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Mathematical Models for Predicting the Mechanical Properties of Poly(Lactic Acid) for Load-Bearing Applications

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Abstract

In order to widen the areas of application of poly (lactic acid) (PLA), there has been a multiplicity of experiments. This study attempts to develop mathematical models for predicting the mechanical properties of PLA to reduce the number of experimental runs and material wastage. The melt-cast method produced unreinforced PLA samples with different slenderness ratios (λ) in triplicate using. The samples were subjected to a compression test to obtain the mechanical properties captured at three main points on the stress-strain curve: yield, ultimate stress, and fracture. Regression models were developed from the data obtained at the three points, and their validity was examined by testing them against the previous relevant experimental studies from various authors. The coefficient of determination (R2) and coefficient of correlation (ρ) was also examined for each model to establish their degree of correctness further. Analyses show that the developed models give reasonable approximations of some of the properties examined.

The mass (M) and the modulus of elasticity (E) were the most accurately predictable properties with [R2, ρ] of [99.97%, 0.9998] and [91.55%, 0.9568], respectively. Results also show that apart from the melt-cast method, the compressive modulus of PLA (both circular and rectangular cross-sections test samples) produced via injection molding and fused filament fabrication can be predicted with near accuracy using the model developed in this study. This study gives researchers the tools needed to avoid material wastage by having close-to-real values of the mechanical properties of PLA through prediction before carrying out any experiment.

References

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