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Effects of Particle Sizes, Filler Contents and Compatibilization On The Properties Of Linear Low Density Polyethylene Filled Periwinkle Shell Powder

[1*] S. C. Nwanonenyi, [2] M.U Obidiegwu, [3] G.C Onuegbu.
[1,2&3] *Department Of Polymer And Textile Engineering, Federal University Of Technology Owerri, P.M.B. 1526 Owerri, Imo State, Nigeria.*

--Abstract--

Thermoplastic composite was prepared from linear low density polyethylene and periwinkle shell powder (psp) of varying particle sizes (75μm, 125μm and 150μm) using injection moulding machine with and without compatibilizing agent and some its mechanical properties were studied. Maleic anhydride was used as compatibilizer, which act as interfacial agents between LLDPE and organic filler phases. The mechanical properties of filled linear low density polyethylene investigated were at filler loadings of 0 to 30 wt %. Also, the effects of particle sizes and compatibilizer contents (0.5 to 2.5 wt %) on some mechanical properties of the composites were investigated. The mechanical parameters investigated on the prepared composite samples include; tensile strength, elongation at break, tensile modulus, flexural strength, impact strength, and hardness. Experimental results showed that outstanding mechanical performance, especially elongation at break (lower values), and tensile strength, modulus, hardness, flexural strength, impact strength, (higher values) were obtained with increase in filler content and compatibilizer content at lower particle size.

Keywords: *linear low density polyethylene, periwinkle shell, maleic anhydride, compatibilizer, and mechanical properties.*

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I Introduction

The wide spread of plastic products in various applications has attracted greater attention due to their unique properties, which includes good mechanical properties, resistance to chemical attack and corrosion, ease of processing and recycling, cost effective, light weight, and others. However, these properties are affected by many factors such as stress, temperature and environment when plastics are exposed to service or during processing. In fact, this leads to vehement objection of plastics in some specific applications. The attempts to overcome these obstacles led to incorporation of fillers (inorganic and organic) into plastics with a view to obtained a plastic composite whose constituents act synergistically to withstand the challenges, thereby making plastics more reliable during use or processing. Generally, the composite properties are influenced by many factors such as filler characteristics, filler content, and interfacial adhesion and dispersion due to combination of more than one material (Addullah, Rusel and Abdulwahab, 2011). This can cause the performance of plastic composite to be different from the unfilled counterpart. In addition, the mechanism of polymer reinforcement by fillers is not yet fully understood, and is the subject of many publications in the scientific literature (Payne A.R. and Whittaker R.E., 1971; Leonov A.I., 1990; Donnet J.B, 1998).The use of organic fillers as property enhancement by way of filler initialization (Anyanwu, and Ogbobe, 2007) in the production of plastic composites is experiencing a chain growth in the plastic industries due to their renewable resources, biodegradability, low energy consumption, low cost of industrial economic importance, possibility of high filling level, high specific properties, and the growing global environmental concern. The major limitations to the use of organic fillers in reinforcing plastic are the high moisture absorption of the organic fillers, poor interfacial adhesion and dispersion between the plastic and filler, and low processing temperature permissible to organic fillers due to possibility of degradation or emission volatile substance that can affect properties of the composite (Rowell et al, 1999). Though, many coupling agents have been used in scientific reports to clear the doubts associated with the lack of compatibility between the hydrophilic organic fillers and hydrophobic polymers (Onuegbu, Madufor and Ogbobe, 2012).

The wide range of applications of filled polymers is becoming important commercially due to recent availability of modern devices that are capable of breaking down fillers into nanoparticles sizes (Igwe and Onuegbu, 2012). Periwinkle shell contains calcium carbonate as one of the major chemical constituents. It is a domestic waste and found littering many dustbins in our big cities, farm yards and markets in many coastal communities.

In scientific literature, the use of different biomaterials and compatibilizers in preparation of thermoplastic composites has been reported. For instance, researchers such as Liang, 2007; Arukalam and Madufor, 2011; Wang and Qu, 2006; Hyun and Han, 2006; Chun, Chung Cho, 2006; Rozman et al, 1999; Ewulonu and Igwe, 2011; Wenyi et al, 2006; Yuan et al, 2008, and others have made a tremendous impact in this field. Finally to the best of our knowledge, there is no report in the accessible literature dealing with studies on effects of particle size and compatibilization on the mechanical properties of linear low density polyethylene filled periwinkle shell powder using maleic anhydride as a compatibilizer.

