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The Study of Gravimetric Thermal Analysis and Some Physical Properties of a Binary Polymeric Mixture of Unsaturated Ester and Peach Seed Powder

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Abstract

Strengthening polyester resin and increasing its hardening was studied by adding peach seed powder. We also studied how to change the thermal properties after strengthening the resin by adding different weight percentages of peach seed powder (5%, 10%, 15%). The thermal properties of polyesters were studied before and after cementing, which included thermogravimetric analysis (TGA) and treatment at different temperatures (21, 51, 81, 121, 151ºC.) The effect of acidic functions (pH 5, 7, and 8) was also studied. The following results were obtained: When comparing the weight ratio values at 310°C $(Wt\%)_{310}$ with the TGA values, it was found that these values are in agreement with the variable temperature TGA. This behavior can be attributed to the unsaturated polyester containing the peach seed powder, which makes it slightly affected by heat. This observation indicates that the TGA values can be considered a good measure of thermal stability. It was also found that the initial decomposition temperature (IDT) values were less than 350° C in all these treatments, while the complete decomposition temperature (CDT) values ranged between 416°C and 550°C and did not reach 600°C. The average values of $(Wt\%)_{310}$ did not exceed 55%. The highest weight ratio values were found at (Wt%)310 and IDT and CDT were found in neutral medium. It is also found that the IDT and CDT values of the composite polymeric compounds containing peach seeds powder at 10% were high.

Keywords: Thermogravimetric analysis, peach seed powder, polymeric composites, unsaturated ester

INTRODUCTION.

As a result of scientific research, the need for polymeric materials with specific characteristics that cannot be obtained from one type has emerged. Therefore, many attempts have appeared to mix two or more types of materials to obtain a polymer mixture with industrial specifications [1]. A composite polymer, defined as consisting of two or more materials with different specifications that are linked together in a specific way to give the required composition [2], and the appropriate specifications, which differ from the specifications and properties of the materials included in its composition, and thus it combines the good properties of the various materials included in its composition in addition to getting rid of the existing defects [3]. In order to be more suitable for the desired industrial applications, resins are thermally hardening polymers and one of the most desirable systems currently in use due to their low cost and high performance properties. The saturated polyester resin of low viscosity is the most commonly used [4]. Here studies show that the uses of this polymer in practical life are varied and numerous, such as its use as binders in the manufacture of many of the same industrial use and as varnishes for polishing purposes and in the manufacture of dyes in addition to its use as thermal insulators after reinforcing them with some additives as well as use in drugs [5, 6]. The

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distinctive properties of this substance made it popular in many industrial applications. Fillers are an important part of polyester resins, filler levels range from the weight of the compound used (1%–30%) to the weight of the compound used, and the viscosity of the resin is the main factor determining the amount of filler. The unsaturated polyester is in the form of a viscous liquid that includes the diluent or the crosslinking agent (styrene), where it is polymerized and hardened by the addition polymerization process (by the free radical method) and converting it to the final form that cannot be melted. Abstracting soluble in most organic solvents [7, 8], and to the thermal properties of unsaturated polyester composite polymer supported by some industrial wastes (industrial wastes, glass particles, sawdust, wood flour) and by weight ratios whereas the results of the thermogravimetric analysis (TGA) indicated an increase in the thermal stability of the composites with an increase in the percentage of fillers, and the largest possible at 20% of the glass particles compared with sawdust. It can also be seen that the initial and maximum dissociation temperature and the temperature of which. The compound loses half its weight (wt%)310, the percentage of charcoal and the activation energy of the dissociation process increases with the increase in the percentage of fillers. It has also been observed that the values of the maximum dissociation temperatures (Wt%)310, supported with sawdust are higher than that with glass participles [9], and the preparation of polymeric compounds from molten unsaturated ester as a base material with sawdust powder as a reinforcing material. Some of its mechanical properties were studied, which included shock resistance (IS), UNC's modulus (E), Brinell hardness (BH), and compressive strength (CS). It was found that the modulus of elasticity decreases with increasing temperature. Reinforcement was found to increase the shock resistance, Brinell hardness and compressibility resistance, Some acids, such as HCl, H_2SO_4, and HNO_3, at concentrations of 0.5 N, 1 N, and 1.5 N affect the physical properties such as absorption and diffusion coefficient of polyesters before and after consolidation. The results showed that the increase in the acid concentration and the increase in the immersion time of polymers increased these properties [10].

Recent Literature Survey

Materials science, represented by the science of superimposed materials, has proven to be of great success in the possibility and ability to use the superimposed material in many different applications and to achieve the desired goal of using it successfully, which motivated many researchers in this field to conduct many different research studies that include modifying raw materials and integrating them in different ways. [11] and study the final properties. For the products, we mention the following.

