The Use of Cassava Leaves as a Potential Reinforcement of Polypropylene Based Composites

Balogun, O. P, Sanusi, K. O, Rominiyi, A. L, Adetunji, A. R

Abstract
The use of cassava leave as potential reinforcement of polypropylene based composites is investigated. Cassava leaves particulates was obtained from the cassava leaves with a sieve size analysis of 106µm.The particulates were mixed with 5% MAPP and polypropylene which served as the matrix using a twin screw extruder and compounded into composites sheet using compression molding. The cassava leaves and the composites was characterized using scanning electron microscope (SEM).The mechanical properties was analysed using Instron tensile test, impact strength was obtained using the impact tester while the hardness of the composites was obtained using the Vickers hardness tester according to the ASTM standard of D638, 1S0 197 and ISO 868 respectively. The SEM results show an even distribution of the cassava leave in the matrix with increasing filler loading. The tensile properties, impact strength and hardness of the composites revealed an improvement in the mechanical properties of the composites with the increasing the filler loading. The mechanical properties obtained an optimum with the 7%wt filler loading hardness for the all the composites as compared with the unreinforced composites.

Keywords: Extrusion, polypropylene, cassava leave powder, SEM, mechanical properties

1 Introduction

Over years, polymer composites have been prepared and combined with various types of natural reinforcing fillers in order to improve the mechanical properties and obtain the characteristics demanded in actual applications [1]. The use of natural filler as potential reinforcement of the composites in Engineering application has continue received a lot of attention among researcher and industrial sectors [2]. Natural filler have been found to have significant advantages over synthetic filler and fibres such as light-weight, low cost, ability to reduce abrasion of machinery, renewable and biodegradable. They are also abundantly available as a waste from agricultural products and the provided economic and environmental benefits for various applications in the sporting goods, modern board, bicycle frame, packaging, building, furniture and automotive industries by Rattana et al. [3].

Presently, a lot of work has been done by researchers on the use of natural fillers including flax, hemp, wood, wheat, barley, and coconut fruit crust, sugar cane bagasse as potential reinforcement of composites [4]. They are now fast evolving as potential alternatives to inorganic or synthetic materials for various applications as building materials and automotive components [5], [6].

One of the natural filler with great potentials is a processed cassava leaf which has continued to attract the interest of researchers in the areas of surface treatment of steel. Steel attracted interest of researcher due to the high percentage of carbon and nitrogen that present in the composition of materials. Most of the research works on surface modification of engineering components using cassava leaves powders. Adetunji et al. [7] worked on Use of Cyanide Solution from Cassava for the Extraction of Gold. Akinluwade et al. [8] investigated on Light and Electron Microscopy Studies of the Visible Diffusion Zone of Mild Steel Pack Cyanided in Processed Cassava Leaves. Arthur [9] investigated Abrasive Wear Studies of Pack Cyanided Mild Steel (PCMS) whereas the Development of an Environmentally Friendly in-situ Pack-Cyaniding Technique has been studied by Akinluwade et al. [10].

Based on the previous works, no research has been focused on processed cassava leaves as reinforcement in polymer matrix composites. If one is to consider processed cassava leaves as potential polymer filler, it is important to know about its composition because, apart from containing cellulose and hemicelluloses, it also contains a high amount of carbon and nitrogen, a natural polymer that has a high polarity due to the presence of large amounts of hydroxyls in its macromolecules, which interact with lignocellulosic fibres, resulting in improved mechanical properties [11]. The use of polypropylene as a matrix polymer in composites has been studied extensively due to their excellent mechanical, physical and thermal properties [12], [13]. Processed cassava leaves is

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expected to be a potential reinforcement in polymer matrix composite. Processed cassava leaves are biomass by-product from cassava firm that can be obtained locally. The aim of the research work is to convert waste to wealth by using locally waste materials (cassava leaves) as a potential reinforcement of thermoplastic materials.

Hence, this study is focused on the use of cassava leaves particulates as a potential reinforcement polypropylene based composites.

2. Materials and Method

2.1 Materials

Fresh cassava leaves of specie Manihot esculenta (bitter local variety) were sourced locally from Ile-Ife, Osun State, Nigeria. The cassava leave powder was obtained by oven dried, pulverized and then sieved to obtain fine powder (< 106μm). The chemical composition of the cassava leave powder is presented in Table 1.

