PERFORMANCE OF CRUSHED FRUIT PITS REINFORCED EPOXY COMPOSITES UNDER IMPACT LOADING CONDITIONS

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Abstract: In the past decade, widespread research work has been carried out on the natural fibre reinforced composite materials used in many applications. Natural fibres are available in large quantities in nature and can be used to reinforce polymers to obtain light and strong materials. Natural fibres from plants are beginning to find their way into commercial products in both automotive and domestic applications. This paper aims to present the results of an investigation into the mechanical performance of a novel natural fibre composite material developed from the crushed fruit pits (a waste by-product of any fruits) when used as a reinforcing material for epoxy polymer. The paper will present all the relevant results of the different tests including impact and scanning electron microscopy.

1. Introduction

The waste, produced during the final process of consuming fruits includes the skin and the pits which can be used for many purposes, specifically in heating (Figure 1). Otherwise it is either discarded or it has been added to the earth for different purposes as shown in Figure 2 (Fisher, 2004)

Salem et al (2007) investigated the chemical properties of the fruit pits waste and identified the nutritive elements of the fruit pits, accordingly the most important elements are:

- cellulose 33–42%
- hemi-celluloses 35–43%
- lignine 15–23%

The main chemical compounds in the dry matter of fruit pits include humidity, ash, nitrogen, potassium, phosphor, sugars, as well as some mineral elements including Ca, Mg, Mo, Cu, Fe (Salem 2006)

Kılıc et al (2008) studied the physical properties and mechanical behaviour of dry fruit pits under compression loading, and it was the first time any fruit pits had been tested under compression testing. They found out that the parameters used to indicate the mechanical behaviour of fruit pits were dependent on the deformation rate, pit size, the compression force along the X-, Y-, and Z-axis. They measured the last rupture force and rupture energy for the fruit along the Z-axiswhile the least specific deformation was along Y-axis (kan, 2007).

Figure 1 Wasted fruit pits used for heating purposes

Figure 2 Discarded fruit pits added to the earth

In the present study a new type of composite material viz. crushed fruit pits reinforced epoxy composite has been developed. Fruit pits are abundantly available in Mediterranean countries. The crushed fruit pits powder is the waste by-product of the fruits, which is normally discarded by the manufacturers.
This paper examines the effects of the crushed fruit pits owder as a type of filler loading on the mechanical properties of the composites under impact loading. To identify the optimum proportion of the reinforcement within the composite material, fruit pits powder loading was varied from 0% to 40% w/w. Scanning electron microscopy (SEM) studies were carried out to determine the failure mechanisms operating in the composites.

2. Materials and experiments

The materials used in this project included the epoxy matrix material using Araldite MY750 with Aradur HY1300 as the catalyst

supplied by Robnor resin Ltd. The reinforcement material included the fruit pits powder (collected and supplied by Abdul Kareem Abdul Salam Ltd, Daraa, south of Syria).
The process of preparing test samples involved separating the skin from the crushed fruit pits using a laboratory table top centrifuge. The remaining powder which contained the fibres was then dried in an oven at 80^0C for 24 h to expel moisture. Mixing of the powder and the matrix resin was carried out in a conventional laboratory fume cupboard. The mixture was then poured into a mould and cured for 24 hours at room temperature (22 ^{0}C).

2.1 Impact test

Preparation of the samples and the testing procedure were conducted according to the British Standards Institution, BS 2782: Part 3 for falling dart low velocity impact test. The test equipment used was Ceast-Fractovis with a speed setting of 4.43 m/s.

2.2 Scanning electron microscopy

Examination of the fracture surfaces resulting from the impact testing was carried out using a scanning electron microscope (SEM) supplied by Joel JSM-6460-LV, after first sputter coating with gold to avoid electrostatic charging and poor image resolution.
SEM is a microscope that uses electrons rather than light to form an image. There are many advantages to using the SEM instead of a light microscope:

- The SEM has a large depth of field which allows a large amount of the sample to be in focus at one time.
- The SEM also produces images of high resolution, which means that closely spaced features can be examined at a high magnification.
- Preparation of the samples is relatively easy since most SEMs only require the sample to be conductive.

