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Mechanical and BiodegradabilityProperties of Linear Low Density Polyethylene Modified with *Icacina trichanta* Starch and *Holcus sorghum* Husk

GARBA S., AWE O.A.

Department of Chemistry
Nigerian Defence Academy Kaduna, Nigeria.

Department of Chemistry
Nigerian Defence Academy Kaduna, Nigeria.

Abstract: ***The mechanical and biodegradability properties of Linear Low Density Polyethylene blended with Icacina trichantha starch (ITS) and Holcus sorghum (Guinea corn) husk (GCH) were assessed using standard methods. The tensile strength and percentage elongation at break decreased with increase in filler contents of the blended materials, with the tensile strength and percentage elongation of LLDPE blended with ITS decreasing from 7.89N/mm^2 to 1.60N/mm^2 and 19.6 to 8.2% respectively whereas LLDPE blended with GCH decreased from 7.23N/mm^2 to 1.89N/mm^2 and 33% to 12.4% respectively. The results of biodegradability test showed changed in pH from slightly acidic to slightly basic with all the two blended samples giving a pH range of 6.98 to 7.98. The percentage weight loss of each blended LLDPE increased with increase in amount of filler content with LLDPE blended ITS showing weight loss ranging from 1.3% to 38.6% and LLDPE blended with GCH giving weight loss range of 0.6% to 32.6% after 14 days incubation period. This showed that ITS improved the biodegradability of LLDPE more than the GCH and the overall results showed that biodegradability of polyethylene can be increased by blending with plant materials.***

Keywords: Biodegradability, *Holcus sorghum* husk, *Icacina trichantha* starch (ITS), Linear Low Density Polyethylene.

1. Introduction

Polyethylene (PE) bags have been used for decades for a variety of storage and packaging applications. The primary challenge in disposing these bags after use is its lack of degradation [1]. In order to overcome these problems, a new type of plastic bag is being developed by commercial companies. These bags are called "biodegradable" plastic bags. A "biodegradable" plastic is defined as "a degradable plastic in which the degradation results from the action of naturally occurring microorganisms" (American Society for Testing and Materials (ASTM) standard D6400). The ASTM D6400 standard lists that in order for bags to be considered biodegradable, they must disintegrate during composting so that any remaining plastic is not readily recognizable. Bags that consist of one polymer must have 60% of the organic carbon converted to carbon dioxide while bags that have more than one polymer must have 90% converted if the polymer is present [2].

Linear low density polyethylene (LLDPE) is an important commercial polymer which is widely used for different applications in modern technology. It has higher tensile strength, impact and punctures resistance when compared to low density polyethylene, and is very flexible, elongates under stress, and can be used to make thinner films, with better environmental stress cracking resistance.
Starch is a polymer which occurs widely in plants. The principal crops used for its production include potatoes, corn and rice. In all of these plants, starch is produced in the form of granules, which vary in size and somewhat in composition from plant to plant.

Icacina triachantha, family: *Icacinacea* which is known as urumbia or eriagbo (meaning to induce vomiting when eaten) among the Ibo speaking tribes of eastern Nigeria, or gbegbe (meaning to carry away) by Yoruba speaking tribes of western Nigeria [3]-[4] is a shrub up to 2m with scandent growth above. Although, its tuber has not be included as a conventional source of starch but it has been reported to contain up to 80% carbohydrate [5].
Sorghum bicolor is typically an annual but some cultivars are perennial. It grows in clumps that may reach over 4m high. The grain is small, ranging from 3 to 4mm in diameter. It is known under a variety of names: great millet and guinea corn in Nigeria. Sorghum grain contains high complex of carbohydrate, 72grams per ½ cup, as well as providing 11grams of protein [6]. The aim of this research work is to investigate the possibility of using plant materials in improving the biodegradability and mechanical properties of LLDPE.

2. Experimental

A. Sample Collection

The Linear low-density polyethylene (LLDPE) was obtained from the Nigerian Institute of Leather and Science Technology (NILEST), Samaru. Zaria. Tubers of *Icacina trichantha* was gotten from Ore, Ondo state, South-West Nigeria and *Holcus sorghum* husk was bought from a local herb vendor in Mando, Kaduna, Kaduna state. The extraction of starch from *Icacina trichantha* starch (ITS) was based on method reported by Omojola *et al*., [7].
The linear low density polyethylene was separately mixed with ratio of *Icacina trichantha* starch and *Holcus sorghum* husk in

accordance with the methods reported by Nwanonenyi *et al.*, [8].

