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Caladium bicolor and Wild *Dioscorea dumetorum* Starches As Dual Purpose Polymer Additive

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ABSTRACT: Increased elastic modulus and ultimate tensile strength of low density polyethylene has been achieved by incorporating *Caladium bicolor* (ornamental cocoyam) and wild *Discorea dumetorum* (sweet yam) starches into low density polyethylene using a standard hot-melt compounding technique. Some mechanical properties of compression moulded dumb bell shaped films of low density polyethylene containing up to a maximum of 20 wt % of each starch is reported. Increased density of the composite with time after being buried for a total of 12 weeks in composting environment is an evidence of the degradation of LDPE which may be linked to an initial breakdown of starch by microorganism in the soil which probably give rise to diffusion of unsaturated lipids into the porous polymer resulting in degradation by auto-oxidation. @JASEM

Starch derives mainly from maize, wheat, potatoes, tapoica, rice and other sources has wide spread applications in the food, paper, textile and pharmaceutical industries (Knight, 1969, Griffin, 1978). In the food industry, it is used as thickeners and sometimes added to certain cooking oils as an emulsifying agent. It is used for sizing and strengthening of paper. Starch functions as sizing materials in the textile industry. Its film forming propensity and the properties of its film makes it useful in the pharmaceutical industry for coating of tablets. (Norman, 1992). Recently starch has received attention for use as a filler in the polymer industry due to its high elastic modulus which is known to be at least twice that of low density polyethylene (LDPE), the potential in elimination of blocking and static build up and its biodegradative properties (Ogbobe 1997). The first commercial venture involving polymer and whole starch grains as fillers was as starch extended LDPE blown film for carrier bags (Griffin, 1978).

Caladium bicolor (ornamental cocoyam), a tuberous perennial that provides brightly coloured foliage in warm, shady areas and wild *Dioseorea dumetorum* a climbing vine with stems up to 6-8m high, twinning in a clockwise direction (Onwueme, 1978 and Cobley, 1976) were used in this research work. These crops are inedible and grow wild in the South Eastern part of Nigeria. The work reported here is a preliminary work on the possible use of wild *Dioscorea dumetorum* and *caladium bicolor* starches in LDPE as alternative dual-purpose polymer ingredients for possibly enhancing mechanical and biodegradative properties.

MATERIALS AND METHOD

Extrusion grade LDPE density 0.92 gcm^{-3} at 25^0C and melt flow index 2 was used. Ornamental cocoyam and wild sweet yam were harvested from the farm in the month of November at Iko Town in Eastern Obolo and Nung Ukot Itam in Itu areas respectively in Akwa Ibom State, Nigeria.

Extraction of the starch from the ornamental cocoyam and wild sweet yam were carried out by filtering grated mixtures of each with a cheese cloth to obtain a filtrate free of fibres. Starch was collected from each filtrate after standing for 24 hours and dried in an oven at 40^0C. Particle size of the extracted starch was determined using an olympus laboratory microscope equipped with a graticule and an olympus camera. Specimens prepared by adding 70% Iodine solution in alcohol to a 1% starch were put on a glass slide covered with a glass cover-slip and viewed under a microscope. A 40 x objective lens and a 10 x eye-piece were employed. The size of the starch grains was recorded with the help of a microscope graticule. (Ogbobe, 1997). Densities and refractive indices of the starch were obtained using standard procedures.

LDPE supplied as granule were further chipped and mixed with varying percentage (0-20%) each of the two starches using silicone oil as processing aid. Dumb bell shaped composites were obtained using 200mm thick aluminum sheet moulds filled with LDPE/starch mixture. The composites were made by compression moulding using two steel blocks. The tensile properties were measured using an Instron Tensile Testing Machine (model 1041 system) with a full-scale deflection of 5000N. A gauge length of 10cm was employed for all the samples. A crosshead speed of 1000mm/min was used. All measurements were made at 65% relative humidity at 20^0C. The variation of stress with strain, ultimate tensile strength and elongation-at-break were determined.

Modified compost similar to that employed by Griffin, (Griffin, 1978) and described elsewhere

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was simulated (Okeke, 1988). Starch/polymer composites containing varying weight percent (0 – 20%) of each starch were buried for a total of 12 weeks in compost. After two weeks interval, the specimens were removed, washed, dried and their densities determined.

RESULTS AND DISCUSSION

The physical properties of the wild cocoyam and wild sweet yam starches studied are indicated in Table 1 The range of particle size of the starches studied fit into the particle size range of 3-100μm cited in the literature for various other starches. (Reichart, (1913), Wistler and Paschal, (1965).

The ultimate tensile strength, modulus and the elongation-at-break of the composite specimens compared to the weight % starch in the specimen are shown in figures 1-3.

Table 1: Some physical properties of wild cocoyam and wild sweet yam starches

Property	Wild cocoyam	Wild Sweet yam
Particle size range (μm)	1-5	1-6
Mean particle size (μm)	2.5	3.5
Refractive index ($\eta^{25}{}_{D}$)	1.45	1.46
Density (gcm^{-3})	1.52	1.51

