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Assessment Study on the Mechanical Behavior of Polyester – Fiber Composite Laminates Filled with Waste Tire Rubber Particles

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Abstract

In the present study, A composite of polyester – fiber with the addition of rubber particles resulted from the recycling of wasted tires of railway vehicles, Coupled with the fast development of the automobile industry. The advantage of the developed product is being a solution for one of the most modern environmental challenges beside that it is economical and environment friendly. This developed composite can be used in many applications like car bodies specially in automotive bumper and in the aviation and marine industries. Different particles sizes range 20 mesh, 40 mesh, 1-3 mm and 3-5 mm were used in the present work to possess their variation effect on the mechanical behavior of the novel composite. Generally, addition of waste tire rubber led to decrease of tensile properties. This was accompanied with poor adhesion between waste tire rubber and polymer matrix at interface. It was observed that the size of waste tire rubber particles has an inversely relation to the tensile strength of the developed composite, Also the impact toughness shows better and tangible progress as the particles size increases till 40 mesh size then slightly decreases. All the mechanical testing were done according to ASTM standard.

Keywords: Polyester, Fiber-Reinforcement Composite, Rubber/Polyester Composites, Mechanical Behavior, Recycling, Particle Size.

1. Introduction

Solid waste management is an urgent problem that is faced now-a-days. Waste tires are one of the major issues as they do not derogate which results in environmental problems. Therefore, a big effort is devoted to seeking profitable and eco-friendly solutions for the recovery and reuse of wasted tires [1,2]. An effective recycling approach hope to add waste tires into polymer composites laminates to produce value-added products for various applications.

Polymers (thermoplastics, thermosets, and rubbers) are involved in numerous applications but mainly the thermoplastics polymers used as a base for waste tire rubber composite giving the flexibility from the rubber phase and reprocess ability from the thermoplastic resin [2]. Thermoplastic elastomer composite to be a solution to utilize the waste tire rubber in thermoplastics. Variation of particle size of waste tire rubber and the volume friction of the added waste tire as a filler have an influence on the mechanical properties, also the properties may differ depending on whether the product is injection molded or compression molded [3].

Colom et al. [4] observe a decrease in tensile modulus of approximate 25% when only 20 wt.% waste tire rubber was added to HDPE. Tantayanon and Juikham studied the impact strength of a PP/Waste tire rubber blend containing 420 µm, 1.2 mm, and 2.4 mm sized particles [5], and it was that only the smallest particle size results in a significant increase in impact strength (20%), while the other two larger particle size composites only show a minor improvement. Ismail et al. [6] reported that particle size <500 µm has better mechanical properties compared to bigger size. K F Abo Elenien et al. [7] concluded that the Impact strength of polyester and recycled rubber composite increased by 23% at 50 vol.% of waste tire rubber particles while the yield strength and strain up to yield increased by 10% and 63 % at 10 vol.% of waste tire rubber particles respectively. However ultimate tensile strength decreased with the increase of waste tire rubber particles vol%.

2. Materials and Methods

2.1. Material

Unsaturated polyester resin was supplied by SUNPOL, Turkey, with density 1.23 g/cm3. Particles size of 20 mesh, 40 mesh, 1-3 mm and 3-5 mm of recycled rubber particles were supplied by HOPPEC company, Egypt, of average density 0.4 g/cm^3. Fiberglass was supplied from Jushi Chinese-Egyptian company, product no. E01 of area weigh 300 g/m2 and roll width of 1524 mm.

Composite preparation done in layers as shown in table 1, with following steps

1. For the needed tensile and impact specimens, standard dimensions were employed to construct a silicon rubber mold.
2. Polyester resin was weighed to the desired volume fraction and degassed for 5 minutes in a vacuum container.
3. The hardener was added as specified by the supplier, and the mixture was degassed in the vacuum chamber for 3 minutes.
4. Pour the mixture into a silicone rubber mold and leave it aside to harden and solidify.
5. Step 2 was repeated, followed by the addition of rubber particles powder, followed by steps 2 and 3.

6. Place the fiber glass material according to the specimen's dimensions and repeat steps from 1 to 3.

Table (1) list of composite laminates.