After compactibilising the blended samples, the mechanical properties of each of the compounded materials such as tensile strength, elongation at break, and tensile modulus were determined using a Monsanto Tensometer with Serial Number: 9875 (Type 'W') following the procedure reported by Mu'azu, [9].

The biodegradation of the non-blended and blended polyethylene materials was determined using shake flask method as reported by Merina and Santosh, [10]; and Okoh and Atuanya, [11].

3. Results and Discussion

3.1 Mechanical Properties

The results of the mechanical properties of the blended polymer is presented in Figure 1to 4. Fig 1 shows the variation of tensile strength of LLDPE blended with ITS and LLDPE blended with GCH. The tensile strength was observed to decrease with increase in the quantity of the filler contents. However a decrease in tensile strength of pure LLDPE from 18.84N/mm^2 was observed when blended with both fillers, i.e. a difference of 1.60N/mm^2 was observed between LLDPE blended with ITS, to that of LLDPE blended with GCH at the same ratio. (See Fig 1) This reduction could be due to the poor interfacial adhesion between the Fillers and LLDPE phases which causes poor stress transfer between matrix and the dispersed phase [12].

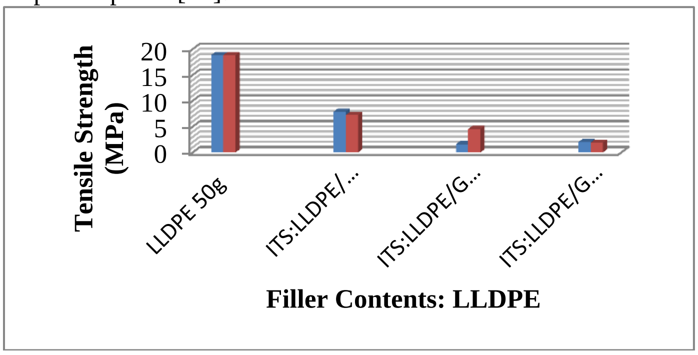

Fig 1: Variation of Filler contents against Tensile Strength (N/mm^2)

The results percentage elongation at break shows that LLDPE blended with ITS gives lower percentage (19.6%) compared with LLDPE blended with GCH (33%) at the same ratio of 20:30 g. There was general reduction in percentage elongation at break when the filler content increases (see Figure 2 below). This showed that the filler content in the LLDPE matrix resulted in the stiffening and hardening of the composite which reduced its ductility, and led to lower elongation property. The reduction of the elongation at break with the increasing filler contents indicates the incapability of the filler to support the stress transfer from the fillers to polymer matrix. Such a reduction in elongation at break of a polymer composite with increase in filler contents has been reported by Siti Shuhadah and Supri [13].

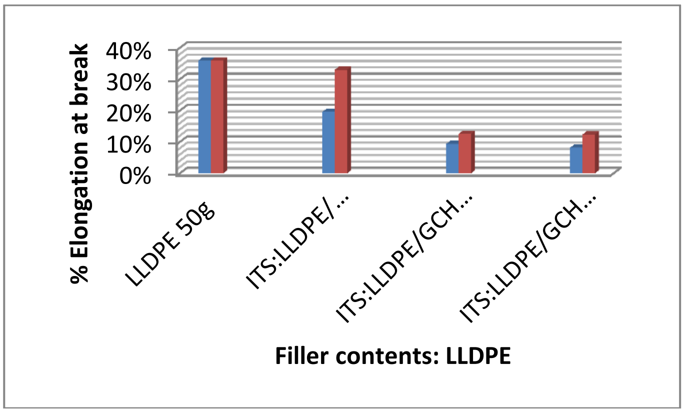

Fig 2: Variation in the Filler-contents: LLDPE against % Elongation at Break

The results of variation of tensile modulus of ITS/LLDPE and GCH/LLDPE showed that it decrease with increase in the filler content for ITS/LLDPE, although a sudden increase was observed at 40:10 ITS/LLDPE which could be due to stiffness of the starch granules (see Fig 3). For GCH blended with LLDPE, fluctuations was observed as the blend of GCH with LLDPE at 30:20g has a higher value of 37.73MPa and that of 20:30g was with 22.25MPa with least been 16.21MPa at 40:10g. These fluctuations have also been reported by other researchers to be due to higher stiffness of the starch granules over the flexible polymer matrix in which they were dispersed [14]-[17]. This stiffening effect of starch is due to hydrogen bonding in its sub-macromolecular structure which is absent in LLDPE. [16], [18]-[19].

