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DEVELOPMENT OF BIODEGRADABLE -POLYLACTIC ACID - DATE PALM WASTE COMPOSITE AS THERMAL INSULATION MATERIAL

by

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Abstract

This study aims to develop a green polymer composite from local natural waste, such as date pit powder (DPP) and date palm wood powder (DPWP), as an insulating material. The recycle and reuse of natural waste as filler for green insulation materials has many significant benefits for the environment of the UAE. Date palm waste was mixed with a poly lactic acid (PLA) polymer with various proportions in a melt extruder. The mixtures produced were then shaped differently after testing in a thermal compression machine. These composites were tested to evaluate their physical (water absorption, chemical resistance and bulk density), thermal (thermal conductivity, thermal diffusivity, and degree of crystallization) and mechanical properties. As thermal insulation material should exhibit low thermal conductivity and acceptable levels of mechanical strength, the samples of pure PLA were subjected to different annealing conditions after the thermal compression stage. The PLA specimens were heat treated at 95℃ at different time intervals before cooling. The 24-PLA samples given longer annealing times displayed higher strength, greater thermal conductivity and improved density. Based on these results, processing parameters for composite production (melting temperature, mixing temperature and annealing conditions) were selected in order to produce composites with optimum thermal conductivity and mechanical strength. The results showed that date palm wood powder (DPWP) and date pit powder (DPP) were suitable fillers when combined with PLA to produce a stable green thermal insulation material. The use of date palm wood powder (DPWP) in different ratios, ranging from 0 to 50 wt. %, produced composites with a thermal conductivity value between 0.0692 and 0.0757 $W/(m\,.K)$, while the minimum thermal conductivity was reported at 30 $wt.\%$ DPWP content. On the other hand, the composites containing 0 - 40 $wt.\%$ DPP had a thermal conductivity in the range of 0.0712 to 0.0794 $W/(m\,.K)$. The lowest thermal conductivity was found in composites with a DPP content of 40 $wt.\%$. In addition, the thermal diffusivity of both types of composite decreased as filler content increased, reaching a minimum value of 0.043 and 0.036 mm^2/s for the PLA-DPWP and PLA-DPP composites, respectively.The PLA-DPP composites showed higher water retention than the PLA-DPWP composites. This also increased as filler content increased. At 50 wt. % DPWP, water retention was less than 1.5%, while in the case of 40 wt.% DPP composites, water retention reached approximately 6%. For both types of composite, adding fillers to the PLA matrix initially reduced compression strength until it reached a constant value (~ 65 MPa) at 30% filler content. Replacing 50 wt.% of pure PLA with DPWP decreased the compression strength by 32%, while it increased the compression modulus by 11%. On the other hand, 40 wt.% DPP filler reduced compression strength and modulus by 33% and 17.5%, respectively. Furthermore, scanning electron microscopy (SEM) was used to investigate the microstructure of the composites and to explain their thermal and mechanical behavior. Ultimately, although addition of both types of waste to the PLA matrix reduced mechanical strength, the composites displayed good mechanical properties when compared with many commercial thermal insulators and construction materials currently available. Moreover, replacing part of the concrete used in a typical building wall with PLA-DPWP or PLA-DPP composites increased the R-value by 220.2 % and 211.8 %, respectively. Therefore, recycling of cheap natural waste as filler materials for green thermal insulators is a potentially significant benefit to both the economy and environment.

Keywords: Green thermal insulators, composite, poly lactic acid, natural waste, date wood powder, date pit powder.