Layer 1	Polyester resin 28.3 % of total composite’s volume.
Layer 2	Rubber particles 10 % of total composite volume mixed with another 28.3 vol. % of total composite polyester.
Layer 3	Fiberglass material with another polyester resin 28.3 % of total composite’s volume.

2.2. Tensile Test

Tensile tests were carried out, for the composite’s specimens, using Shimadzu UH-200KNA universal testing machine, Japan. Tensile test was carried out at room temperature using constant cross head speed of 2 mm/min, The specimen dimensions are shown in Fig. (1), The tensile tests were performed according to ASTM D 3039 / D 3039M [8]. The specimen of tensile test prepared in silicon mold shown in fig. (2).

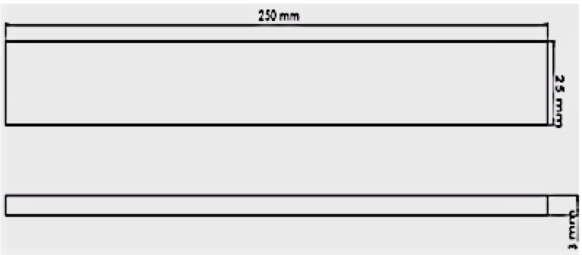

Fig. (1) Dimensions of the tensile test specimen.

Fig. (2) The tensile test specimen.

2.3. Impact Test

Charpy impact tests were performed to evaluate the impact toughness of the specimens at room temperature using JB-300B impact tester from Jinan Shijin group corporation, The impact specimens have V-notch and have the dimensions of 2.5 mm. The notch was machined in the specimens using notch cutter machine. The dimension and shape of specimen are shown in figures 3 and 4 respectively. The performed impact test is done according to ASTM D 6110-04 [9].

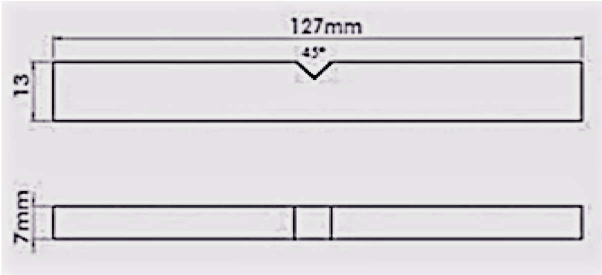

Fig. (3) Impact test specimen dimensions and notch position.

Fig. (4) Impact test specimen.

3. Results and Discussion

3.1. Tensile Test

Typical stress strain curve shows the decrease of ultimate tensile strength with the increase of waste tire rubber particle size, with the decrease of strain up to failure, as shown in Figure 5.

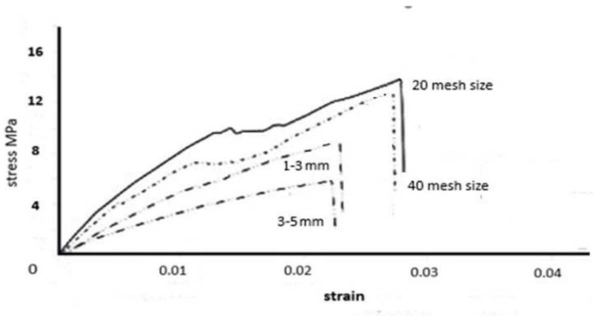

Fig. (5) Stress strain curve.

The tensile characteristics usually decline with increase of rubber size. This was accompanied by poor interface adhesion between tire rubber and the polymer matrix. Because of the poor contact, there is a lot of interfacial tension, which causes the waste tire rubber particles to clump together and create voids. The ease with which the waste tire rubber particles can be removed from the polymer indicates a lack of interfacial adhesion [10, 11].

3.2. Impact Test

The impact toughness of the specimens is tested, where the absorbed energy slightly increase reaches the maximum value at particle size 40 mesh, then start to show little decrease with the increase of size of rubber particle as shown in table 2. Figure 6 reveals the effect of particle size on the impact toughness.

Table (2) Values of Avg. absorbed energy with particle size.