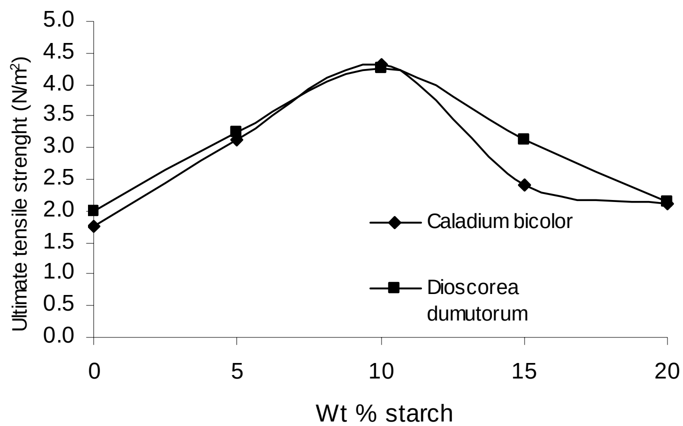

Fig. 1: ULtimate tensile strenght as a function of w t % starch

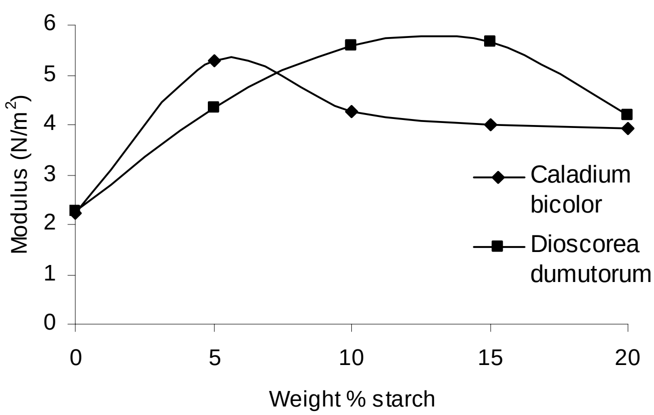

Fig. 2: Modulus as a function of wt % starch composition

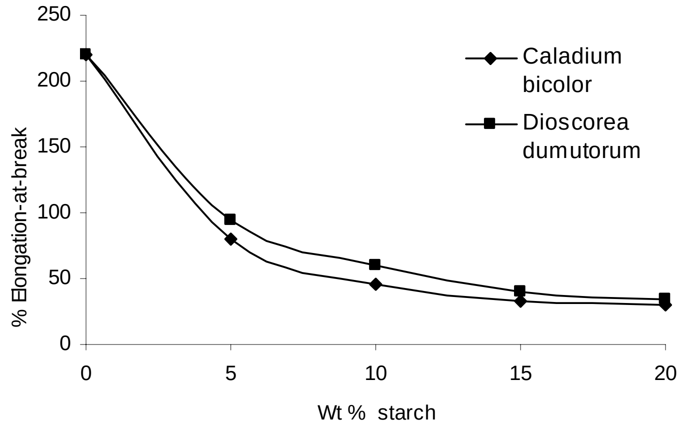

Fig. 3: % Elongation-at-break as a function of wt % starch

From Fig. 1 it is observed that wild cocoyam starch increases the ultimate tensile strength of the composite between 0-10 wt % starch composition. The figure also shows that a similar trend is observed on addition of wild sweet yam starch. The increase in ultimate tensile strength on addition of these starches to LDPE is an indication that the starch is exerting a reinforcing effect on the LDPE. In Fig. 2, it is seen that wild cocoyam starch upgrades the modulus of LDPE between 0-5 wt % and beyond this point there is no significant effect on the modulus of its composites with LDPE. The figure also shows that wild sweet yam starch upgrades the modulus of LDPE between 0 - 10 wt %. This is also an indication that both starches are exerting a reinforcing effect on LDPE. The modulus of the composite is positively synergistic for wild cocoyam starch at 5 wt %. The variation of % elongation-at-break with wt % starch in the specimen is shown in figure 3. From the figure, it can be seen that both starches down grades the elongation at break of the LDPE at all starch compositions.

The changes in the densities of the composites with composting time are as indicated in figure 4.

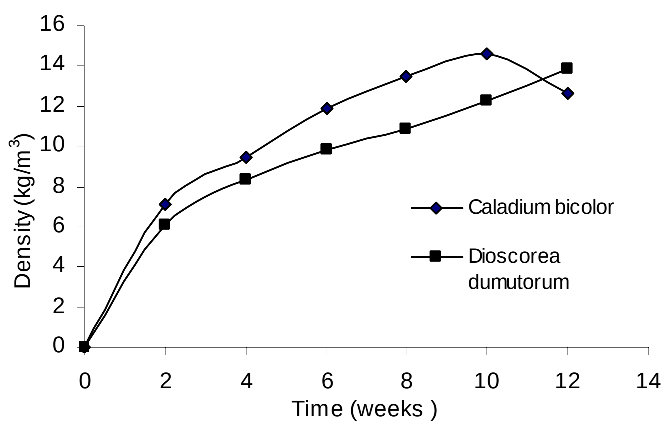

Fig. 4: Density of LDPE/5wt % starch composite after exposure in warm compost for 12 weeks

From the figure, it can be seen that there is an increase in density with composing time in each case. Also, it is observed that the density reaches a maximum after 10 weeks in case of *caladium bicolor* starch in the compost. This may be an indication that there is a breakdown in the structure of LDPE. The mechanism through which this happened is not clear but may be thought to occur as a result of initial breakdown of the starch molecules by microorganism in the compost environment. This then gives rise to a porous material, which then easily allowed access of unsaturated lipids from the compost that leads to degradation by auto-oxidation.

CONCLUSION

It has been shown that both elastic modulus and ultimate tensile strength of LDPE has been increased on incorporating wild cocoyam (*Caladium bicolor*) and wild sweet yam *(Dioscorea dumetorum*) starches to it. Densities of the composites increase with time in composting environment indicating that the starches can be used as a biodegradable filler. This is a significant advantage judging by the concern being shown in the environmental problems posed by polyolefin films disposal. Therefore both starches have been shown to be dual purpose additive for LDPE.

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