3. Results and discussion

3.1 Impact testing of the fruit pit reinforced epoxy composite

Table 1 presents the main results of this investigation including the peak load, the impact time, the energy and the peak velocity for the composites with different filler loadings. Figures 3-5 show the effects of the fruit pits filler loading on peak load, impact energy and impact velocity during the impact process.
Table 1 and Figure 3 show the peak loads and times for the pure epoxy samples and for the fruit pits/epoxy composite samples and they show that the striker was in contact with the impact test samples to all the fruit pits powder/epoxy composite samples higher than the pure epoxy samples.
The Energy/time curves shown in the Figure 4 and Table 1 and the available energy for the 30%Wf for the impact test was [0.395 (J)] and it was nearly [0.35 (J) and 0.26 (J)] for the 10% and 20% Wf of the fruit pits powder reinforced epoxy composites in the same time it was [0.16(J)] for the pure epoxy sample , but the total energy absorbed by the sample 30%Wf was [0.71(J)] same to be the largest between all the samples { 0.27 , 0.504 and 0. 45 } for the samples {pure epoxy , 10% Wf and 20% Wf }.

Filler (% w/w)	Impact Time (ms)	Peak load (kN)	Energy (J)			Peak Velocity (m/s)
			Peak	Total		
0%(Pure epoxy)	0.489	281.9	0.1617	0.2702		4.4362
10%	1.266	206.5	0.352	0. 5043		4.4311
20%	1.157	196.3	0.2637	0.4574		4.4309
30%	0.892	299.1	0.3946	0. 7093	4.4289	

Table 1 Impact test results for the fruit pits powder-epoxy composites with different weight fractions of filler

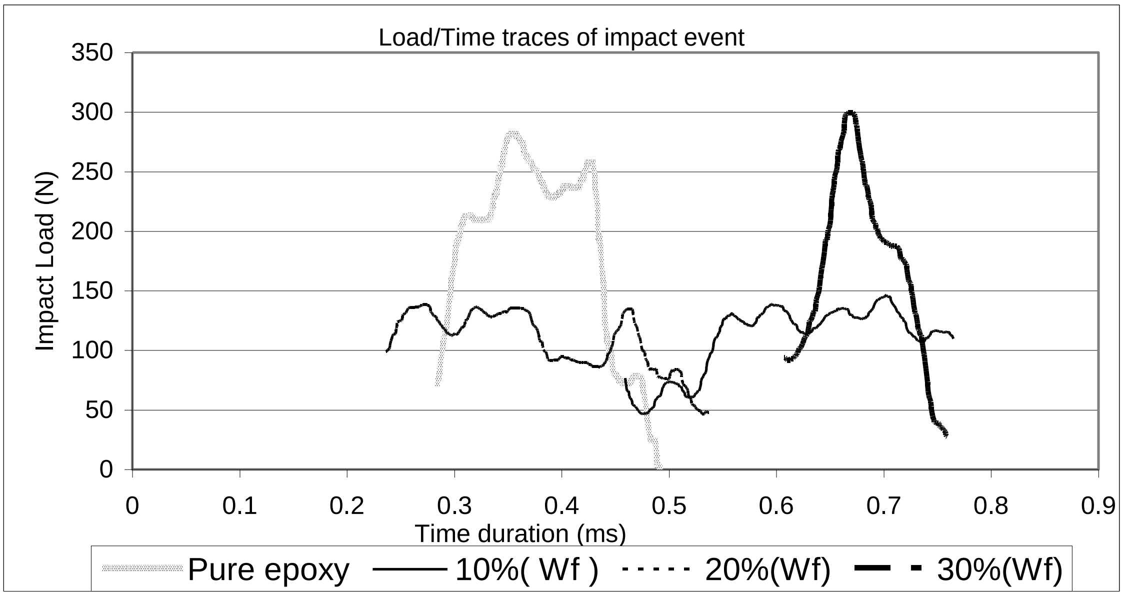

Figure 3 Peak load/Time for the composites with different fruit pits filler loadings (fibre weight fractions) w/w%