Table 1. Elemental composition of cassava leave powder

Element	wt %
Oxygen	17.04
Carbon	32.46
Nitrogen	49.39
Chlorine	0.63
Calcium	0.49

2.2. Composite Production

The cassava leaves particulates and the polypropylene matrix was mixed and the mixture was extruded using a Twin-Screw extruder and compounded using a compression moulding to produce the composites. The variation of the cassava leave was weighed in 0wt%, 3wt%, 5wt% and 7wt% and mixed with 5% MAPP compatibilizers .The mixture was fed into a Jones high speed mixer for proper mixing of the powder and the matrix. Thereafter, the mixture was allowed to dry in an air circulated oven at 600C for 8 hours to ensure total removal of the moisture. However, the mixture was charged into the extruder at the temperature range from 130-1900C and the screw speed was fixed at 60 rpm. The extrudate which was granulated into pellets using industrial granulator were compounded for 10 minutes at 1900C under a constant pressure allowing thorough penetration and well distribution of the particles into the matrix. This was transferred to another compression moulding machine and cold-pressed at 100 MPa for 12min. Representative sizes of composites produced from the Twin –Screw extruder process are presented in Fig. 1.

2.3 Microstructural Characterization.

The cassava leave particulate and the fractures surface of the cassava leave composites were examined using a JEOL JSM-7600F model scanning electron microscope. Sample were placed in vacuum chamber, air dried and coated with 100A thick irradium in JEOL sputter ion coater at 15Kev.

(a) (b)

Fig.1. Extruded polypropylene based composites produced for (a) pure polypropylene, (b) Cassava leave powder reinforced with polypropylene.

2.4. Mechanical properties.

The hardness values of the composites were evaluated on a hardness testing machine using the Vickers hardness test apparatus (FM-800). It has a square based diamond pyramid as indenter. The value of the load (50 gm) and the time duration (10 seconds) that is to be applied was set. The sample preparation and testing procedure was performed in accordance ISO 868 standard. Seven hardness indents were made on each specimen and readings within the margin of ±2% were taken for the computation of the average hardness values of the specimens.

2.5 Tensile Strength

Tensile test was carried out in accordance with ASTM D638 [14] at room temperature using a universal tensile testing machine operated at a strain rate of 10mm/min with 10KN load cell. Six repeated tests were carried out to confirm the reliability of the results obtained.

2.6 Impact Strength

The impact strength of the composites produced was evaluated using an Izod impact test machine. The sample preparation and testing procedure were in accordance with ISO180 standard [15]. The entire composite specimens were notched, the test specimen which was supported by a cantilever beam with hammer head of 7.5 J was released with impact velocity of 2m/s to strike and break the notch specimens. Six specimens were tested at room temperature and the values were taken.

3 Results and discussion

3.1. Microstructure

SEM micrograph of the pulverized cassava leaves is presented in fig.2. Fig. 3 (a- d) shown the SEM micrographs of cassava leave reinforced composites. It is evident that, the cassava fillers were evenly distributed within the matrix with the increasing filler loading. Addition of the cassava fillers improved the microstructure as a result of better packing factors and well dispersion of the filler in the matrix. Better packing of the filler in the matrix is more pronounced for the 7wt% as a result of the particle size and better filler- filler interactions. This is confirmed by the tensile properties of the composites as shown in fig. 5. However, Ayswarya et al. [16] revealed that, the mechanical behaviour of fibre–cement composite is largely dependent on the bond between fibre and cement matrix which depends on many factors like the physical characteristics of the fibres such as geometry, type, and surface characteristics, fibre orientation, fibre volume ratio and fibre distribution, the chemical composition of the fibre, but also the treatment of the fibre and additives in the cement mixture. The interfacial bond may be chemical or physical or a combination of both.

