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DEVELOPMENT OF HEAT INSULATION COMPOSITE MATERIALS BASED ON BIO-POLYESTERS AND NATURAL FILLER

by

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Abstract

The increasing waste - bio or synthetic - is a critical issue, and managing this waste is a huge challenge for industry and academia. Use of biodegradable materials is sought as an eventual factor in decreasing the current level of waste generation. Therefore, one of the main research areas nowadays is to develop bio-composite materials over fuel-based materials where the bio-composites or waste-based composites serve several advantages both environmentally and economically, including the biodegradability feature of the bio fillers, and the affordability due to its abundant presence in nature. Biowaste, specifically from agricultural sources, can be used as fillers in biopolymer matrices to form true bio-composite materials for various applications. The aim of this study is to investigate the potential use of bio-composite materials in construction as heat insulators. The polymer composites in this study consisted of biodegradable polyester which is [Polylactic Acid (PLA) matrix] and a natural filler [date palm wood fibers]. Biocomposites with filler percentages ranging from 10 to 40 wt.% were prepared and characterized for their physical and mechanical properties. The composites were characterized for tensile strength, water retention, fire retardation and microstructure using Scanning Electron Microscope (SEM), and thermal properties were evaluated by thermal conductivity measurement, Thermogravimetric Analysis (TGA), and Differential Scanning Calorimetry. In addition, in order to increase filler/polymer compatibility, alkaline treatment as surface modification of the filler, silane treatment as coupling agent, and chemical additives were also used. Moreover, a fire retardant [Ammonium Dihydrogen Phosphate (ADP)] was added to the composites to reduce flammability of the composites.

Promising results were achieved throughout this experimental research. The silane treatment significantly enhanced the mechanical properties by increasing the tensile strength from 14 MPa for untreated fibers to 30 MPa for silane-ethanol treated composites. The silane-ethanol treatment also reduced the water retention for the 40 wt.% sample from 1.963% to 1.148%. The crystallinity for the silane-acetone samples were the highest among all the systems, reaching up to 58.8% for the 40 wt.% filler sample. The alkaline treatment significantly increased the water retention and the thermal conductivity due to the removal of impurities, leading to higher cellulose ratio. Moreover, the Alkaline treatment heavily affected the thermal stability, leading to faster degradation of the samples when compared to neat PLA, silane treated and untreated composites. The introduction of ADP fire retardant achieved inflammable characterization of ULV-0 according to UL 94 criteria, and dropped the thermal conductivity to a value of 0.043 $\frac{W}{m.K}$, which is lower than the thermal conductivity of commercial heat insulation of such as XPS and EPS of 0.050 $\frac{W}{m.K}$.

Keywords: Bio-composites, Polylactic acid, Date wood fibers, Heat insulation, Silane treatment, Alkaline treatment, Thermal conductivity, Tensile strength.