Development of Sustainable Biobased Plastics and its Green Composite Products from South African Agricultural Waste/Crop Residues: *Opportunities and Challenges*

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R&D OVERVIEW: AGRICULTURAL BIOMASS FOR BIOPLASTICS AND ITS BIOBASED COMPOSITE PRODUCTS

The Conversion Chain

Biomass

- Sugarcane bagasse
- Maize stalk

Manufacture

- Cellulose
- Starch
- Hemicellulose
- Lignin
- Oil

Intermediates

- Additives (Modifier)
- Adhesives, Coating, Microfibrillated cellulose nanofibres

Biobased Products

- Biodegrade

Biocomposites

- Biodegrade
- Reuse
- Disposal
- Recycle

Plastic products: Packaging & household.

Use

- Biobased Products
Current Situation of Sugarcane and Maize Industry in South Africa

**Sugarcane Industry**
- World leading cost competitive produces of high quality sugars
- Makes important contribution to employment, sustainable development and to national economy
- SA sugar mills produce 24.7 mtons of sugarcane annually
- Each 10 tons of sugarcane crushed produces 3 tons of bagasse.

**Maize Industry**
- SA maize industry is the largest in Africa, employing 170,000 maize farmers and workers.
- Annual production is around 8 mtons.
- Maize waste residues comprise of cobs, leaves and stalks.
- Small amounts of residues are being used as feed for livestock
- Largely underutilized

Source: Bureau for Food and Agricultural Policy 2015
OVERVIEW OF R&D INITIATIVE

Maize Stalk

Sugarcane Bagasse

Mtibe A, 2015(118) Carbohydrate polymer

Cutter

Crusher

Supermass colloidier

CELLULOSE PULP

CNWs

CNFs
Extraction of cellulose and nanocellulose

1.5% NaOH
1.5% NaClO₂
1.5% KOH

Maize stalks → Grounded maize stalks → Cellulose

Supermass colloider
Acid hydrolysis

CNF – web structure with diameter ranges from 4 to 10 nm and length from 4 to 10 microns

CNC – rod shaped with diameter ranges from 3 to 7 nm, length from 150-450 nm.
Characterization of Cellulose, Cellulose Nanofibres and Nanocrystals from Maize Stalks

<table>
<thead>
<tr>
<th>Sample</th>
<th>Crystallinity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated maize stalks</td>
<td>53.8</td>
</tr>
<tr>
<td>NaOH treated maize stalks</td>
<td>64.0</td>
</tr>
<tr>
<td>Bleached maize stalks</td>
<td>66.1</td>
</tr>
<tr>
<td>KOH treated maize stalks</td>
<td>70.5</td>
</tr>
<tr>
<td>CNFs</td>
<td>66.4</td>
</tr>
<tr>
<td>CNCs</td>
<td>72.6</td>
</tr>
</tbody>
</table>
Development of Thermoplastic Green Composites based from Natural Fibre/Bioplastics

Ref. Muniyasamy et al., Industrial Crops and Products 43 (2013) 812–819
Improving Poly Lactic Acid (PLA) Bioplastic Performance

Significant elongation increase of PLA while keeping high tensile strength.
Biobased Composite products for Green Packaging: Opportunities for SA BioEconomy Strategies

FRUIT CRATE (thermoplastic cellulose blended PLA/tough biopolymer)

Recyclable and biodegradable biobased composite Products from Maize stalk residues

Ref: Science Scope, Ideas that work (2015), Vol 8, pg 44-46
Development of Thermoset Poly Furfuryl Alcohol (PFA) based Composite Materials from Sugarcane Furfuryl Alcohol (FA): Opportunities for SA BioEconomy Strategies

CSIR PATENT: Polymerization of Furfuryl Alcohol (FA) to PFA and developing light weight, tough and durable biocomposite Materials

Degradation Mechanism of PE containing biobased additives

FT-IR

Effect of formulation

Mulching films
Aggressiveness of Biodegradation and its Mechanisms of Biobased Biodegradable Polymeric Materials

BIOPLASTICS - Are they solution for Plastic waste problems?

- Less knowledge on bioplastics, biodegradable polymers and its applications
- Not all bioplastics are biodegradable
- Biodegradation of plastics is mainly depended on chemical structure and environment, not from either fossil or biobased origin
- Some biobased biodegradable plastics are low properties and limited applications
- More expensive and less production
- Threat to the plastic recycling industry
- R&D must shifted towards to second generation of bio-based materials.

Source: European Bioplastics 2015
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