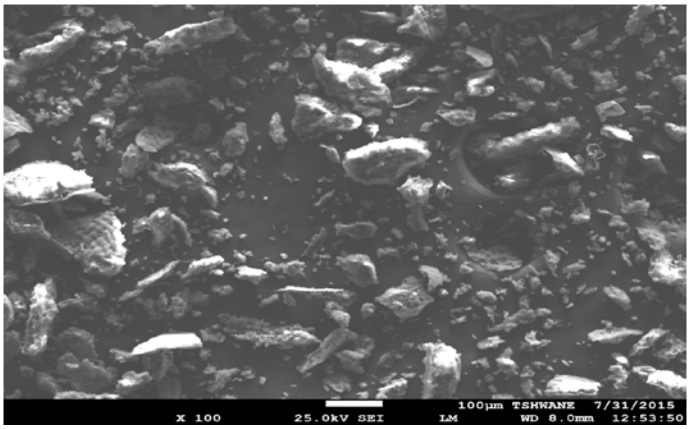

Fig.2. SEM micrographs of cassava leaves

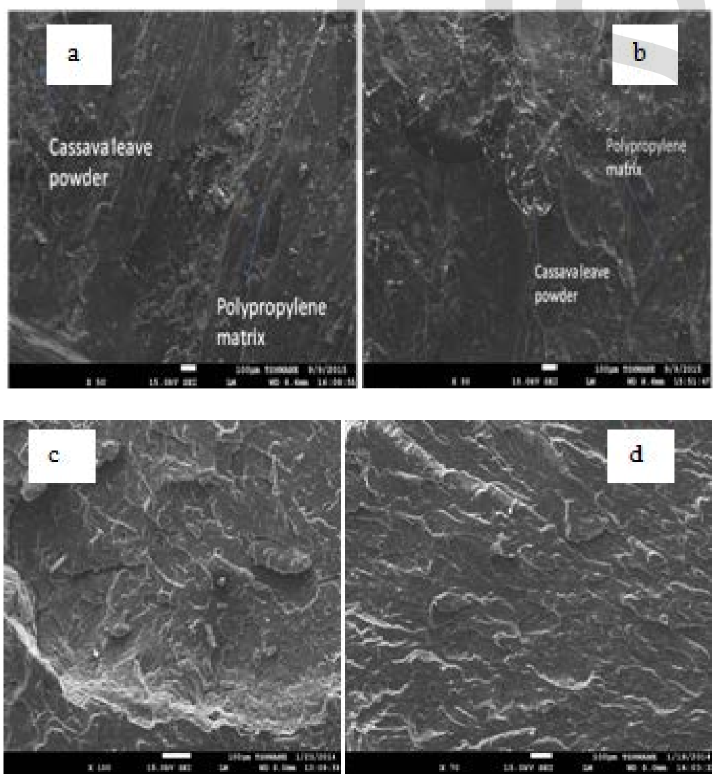

Fig.3. (a) Representative SEM photomicrograph of the composite having 3wt% cassava leave powder particles dispersed in the polypropylene matrix; (b) Representative SEM photomicrograph of the composite having 5wt% cassava leave powder particles dispersed in the polypropylene matrix. (c) 7% cassava reinforced composites (d) Pure pp

3.2. Mechanical behaviour

The mechanical properties of the composites produced are presented in Fig. 4-7. From Fig. 4 it is observed that there is a general increase in hardness with increase in the weight percent's of cassava leave powder in the composites. The increase in hardness of the composites was due to the size of the pulverized cassava leaves particles and evenly distribution of the particulates in the matrix. The mechanical properties of particulate–polymer composites depend strongly on the particle size, particle–matrix interface adhesion and particle loading. Particle size has an obvious effect on these mechanical properties. Lau et al. [17] reported that smaller calcium carbonate particles provide higher strength of filled polypropylene composites at a given particle loading. Hence, the introduction of the filler into the matrix has shown a better improvement on the composites as compared to pure polypropylene.

The tensile strength and Young modulus properties of the composites are revealed in (Fig. 5-7) which follows the same trend as the hardness results (Fig. 4). It is evident that the tensile strength and modulus of the composites increased with increase in the cassava leaves filler loading content from 3%-7% and this can be attributed to the homogeneity of the composite matrix. Hsueh, [18] found out that for well-bonded particles, the applied stress can be effectively transferred to the particles from the matrix, this clearly improves the strength. The result is in contrary to what Fabiane et al. [19] revealed that, tensile properties of the composites produced had induced cracks due to poor distribution of the cassava in the matrix thereby reduces the tensile properties of the composites. The high strength -to-weight and modulus-to-weight ratios relate strength properties of the reinforcing materials as it increases. This is due to the better wet ability of cassava leave with the polypropylene matrix. The increase in modulus of composites (fig. 6) as the content of reinforcing material increases confirmed that the composites produced becoming stiffer and rigid.

Impart strength of the composites is observed in Fig. 7. The resistance to impact damage of a polymer matrix composite structure increase as content of cassava leaves powder increases. Also, the toughness of the polypropylene matrix was not impaired as content of cassava leave powder is increasing but improve the impact resistance to damage of composites. This is due to compression pressure which eliminates voids contents in the composites.

