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Effect of Particle Size of Sawdust on Behaviour of Sawdust/UPE Composites in Water

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Abstract

The aim of the present work is to develop a new class of natural fillers based polymer composites with sawdust (S.D) which used two particle sizes (1.2 µm & 2.3 µm) and different weight percentage from sawdust (10%, 15%, and 20%). The mechanical properties studied include hardness (shore D) for all samples at normal conditions (N.C). The unsaturated polyester (UPE) and its composites samples were immersed in water for 30 days to find the effect of particle size of sawdust (S.D) on the weight gain (Mt %) by water for all the samples, also to find the effect of water on their hardness. The results show that the composite materials of sawdust (S.D) fillers which has particle size (1.2 µm) better than (2.3 µm) particle size before & after the immersion in water. Also the results show a decrease in the values of the hardness for the UPE and its composites samples after immersion in water. The results show that the UPE and its composites samples have relatively increased values of weight gain (Mt %) by water with time of immersion, for sawdust composite samples (1.2 µm) particle size the samples of (15%) weight percentage have relatively highest values of weight gain (Mt %) by water but for samples of (2.3 µm) particle size the samples of (20 %) weight percentage have relatively highest values of weight gain (Mt %). Finally results show that the value of weight gain (Mt %) increased with increasing of particle size of sawdust so that the composites samples have highest value of weight gain (Mt %) than UPE sample.

Key Words: sawdust, unsaturated polyester, hardness, absorbance of water.

Introduction

Composite is generally defined as any physical combination of two or more dissimilar materials used to produce a new material which is that cannot be obtained by each component individually. Composites consist of one or more discontinuous phases embedded in continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the reinforcement, reinforcing material or fillers, whereas the continuous phase is termed the matrix. The boundaries between the two phases are called interface. The properties of composites are strongly influenced by the properties of their constituent materials, their distribution and the interaction between them. Besides specifying the constituent materials and their properties, a composite material as a system is described by the geometry of the reinforcement that may be described by the following factors: Shape, size and size distribution of reinforcing materials. Concentration, concentration distribution and orientation of reinforcing materials [1, 2].

Unsaturated Polyesters resin is a linear polymer with low molecule weight. The polyester backbone contains double bonds and carboxylic groups. In general, unsaturated polyester resin is prepared by the process of condensation polymerization for three basic components: saturated carboxylic acids, unsaturated carboxylic acids and glycols with splitting out water, and increasing in molecular weight by process called esterification. The general purpose of polyester is the product of phthalic acid, maleic acid and propylene glycol [3, 4, and 5].

On the past decade, it was seen fast and steady growth of wood plastics industry. Among many reasons for the commercial success, the low cost and reinforcing capacity of the wood fillers provide new opportunities to manufacture composite materials. Although the use of wood-based fillers is not as popular as the use of mineral or inorganic fillers, wood-derived fillers have several advantages over traditional fillers and reinforcing materials: low density, flexibility, during the processing with no harm to the equipment, acceptable specific strength properties and low cost per volume basis. The main application areas of wood flour filled composites are the automotive and building industries in which they are used in structural applications as fencing, decking, outdoor furniture, window parts, roofline products, door panels, etc. The environmental awareness of people today is forcing the industries to choose natural materials as substitutes for non-renewable materials. Wood has been used as building and engineering material since early times and offers the advantages of not just being aesthetically pleasing but also renewable, recyclable and biodegradable [6, 7].

Pothan *et al.*, (1997) [8] studied the short banana fiber reinforced polyester composite concentrated on the effect of fiber length and fiber content. The maximum tensile strength was observed at 30 mm fiber length while maximum impact strength was observed at 40 mm fiber length. Incorporation of 40% untreated fibers provides a 20% increase in the tensile strength and a 34% increase in impact strength.

Mishra et al. (2003) [9] studied the mechanical performance of biofiber / glass reinforced polyester hybrid composites. They found that addition of small amount of glass fibers in the pineapple leaf fiber and sisal fiber reinforced polyester showed positive hybrid effect which improved the mechanical properties of these composites.