Mandell et al. used epoxy resin reinforced with cut glass fibers and studied the effect of frequency change on the flexural fatigue characteristics of the used superimposed [12].

Gamsted and his group presented a study on the effect of random laminated glass fibers on the flexural fatigue behavior (tensile-compressive) of polypropylene resin, and the results showed that the reinforcement with laminated glass fibers showed high efficiency in mechanism of load transfer and distribution during cycles of cyclic stress [13].

Khan and Simpson also studied the compressive behavior of the polyester resin reinforced with multiple layers of glass fibers oriented in the direction (90° and 0°) relative to the direction of the force applied to the fiber, and they noticed that the best resistance to fracture and the highest modulus of elasticity for the resulting composites were for those containing fibers in the direction of 90°. It was also found that the strength of this type of reinforcement increased by 16% to 18%) compared to those without reinforcement [14].

Compston et al. mixed two polymeric materials, rubber and vinyl ester, and studied the effect of that mixing on the flexural fatigue behavior of that material [15].

Kereem studied the mechanical properties of epoxy reinforced with nickel particles. He used particles of different sizes with different volume fractions. He found that the values of the modulus of elasticity and yield strength increased with the increase in the volume fraction of the particles, as well as the increase in the size of the particles improved the properties up to (32 μm) [16].

Prota and his colleagues studied the static bending resistance of an epoxy-based superimposed material reinforced with steel wires with a diameter of 0.8 mm in a twisted form [17].

Ferreira and his group, they were interested in studying the effect of the interface between the support material and the base material on the mechanical properties (tension and bending fatigue) of a composite made of unsaturated polyester resin reinforced with aluminum [18].

Dhakal et al. studied the effect of volumetric fracture of natural and random woven hemp fibers on the absorption of shock energy. The researchers found that increasing the volumetric fraction reduces the damage resulting from the impact of shock and increases the susceptibility to energy absorption [19].

Faten also studied the mechanical properties (static curvature and shock) of Novaflak when pure aluminum powder was added to it with different granular sizes (201, 250, 106 μm) and with different forming temperatures (75, 100, 125, 150, 200°C), the results showed that the bending strength and hardness of the tested composite increased by increasing the particle size of the added particles [20].

Saleh and Shnean presented a study on the effect of adding titanium oxide ((TiO_2) and iron oxide (FeO) in different weight ratios, to the low-density polyethylene resin (LDPE), on the modulus of elasticity, tensile stress, hardness and shock resistance of the resulting composites [21].

Nallis conducted a study on the effect of different quality and quantity of reinforcement materials, in addition to the surrounding environmental conditions, on the mechanical properties of polymeric composites, where he found that the addition of rice fibers and glass mica powder to the polypropylene resin led to a decrease in the tensile strength. and shock to the prepared super positions [22].

Satish and his colleagues conducted a study on the mechanical properties of unsaturated polyester reinforced with steel fibers and nylon fibers in a hybrid form, where the volume fraction of each of the base material and nylon fibers was fixed and the volume fraction of steel fibers was changed [23].

Aruniit et al. conducted a study on the effect of the volume fraction of alumina trihydrate added to the unsaturated polyester resin, on the modulus and strength of static bending, as well as on the hardness of the composite prepared from that material [24].

Aruniit et al. further studied the mechanical properties of a composite consisting of epoxy and E-glass fibers reinforced with different oxides, including alumina [25].

Ahmed studied the mechanical properties and tensile strength of hybrid composite materials (carbon fiber / glass fiber / epoxy) and compared these properties with composite materials (glass fiber / epoxy) and concluded that the mechanical properties of hybrid composite materials are superior to their counterparts in non-hybrid composite materials [26].

Al-Rawi and Salman studied some mechanical properties of the epoxy-MgO composite, and a polymeric-based composite material was prepared by hand casting method. The composite material was prepared from epoxy resin as a base material supported by magnesium oxide (MgO) powder and with different weight fractions (0,5%, 10%, 15%, 20%, 25%), and the bending test (three-point) and the accurate hardness test were carried out on it [27].

Haitham et al. studied the mechanical properties of epoxy-based hybrid composites reinforced by glass fibers and silicon carbide particles [28].

Jasim prepared compounds of epoxy and eggshell powder for use in coating surfaces [29].

Ahmed studied the mechanical properties as well as the physical properties of a polymeric mixture of epoxy resin with polyurethane rubber by weight (wt% 15) [30].

Kalel also referred to the evaluation of the mechanical properties of aluminum-based composite materials reinforced with ceramic materials (Al_2O_3, SiC), and he studied the mechanical properties and microstructure of metal-based composite materials of aluminum alloy type (A 6061) reinforced with ceramic materials (Al_2O_3, SiC) [31].

