ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 4 No. 1 January 2013 Academic Research International

WATER ABSORPTION, FLAMMABILITY AND MECHANICAL PROPERTIES OF LINEAR LOW DENSITY POLYETHYLENE/EGG SHELL COMPOSITE

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ABSTRACT

Polymer composite samples were produced using injection molding by mixing LLDPE with varying (5, 10, 15, 20, 25) wt % of egg shell powder to obtain desired and enhanced properties. Water absorption, flammability and mechanical properties of linear low density polyethylene/egg shell powder composites as a function of filler content in the particle sizes (75, 125, 175µm) were investigated. The parameters such as tensile strength, elongation at break, tensile modulus, and impact and flexural test were carried out on the prepared composite samples. Experimental result showed significant decrease in tensile strength, % elongation at break, tensile modulus, flexural strength and flexural modulus on addition of egg shell powder into the matrix. Flammability behaviour of the composites as a function of filler content examined showed gradual reduction as the filler content increases while water absorption behaviour of the composites as function of time of exposure investigated increased as the time of exposure and filler content increases.

Keywords: LLDPE, polymer composite, egg shell, water absorption, flammability.

INTRODUCTION

Thermoplastics are polymers that soften without chemical change and harden when cooled, and may be remoulded many times but subject to chemical degradation (Katchy, 2000). They are increasing replacing conventional materials such as metal, glass, wood and paper in diverse applications (Obasi, 2007). The broad spectrum of properties offered by the variety of thermoplastics together with the techniques of compounding them with other polymers, chemical additives and fillers has been an effective and vital tool for achieving specific balanced combination of physical properties and processing characteristics (Obasi, 2007). The selection of thermoplastic composite for a specific composite application is determined by the processing history, mechanical properties, thermal stability, chemical properties and cost. Many factors such as the filler properties, filler content, interfacial adhesion and distribution influence the properties of thermoplastic composites due to combination of more than one material in the composite (Hussein, et al., 2011).

Linear low density polyethylene (LLDPE) is a commodity thermoplastic (Fried, 2003) and widely used in different applications which include; film packaging (bags and Sheet), cable covering, toys, lids, buckets, containers, pipes (Hans Dominighaus, 1993). The predominant applications of linear low density polyethylene is due to its toughness, flexibility, relative transparency, low moisture absorption, chemical and corrosion resistance, good dielectric characteristics and barrier properties, environmental stress cracking resistance and excellent heat seal strength. In order to enhance the physical properties and reduce cost of processing LLDPE composite, some additives can be incorporated into the composite. Particulate fillers

ISSN-L: 2223-9553, ISSN: 2223-9944
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such as mica, snail shell, calcite, rice husk, periwinkle shell. Arukalam & Madufor (2011), Nwanonenyi & Obidiegwu (2012), Mahanar & Bose (2004), Anyanwu & Ogbobe (2007), and Njokua et al. (2011) have been reported in scientific literature for improving the mechanical properties of thermoplastic composites at reduced cost. This study focused of the effect of filler content and particle size on the flammability, water absorption and mechanical properties of egg shell powder filled linear low density polyethylene.

EXPERIMENTAL

Materials

The LLDPE used in the study was purchased from a Chemical Store at Aba, Abia State, Nigeria. It has a melt flow index of 2.5 g/min and density 0.929 g/cm^3. Egg shell powder was obtained from a local market.

Preparation of Composite Samples

The eggshell was subjected to cleaning with water to remove contaminants , dried at room temperature for six hours in an oven to eliminate odour and ground to powder with the of blender. Different set of sieve were used to obtain average particle size of (75, 125, 175µm). After that eggshell powder was added to the matrix in different (5, 10, 15, 20, 25) wt % as shown in Table 1. Then, egg shell as a fine powder was mixed, melt blended with LLDPE at 190^{0}C in a single screw injection moulding machine and a square frame sample was fabricated in 2-5mins (processing time), and after this period the sample was allowed to cool.

