Effect of Fly Ash Based Geopolymer Reinforced Low Density Polyethylene (LDPE) Composite

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Abstract. Composite is commonly used today attributed to the distinctive characteristics that can be acquired from the mixture of the components in them. However, as time passes on, our globe is heading towards providing green technology for the sector to use environmentally friendly methods. In this study, Fly Ash geopolymer is used as filler, in the production of LDPE / FA composite, to be inserted in a low-density polyethylene matrix. To enhance bonding between the fly ash filler and the LDPE matrix, alkali activator therapy with the use of sodium hydroxide and sodium silicate at the molarity of NaOH is in range of 12M and the ratio for fly ash to alkali activator is about 2.0. In this research properties of these composites are investigate using tensile test, morphology analysis, thermal properties and infrared spectrum analysis, FTIR. The result found that the tensile strength and modulus of elasticity of the composite increased with increasing of filler loading but the percentage of elongation decrease due to filler loading increase while fly ash filler show the interfacial adhesion on LDPE matrix as evidenced by images of scanning electron microscopy (SEM) and this also proved by FTIR spectra explain that LDPE/FA charged with SiO which is fly ash composed with silica. Moreover, thermal properties explain that fly ash interface reaction which can change to amorphous crystallization during the temperature increase.

1. Introduction

Composite is one of the most flexible engineering products in the sector of material science and technology for produced this fascinating and gorgeous material while the composite is disparate and is formed by a convention of two or more filler-or strengthening-fibre components and a compacting matrix. The matrix can be composed of plastic, steel or ceramic. The composite matrix is created by toleration of the environment, surface dimension, and its resilience during the fibrous phase. from that, reinforcement conveys the great majority of the basic load through strength and macroscopic stiffness [1]. A composite may establish prevailing physical and mechanical properties, because it incorporates the most important characteristics of the element, thus weakening its least desirable characteristics. In the automotive industry, the aerospace industry and other engineering fields, actually composites play a key role because they demonstrate an extraordinary ratio of strength to weight and weight unit. Due to their use in aerospace engineering and space vehicles, a wide range of high-production rigid composites manufactured from steel, boron, Kevlar, graphite or silicon carbide fibres are considered [2]. Previous research reported that a composite material can satisfy the idea of biodegradability and have good compressibility coupled with excellent resistance to tensile. Composite fabrics usually
consist of two parts which are matrix and filler to make them adaptable in wide position space. The filler is known to be reinforcing, while the matrix integrates the particles of the filler and also allows proper shaping of the material. Similar to a ceramic matrix and a composite metal matrix, the polymer matrix material is the most widely developed plastic, known as a resin solution [3-6]. Fly ash regarded as the intently separated material resulting from the burning of floor or powdered carbon and transferred by flue gasses from the storage area to the chip extraction scheme [7, 8]. By applying geopolymer system in this area, fly ash can functions as a raw substance. This is because fly ash mainly consists of a glassy spherical and hollow particle during electricity production and also generally highly heterogeneous with a crystalline phase such as quartz, mullite, and various iron oxide [9-14].

2. Experimental

2.1 Materials
The LDPE that used was manufacturing from Lotte chemical Titan (M) Sdn Bhd. The fly ash used as the reinforcement for LDPE / FA composite was purchased from the Cement industry of Malaysia Berhad (CIMA). The fly ash that used is class C and sodium hydroxide, sodium silicate using as alkaline activator

2.2 Methods
The alkali solutions consist of sodium hydroxide (NaOH) and sodium silicate (Na₂SiO₃). Sodium hydroxide and sodium silicate were mixed in a volumetric flask with molar concentration of 12M and cooled up to room temperature (30°C). An alkaline activator with a combination of NaOH and Na₂SiO₃ was prepared just before mixing with fly ash to ensure the reactivity of the solution [15, 16]. The mixture of sodium hydroxide and sodium silicate was stirred until form a homogenous to form alkaline activation solution.

This mixture basically as a function to activate the fly ash and speed up the chemical reaction between fly ash and sodium hydroxide. Then, fly ash and alkali activator were weighed accurately before undergoing mixing process. Then, the fly ash geopolymer is added in alkali activator solution and stir them together until the achieve homogeneity. After that, the paste is rapidly poured into the plastic tray. Fly ash paste was cured at room temperature and change into a solid form which is harder as cement. The crushing process proceeded to crushed a fly ash filler into a piece’s form by using a jaw crusher to make the grinding process easier and finally after the grinding process the fly ash filler turn out to rough particle. To obtain an excellent fine powder the sieving process at 75μm continued to 5 minutes which the rough particle was a trap at the top of the sieve pan and the process rapidly run. After the raw material weighed to the needed amount, the material was compounded to 5, 10, 15, 20 and 25 phr (per hundred resin). Low density polyethylene. (LPDE) was compounded with the fly ash filler according to the formulation. After that, the material was placed into extrusion hopper to produce LDPE/FA composite pellets and finally the material was placed to injection moulding to produce a dumbbell shape. Apart from the, tensile properties each of sample with different parameter was obtained from the tensile test by using Shimadzu’s 50KN AG-X plus series universal tester equipped with trapezium X software. Young modulus, elongation, and tensile strength at break will be obtained from the tensile test graph result. For morphological studies, all samples were characterized using Scanning Electron Microscope. In the field of material science, morphology studies include the shape, size, texture and phase distribution of physical objects. The morphologies of the materials used in this research were determined using a JEOL JSM-6460LA scanning electron microscope (SEM).

