



IMPROVED SOME PROPERTIES OF HIGH DENSITY POLYETHYLENE SYNTHESIS USING FIBER GLASS FOR PIPES AND RESERVOIRS APPLICATIONS

Najim A .Saad Ali A.Ameer Mays Sadiq mahmood
Polymers and Petrochemical Industries Dept / University of Babylon
College of Materials Engineering

ABSTRACT

In this paper, the effect of surface modification of short glass fiber on some properties of high-density polyethylene composite was investigated. The chemical treatment of short glass fiber (SGF) with solvent ethanol was achieved, and composites with weight fraction (0.5, 2.5, 4wt. %) were fabricated. Mechanical behavior tests include (tensile strength, impact, and hardness tests) and structure test (FTIR) were used. Values of mechanical tests for treated short glass fiber – reinforced High density polyethylene composites were much better than the neat high density polyethylene. The tensile strength value of composite from (37 to 41 MPa), impact strength from (83 J/m² to 100 J/m²), and hardness from (64 to 86 N/m²). Result of FTIR test showed physical reaction without the formation of new peaks.

KEYWORD : High density polyethylene, Short Glass fiber, Tensile strength, Impact, Hardness

تحسين بعض خصائص البولي اثيلين عالي الكثافة باستخدام الألياف الزجاجية لتطبيقات الأنابيب والخزانات

نجم عبد الامير سعيد علي عبد الامير ميس صادق محمود

الخلاصة :

في هذه البحث ، تمت دراسة تأثير معالجة سطح الالياف الزجاج القصيرة على بعض الخواص للمواد المركبة والمقواة بالألياف الزجاج المعالجة. تمت عملية المعالجة الكيميائية لألياف الزجاج القصيرة باستخدام مذيب الايثانول، وتم تصنيع المواد المركبة مع نسب وزنيه (0.5, 2.5, and 4 wt. %). تم استخدام فحوصات الميكانيكية تشمل (معامل المرونة، الصدمة والصلادة) والفحص التركيبي (FTIR). كانت قيم الفحوصات الميكانيكية لعينات المواد المركبة المقواة بالألياف الزجاجية القصيرة المعالجة اعلى من قيمتها للمادة البولي اثيلين عالي الكثافة. قيم معامل المرونة لعينات المواد المركبة من (37 MPa الى 41 MPa) ، متانة الصدمة من (83 J/m² الى 100 J/m²) ، و الصلادة من (64 N/m² الى 86 N/m²). أظهرت نتيجة فحص FTIR حدوث تفاعل فيزيائي دون ظهور قمم جديدة.

INTRODUCTION

The composite materials are classified according to Matrix and dispersed phase where polymer composite materials are one of the important materials in the industry. It is the biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes, Bruce et al. [2005]. The polymer can be modified by reinforcing it with various types of reinforcing materials such as fibers, particles and other fillers, and chemical and mechanical stability enhancers that have stable characteristics such as titanium, dioxide, alumina, etc., Bosco et al. [2016]. Fillers, in the form of particulates and short fibers are often added to polymeric materials to enhance their process ability and mechanical compound properties, as well as to reduce material cost, Arambakam et al. [2013]. smaller fillers can provide higher tensile and flexure strength, due to increased contact surface area provided by the fine particles, increased stress is transferred to the filler. In contrast, larger particles contribute to larger cavities, which eventually decreased the tensile strength of specimens, Wan et al. [2015]. Fiber-reinforced polymers are increasingly becoming potential candidates for replacing conventional materials due to their many advantages. The main advantages are their low cost, renewability, biodegradability, low specific gravity, abundance, high specific strength, lightweight and stiffness, Hemanth et al. [2014]. Resistance to craze initiation and slow crack is improved by selecting glass fibers (GF) are the reinforcement agent most used in thermoplastic-based composites, as they have good balance between properties and low costs. However, high tensile strength, high chemical resistance, and excellent insulating properties, Maadeed et al. [2013]. Glass fibers are low cost, high tensile strength, lightweight, flexible, high chemical resistance, and excellent insulating properties and disadvantages are relatively low tensile modulus and high density (among the commercial fibers), sensitivity to abrasion during handling (which frequently decreases its tensile strength), relatively low fatigue resistance, and high hardness (which causes excessive wear on molding dies and cutting tools), all glass fibers have a similar stiffness, but different strengths and resistance to environmental degradation, Rajesh et al. [2010]. Glass fiber reinforced plastic (GFRP) was widely adopted to reduce the weight of the vehicle structure and replacement of conventional materials with GFRP composites into specific vehicle zones, such as roof, floor segment, body panels, frame parts, and seating systems, allowed weight reduction from 40% to 60% and best performance, E-glass has the lowest cost of all commercially available reinforcing fibers, which is the reason for its widespread use in the FRP industry. E-glass fibers are used when high tensile strength and good chemical resistance are required, which makes these fibers a preference in structural applications because of their good mechanical performance, corrosion resistance. When composite materials reused extensively in storage water tank and pipe application the optimum material for this industrial is polymer thermoplastic matrix from specifically high density polyethylene, Waigaonkar [2008], Kihila [2014]. This offered advantages compared to more traditional materials such as good ability to environment resistance such as erosion wettability and temperatures. Easy to processability and design composite parts into complex shape with huge volume and good fatigue durability, Amin [2017]. HDPE is easy to process of manufacturing solid, its resistance to chemicals and a common material used for storage water tanks have a maximum storage temperature of 130 F°. It is in base insulator materials, cheap and maintaining thermal stability resulting from the existence of glass fiber which acts as thermocouples to dissipate heat, ultraviolet light stabilizers are usually added for use in outdoor applications, Khoshravan and Khalili [2015]. High-Density Polyethylene reinforced with glass fiber used in piping are used to carry

