Study of Some Mechanical Properties of Unsaturated Polyester Filled with the Seed Shells of Sunflower and Water-Melon

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Abstract

It is very important reducing the cost in the modern industries also declining the pollution which represents a big harmfulness to the environment. These days, the waste materials were used increasingly in reinforcement and formation new materials, therefore this research came to use a waste material to create a composite material has good properties and use in different engineering applications. In this research, the effect of sunflower and water-melon seed shells powder on some mechanical properties of unsaturated polyester thermoset, that comprised each of bending modulus, flexural strength, impact strength, compressive strength and hardness were studied. The seed shells were collected and milled by electrical mill, the set of sieves were employed to get on seed shell powder by the suitable size. The seed shell powder was added to unsaturated polyester from 5 wt% to 25wt% and then bending, impact, compression and hardness tests were carried out for prepared specimens. The results showed that the flexural strength, modulus of elasticity, hardness and compressive strength increased with increasing of the shells powder percent. The flexural strength was (37.99 MPa) for pure unsaturated polyester, while was (45.26 MPa) at percent of powder (25 wt %). It was observed that the impact strength decreased with increasing of powder percent. The impact strength was (8.24 kJ/m^2) for pure unsaturated polyester, while was (3.77 kJ/m^2) at percent of water-melon seed shells powder 25 wt%.

Keywords: Unsaturated Polyester; Shells; Mechanical; Properties.

ملخص البحث

يعتبر تقليل الكلفة في الصناعات الحديثة وكذلك تخفيض التلوث الذي يمثل خطراً كبيراً على البيئة أمر في غاية الأهمية. في الوقت الحالي، زاد استخدام مواد رخيصة في تقوية وتكوين مواد جديدة، ولذلك جاء هذا البحث بفكرة استخدام مواد مهملة وضارة للبيئة في تكوين مادة مركبة ذات خواص جيدة واستخدامها في التطبيقات الهندسية المختلفة. في هذا البحث تم دراسة تأثير إضافة مسحوق قشور بذور كل من عباد الشمس والرقي على بعض الخواص الميكانيكية للبولي أستر والتي شملت كل من معامل المرونة الانحنائي، مقاومة الانثناء، مقاومة الصدمة، مقاومة الانضغاط والصلادة. تم تجميع القشور وطحنها بطاحونة كهربائية وتم الحصول على مسحوق بالحجم الحبيبي المناسب عن طريق منظومة مناخل كهربائية اهتزازية. تم إضافة مسحوق القشور بنسب مختلفة تراوحت من (٥% - ٢٥%)wt بزيادة مقدارها wt%5 إلى البولي استر غير المشبع وتم إجراء فحص الانحناء، الصدمة،الانضغاط والصلادة للنماذج المحضرة، وقد وجد أنه بزيادة نسبة المسحوق تزداد كل من مقاومة الانثناء، مقاومة الانضغاط، معامل المرونة الانحنائي والصلادة حيث بلغت مقاومة الانحناء (37.99 MPa) للبولي استر غير المشبع النقي في حين كانت (45.26 MPa) عند نسبة مسحوق مقدارها ٢٥ wt% . كذلك لوحظ إن قيم مقاومة الصدمة تقل بزيادة نسبة الإضافة فقد بلغت قيمة مقاومة الصدمة (8.24 kJ/m^2) للبولي استر النقي في حين بلغت (3.77 kJ/m^2) للبولي استر المضاف إليه مسحوق قشور بذور الرقي بنسبة wt%٢٥ .

1. Introduction:

These days various synthetic polymers are being prepared combined with various reinforcing fillers in order to improve the mechanical properties and obtain the characteristics demanded in actual application. The need for materials that are non-toxic to the human body and have appropriate characteristics for specific purposes is ever increasing due to the lack of resources and increasing levels of environmental pollution. These natural fillers are especially being sought since the production of composites using natural substances as reinforcing fillers is not only inexpensive but also able to minimize the environmental pollution caused by the characteristic biodegradability [Premalal *et al*, 2002], enabling these composites to play an important role in resolving future environmental problems.

Thermoset is a hard and stiff crosslinked material that does not soften or become moldable when heated. Thermosets are stiff and do not stretch the way that elastomers and thermoplastics do. Several types of polymers have been used as matrices for composites. Most commonly used thermoset polymers are epoxy resins and other resins (Unsaturated polyester resins Vinyl Ester, Phenolic Epoxy, Novolac and Polyamide) [Saira Taj *et al*., 2007].