II. MATERIALS AND METHODS

Materials

The linear low density polyethylene used in this study was obtained from Indorama Petrochemical Company Limited, Eleme, Rivers State, Nigeria. It has a melt flow index of 2.5 g/min and density 0.926 g/cm^3. The periwinkle shell powder (PSP) was obtained locally from Naze, Imo state, Nigeria and sieved to particle sizes of 75µm, 125µm and 150µm respectively. The compatibilizer (maleic anhydride) was bought from Sigma - Aldrich Cheme GmbH, Germany and was used as received.

Preparation of Composite Samples

The thermoplastic composite of linear low density polyethylene and periwinkle shell powder (of varying particle size of 75µm, 125µm and 150µm) was prepared by proper and thorough mixing of 200g of LLDPE with periwinkle shell powder contents of 0, 5, 10, 15, 20, 25 and 30 wt % for each composite samples without compatibilizer. Then, the resulting mixture of the composite constituents of each sample was melt-blended and homogenized in an injection moulding machine at 170^{o}C and the resulting composites were produced as sheets.In the second set of composites preparations, 200g of LLDPE with periwinkle shell powder content of 20% wt and compatibilizer contents of 0.5, 1.0, 1.5, 2.0, and 2.5 wt % for each composite samples were mixed, fed into an injection moulding machine and processed as stated above.

Mechanical Properties of Composite

The mechanical properties of the prepared composites were determined using standard method. Tensile stress-strain measurements were carried out using an Instron Universal Testing Machine according to ASTM D638 from which tensile strength, % elongation at break, tensile modulus were determined. Impact strength (ASTM D 256), Brinell hardness (ASTM D 785), and Flexural Strength (ASTM D 790).

III . Results And Discussion

Mechanical Properties

Tensile Strength The effects of particle sizes, periwinkle shell powder and maleic anhydride contents respectively on the tensile strength of filled linear low density polyethylene are presented in Figures (1 & 2). It is shown in these figures that the tensile strength of linear low density composites increased with increase in periwinkle shell powder filler and compatibilizer contents respectively for the entire particle sizes investigated. The increase in tensile strength with increase in filler contents is in agreement with the findings of Onuegbu and Igwe (2012) who studied snail shell powder/ polypropylene system and reported increases in tensile strength of polypropylene composite with increase in snail shell powder contents. Figures (1 and 2) also depict that the smaller the particle sizes of the filler, the higher the tensile strength of filled LLDPE. The experimental results envisaged better dispersion of the smaller sized filler in the LLDPE matrix, and good filler-matrix interaction may be the factors responsible for the trend observed in this study. This suggested that improved chemical and physical bondings within the composite expected from the maleic anhydride had better effect. At the entire particle sizes of the fillers examined, the order of increment in the tensile strength of filled LLDPE is 75µm > 125µm > 150µm.