potable water, wastewater, and slurries Offers High Safety and Reliability Even at low Temperatures , Masilamani [2016]. Sami [2012] discussed the enhance the mechanical properties of polypropylene with glass fibers reinforcement. It was found the value of Impact strength increased and compressive strength will increase with increasing percentage of reinforcement. The effect of high-density polyethylene with glass fiber filler composite on improvement the hardness property of composite is defined as; Khalaf [2015] presented the resistance of a material to deformation. This study aims to understand the role of treated short glass fiber with ethanol solvent in improving structure and mechanical properties of composite.

EXPERIMENTAL

Materials Used

The type of HDPE used in this study has the properties commercially available HDPE granules supplied from Amir Kabir Petrochemical Company (Iran) .The commercial name of the HDPE is "HD-52518". HDPE, melt flow index (MFI) was (190°C/2.16 Kge, 18 g/10min), Density was 0.952 g/cm³. E-glass fiber was used to reinforce the high-density polyethylene matrix supplied as a Woven Roving (0°/90°).

Sample preparation

Composite of glass fiber and polymer matrix are prepared by chopped glass fiber into length 10 mm by hand, shown in **Fig.1**. Weighted in the required weight fraction (0 ,0.5, 2.5, and 4 wt.%) respectively according to ratio of high-density polyethylene. Short glass fiber were heated at 110 °C for 60 min. in oven to release of humidity then treated with ethanol solvent at 30 °C for 15 min and dried at 80 °C in oven. The procedure of preparing HDPE composite consisted of mixing the HDPE grains with the treatment chopped glass fiber and the result mixture was molten in rotating twin screw extruder at constant temperature (190 -200) °C and constant speed (20 rpm).

Microstructure measurement

Fourier Transform Infrared Spectra (FTIR) analysis

Fourier transform infrared spectra technique is used for the characterization of very complex mixtures by FTIR analysis instrument type (IR Affinity-1) made in (Kyoto Japan), which is available in laboratory of Materials Engineering collage /University of Babylon in order to measure a sample. Calibrate the device using the KBr, and then prepare powder of the sample to be examined, and mixed with KBr (mixing ratio 99% KBr). The mixing processes achieved thoroughly then pressed as tablet-shaped semi-transparent to the possibility of penetrating radiation.

Mechanical measurement

Tensile Test

Instron 5556 Universal Testing Machine type (WDW/5E) used to perform tensile test according to ASTM D-638-IV standard test, ASTM [2007]. HDPE and (HDPE +0.5, 2.5, 4 wt. %) glass fiber are tested and the mean values were considered, shown in **Fig.2** . Before loading the specimens putting in the instron machine, the computer system is connected to the machine, which was set up by inputting the necessary information of gauge length and width of the specimen, and then the test starts by applying specified load (5KN) and the cross head speed was 5 mm/min. The results, which have been obtained directly from this test, are (stress-strain) curve and tensile properties such as tensile strength.

