Tough 3D printed biopolymeric cellular beams

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ABSTRACT

3D printing cellular structures with biobased polymers that possess high mechanical efficiency offer an attractive way for fabricating sustainable engineering materials. Herrin, two biobased polymers, polylactic acid (PLA) and polyamide-11 (PA-11) are melt-blended with and extruded as a co-continuous PLA/PA-11 filament for 3D printing. Fused deposition modelling (FDM) is used to manufacture samples which are then tested under quasi-static and impact loads, and the results demonstrate high impact toughness. Furthermore, a 200% increase in the impact toughness has been obtained by optimizing the print parameters. This indicates that optimization of 3D printing parameters is the key to additively manufacturing cost-efficient and eco-friendly parts that deliver mechanical/structural properties comparable to those made by injection molding. In addition, lightweight auxetic cellular beams are designed to reach a toughness-to-weight ratio much higher than the solid, hexagonal cellular, and rectangular cellular beam counterparts. An Ashby chart has been plotted, demonstrating impact toughness versus densities for comparing the performance of alternative polymers manufactured by FDM and injection molding. Finally, a 3D printed lightweight and tough biobased material is presented with significant potential for industrial applications.