3. Result and discussion
The tensile strength of the LDPE/FA Composite. In this case, the tensile slightly increases due to the addition of fly ash filler from 5phr to 25phr filler loading. This result was caused by the fly ash filler
that resists the crack propagation in the structure of the composite [17, 18]. This has been reported by Prakash Mahanwar that the filler can make the composite stronger in terms of tensile properties. This was explained when the strength and stiffness of fiber is much higher than pure LDPE was because of the high configuration on neck region of molecules while under the high strain this was reported by Iftikhar Ahamad (2015). However, as can be seen in figure 1, the value of tensile strength of 20phr and 25phr LDPE/FA composite dramatically decrease this was caused by poor interfacial bonding between the matrix and the filler while comparing to 15phr LDPE/FA Composite the tensile strength was higher due to the relationship of the strength between matrix and fiber improved [19].

Figure 1. The tensile strength of pure LDPE and LDPE/FA composite with different loading

FTIR spectra of the pure LDPE and LDPE/FA composite. There were several regions which the difference can be seen. The absorption band at 2914.16cm⁻¹ and 2929.15 cm⁻¹ for pure LDPE and LDPE/FA represent the stretching of the C-H. The absorption band at 2827.58cm⁻¹ and 2839.22cm⁻¹ of pure LDPE and LDPE/FA even rather but still assigned to C-H stretching. The spectra at 737.62cm⁻¹ for LDPE/FA composite explain due to C-H banding this was reported by Merrouche (2013) that most of the pectin and lignin was removed which was resulting on rougher surface. This explained why LDPE/FA composite possess higher tensile strength. Moreover, the absorption peak band reduced from 1473.41cm⁻¹ to 437.20cm⁻¹ in LDPE/FA composite when compare to pure LDPE were due to Si-O. Previous research were reported that below 500cm⁻¹ specifies the Si-O-Si and O-Si-O bond bending vibrations cause of adding more fly ash filler [20-23]. This caused the tensile strength of LDPE/FA composite became higher than pure LDPE.

Figure 2. FTIR Spectra of pure LDPE and LDPE/FA composite.
SEM micrographs of tensile fracture surface for pure LDPE, LDPE/FA composite at 5phr, 15phr and 25phr and the particle size of Fly ash filler. The tensile fracture surface morphology for pure LDPE shows ductile rough lines. This was due to the natural properties of the LDPE that have branches and these also provide that polymer possess the ductile characteristic.

![Figure 3. SEM micrographs images of tensile fracture surface for pure LDPE, LDPE/FA composite at different loading of filler and fly ash filler at 200x magnification](image)

The tensile strength of 15phr LDPE/FA composite undergo the aging process with a different temperature that started with 50°C, 70°C and 90°C. The value of 15phr LDPE/FA composite increase gradually due to temperature even after an exposure time of 3 days. According to Shabu Thomas (2014) that these results indicate probably due to its improved interfacial adhesion, the thermoplastic composite heating will significantly improve for a very brief period near its temperature reduction.
4. Conclusion

From the result of the tensile test, the tensile strength of the LDPE/FA composite increased when the FA reinforcement added into the LDPE matrix. Moreover, the modulus of elasticity also increases due to interfacial adhesion. In this case, elongation at break reduces during the expansion of filler on the LDPE matrix which was known that pure LDPE reaches plastic deformation before the fracture this is because of long branches polymer chain in LDPE. Besides, adding more filler such as 20phr and 25phr LDPE/FA composite at tensile result can see that tensile strength dramatically decrease due to enlargement of filler fraction. The FTIR analysis explain that decrement on absorption intensity ratio due to adding of more filler on LDPE matrix can cause chemical interaction. Besides that, in morphology analysis explain that the structure of pure LDPE/FA composite is better interfacial adhesion and at the same, the particle size of fly ash also has been shown in this analysis which was contained with pore and geopolymer binder. From the thermal analysis we can observe that fly ash can improve the mechanical behaviour during the temperature increased can reduce the pore size and phase characterization in terms of amorphous and crystalline.

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