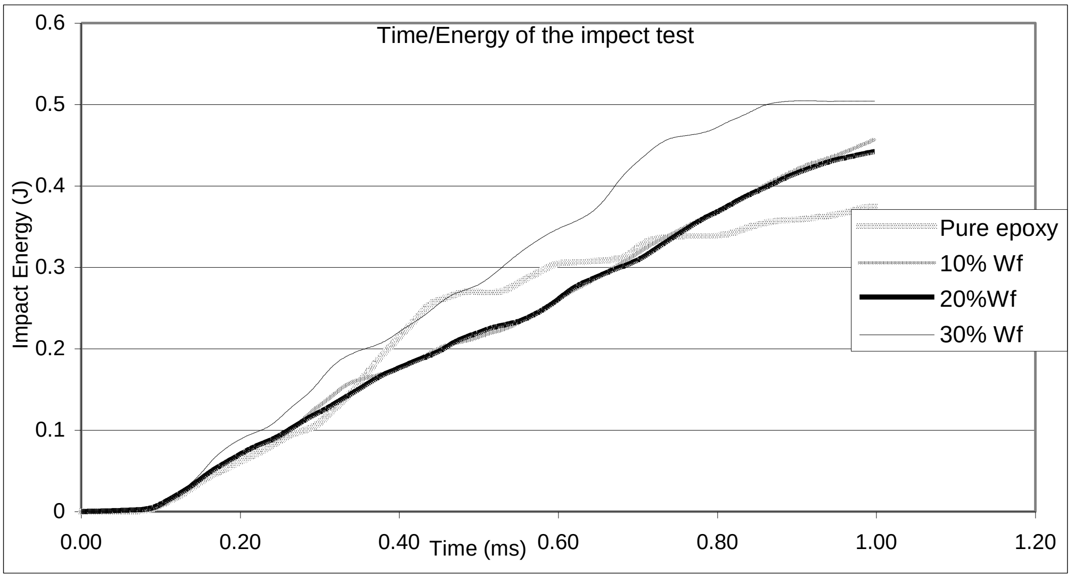

Figure 4 Impact Energy (J) vs Time (ms) for the composites with different fruit pits filler loadings (fibre weight fractions) w/w%

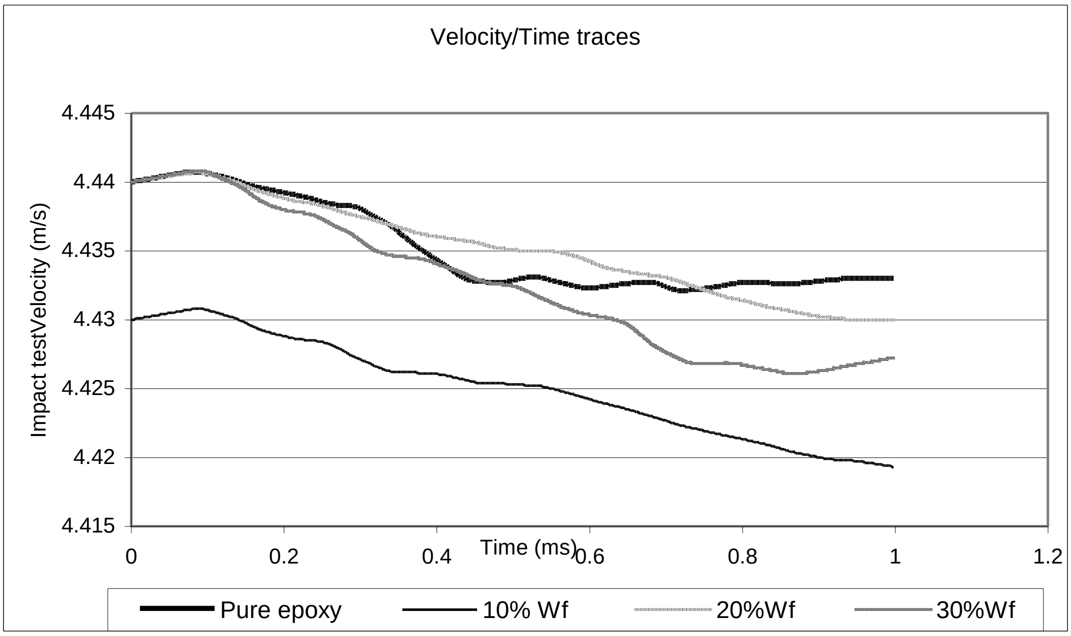

Figure 27 Impact Velocity vs Time for the composites with different fruit pits filler loadings (fibre weight fractions) w/w%

