Low temperature tensile strength of Polylactic acid filled with ceramic nanopowders and glass bubbles

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Polylactic acid (PLA) is a starch-based biopolymer considered the most promising candidate for replacing many fossil-based polymers for structural and functional applications. Because of its biodegradability it is already being used widely in many in-vivo medical applications as well as certain single-use packaging applications.

PLA displays very impressive strength and rigidity with satisfactory toughness at room temperature but its softening temperature is rather low, at about 55-65^{o}C, restricting its use at higher temperatures. In this work we present a systematic study of the mechanical properties of PLA at low temperatures, as produced and with the additionof 1-3wt% fillers, either nano-structured ceramic powders or glass bubbles. Specimens were produced by filament extrusion of PLA-filler mixtures and subsequent 3D printing of tensile test coupons. The tensile strength and elongation at fracture were determined in tension at temperatures down to about -20^{o}C and it was found that the tensile strength increases as the temperature decreases, for both the unfilled and filled materials, while the elongation at fracture decreases, without actually displaying clear brittle behavior.

The thermal conductivity and thermal expansion of the materials were also determined and it was found that they remained approximately constant irrespective of the type or amount of filler used. SEM observations showed that the filler materials were well-bonded to the matrix.