Ergun studies the mechanical properties of polymeric composite materials using solid ceramic fillings (Al_2O_3, SiO_2, MgO, TiO_2), where epoxy resin was used as a base material, and these powders were mixed with different weight ratios, and mechanical tests were conducted for these. The materials have a modulus of curvature and hardness, and good mechanical results were obtained [32].

Hazim et al. studies the effect of metal particles (Al, Ni, Fe) on the mechanical and thermal properties in different weight ratios (3%, 6%, 9%, 12%) with epoxy, and fouud that the higher the proportions of the supporting materials, the higher the properties (mechanical, thermal and electrical conductivity) [33].

Albozahid et al. studied the effect of adding graphite to the epoxy material on the mechanical properties, which included flexural modulus, tensile strength, and hardness, in different weight ratios (0.5%, 1%, 1.5%, 2%) using ultrasound scattering method. The results of the tests showed an improvement in the tensile strength, bending and hardness at 0.5%, 1%, and 1.5% except for 2%, the properties decreased due to the decrease in the energy of the sound waves [34].

Outcome of Work

The idea of the research stemmed from the increasing importance of composite materials in our daily life, as they carry distinctive and important characteristics to be a basic material in many modern applications and industries. Aluminum and copper were added to improve the mechanical properties represented by hardness, modulus of elasticity, shock, compressibility and the physical properties represented by thermal conductivity. Thermogravimetric analysis (TGA) of samples was performed before and after reinforcement.

PROCEDURE

Materials and Procedure

- Preparation of raw materials, including:
- Additive preparation stage (peach seed powder)

The peach seed powder is dried in a drying oven at a temperature of 110°C for a period of 24 hours to remove the moisture present in it, then it is ground using an electric grinder until it reduces to a powdery form. After some experimental tests, it was found that the best percentage was 2% to mix the solid material methyl peroxide ethyl ketone (MEKP) with unsaturated polyesters melted at 165°C and pressed at 1.5 tons to turn into a gelatinous material that solidifies at room temperature. Polymeric compounds were prepared by adding peach kernel powder in the ratio 5, 10, and 15 wt% to unsaturated polyester, where the unsaturated polyester liquid is mixed alone with peach kernel powder for 30 minutes until homogeneity is achieved between the base material and the reinforced material. Then the solid material is added and mixed well and then the mixture is poured into special molds and left for 24 hours to obtain chips with a thickness of 1 ± 0.1 mm. The forms are separated from the molds using a sharp blade, and then cut into small pieces that fit into what is needed for study. The weight ratio was obtained from the following relationship [35]:

$$\%Wt = (Wf/Wc) \times 100$$

$$W_c = W_p + W_m$$

where (Wf/Wc is the weight fraction of the powder in the superposition, and
W_c, W_m, and W_p are the the mass of composite, matrix, and peach seed powder, respectively.

According to the standard specifications (ASTM) for each test, four samples were prepared from compounding peach seed powder fibers with unsaturated polyesters.

Heat Treatment of Models

Five different groups of samples were thermally treated for 10 hours at the following temperatures: 21, 51, 81, 121 and 151°C. After the end of the specified period, the samples were removed from the oven and kept in a dry place [36].

Acid Treatment of Samples

Three different groups of samples were treated in three aqueous media with different acidity (pH): 9, 7, and 5. After the end of the specified time, that is, 50 hours, the samples are removed from the solutions, washed with water, dried in air only at laboratory temperature, and then kept in a dry place.

Preparation of HCl and NaOH Chemical Solutions

Devices Used

TGA Test Instrument

Thermalgravimetric analysis test instrument: The Shimadzu TA-50 thermogravimetric analysis device was used. The device, shown in Figure 1, consisted of a sensitive balance whose scales swing and an electric oven, as it was placed in the pan made of platinum, a model with a weight of 6 to 12 mg, then the oven was gradually heated at a regular speed (10°C/min) with nitrogen gas. Graphs were obtained through the device screen showing the loss in weight with the increase in temperature, and the weight of the model is continuously measured with the increase in temperature At each temperature, all the obtained weights are converted into weight ratios for the remaining part, and this is done when the entire model is decomposed [37].

RESULTS AND DISCUSSION

Thermal Resistance of Polymer Composites

The thermal resistance of polymeric compounds was studied using thermal variable temperature analysis (TGA). The thermal resistance of the various embodiments was measured by the temperature at the beginning and end of the decomposition and compared with some and the percentage of residual weight of the polymer [38] in the middle of the beginning and the end:

Decomposition initiation temperature (IDT):

- Decomposition end temperature (CDT)
- Model weight ratio 310 (weight %)$_{310}$

Figure 1. The Constand and variable temperature thermogravimetric analyzer.