Table 1. Formulation of LLDPE and Eggshell

Sample ID	LLDPE (%)	Eggshell (%)
1	100	0
2	100	5
3	100	10
4	100	15
5	100	20

CHARACTERIZATION AND MEASUREMENTS

Tensile Test

Tensile strength (ASTM D638) was evaluated using universal tensile testing machine of LR10K. Flexural properties according to ASTM D790 were tested using LR10K machine.

Water Absorption Test (ASTM D570)

Water absorption test (ASTM D570) was done by total immersion of three specimens in distilled water at room temperature. The water absorbed was determined by weighing the samples at regular intervals (i.e, weight gain) with the aid of digital weighing balance. The water adhering on the surface of the specimen was carefully removed using filter paper; care was taken during the wiping process not to remove the water absorbed by the specimen. The percentage of water absorption (W %) was calculated using the expression (Shuhadah, Supri and Kamaruddin, 2008):

$$W (\%) = [(W_2 – W_1) / W_1] \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, W_1 and W_2 are the dry and wet weight specimens respectively.

Flammability Test (Astm D 635)

A 60mm mark was measured and marked out on each of the specimen. The specimen was then clamped horizontal in a retort stand with the marked 60mm distance protruding out of the clamp. The free end of the sample was ignited and the time taken for the sample to ignite was recorded as the ignition time (I_t). The sample was allowed to burn to 60mm mark (D_p). The relative rates of burning for the different samples were determined using the expression Ewulonu (2009) stated below:

Flame propagation rate (mm/s) = D_p (mm)/P_t(sec)–I_t(sec) …………………….. (2)

Where D_p = Propagation distance measured in mm, P_t = Flame propagation time measured in seconds. I_t = Ignition time measured in seconds.

RESULTS AND DISCUSSIONS

Tensile Properties

Fig 1 shows the variation of tensile strength with filler content. It is observed that the tensile strength of the composites exhibits significant decrease with increase filler content all the particle sizes investigated. The decrease in tensile strength may due to poor interfacial adhesion and distribution of filler within the matrix, thus providing poor reinforcement. Elongation properties as seen in Fig 2 showed gradual decrease as the filler content increases. The decrease in elongation at break is an indication that the filler is incapable of supporting the stress transfer from filler to matrix. Again, the presence of the filler within the matrix decreased the elasticity of composite which leads to decrease in the strength of the composite. Fig 3 exhibits tensile modulus as a function of filler content. The tensile modulus of the composites investigated decreased with increase in filler content. This decrement in tensile modulus shows poor resistance of material to deformation. This is because at high filler content the composite will not be able to withstand greater loads.

Flexural Properties

Fig 4 depicts the variation in flexural strength with varying filler content. The flexural strength decreased with the increase in filler content. It is observed that increase in weight percentage of filler reduced the deformability of the matrix, and in turn reducing the ductility of the composite thereby forming a weak structure. Fig 5 presents the variation in flexural modulus. It is seen that flexural modulus decreased with in filler concentration.

Water Absorption Properties

Fig 6 and Fig 7 show the variation of % water absorption as a function of time exposure with different filer contents and particle sizes (75µm and 125µm). It is observed that the composite with higher filler content and surface area has better water absorbing capacity. As the filler content increases, the formation of agglomerations increases due to difficulties of achieving a homogeneous dispersion of filler at higher filler content within the matrix. The agglomeration of the filler in the composites increases the water absorption of the composite. The figures show that the composite with particle size of 75µm has higher % water absorption than the composite with 125µm particle size for all the composites investigated.

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Flammability Properties

Fig 8 presents the rate of flame propagation versus filler content. It is clear from this that flame propagation property decreased steeply with increase in filler content. A significant decrease in flame propagation was expected because chemical composition and nature of egg shell. Lower particle of egg shell resulted in higher thermal stability. This may be attributed to the increase in the matrix filler contact.