Unsaturated polyesters are a family of polyesters characterized by vinyl unsaturation in the polyester backbone. Unsaturated polyester is thermosetting polyester that is cross-linkable by reaction with an unsaturated monomer or prepolymer by virtue of the presence of carbon-to-carbon double bonds in its polymer chain. Generally, the unsaturated polyester is dissolved in the reactive monomer.

Unsaturated polyesters find their widest use in laminates, composites such as tanks, boat bodies, lampposts, storage products, etc. Some unsaturated polyesters are used in dough molding compounds, sheet molding compounds, and molding compound in pellet form. Applications include those requiring good electrical properties and where heat resistance is beneficial [Harper and Petrie, 2003]

Many investigators have studied effect of locally available materials on mechanical properties of polymer:

(Sarkawi and Yusof Aziz, 2003) studied utilizing ground rice husk, without burning it as filler in rubber compounding by evaluating the rheological behaviour and physical properties of rice husk powder (RHP)-filled rubber vulcanisates. For comparison purposes, commercial silica was used at 40 and 50 pphr whilst carbon black was used at 50 pphr. The results showed that the physical properties of RHP-filled vulcanisate are still inferior to carbon black-filled vulcanisate but some of the properties are comparable to silica-filled vulcanisate. The RHP also offers processing advantages over silica.

(Ahmed, 2004) made an investigation into the properties for unsaturated polyester resin reinforced with rice husk. Results were showed that composite materials of rice husk gain better mechanical properties compared with composite prepared from unsaturated polyester resin without filler.

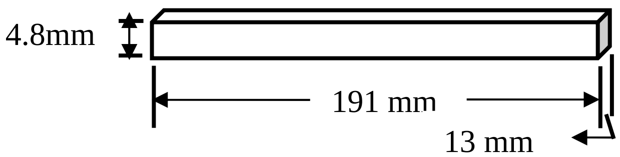
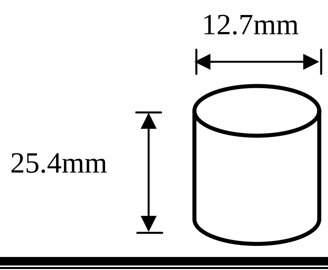
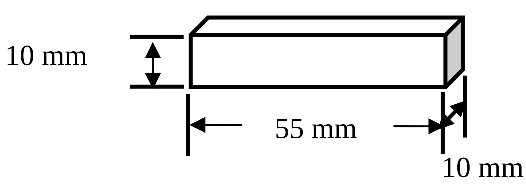
(Han-Seung Yang et al., 2004) studied the effect of rice-husk flour on some the physical, mechanical and morphological properties of polypropylene composite materials. They concluded that the tensile strengths of the composites slightly decreased as the filler loading increased. Tensile modulus improved with increasing filler loading. Notched and unnotched Izod impact strengths were lowered by the addition of rice-husk flour.

(Osabohien and Egboh, 2007) investigated the cure characteristics and the physico-mechanical properties of natural rubber, standard Nigerian rubber, SNR10 filled with cherry seed shell (CSS) and standard carbon black CB (N330) were determined. The tensile strength of both CSS and CB-filled vulcanizates increased to a maximum at 40 phr filler content before declining. The moduli (M100 and M300), specific gravity (S.G), hardness and abrasion resistance increased while the elongation at break and Dunlop resilience decreased with increasing filler content for both vulcanizates.

In the present study, it was used a thermoset polymer (polyester) as the matrix and a sunflower seed shell powder and water melon seed shell powder as the reinforcing filler to prepare a particle-reinforced composite to examine the possibility of using these waste material as reinforcing fillers and to determine some mechanical properties of the composite according to the reinforcing filler content in respect to unsaturated polyester.