Lalyetal. (2003) [10] have investigated banana fiber reinforced Polyester composites and found that the optimum content of banana fiber is 40%.

Ahmed, (2004) [11] Found that the composite materials were prepared from unsaturated polyester resin with different types of flakes (wood flour and rice husk), also a hybrid was prepared using the two kinds that mentioned above, with the almost the same volume fraction. Results showed that the composite materials of (wood flour) gained better mechanical properties compared with others, the hybrid gained better thermal insulation compared with rice husk and wood flour composite.

Mosadeghzad et al, (2009) [12] found that the Polyethylene therephthalate (PET) waste bottles had been depolymerized by glycolysis and reduced to its monomer and dimer. The glycolysed product was used to produce unsaturated polyester resin (UPR). DSC and FTIR analysis were conducted on the resin and the glycolysed product. The resin was then mixed with sawdust (*acacia*) to produce the sawdust/UPR composite based on recycled PET. The effect of surface treatment and filler loading on mechanical properties of the composites were studied. The results showed that the modulus of both tensile and flexural increased with increasing filler contents whereas the strength decreased. This was overcome by treating the sawdust fillers with 10% sodium hydroxide (NaOH). The tensile, flexural, hardness and water absorption tests showed that the alkali treatment has enhanced the adhesion between the sawdust and the UPR matrix.

Sanaa,(2010) [13] studied the effects of different volumetric fractions from sawdust and short chopped fibers on the mechanical properties of unsaturated polyester composite then these results were compared with the properties of sawdust –fiber filled composites immersed for different periods in a salt solution of (2 N) . wood volume fractions {(20, 30, 50) vf %} selected to be added for un saturated polyester were studied which gave improvement in their selected studied mechanical properties for all reinforced composites - (only impact is decreased) - and particularly at higher values of volume fractions, were hardness showed an improvement by (15%), compressive strength gave obvious Improvement by (38%), while impact resistance decreased by (16%) with the reinforcement of (50 vf %) sawdust. The above values were reduced when the items were immersed in a salt solution for (60days).

Ahmed & Harith ,(2011)[14] studied The mechanical properties were studied including flexural strength and Young's modulus for composite materials were prepared using unsaturated polyester resin as binder with two types of fillers (sawdust and chopped reeds) at normal conditions (N.C). The Commercial wood, UPE and its composite samples were immersed in water for about 30 days to find the weight gain (Mt %) of water for the samples, also to find the effect of water on their flexural strength and Young's modulus. The results showed that the samples of UPE / chopped reeds composite gained highest values of flexural strength (24.5 MPa) and Young's modulus (5.1 GPa) as compared with other composites . The wet samples of sawdust composite have lowest values of weight gain (Mt %) of water (0.043%) as compared with other composites after immersion. Also it’s showed a slight decrease in values of Young's modulus and flexural strength except for the composite material formed from UPE / chopped reeds which showed an increase in the value of flexural strength for all the samples after immersion where the wet samples of UPE / chopped reeds composite gained (29 MPa) as compared with the samples at (N.C).

The objectives of this study were preparation of composites materials from natural low cost material sawdust (S.D) and unsaturated polyester by different particle size of sawdust with different percentage and show that which percentages are the best then studying the mechanical properties such as hardness of the composites material & absorption of the composites to water.

Experimental Work

1- Materials

Unsaturated polyester resin, (source china), (0.5%) of cobalt naphthenate as accelerator and (2%) of Methyl Ethyl Ketone Peroxide (MEKP) as hardener.

Two particles size of sawdust (S.D) are used (1.2µm) and (2.3µm) .these particles are obtained by using standard sieves have different sizes. Figure (1) shows the sawdust filler.

2- Composites Preparation

The sawdust (S.D) filler were passed to heat treatment in an oven shows at 80 ^{o}C for 24 h until the weight of the sawdust was constant. It was necessary to remove the residual moisture in the sawdust, which could greatly affect the mechanical properties of the composites [15].