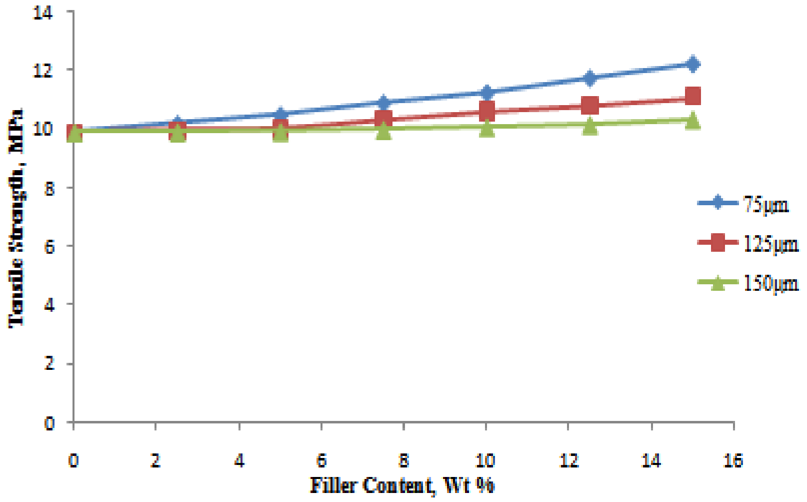

Figure 1: Plot of Tensile Strength versus Filler content

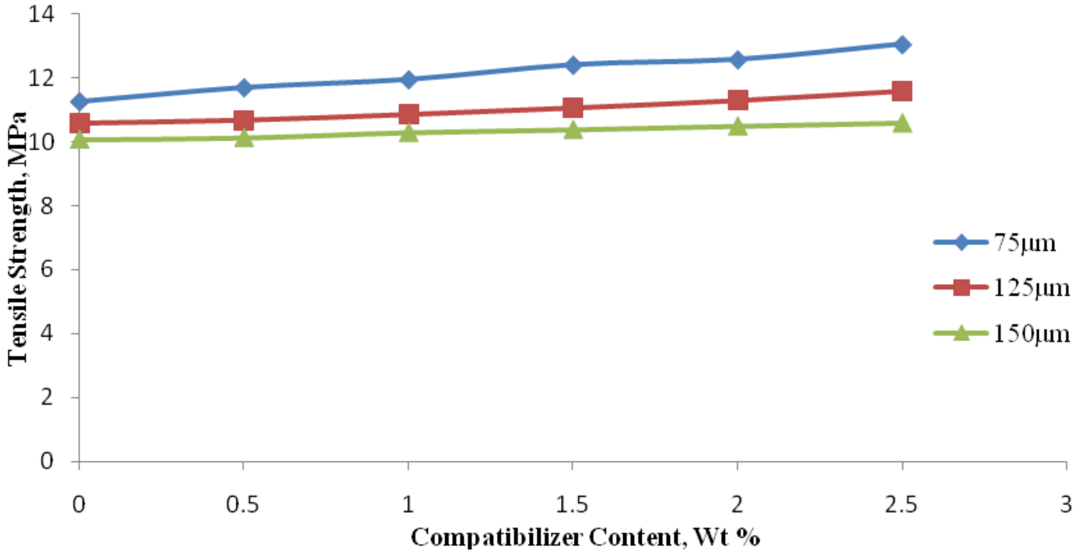

Figure 2: Plot of Tensile Strength versus Compatibilizer content at 20 %wt of Filler content..

Elongation at Break, % (EB)

Elongation at break (EB) is a measure of the ductility of a material. The data on elongation at break obtained for filled linear low density polyethylene at different particle sizes, filler and compatibilizer contents are illustrated in Figures (3 & 4). These figures show that the EB of filled linear low density polyethylene decreased with increase in the filler and compatibilizer contents at any filler particle size considered. Such a reduction in elongation at break of linear low density polyethylene composites on addition of fillers is line with findings of Onuegbu and Igwe (2011), Fuad et al (1995), and Basuki et al (2004). The experimental results show the reduction in the ductility of the composite with increase in both in the filler and compatibilizer contents respectively for the entire particle sizes considered due to increase in the deformation of a rigid interfacial interaction between the fillers and matrix. This indicates that the composite is tending towards brittle nature.