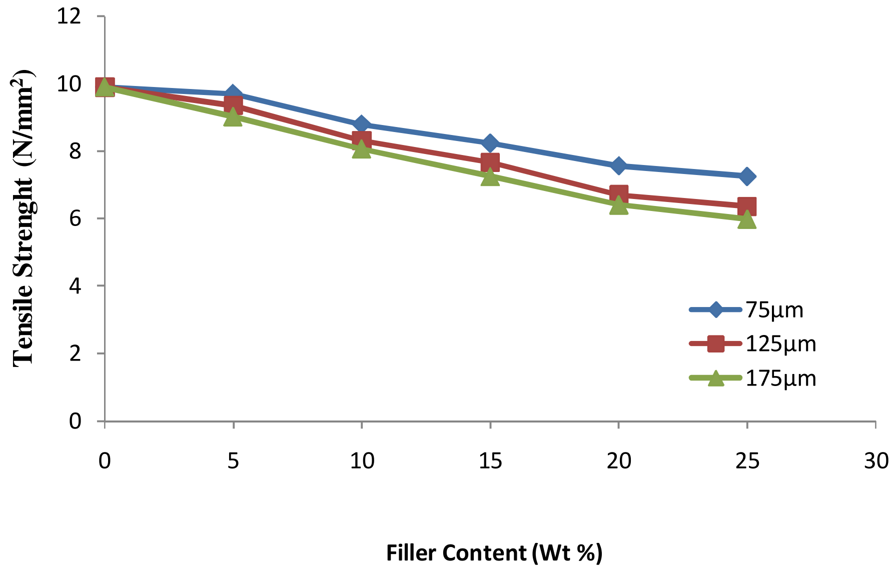

Fig 1. Effect of filler content on the tensile strength of egg shell powder filled LLDPE

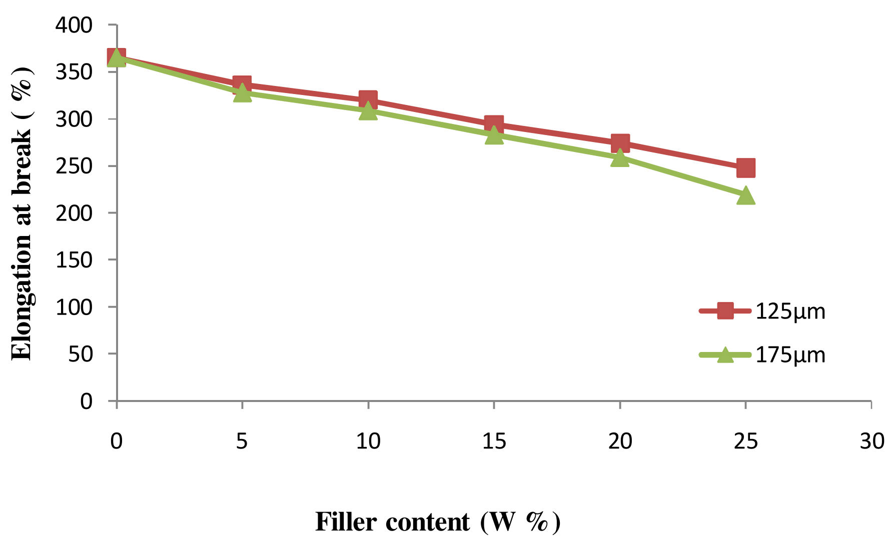

Fig 2. Effect of filler content on the % elongation at break of egg shell powder filled LLDPE

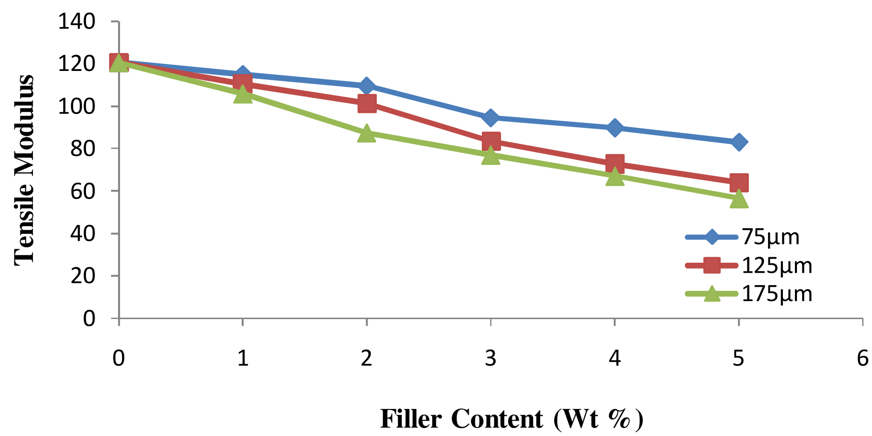

Fig 3. Effect of filler content on the Tensile Modulus of egg shell powder filled LLDPE.