2. Experimental Procedure
2.1. Materials
2.1.1. Matrix Polymer
Unsaturated Polyester (UPE) was used in this research. The mixing ratio used was 100g of UPE resin with 0.5g accelerator (Cobalt napthenate) and 2g hardener (Methyl Ethyl Ketone peroxide).
2.1.2. Reinforcing Filler
Two types of filler were used in this research. These types were sunflower and water-melon seed shells powder. The shells were collected and crashed by using an electrical mill. The particulates shells were sieved by vibratory sieve shaker to get a suitable size. The grain size in this research was (75 µm), that it was resulted from sieve had mesh (200). The seed shells powder was used (5, 10, 15, 20 and 25) wt. %.
2.2. Samples Preparation
The samples of polyester and shells powder were prepared by mixing unsaturated polyester with sunflower and water-melon seed shells powder using different filler content. The two shells powder were added to polyester and hardener and then they were homogeneously mixed. The mixed of composites was poured into the mold according to test. The dimensions of test samples were showed in the table(1).

Table (1): Shapes and dimensions of samples

The test	Sample shape	Standard specification
Bending Test		ASTM D-790
Compression Test		ASTM D-695
Impact Test		ASTM D-256

2.3. Mechanical Tests

2.3.1 Bending Test

The three point bending test was conducted according to ASTM D790 with microcomputer controlled electronic universal testing machine model (WDW-5E) made in China (Time Group Inc.). The test was conducted at 3mm/min deformation rate. The support span was set at 90mm.

This test gives information about load-deflection and then elastic modulus was extracted by using the following equation:

$$E_{bend} = PL^3 / 48\, I\delta \quad \ldots\ldots\ldots\ldots(1)$$

The flexural strength was calculated by following equation:

$$F.S = 3PL / 2\, bd^2 \quad \ldots\ldots\ldots\ldots(2)$$

The maximum shear stress (τ) was concluded using the following equation:

$$\tau = 3P / 4\, bd \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where:

F.S : flexural strength (MPa), P: applied force till the failure of specimen occurs. L:span, b: width of specimen, d: thickness of specimen, δ: the deflection, I: moment of inertia.

2.3.2 Charpy Impact Test

The unnotched Charpy impact strength tests were conducted according to ASTM D-256 at room temperature using gunt Hamburg pendulum impact tester WP 400 made in Germany. The impact strength was concluded from this test. Impact strength (I.S.) is calculated by applying the relationship:

$$I.S. = UC / A \quad \ldots\ldots\ldots\ldots(4)$$

Where: UC is the fracture energy (Joule) which is determined from Charpy impact test instrument. A is the cross – sectional area of the specimen.

2.3.3 Compression Test

Compressive strength test was carried out according to ASTM D695 at room temperature using gunt Hamburg hydraulic universal material tester 50 kN made in Germany. In this test, the load is applied gradually to the longitudinally fixed sample, and then the reduction in the length is determined by the dial gage, the increasing in the load continues till sample fails. Compressive strength was determined from this test by divided maximum load on cross sectional area of sample.

2.3.4 Hardness Test

Hardness test was conducted with TH-717 (Digital Micro Vickers Hardness Tester). The load time was used in this test was 15 seconds and maximum load was 2.942 N.

3. Results and discussion

3.1. Flexural Properties

The variation of flexural strength with filler addition is shown in Fig. (1). The flexural strength of composites climbs with increasing of concentration of seed shells. The increment in flexural strength is due to the better increased surface area of filler in the matrix. It is worth pointing out that the total area for deformation stress also has an important role to play [He,D. and Jiang, B., 1993].