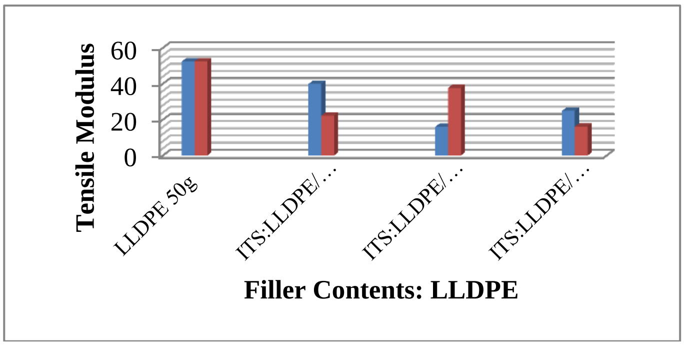

Fig 3: Variations of Filler contents: LLDPE against Tensile Modulus (GPa)

3.2 Biodegradation Properties

The results of biodegradability properties of LLDPE blended with ITS and GCH showed that as the polymer degrades, there is general increase in pH of the media due to the presence of different monomer products. For instance, it was observed that the specimens of both blends at 30: 20 g ratio had a higher pH value of 7.98 and 8.05 respectively while those of 20: 30 g ratio had a lesser pH value of 7.53 and 7.83 each. But after 14 days (a period of 2 weeks), the pH was observed to have reduced with LLDPE blended with ITS at 40: 10g having the lowest pH value of 7.04 and LLDPE blended with GCH at 20: 30g was 7.68(see Fig 4).

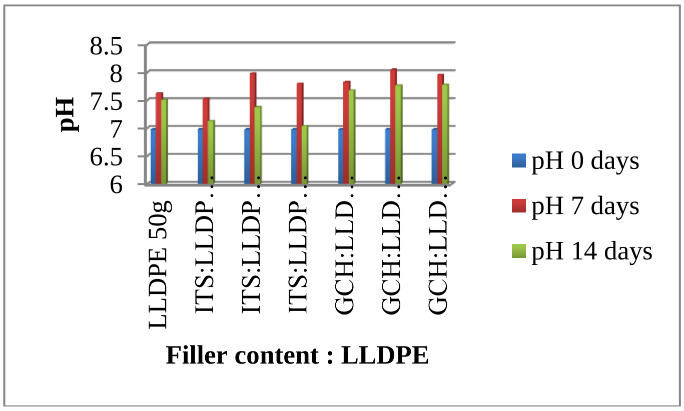

Fig 4: pH ranges at day 0, 7 and 14 of degrading Filler contents: LLDPE

There was steady increase in the percentage weight loss during the degradation process of the blended LLDPE compared to the pure LLDPE. For instance no weight loss was observed for pure LLDPE but the results of blended LLDPE showed that for LLDPE blended with ITS, the weight loss ranges from 1.3 – 38.6% whereas the LLDPE blended with GCH the weight loss ranges from 0.6 – 32.1% (see Fig 5).

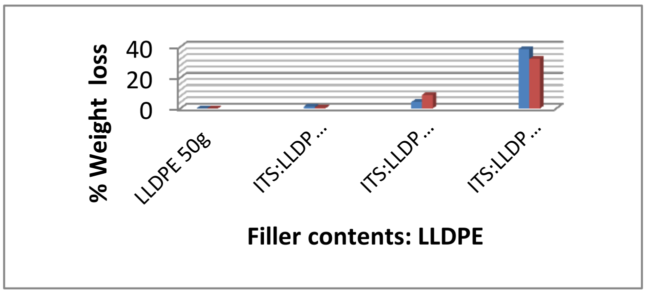

Fig 5: % Weight Loss of Filler contents: LLDPE over a period of 14 days

This results showed that biodegradability of polymer increase with increase in the filler content indicating that the filler contents are been used mainly as carbon source by micro-organisms for growth in the salt media as reported by Okoh and Atuanya, [11].

Conclusion

This research work has revealed that the degradability of LLDPE could be improved using *Icacina trichantha* starch and Guinea corn (*Holcus sorghum*) husk and could therefore help in reducing pollution hazard caused by waste polyethylene materials in our environments.

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