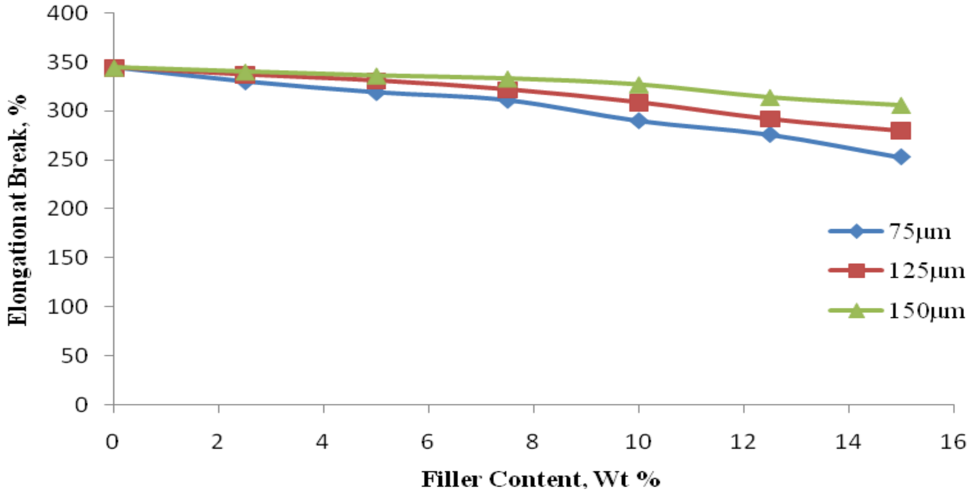

Figure 3: Plot of Elongation at Break versus Filler Content

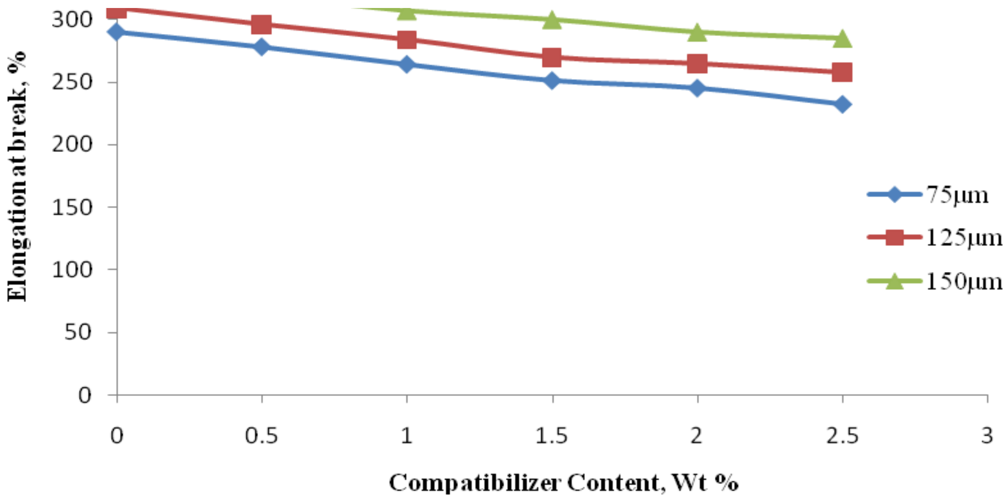

Figure 4: Plot of Elongation at Break versus Compatibilizer Content at 20 %wt of Filler Content

Tensi

Tensile modulus measures the stiffness of a material. The effect of the particle sizes, filler and compatibilizer contents on the properties of filled linear low density polyethylene are reported in Figures (5 & 6). It is observed from the figures that the modulus of filled linear low density polyethylene was higher than the modulus of unfilled linear low density polyethylene, and increased with increase in filler and compatibilizer contents respectively for all the particle sizes investigated. This experimental observation could be attributed to the fact that stiffness of the composite is improved on addition of filler and compatibilizer. Again, both the filler and compatilizer enhanced the properties of the matrix. The result obtained in this study conforms to findings of Onuegbu and Igwe (2011) who reported an increase in tensile modulus of polypropylene on addition of snail shell powder.

