Tailoring Bio-based Polyester UV-curable Resins with Tunable Mechanical Properties suitable for SLA 3D Printing Applications

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Abstract:

Stereolithography (SLA) 3D printing enables the fabrication of high-resolution and complex structures, however, the mechanical properties of SLA-printed objects are often limited by the resins used. This study focuses on developing and characterizing bio-based polyester UV-curable resins with tunable mechanical properties optimized for SLA 3D printing. Bio-based polyester resins were synthesized by direct esterification polycondensation reaction of diacids (Itaconic and succinic acids) with diols (1,2-propanediol, 1,4-butanediol, and 1,8-octanediol). The bio-renewable nature of the resin components provides several advantages over traditional petroleum-derived resins. The diacid and diol monomers come from renewable feedstocks like corn, soybean and vegetable oils rather than finite fossil fuel reserves. Furthermore, bio-renewable materials lower dependence on petrochemicals and increase the sustainability of 3D printing. Additionally, plant-derived monomers provide a greater diversity of chemical structures to modify resin properties compared to petroleum-derived chemicals. The effects of diacid structure and diol chain length on resin properties were systematically investigated. Physicochemical characteristics were investigated by NMR and FTIR and suggested successful synthesis of the desired bio-based polyesters. By varying the diacid and diol building blocks, the molecular weight, crosslink density, and mechanical performance were tailored. The resins were characterized by gel permeation chromatography, rheology, and tensile testing. Rheological studies confirmed all resin formulations displayed shear-thinning behavior ideal for SLA printing. Mechanical testing revealed that tensile strength and elongation at break could be modulated from 1.60 – 0.18 GPa and 1.9 – 7.3% respectively by varying diacid and diol components. Printability was assessed by printing a print resolution test structure on an SLA 3D printer equipped with a 405 nm UV source. This ability to tailor the properties of bio-based polyester resins by molecular design provides an avenue for fabricating high-performance SLA-printed objects targeted for specific applications ranging from prototypes to end-use products.