BRIEFING NOTE

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SUSTAINABLE UTILIZATION AND CONVERSION OF POST-HARVEST AGRICULTURAL WASTE RESIDUES INTO VALUE ADDED MATERIALS

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KEY FINDINGS

The disposal of biomass waste in an economically and environmentally acceptable manner is a critical issue facing the modern industries. This is mainly due to increased difficulties in locating disposal works and complying with even more stringent environmental quality requirements imposed by waste management and disposal legislations. The waste streams generated by the agricultural biomass processing sectors are composed of valuable materials that can potentially be utilised as a raw material feedstock to produce high-value products. The specific aim of this project is to develop value added materials from agricultural waste residues (maize stalks and sugarcane bagasse) that are abundantly available in South Africa. This is to replace petroleum based non-biodegradable materials that pose serious environmental problems due to land fill. In this project, agricultural residues (maize stalks and sugarcane bagasse) were fractionated to obtain cellulose, lignin and hemicellulose fractions. The lignin and hemicellulose fractions was converted to biocomposite products.

INTRODUCTION

The current problems of depleting petroleum reserves, global warming and environmental pollution has stirred global efforts to finding a bio-based feedstock (as a replacement for petroleum-based reserves) from which bio-based chemicals and materials can be derived. Waste biomass comprises of agricultural (bagasse, corn stover, straws) residues (Figure 1) and are composed of valuable materials that can potentially be utilized as a raw material feedstock to produce high-value products.

Figure 1. Agricultural waste residues

Currently most of the wastes residues are traditionally land-filled or burned resulting in air pollution and environmental hazards. Agricultural waste residues comprises of cellulose, hemicellulose and lignin which can be converted to value-added bio-based products. This study provides solutions to waste disposal as well as finding an alternative to petroleum derived products by deriving novel bio-based products from agricultural waste residues.

Sugarcane bagasse is the fibrous residue after extraction of sugarcane juice from harvested sugarcane. Sugar mills produce 3 tonnes of wet bagasse for every 10 tons of crushed sugarcane. Bagasse is generally burnt for generation of power for the sugar mill but studies have indicated that more than 50% of this residue is available from sugar mills for conversion to value-added products. The South African maize industry is the largest in Africa employing nearly 169000 maize farmers and workers. The annual production of maize in South Africa is around 8 million tons, cultivated in nearly 3 million hectares of land. Maize waste residues comprise of cobs, leaves and stalks; currently small amounts of these residues are being used by farmers as feed for livestock and the rest of these are largely under-utilized. Reports suggest that for every 1 kg of dry corn grains processed, about 0.15 kg of cobs, 0.22 kg of leaves and 0.50 kg of stalks are produced as waste residues [1]. These agricultural waste residues are rich in cellulose, hemicellulose and lignin fractions and can be used as a resource for developing value-added bio-based products.

MAIN RESULTS

Lignin and xylan fractions were extracted from corn stover residues and bagasse by the process of alkaline extraction. The extracted xylan and lignin fractions were subjected to compositional analysis and FTIR studies.

Lignin based biocomposites

Lignin reinforced poly (lactic acid) composites (Figure 2) were produced by melt compounding and injection molding technique under optimized processing conditions. Mechanical studies revealed that upon incorporation of lignin, the Young's modulus of the samples exhibited an increase while tensile strength registered a decrease.

Figure 2. Lignin reinforced PLA composites

Figure 3. Xylan-alginate samples

Figure 4. Xylan-alginate samples containing clay nanofillers

Hemicellulose based biocomposites

Xylan-alginate films were successfully prepared using the solvent casting method (Figure 3). It was found that with an increase in the alginate content there was an increase in the tensile strength and Young's modulus of the films. The water vapour permeability (WVP) values of the samples registered a decrease with increase in alginate content. This was attributed to greater cohesion between alginate polymer chains leading to restricted flow of water molecules. In terms of optical properties, it was observed that at higher xylan contents, the films were more transparent and exhibited greater UV shielding.

Xylan-alginate films were developed from two types of clay fillers - bentonite and halloysite using the solvent casting method (Figure 4). The properties of the films were investigated for food applications. Incorporation of bentonite resulted in enhanced mechanical, water vapour permeability and optical properties when compared to the neat xylan-alginate films.

Cellulose nanofibres (NFC) was successfully extracted from corn stover waste residues using alkal treatment followed by mechanical grinding in a supermass colloider. Figure 5 presents the transmission electron microscopic (TEM) image of NFC that was produced from corn stover residues. It can be seen here that there are individual fibres of cellulose that are interwoven with each other. The average diameter for theses fibres was determined to be 35.48 ± 12.60 nm. Xylan-alginate films containing NFC were developed using the solvent casting method. It was found that the tensile strength and Young's modulus of the films were significantly improved by the addition of NFC to the films, due the interwoven networks of NFC in the polymer matrix.

The produced xylan-alginate films show potential to be used for edible food packaging applications.

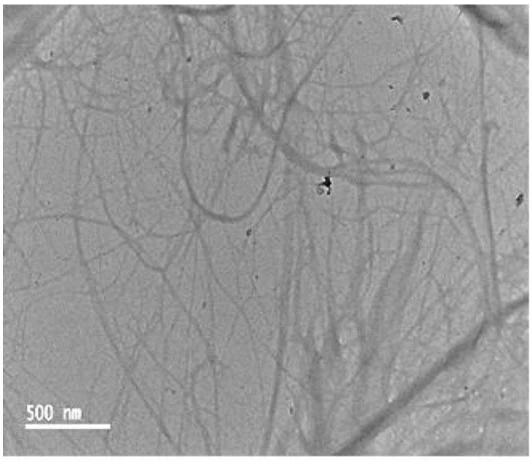

Figure 5. TEM image of NFC produced from corn stover waste residues

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