Particle size	Avg. absorbed energy (J)
20 mesh	1.52 J
40 mesh	2.2 J
1-3 mm	1.16 J
3-5 mm	0.96 J

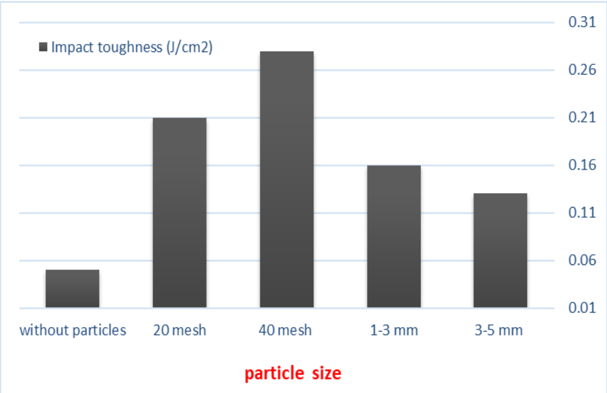

Fig. (6) The effect of particle size on the impact toughness.

4. Conclusions

In this study, the following can be concluded.

- The developed rubber composite shows a considerable improvement in its Mechanical Properties.
- The Impact toughness increased by 23% at particle size 40 mesh of waste tire rubber particles.
- Moreover, the developed composite is expected to become lighter with the addition of waste tire rubber particles, however the ultimate tensile strength decreased with the increase of waste tire rubber particles size

References

[1] A.Fazli, D.Rodrigue, Waste Rubber Recycling: A review on the evolution and properties of thermoplastic elastomers. Materials, vol.13, pp.782, 2020.

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[2] J.Karger-Kocsis, L.Meszaros, T.Bárány, Ground tyre rubber (GTR) in thermoplastics, thermosets, and rubbers. J. Mater. Sci., vol.48, pp.1–38, 2012

[3] A.Fazli, D.Rodrigue, Recycling Waste Tires into Ground Tire Rubber (GTR)/Rubber Compounds: A Review. J. Compos. Sci., vol.4, pp.103, 2020.

[4] X.Colom, J.Cañavate, F.Carrillo and JJ.Suñol, Effect of the particle size and acid pretreatments on compatibility and properties of recycled HDPE plastic bottles filled with ground tyre powder J. Appl. Polym. Sci. vol.112 pp.1882–1890, 2009.

[5] S.Tantayanon and S.Juikham, Enhanced toughening of poly(propylene) with reclaimed-tire rubber J. Appl. Polym. Sci. vol.91 pp.510–515, 2004.

[6] H.Ismail, M.Awang and M.Hazizan , Effect of waste tire dust (WTD) size on the mechanical and morphological properties of polypropylene/waste tire dust (PP/WTD) blendsPolym – Plast. Techno.l Eng. Vol.45 pp.463–468, 2006.

[7] K.A.Elenien, N.Azab, G.Bassioni, and M.Abdellatif. "The effect of tire rubber particles on the mechanical and physical properties of polyester," in IOP Conference Series: Materials Science and Engineering, vol.973, 2020.

[8] A.Standard, "D3039/D3039M-00. Standard test method for tensile properties of polymer matrix composite materials, 2000.

[9] N.ASTM, "D6110-04, Standard Test Methods for Determining Charpy Impact Resistance of Notched Specimens of Plastics

[10] B.H.Mousa and M.H.Abdel-Latif, Mechanical behaviour of rubber hybrid composites IOP Conference Series: Materials Science and Engineering 610 no. 1. IOP Publishing, 2019.

[11] Y.Nakao, K.Yamamoto , Waste tire and its collection systems Nippon Steel technical report no. 86, 2002.

[12] MW.Tantala, JA.Lepore and I.Zandi, Quasi-elastic behavior of rubber included concrete 12th international conference on solid waste technology and management, Philadelphia, PA, 1996.

[13] B.Abu-Jdayil, A.H.Mourad, A.Hussain, Investigation on the mechanical behavior of polyester-scrap tire composites. Constr.Build. Mater. Vol.127, pp.896–903, 2016