The composites were prepared from unsaturated polyester resin (as a matrix) and added sawdust to cap by molding method which can be summarized by the following steps:

- Determine the weight of sawdust by using a digital balance.
- Weigh the weight of resin and its hardener and mix them carefully.
- Mix the content thoroughly in a clean container by a fan type stirrer before casting it as sheets by using aluminum mold.
- Leave the composite at room temperature about 24 hours to take time to solidify such as shown in figure (2).

3- Mechanical Test

The mechanical test applied to the samples is hardness test by using (Quality test device) for polymers type (Sore-D).

4- Water Absorption

The test samples of polyester resin and its composites were immersed in distilled water for (30 days), the immersion test was performed under ambient temperature. The samples removed from water every 72 hours and weighted by using digital balance. (Type: Sartorius, H51, made in Germany). The weight gain percentage (Mt %) was calculated by using the following equation [16].

Water Absorption:

$$M_t\% = \left(\frac{M_t - M_o}{M_o}\right) \times 100 \qquad \text{... (1)}$$

Where (**Mo**) is the weight of the samples before soaking in water and (**Mt**) is the weight after soaking in water for a time period **(t)**.

Results and Discussion

1- Hardness (Shore D)

Figure (3) shows hardness (Shore D) for different weight percentage of sawdust for UPE/sawdust composites from this figure it can be shown that the hardness of (1.2 µm) particle size of sawdust is higher than the hardness of (2.3 µm) particle size of sawdust, also it was showed that a drop (1.2µm) particle size the (15%) weight percentage of sawdust composites because of the large particle size may cause porosity which cause weakness in the composite. But for (2.3µm) particle size at (10%) weight percentage the hardness is the best. Figure (4) shows the relationship of hardness (Shore D) of the composites samples with weight percentage of sawdust after immersion in water for (1.2µm) and (2.3µm) particle size of sawdust it can be seen that the hardness of the samples is decreased after immersion of water except the hardness of the sample which has (15%) percentage of (1.2µm) particle size of sawdust was increased because the water may penetrate to the porosity in the specimen that cause a flotation of sawdust to the surface and make higher hardness and this agreement with Sana [13] . Pure sample of (UPE) the hardness was decreased by 4.5% after immersion of water. Many of the polymers used in composites including UPE take some percentage of water if they are immersed in it for some time.

2- Effect of water

The unsaturated polyester UPE and UPE/Sawdust composites samples were immersed in water about (30 days) to find the effect of water on their weight gain. Weight gain (Mt %) of the samples have been calculate from equation (1).Figures (5) and (6) show the change of weight gain which represents by absorption percentage of water with time of immersion. UPE resin sample has absorption of water less than its composites samples (for each value of particle size of sawdust).

Figure (5) shows the absorption percentage of water with time of immersion for UPE/Sawdust composites for (1.2 µm) particle size of sawdust and different weight percentage it can be shown that composite which have (15%) weight of sawdust have been absorption of water higher than other weight percentage.

But for (2.3 µm) particle size of sawdust the (20 %) weight percentage of sawdust have been largest values of absorption of water which represented in figure (6). In addition, the absorption of water for composite samples which have (2.3 µm) particle size of sawdust have been higher than (1.2 µm) particle size of sawdust and this agreement with Ahmed & Harith [14].

(a)

(b)

Fig. 1, (a) 2.3µm particle size of sawdust. (b) 1.2µm particle size of sawdust.