Impact Test

Impact test of HDPE and (HDPE +0.5 ,2.5, 4 wt. %) glass fiber were performed according to ASTM D-256 standard test , ASTM [2007] by using CEAST Resil impact German, gant (HAMBURG) company; model WP 400 charpy type instrument. The tests were performed at room temperature, Shown in **Fig.3**. In this test, each value of the energy represented the average of two samples. The HDPE composite specimen were fixed in a cantilever position. Then the pendulum arm strokes the HDPE specimen. The energy absorbed by the specimen in joule unit.

Hardness Test

The hardness test samples prepared according to ASTM D- 2240 standard test , ASTM [2007] by using Chinese Hardness Device(Model TH 200), Department of Polymer and Petrochemical Industries/ College of materials Engineering/ Babylon University) to measure hardness of pure HDPE and (HDPE +0.5 ,2.5, 4 wt. %) glass fiber , each value reported was average of five samples.

RESULTS AND DISCUSSION

FTIR Test

FTIR spectrum of HDPE and HDPE with (0.5, 2.5, 4 % wt.) SGF in **Fig.4**, show their absorption band. FTIR test for high-density polyethylene shows many bands such as the bands at 2921 and 2849 cm^{-1} for (C-H stretching), the band at 1465 cm^{-1} for (CH_2 bending), The band at 720 cm^{-1} for (CH_2 rocking) agree with , Mohamed et al . [2015]. It can be seen that the FTIR spectra of pure HDPE, (HDPE+0.5, 2.5, and 4% wt.) composite that recorded at room temperature show no shafting for new bond formation or interaction occurring between the HDPE and short glass fiber confirming that there are no chemical bonds or any chemical interaction between the HDPE and glass fiber but just a physical interaction, This agreed with, Muhammad et al. [2016].

Tensile Strength

The result as shown in **Fig.5**, that with increase addition of glass fiber increase tensile strength of pure HDPE due to the strong interfacial bonding between fiber and plastic matrix, which led to an increase of the composite tensile strength as fiber content increased which avoid the stress concentration formed around the SGF fiber in the stressed composites . This increase to the restriction imposed by fibers on the molecular movement or the deformation of the matrix and on the contrary decrease in other weight fraction because of poor homogeneous structure with pulled – out glass fibers in smaller amount indicating poor bonding with matrix. Similar conclusion was revealed with, Shalwan et al. [2013].

Impact Strength

The result as shown in **Fig.6**.The incorporation of SGFs increase in impact strength compere to the neat HDPE. The maximum impact strength with increase addition of short glass fiber this is due to increase of crystalline level of virgin HDPE. This improved result from the strong bond between the fibers and the HDPE matrix that lead to adsorption of impact energy, on the contrary decrease in other weight fraction because of poor interfacial adhesion between the filler and matrix, this agree with , Saeed et al. [2014].

Hardness Test

The result as shown in **Fig.7**, the hardness improved by adding treated glass fiber to the HDPE. This is because of better interfacial adhesion, and this adhesion increases the hardness of HDPE. With increase addition of SGF increased in hardness of the pure HDPE. This is good result agree with, Alkan et al. [2013].

CONCLUSIONS

In this study, composite materials from treated short glass fiber (SGF) with ethanol solvent treatment and high-density polyethylene were fabricated. The mechanical properties (Tensile strength, Impact, and hardness) and structure properties values of composites were measured. The mechanical and structure properties values are highly affected by the surface modification .of SGFs.The composite reinforced by treated SGFs had the maximum tensile strength of 41 MPa, impact strength 100 J/m² , and hardness 86 N/m² at 4 % improvement compared to the neat high density polyethylene. The result of FTIR test showed physical reaction without the formation of new peaks.



Fig.1 Fiberglass Chopped Stands 10mm.



Fig.2 Experimental Tensile Specimen.



Fig.3 Experimental Impact Specimen.