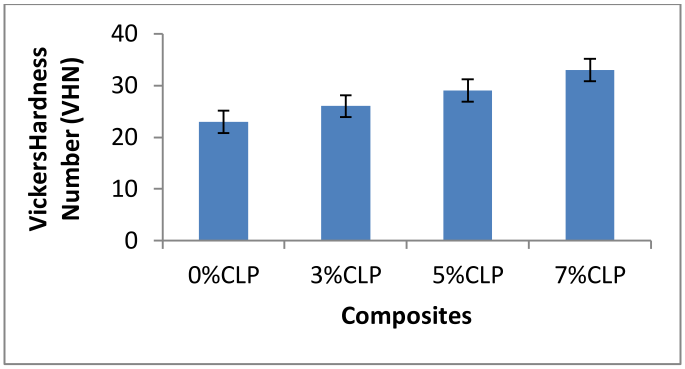

Fig.4. Hardness of the composites

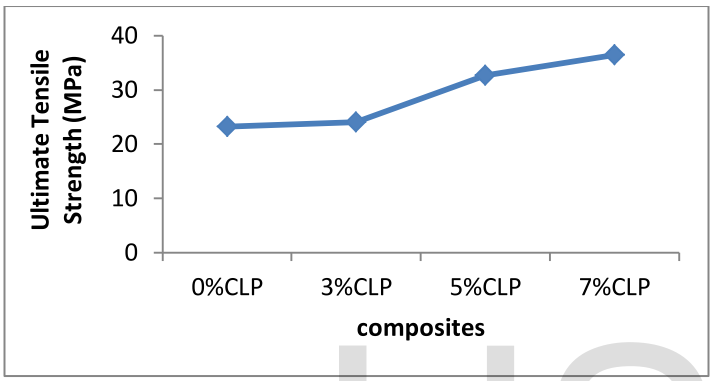

Fig.5. Ultimate tensile strength of the cassava leaves composites

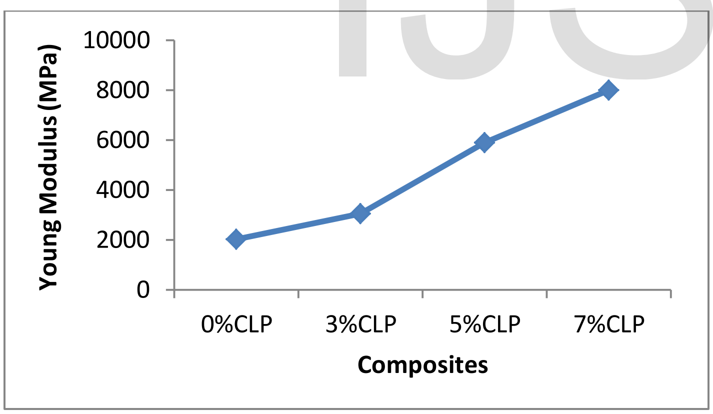

Fig.6. Young modulus of the cassava leaves composites

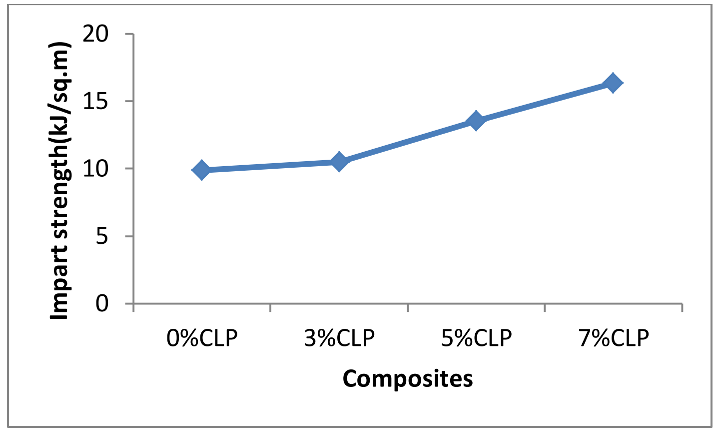

Fig.7. Impact strength of the cassava leaves composites

4 Conclusions

The microstructural characteristics and mechanical behaviour of polypropylene matrix composites reinforced with cassava leave powder was investigated in this research. The results established that:

- There is predominant and well dispersion of reinforcing material in the matrix as revealed by the SEM image in fig. 3
- The tensile strength and hardness for the composites containing 7wt% cassava leave powder was observed to be higher than the other composites and pure polypropylene. The impart strength of the composites increase as percentage of cassava leave powder is increasing.
- The method adopted for the research is reliable to increase tensile strength, impart strength, hardness of thermoplastics materials.

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