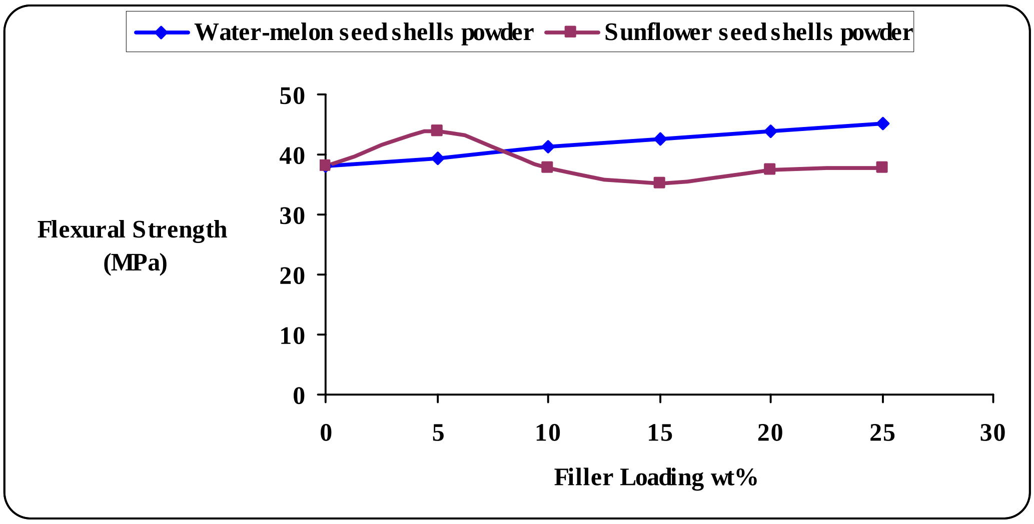


Fig.(1): The effect of filler loading of water-melon and sunflower seed shells powder on flexural strength of unsaturated polyester.

Figure (2) demonstrates the effect of filler loading on the modulus of elasticity of shells -filled polyester composites. Modulus of elasticity for the composites increases with the increasing filler loading. Because of this the rigidity of its composites tends to strongly increase with addition of these fillers. Some authors have also related the increase in composites' rigidity with the reduction of polymer chains mobility in the presence of the filler [Rana et al., 1998].

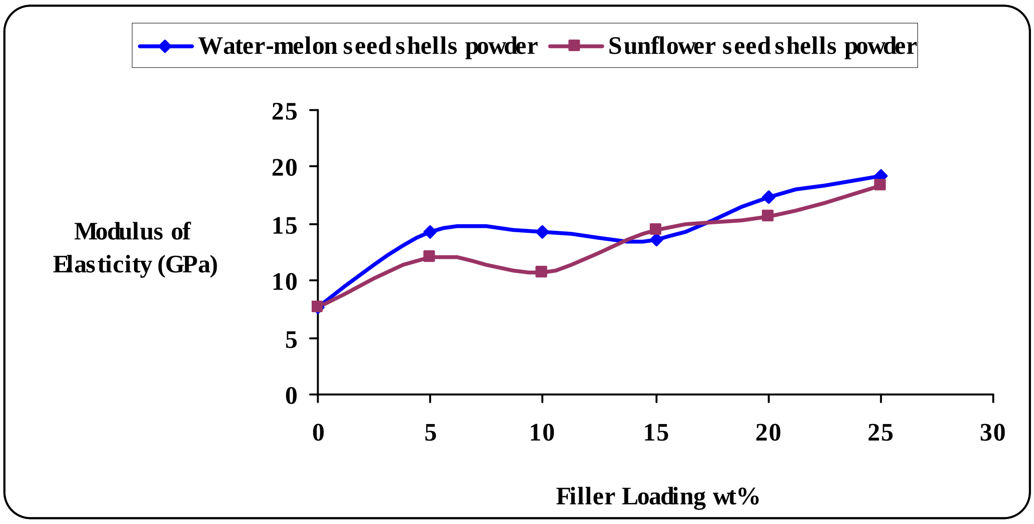


Fig.(2): The effect of filler loading of water-melon and sunflower seed shells powder on modulus of elasticity of unsaturated polyester.

Figure (3) represents the effect of filler loading on the maximum shear stress of shells-filled polyester composites. Maximum shear stress for the composites rose with increasing filler loading. This behavior attributed to the strong bond between the matrix and reinforced material that tend to increase the applied force till the failure of specimen occurs.