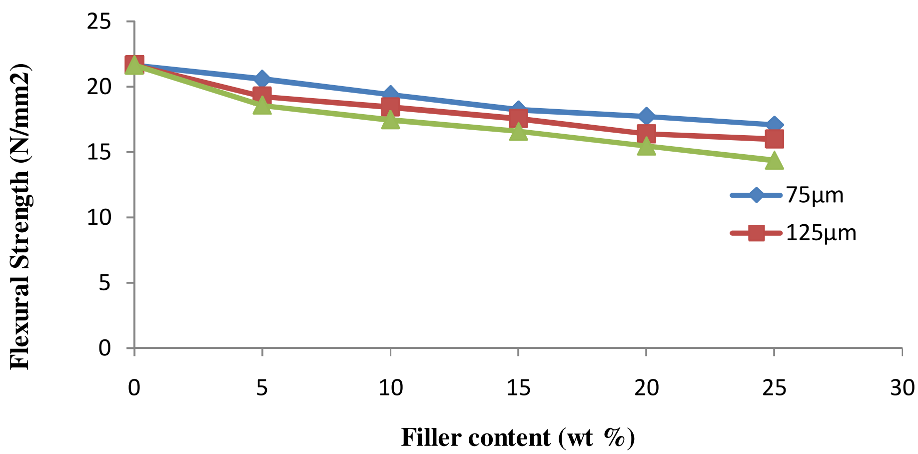

Fig 4. Effect of filler content on the flexural strength of egg shell powder filled LLDPE

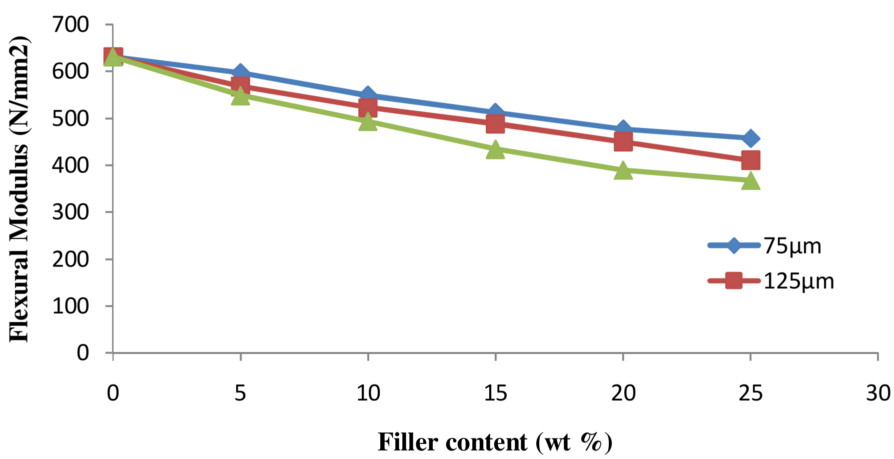

Fig 5. Effect of filler content on the flexural modulus of egg shell powder filled LLDPE

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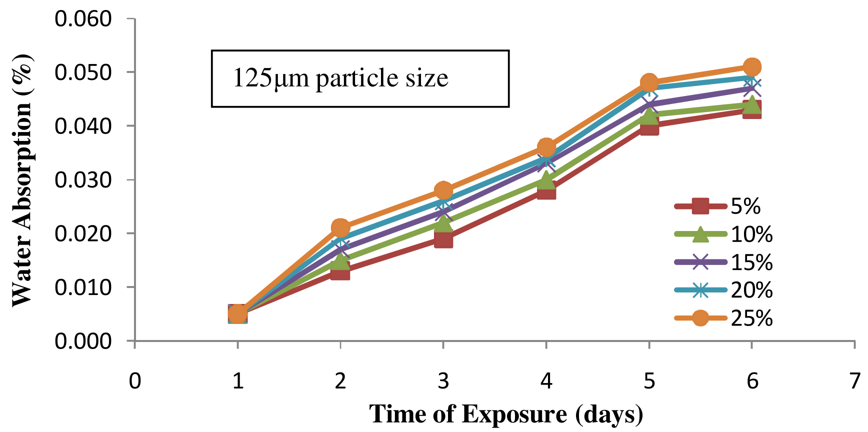