Different in the peak load and the absorbed energy caused by the adhesion and the increasing in the cross-link between the epoxy and reinforcement. this improve make the samples more resistance to the impact and absorb more energy and time to break it.
The energy absorbed by the target during the impact test calculated by the
Formula

$$E = \frac{1}{2} m (v_1^2 - v_2^2)$$

Where: E is the energy , m is the mass of the sample , v_1 is the velocity before the impact test , v_2 is the velocity after the impact test , comparing this formula with Figure 4 (Time/Energy) and the Figure 5 (Time/Velocity) , for example :from the Figure 5 (Time/Velocity) , to compare between the sample pure epoxy (as it the lowest value of the energy the change in the velocity's value at the begging and the velocity's value at the end of the test is very small {4.4400-4.433 =0.0067 (m/s) } .
And the sample 30%Wf of fruit pits powder/epoxy (the highest value of the energy), the change in the velocity's value at start and velocity's value at the end of the test is {4.4400-4.4261 =0.0139 (m/s) }.
And this different shows direct in the Figure 4 (Time/Energy) curve and Table 1, the total energy for the 30% w/w sample energy is 0.7093 (J) and the total energy for the pure epoxy sample is 0.2702 (J) .
The results indicate that the resistance of the epoxy samples under impact loading is relatively low as compared to the composites with a loading of fruit pits filler.

3.2 SEM

SEM micrographs of the impact test's fractured surface to the fruit pit/epoxy composite shown in the Figures 6,7,8,9, and 10. From these Figures it is evident that damage in the impact area and show too void contents, the bobbles and the errors increased with the weight fraction of the fruit pit powder in the composite as it shown in the SEM.

4. Conclusion

1- It has been established that the use of fruit pits powder as a filler can potentially increase the strength of the epoxy polymer under impact loading.
2- The impact test results show that 30% filler loading results in a significant improvement in impact load.
3. SEM results indicate that using higher percentages of filler (30% w/w) leads to more void contents.

5. References

BS 2782: Part 3: Method 350 (1984) low velocity impact testing of polymer composites, British Standards Institution.

Dhakal, H.N., Zhang, Z.Y., Richardson, M.O.W. , Errajhi, O.A.Z.. (2007)The low velocity impact response "of non-woven hemp fibre reinforced unsaturated polyester composites", Elsevier. 81 (4), Pages 559-567

Fisher, M.F.K.(2004). Fruit. Available: Causers Qutaiba Abessalam Desktop fruit pits food museum fruit exhibit.mht. Last accessed 29.08.2009.

Kılıc,A. , Gu¨ner,k. M. (2008), "Physical properties and mechanical behaviour of fruit fruits (Olea europaea L.)Under compression loading", Elsevier, 87 (1), 222–228

Liua, H., Wua, Q., and Zhang, Q. (2009) "Preparation and properties of banana fibre-reinforced composites based on high density polyethylene (HDPE)/Nylon-6 blends" , Elsevier Ltd , 100 (23), Pages 6088-6097.

Salem, Z., Lebik, H. , Cherafa, W.K., Allia, K.. (2007). "Valorisation of fruit pits using biological identification". Elsevier,20,4,(1),72–78

