PREPARATION AND CHARACTERIZATION OF BIODEGRADABLE COMPOSITES BASED ON POLYLACTIC ACID REINFORCED WITH RENEWABLE FIBERS AND COPOLYMER

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A Thesis Submitted in Partial Fulfillment for the Award of the Degree of Master of Science in Advanced Manufacturing and Automation Engineering in the School of Engineering
Dedan Kimathi University of Technology

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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ABSTRACT

Composites have widely been used in the past due to its attractive characteristics in terms of high strength in relation to weight. However, they have been derived from petroleum products which are difficult to dispose. Environmental issues and awareness globally has attracted much research into the development of sustainable composites.

Polylactic Acid is sugar based biodegradable polymer and possesses attractive properties that makes it a suitable polymer material for sustainable composites production. However, there are other properties that limits its application and include: low thermal stability, reduced mechanical performance compared to polypropylene, polyethylene and polystyrene. This study therefore aims at preparation, characterization and comparison of PLA biodegradable composite from Kraft cellulose, wood fiber, Lyocell cellulose and Viscous cellulose with and without Desmodur as a copolymer.

In the study, properties of PLA were improved by compounding and hot pressing it with different natural commercial and readily available fibers of Kraft cellulose, wood fiber, viscose, Lyocell® and Cordenka® in mass proportions of 10%, 20% and 30% relative to the matrix PLA with 10% of an additional copolymer. Charpy impact strength, tensile strength, thermal properties and morphology were investigated and compared for all composites and their possible applications. It was found that Charpy impact strength reduced with increase in fiber content with highest impact of (63 kJ/m2) at 10% viscose fiber loading. A high tensile strength of 67 MPa was obtained from 30% Lyocell fiber in the composite which was 4 MPa and 10 MPa higher than that of Kraft cellulose at the 30% fiber loading and pure PLA respectively. Modulus of elasticity reached a maximum value of 6 GPa at 30 % loading of Kraft cellulose. Addition of copolymer showed reduced stiffness for all the composites due to impregnation of the active sites instead of bonding

hence did not improve the fiber-matrix interaction. Scanning electron micrographs of the fractured surface showed better fiber-matrix interface, fiber pullout and the active role played by fibers in absorbing energy thus enhancing the mechanical properties. Water absorption on the other hand showed prolonged water uptake. Thermal analysis for composite without copolymer revealed a stable crystal structure whereas those with copolymer showed different melting peaks indicative of the presence of different phases in the structure. The results obtained show that the properties of PLA can be enhanced by addition of natural fibers in cellulosic form such as Kraft cellulose, Lyocell and Viscose cellulose. The contribution of this research in practice it the cost reduction associated with blend of expensive PLA with commercial readily available cellulose fibers which reduces the cost of these composites and expected to open up an avenue in which these biodegradable composites can be utilized in this applications to replace the components made from non-biodegradable polymers. Scientifically, the application of copolymer-Desmodur, a blocked polyisocyanate stable at room temperature and dissociates to regenerate isocyanate functionality when heated to 160^0 C, easily reacting with terminal both hydroxyl and carboxyl group present in PLA and Cellulose fiber at melting temperature of PLA. This resulted in a new ductile material, with good interface between matrix and cellulose fibers.