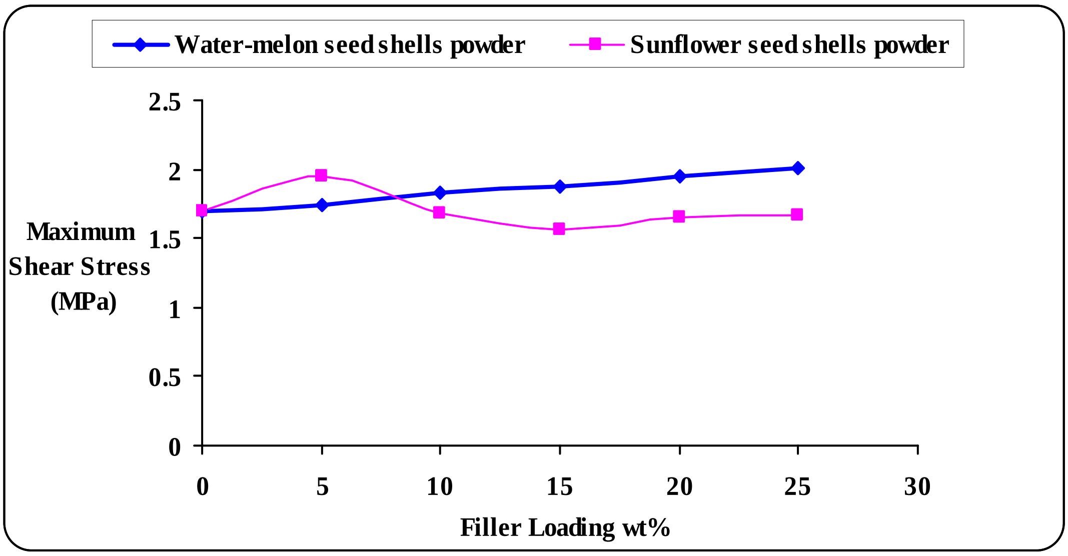


Fig.(3): The effect of filler loading of water-melon and sunflower seed shells powder on maximum shear stress of unsaturated polyester.

3.2. Impact Properties

The impact properties are affected by the crack initiation and crack propagation mechanism between the filler and the matrix polymer.

Figure (4) illustrates that the impact strength slumps with increasing filler loading. This is mainly due to the reduction of elasticity of material due to filler addition and thereby reducing the deformability of matrix. An increase in concentration of filler reduces the ability of matrix to absorb energy and thereby reducing the toughness, so impact strength plummeted [Bose et al., 2004].

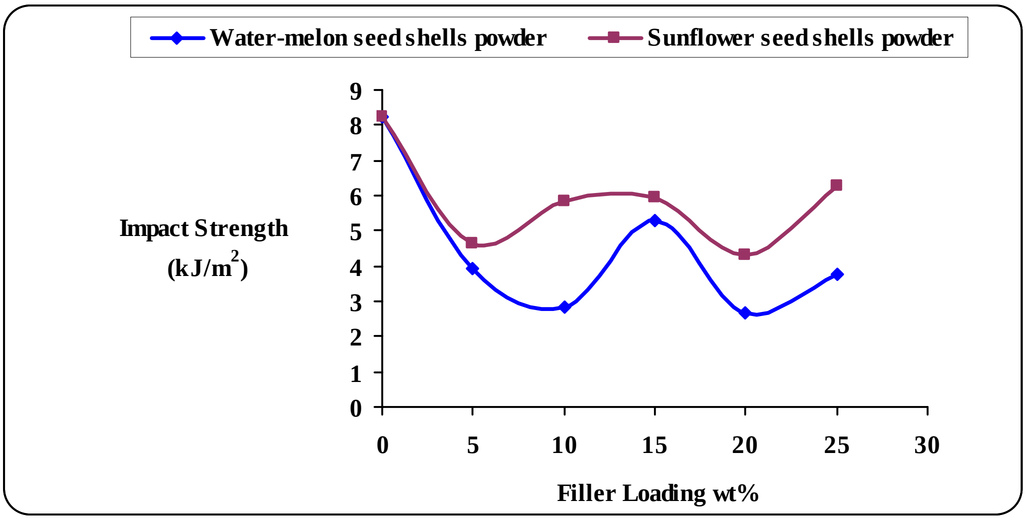


Fig.(4): Variation of the impact strength of polyester with filler loading of shells powder.

3.3. Compressive Strength

Figure (5) illustrates the variation of compressive strength with filler loading. It can be seen that the compressive strength increases with filler addition. The results showed that the compressive strength of the pure UP were higher than of UP reinforced with seed shells powder, this is attributed to a large interface distances among particles that lead to increase of free paths and then lead to failure of sample at applied compressive load. While at addition a high percentage of particles to matrix lead to create a brittle material that it stables to micro cracks, hence the fracture of material was relayed [Lipatov, 1981, Herman, 1987].