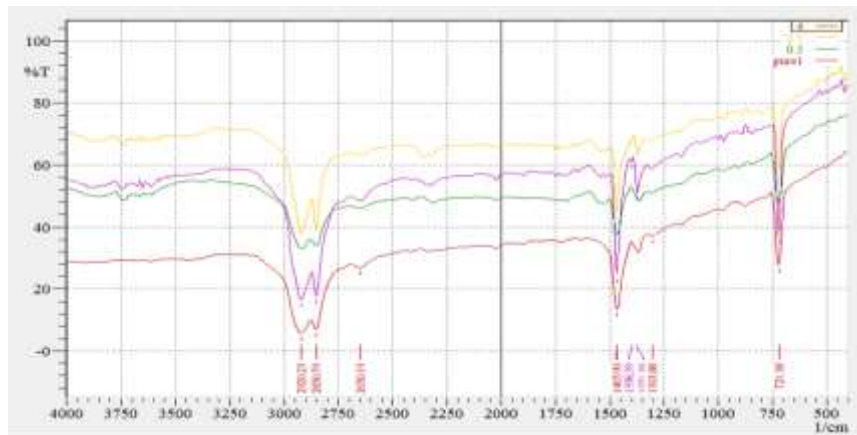


Fig.4 FTIR spectrum of pure HDPE and composite with (0.5, 2.5,4 wt.%).

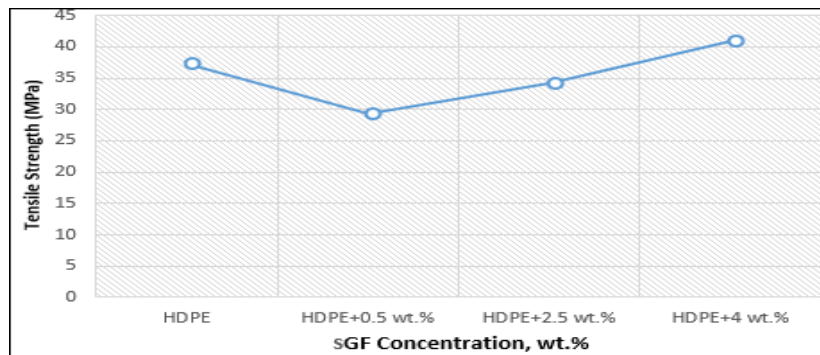


Fig.5 Tensile strength of HDPE Reinforced with SGF composite.

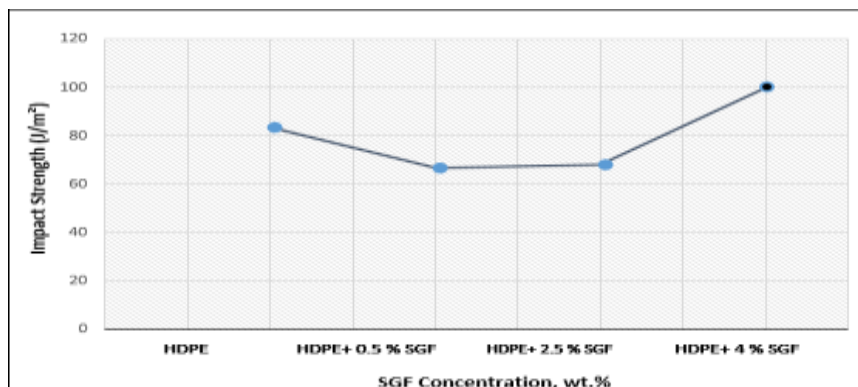


Fig.6 Impact strength of HDPE Reinforced with SGF composite.

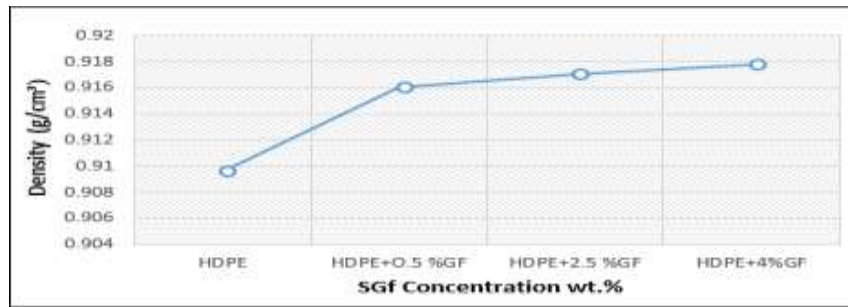


Fig.7 Hardness of HDPE Reinforced with SGF composite.

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