from plant oils which will have lower viscosity, and at the same time have higher levels of functionality.

This will increase the crosslinking density, and they can be cured at room temperature or relatively low temperature.

In view of the above considerations, the work included in this thesis has provided a reasonable solution to the compounded problems highlighted above. Three types of bio-based thermoset resins were synthesized and characterized using NMR, DSC, TGA, and FT-IR, and their processability was studied. The three resins were subsequently reinforced with natural fibers (woven and non-woven), glass fibers, and Lyocell fiber and the resulting natural fiber composites were characterized by mechanical, dynamic mechanical, impact, and SEM analyses. These composites can be used extensively in the automotive industry, particularly for the interior components, and also in the construction and furniture industries. Methacrylated soybean oil (MSO), methacrylic anhydride-modified soybean oil (MMSO), and acetic anhydride-modified soybean oil (AMSO) were found to be suitable for manufacture of composites because of their lower viscosity. The MMSO and MSO resins were found to be promising materials because composites manufactured by using them as a matrix showed very good mechanical properties. The MMSO resin can completely wet a fiber without the addition of styrene. It has the highest number of methacrylates per triglyceride and high crosslink density.

Key words: Bio-based thermoset resin, natural fiber, lyocell fiber, hybrid composite, renewable resources, mechanical analysis, compression molding