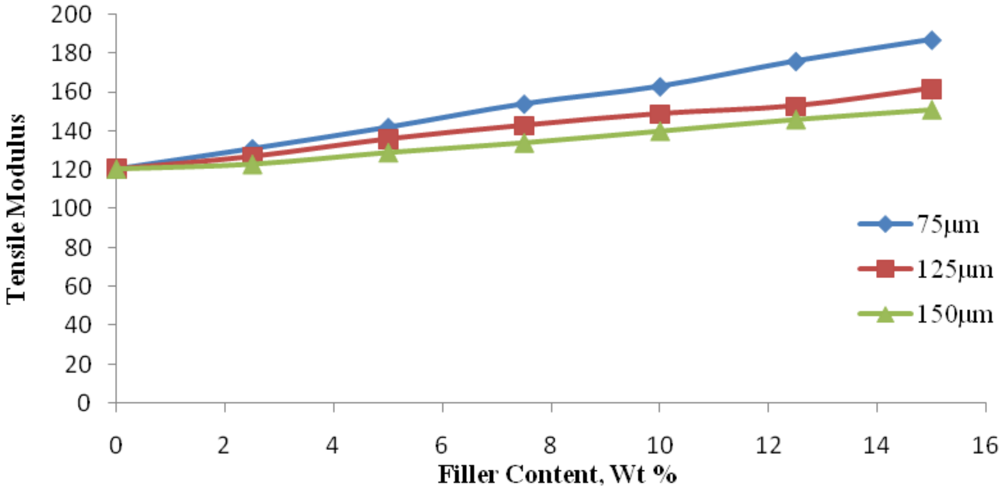

Figure 5: Plot Tensile Modulus versus Filler Content

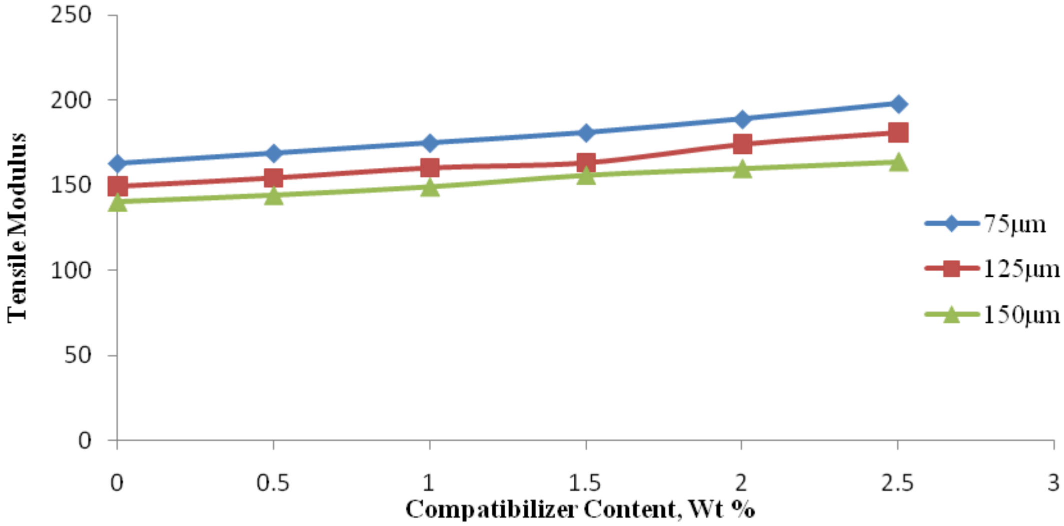

Figure 6: Plot of Elongation at Break versus Compatibilizer Content at 20 %wt of Filler Content

Impact Strength

Figures (7 & 8) depict the impact strength as a function of particle size, filler and compatibilizer content. The addition of periwinkle shell powder and maleic anhydride increased the stiffness of the filled linear low density polyethylene gradually with increasing filler and compatibilizer content respectively for all the particle sizes investigated. This suggests that the periwinkle shell powder added to polymer acts like a solid "additive" which stiffened the flexibility of the polymer and improves its ability to absorb and dissipate energy, thereby enable the composite to possess high impact energy to fracture. This experimental result is in agreement with the work of Guo et al (2005) who investigated polypropylene/carbonate system found that the impact strength of the composites increased at first with increase in filler content, and later, decreased with further addition of fillers. Similarly, it is in line with work of Bigg (1987) who studied the mechanical properties of particulate filled polymer composites and reported that increased in impact strength of a polymer composite with increase in filler loadings.