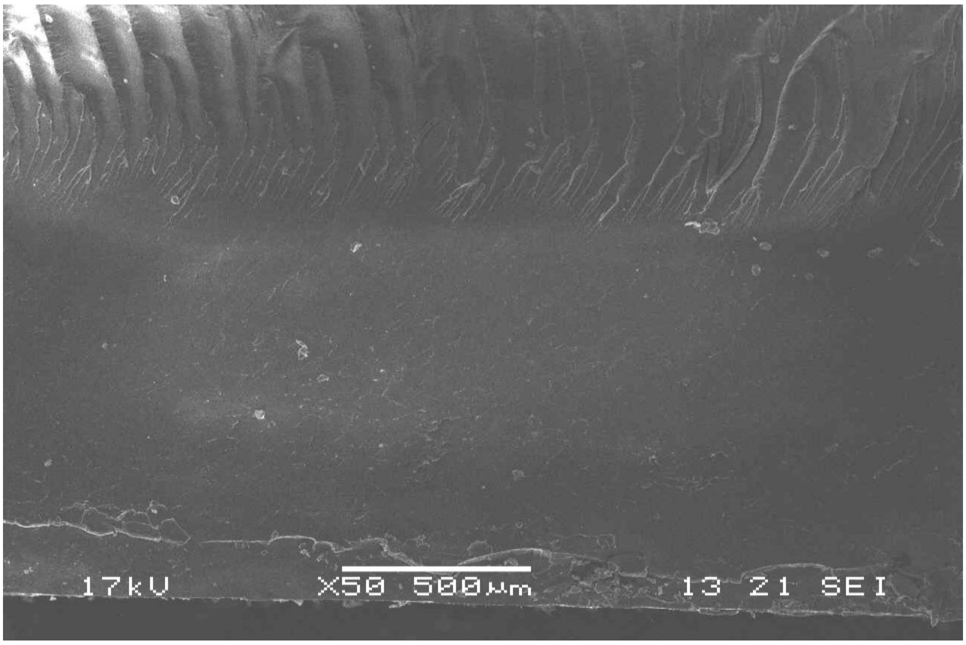

Figure 6 Scanning electron micrograph image (×50) showing the fracture surfaces of pure epoxy sample after impact testing

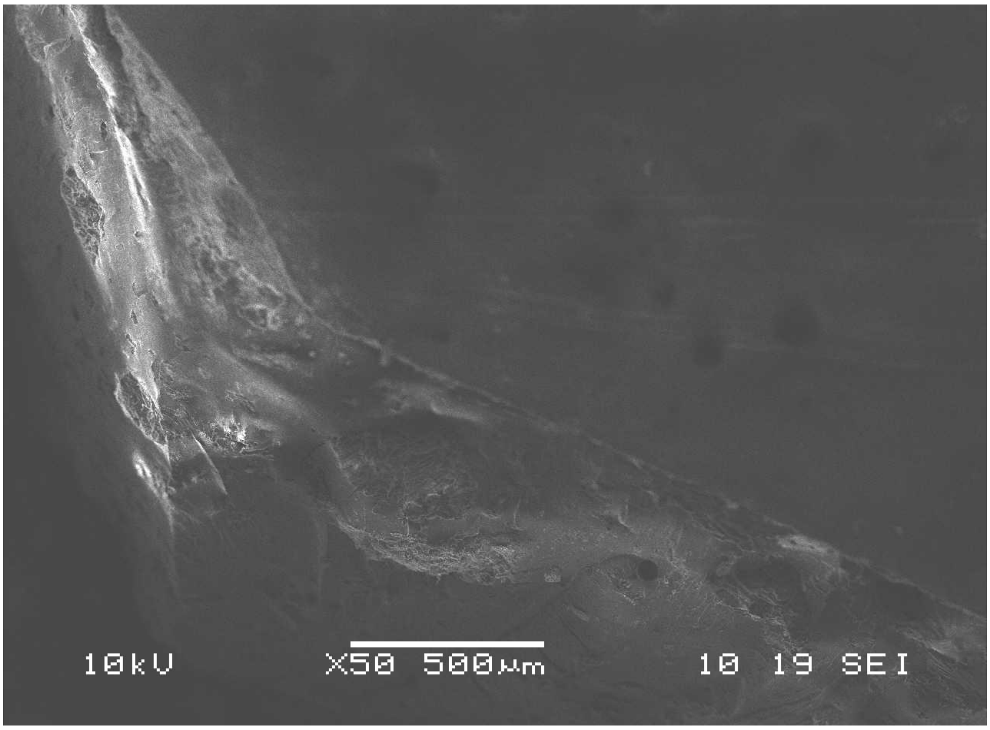

Figure 7 Scanning electron micrograph image (×50) showing the fracture surfaces of the composites with filler loading of 10%

