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Revalorisation of tamarind seed waste for improved PLA wear and hydrophilic behaviour in 3D printing applications

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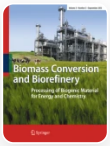

Biomass Conversion and Biorefinery

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Abstract

The study aimed to enhance the wear resistance of fused deposition modelling (FDM)-printed polylactic acid (PLA) by incorporating tamarind kernel filler. Tamarindus Indica (TI)-reinforced PLA composite filaments were fabricated via single screw extrusion and printed using an open-source FDM printer. Dry wear tests were conducted using a pin-on disc tribometer. Results showed improved tribological characteristics with the addition of TI filler, addressing the subpar surface characteristics and susceptibility to wear in FDM-printed parts. The filler addition decreased density and increased the void percentage. Shore D hardness measurements indicated that the addition of fillers enhanced the hardness of the composite. Tribo-testing revealed that the maximum friction force was observed at 2 wt% TI filler concentration. Neat PLA exhibited an increasing coefficient of friction (COF) with load, while TI/PLA showed a declining COF due to thermal stress and filler detachment. The specific wear rate (SWR) increased with increasing applied load and decreased with increasing sliding velocity. The critical filler concentration of 3 wt% in TI/PLA composites exhibited the lowest SWR due to lubrication effects and debris accumulation at the interface. SEM analysis revealed that 3% TI/PLA composites had optimised wear resistance with uniform filler dispersion, improved adhesion, and voids that trapped abrasive particles. The incorporation of TI fillers into the PLA matrix enhanced the wetting behaviour of the composites, which is evident from the reduction in contact angle.