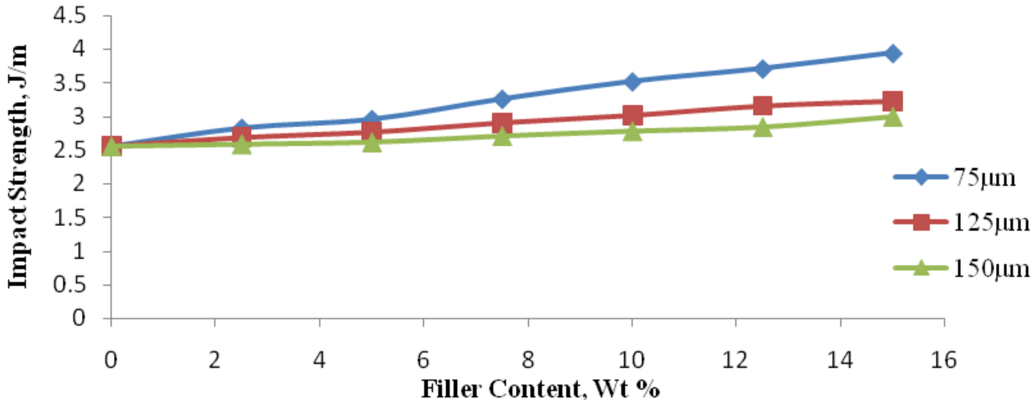

Figure 7: Plot Impact Strength versus Filler Content

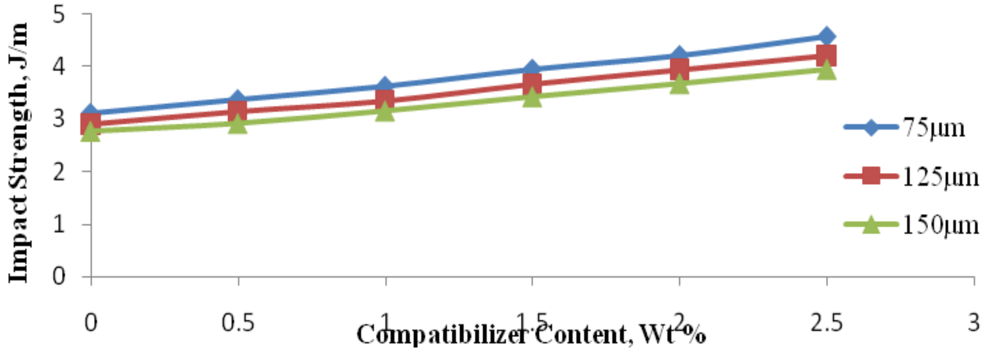

Figure 8: Plot of Impact Strength versus Compatibilizer Content at 20 %wt of Filler Content

Hardness

The effects of particle sizes, periwinkle shell powder and maleic anhydride contents respectively on the hardness of linear low density polyethylene composite are presented graphically in Figures (9 &10). It can be seen from the figures that hardness of the composites increase gradually with increase in contents of the filler and compatibilizer for all the particle sizes considered. From the result, it can be concluded that combination LLDPE and periwinkle shell powder in a plastic composite exhibit synergistic improvement in the hardness of the composite. This may be attributed to the fact that the addition of periwinkle shell powder into the plastic stiffened the elasticity and improved the matrix surface resistance to the indentation. At any particle size of the fillers investigated, the order in the improvement of hardness of linear low density polyethylene composites is 75µm > 125µm>150µm.

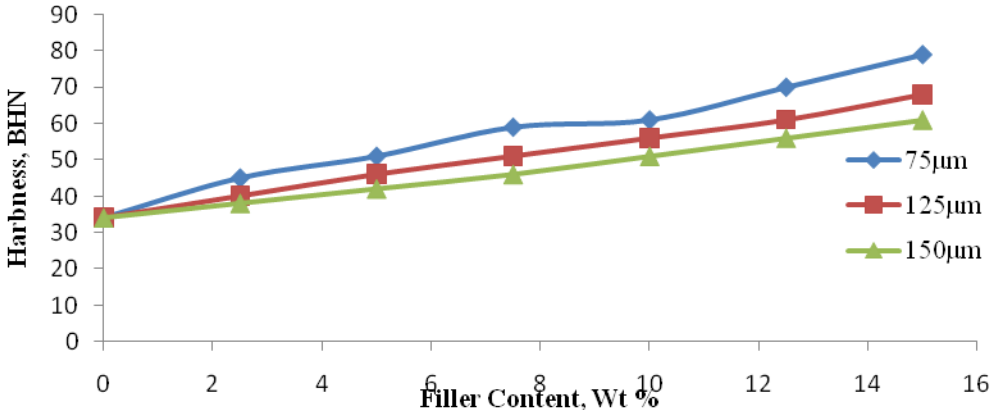

Figure 9: Plot Hardness versus Filler Content

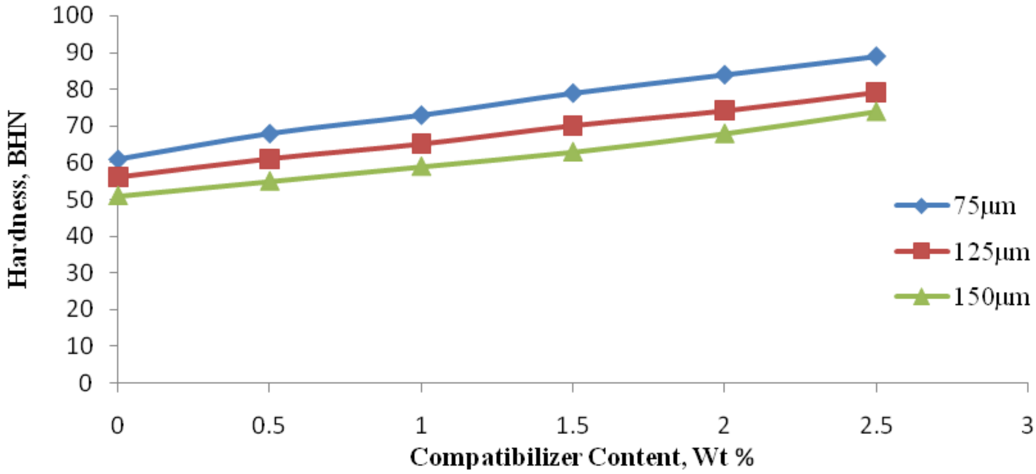

Figure 10: Plot of Impact Strength versus Compatibilizer Content at 20 %wt of Filler Content

Flexural Strength

The experimental data on the flexural strength of linear low density polyethylene composites are illustrated graphically in Figures (11&12). It is seen that at any particle size of the fillers considered, the flexural strength of the composites increased with increase in filler and compatibilizer contents respectively. These figures (11&12) also depict a general decrease in flexural strength of the composites as the particle size of the fillers increased from 75µm to 150µm. The order in the enhancement of the flexural strength of linear low density polyethylene composites at all filler particle sizes considered 75µm > 125µm>150µm.

