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Study of Oxidative-Crosslink Reaction in Polyphenyl Sulfide (PPS) / Carbon fiber and its Influence in Additive Manufacturing

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ABSTRACT

Ever since its development in 1980s, Fused Filament Fabrication (FFF) has been an attractive additive manufacturing technology due to its flexibility to create intricate shapes at lower costs and faster manufacturing process than subtractive techniques. These advantages make FFF suitable for printing molds for use in traditional composites manufacturing processes. Combining FFF with high-temperature thermoplastic composites enables producing molds that not only sustain autoclave conditions but also have low coefficient of thermal expansion (CTE). A semi-crystalline polymer, Poly-phenylene Sulfide (PPS), with 50% by weight of carbon fiber is used as feedstock material for FFF. Nonetheless, PPS is sensitive to undergo oxidative reactions at the processing temperature and thus giving rise to changes in the polymer behavior. Hence, the effects of oxidation on crystallization kinetics and polymer architecture are investigated in the current work. Differential Scanning Calorimetry (DSC) is used first to characterize the changes in crystallization kinetics due to polymer oxidation. Subsequently, Fourier Transform Infrared-Spectroscopy (FTIR) is used to study the changes in the polymer architecture due to the oxidative reaction. From the DSC analysis, the crystallization rate was found to decrease with the oxidation, and the oxidation decreased the max crystallinity developed. On the other hand, the FTIR results revealed the formation of a carbonyl group on oxidized polymer. These results demonstrate that the changes in the polymer structure due to oxidation hinder the growth of crystalline regions and thus reducing the final crystallinity content.

KEYWORDS

Additive manufacturing, 3-D printing, Fused Filament Fabrication (FFF), Polyphenylene Sulfide (PPS), Carbon fiber, Crystallization kinetics, Oxidative cross-linking, DSC