Fig. 2, Composite sample (UEP+S.D) after preparation

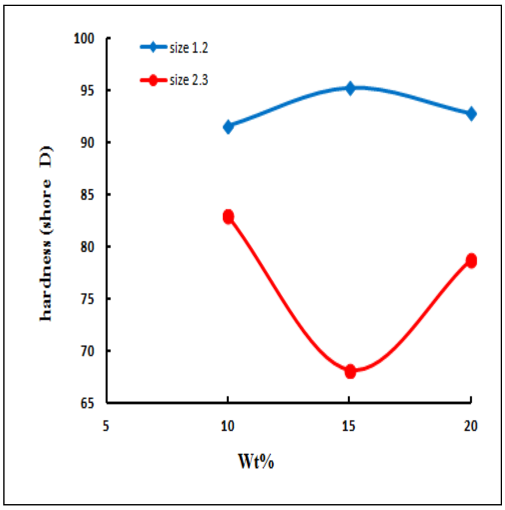

Fig. 3, Effect of weight percentage of sawdust on hardness of composites

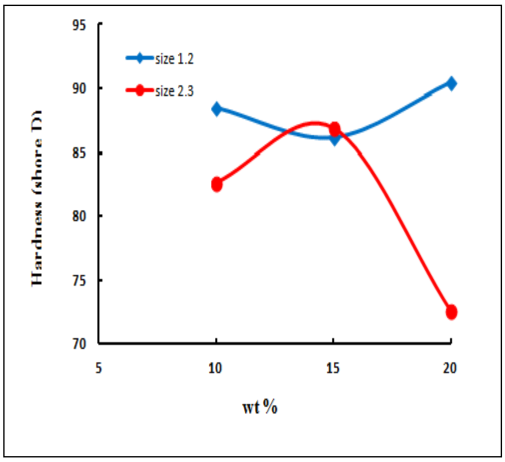

Fig. 4, Effect of weight percentage of sawdust on hardness of composites after immersion

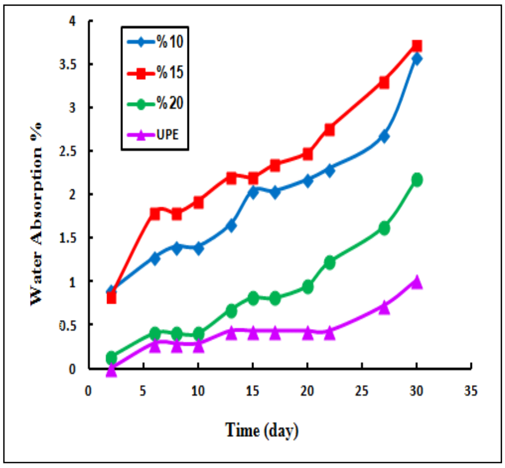

Fig. 5, Effect of time immersion on weight gain for (1.2 μm) particle size composites

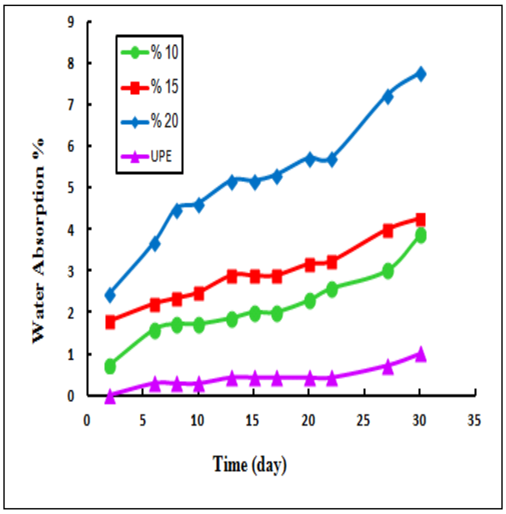

Fig. 6, Effect of time immersion on weight gain for (2.3 μm) particle size composites

Conclusions

The main conclusions of this work can be summarized as follows:

1- This work shows that successful fabrication of natural fillers filled polyester composites with different particle size and weight percentage of sawdust fillers using molding method.

2- The sawdust composites have particle size (1.2 μm) show better behavior in hardness (shore D) test.

3- Adding the sawdust fillers in different weight percentage for two sizes and (15 %) weight percentage of sawdust of (1.2 μm) highest value of hardness compared with other percentages.

4- The composite of (2.3 μm) the (10%) weight percentage of sawdust has highest value of hardness.

5- The UPE and its composite samples have relatively increased values of weight gain (Mt %) after immersion in water.

6- The composite samples of (2.3 μm) particle size have relatively highest value of weight gain (Mt %) of water than samples of (1.2 μm) particle size.

7- The UPE and its composite samples have decrease in the values of the hardness after immersion in water.

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