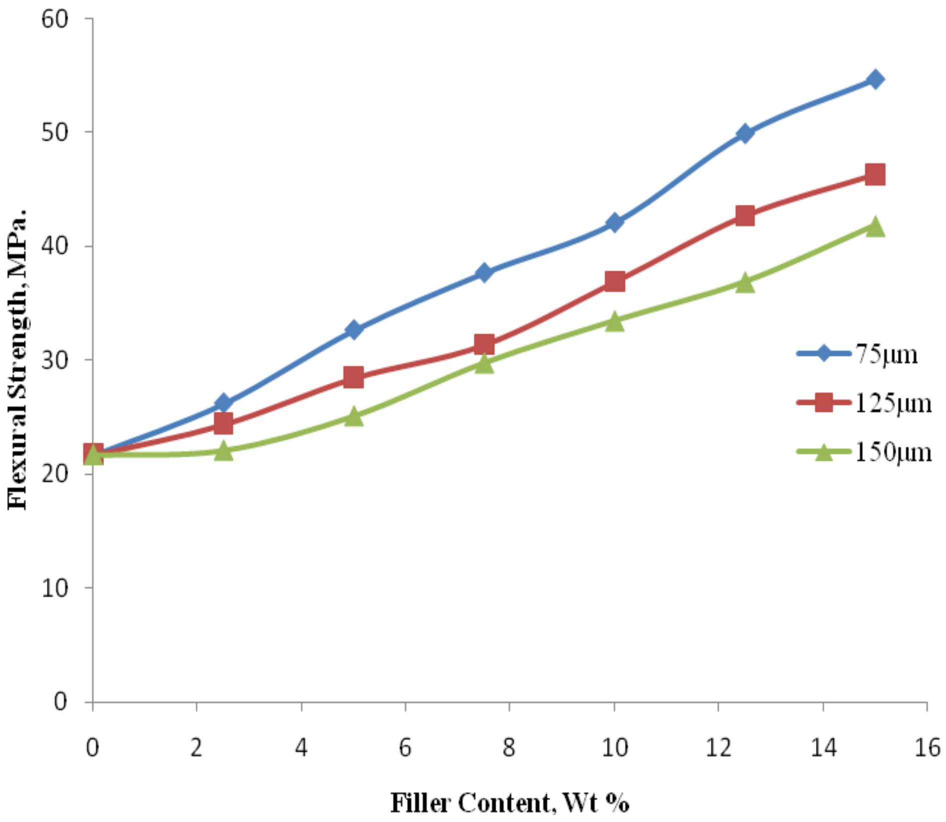

Figure 11: Plot Flexural Strength versus Filler Content

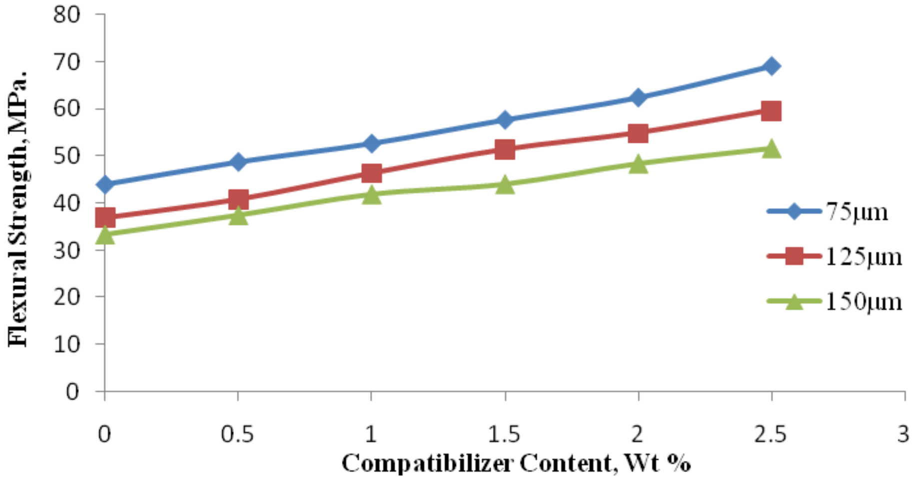

Figure 12: Plot of Flexural Strength versus Compatibilizer Content at 20 %wt of Filler Content