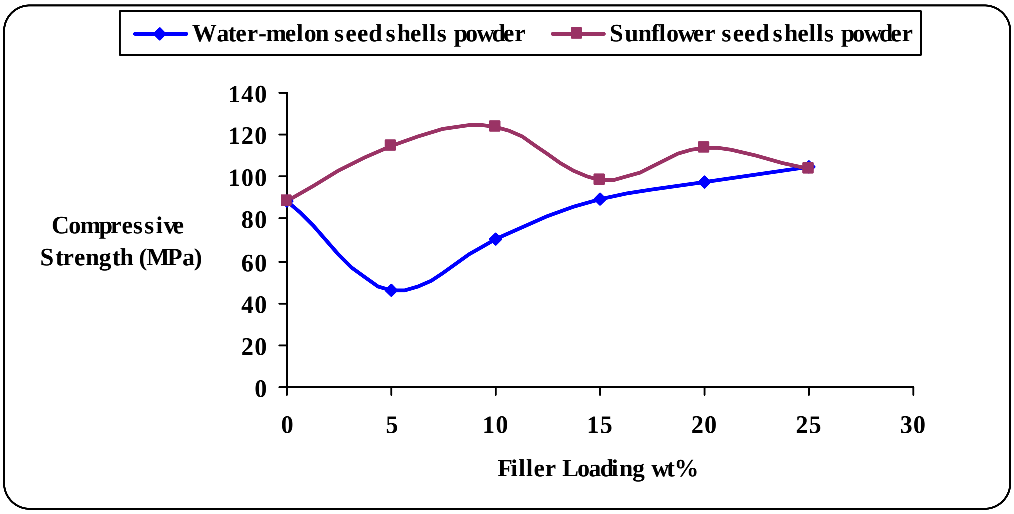


Fig.(5): The effect of filler loading of water-melon and sunflower seed shells powder on compressive strength of unsaturated polyester.

3.4. Hardness

The variation of hardness with filler addition is shown in Fig. (6). The Hardness of composites jumps with the increasing in concentration of seed shells. This is may be attribute to increasing the surface area of seed shells powder in contact with unsaturated polyester and decreasing the movement of polymer molecular which lead to rose of strength of material to scratch and increasing of the material strength to plastic deformation.

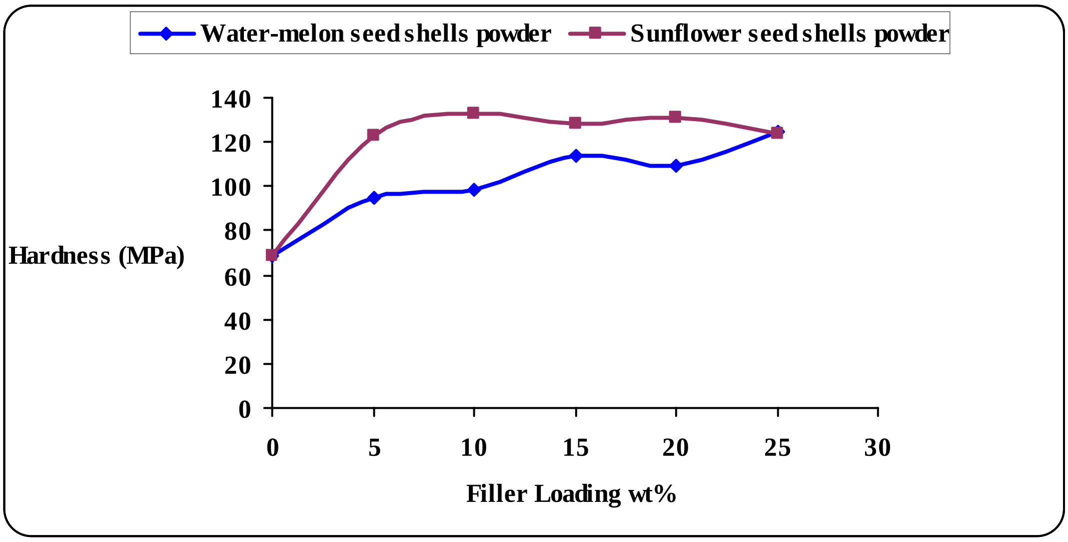


Fig.(6): The effect of filler loading of water-melon and sunflower seed shells powder on hardness of unsaturated polyester.

4- Conclusions:

This work has revealed the potentials of water-melon and sunflower seed shells powder as fillers in unsaturated polyester compounds. The results encourage to use any waste material is not useful lonely but may be very useful as reinforced material to create a new composite material has good properties and cheap, and to reducing the environmental pollutions. The effect water-melon and sunflower seed shells powder on some mechanical properties of unsaturated Polyester were investigated. The flexural strength, flexural modulus, maximum shear stress, compressive strength and hardness went up with increasing of filler addition. The impact strength declines with increasing of filler loading.

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