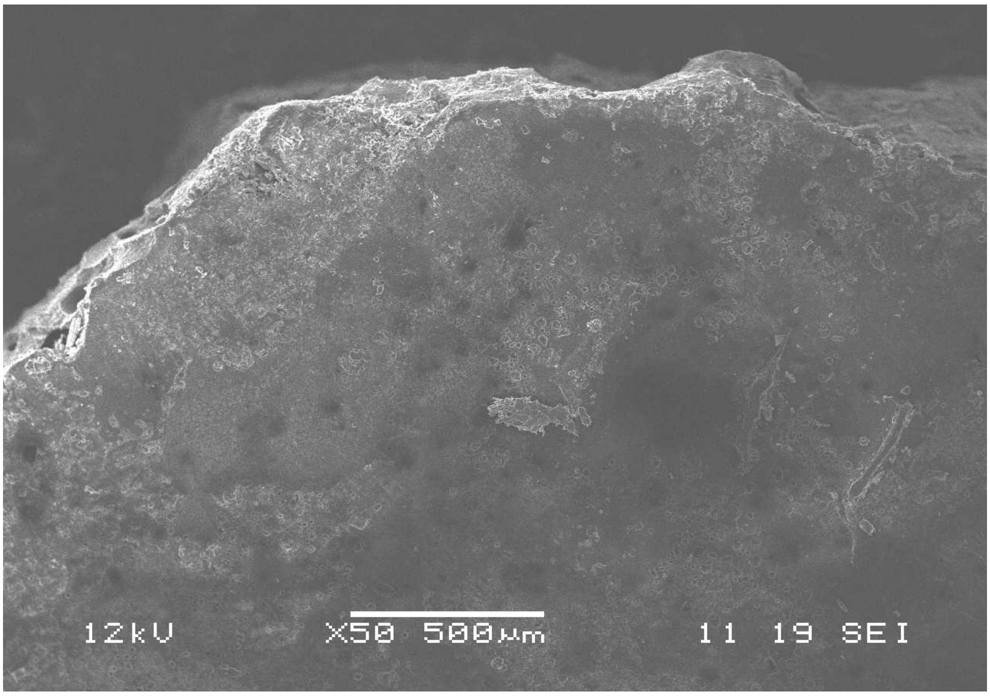

Figure 8 Scanning electron micrograph image (×50) showing the fracture surfaces of the composites with filler loading of 20% w/w

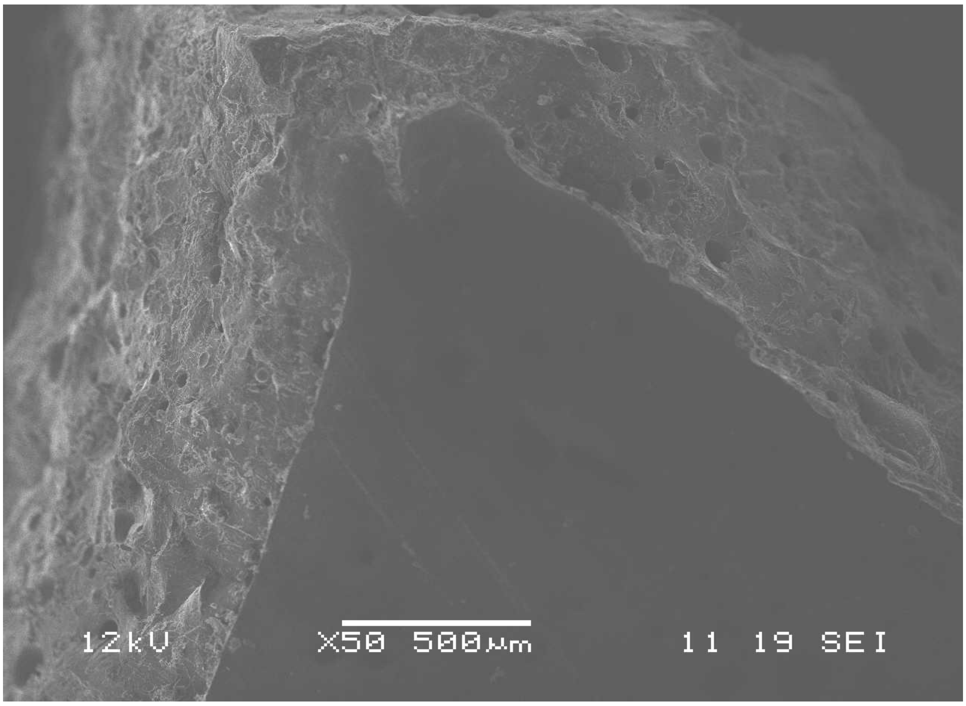

Figure 9 Scanning electron micrograph image (×50) showing the fracture surfaces of the composites with filler loading of 30% w/w