IV Conclusion

It is seen practically that preparation of thermoplastic composite using linear low density and periwinkle shell powder is possible. The tensile strength, tensile modulus, flexural strength, impact strength, hardness, and specific gravity of the linear low density polyethylene composite were found to increase with increase in filler and compatibilizer contents respectively, and decrease in filler particle size. The elongation at break of the prepared composites decreased with increase in filler contents, and particle sizes. Periwinkle shells are available in abundance, renewable, nontoxic, and their low cost are of industrial economic interest. The periwinkle shell fillers can serve as alternative to conventional mineral fillers like talc, asbestors, silica, mica and among others in plastic composite due to the growing global environmental concern and, the high rate of depletion of petroleum and mineral resources, as well as new environmental regulations demanding the search for the composite materials that are compatible with the environment. Generally, the level of property improvement observed in the tensile strength, elongation at break, tensile strength, impact and flexural strength and hardness shown by LLDPE composites is good. It is hoped that this present study will to help place the usefulness of periwinkle shell as filler in the compounding of thermoplastic in the plastic filler market in future and develop its niche in the scientific record.

References

[1]. Addullah A.H, Rusel D.S, and Abdulwahab A.S. (2011). J. Bas. Res (Sci), 37(3A), 36 -42).
[2]. Anyanwu P.I and Ogbobe, O., (2007). Int. Res. J. Engr. Sci. &Tech. 4(2) 177-183.
[3]. Arukalam I.O and Madufor, I.C., (2011). J. Aca. Res. Int. 3(5), 185 – 198.
[4]. Basuki W., Purboro G., and Hanafi I. (2004). Int. J. Polym. Mat. 53(4), 295 – 306
[5]. Bigg D.M. (1987). Polym. Comp. 6 (2). 115- 122.
Chun B.C., Chung C., and Cho B.G. (2006). J. Appl. Polym.Sci. 99, 1583 – 1589.
[6]. Donnet J.B (1998). Rubber Chem. Technol. 71, 323.
[7]. Ewulonu C. M. and Igwe I.O. (2012). Int. J. Eng. Technol. 3(6), 458-471.
[8]. Fuad M.Y.A., Ishmail Z., Ishak Z.A.M. and Omar A.K.M. (1995). Eur.Polym. J. 31(9), 885 - 893.
Guo T., Wang L., Zhang A. and Cai T. (2005). J. Appl. Polym. Sci. 97, 1154 -1160.
[9]. Hyun J.K. and Han S.Y.,(2006). Thermo. Act J. 45(1), 181 – 188.
Leonov A.I. (1990). J. Rheol. 24, 1039.
[10]. Liang J. (2007). J. Appl. Polym. Sci, 104, 1692-1696.
[11]. Machiadikwe G.C and Igwe I.O, (2011). Mat. Sci. and Appli, 2, 810 -816.
[12]. Onuegbu G.C. and Igwe I.O (2011). Mat.Sci.Appl. 2, 801 - 809.
[13]. Onuegbu G.C., Madufor I.C and Ogbobe O. (2012). Aca. Res. Int. 3 (1), 406 -412.
Payne A.R. and Whittaker R.E. (1971). Rubber Chem. Technol. 44, 440.
[14]. Rowell R. M., Sanadi A. R., Jacobson, R.E and Caulfield D.F (1999). Mississippi University, Ag.
[15]. and Bio. Eng., 32, 381 – 392.
[16]. Rozman H. D., Lim, P. P., Abusamah, A., Kumar, R. N., Ismail, H and Mohd Ishak, Z (1999). Int. J. Polym. Mat. 44 (1 & 2), 179 – 195.
[17]. Wang Q. and Qu J. (2006). Polym. Int. 55(11), 1330 - 1335.
[18]. Wenyi W., Xiaofei Z., Guoquan W. and Jianfeng C. (2006). J. Appl.Polym.Sci.100, 2875 – 2880.
Yua Q., Wu D., Gotama J. and Bateman S. (2008). J. Therm. Comp. Mat. 21(3) 195-208