Fig 6. Effect of exposure time on the water absorption of egg shell powder filled LLDPE with different filler content

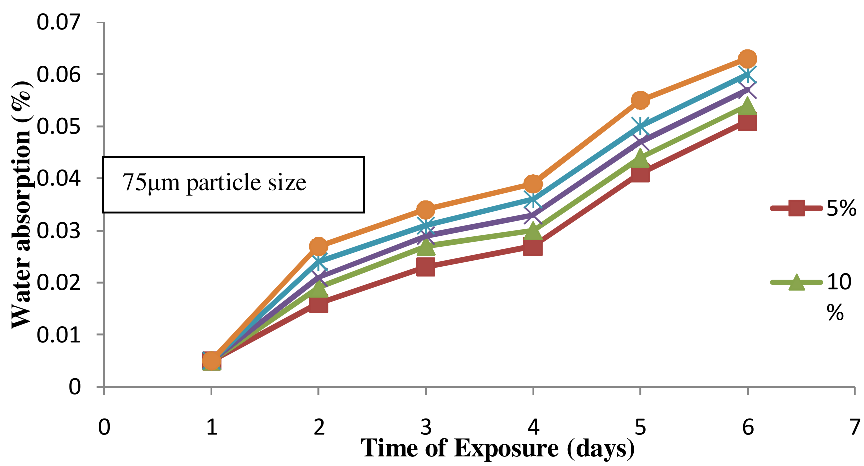

Fig 7:. Effect of exposure time on the water absorption of egg shell powder filled LLDPE with different filler content

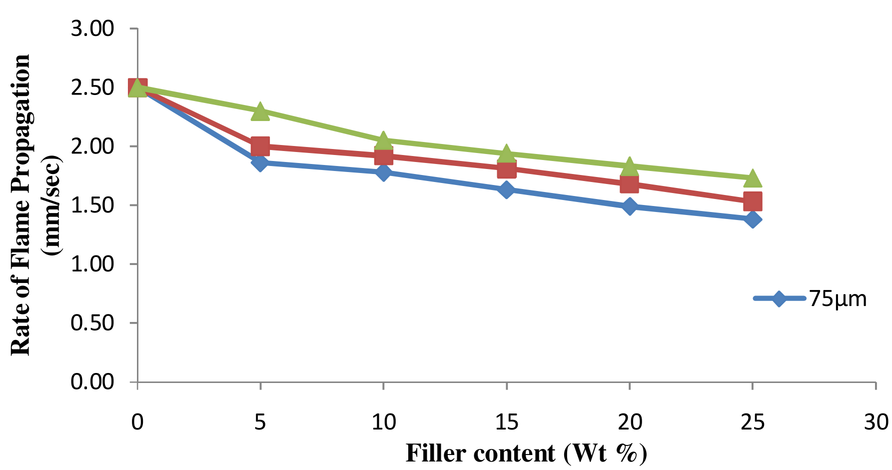

Fig 8. Effect of filler content on rate of flame propagation of egg shell powder filled LLDPE

CONCLUSION

The % elongation at break decreased as the particle size and filler content increased in all the composites investigated. The incorporation of egg shell into LLDPE improved the rigidity and dimensional stability of the composite. Water absorption properties of the composite as function of time exposure increased as the filler content. A significant improvement in the flame retarding property of the composite was found to increase with increase in filler content. It is clear that egg shell can change the properties of linear low density polyethylene based on its nature and morphology, and being extending filler. With further research and advancement in processing techniques, development findings in the areas of egg shell thermoplastic composites could lead to development of composite with better and enhanced properties.

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