The CDT and IDT from the intersection the values were obtained from the TGA tangents at the change points with the straight portion of the curve at the beginning and end of the decomposition. The value of Wt_{310} from the intersection of the column that lies on the curve is determined at 310°C.

Thermal Stability of Composites Cured at Different Temperatures

Figures 2–6 refer to the TGA curves of the unsaturated ester and its polymeric compositions that were prepared in different (hardened) weight ratios at 21°C, 51°C, 81°C, 121°C, and 151°C.

The CDT and IDT values were measured from the intersection of the TGA tangents at the change points with the straight portion of the curve at the beginning and end of the decay. The value of $(Wt\%)_{310}$ was determined from the intersection of the column falling on the curve at 310°C [39].

The reference values (IDT, CDT, Wt%) extracted from the figures are presented in Tables 1, 2, and 3. For the sake of comparison, we reviewed the results of the gravimetric analysis of unsaturated polyesters (alone) and treated at temperatures ranging between 21°C and 151°C. Acidity (pH) ranged between 5 and 9, as it was found that the IDT values were less than 350°C in all these treatments, while the CDT values ranged between 416°C and 550°C and did not reach 600°C. The average values of $Wt\%_{310}$ did not exceed 55% [40].

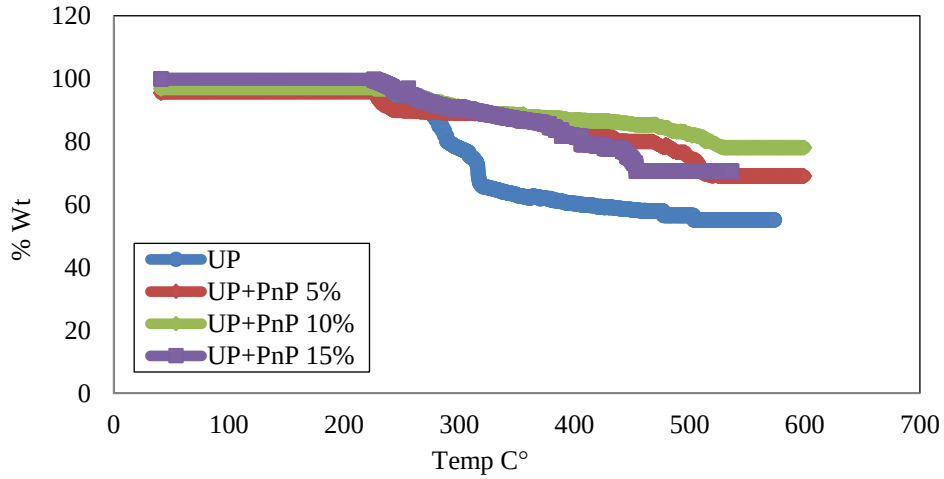

Figure 2. Thermogravimetric analysis of the before and after support at 21°C. PnP, peach uclei powder; UP, unsaturated polyester.

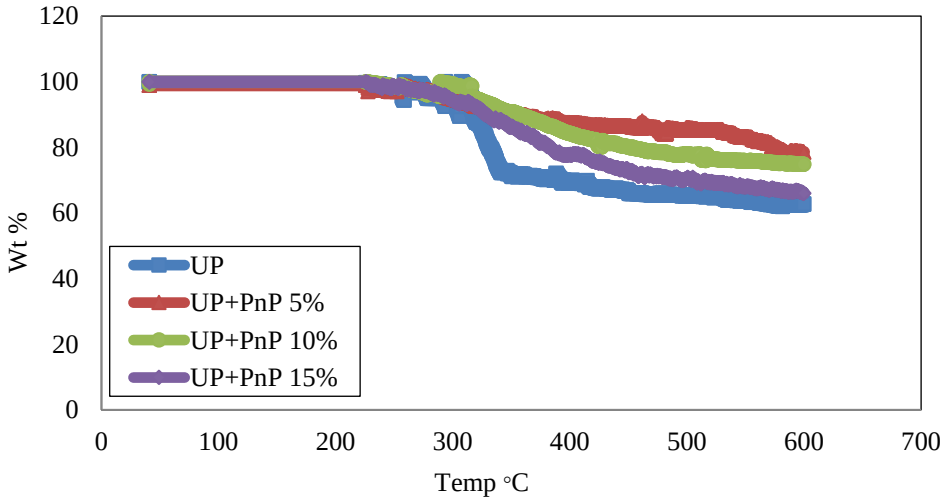

Figure 3. Thermogravimetric analysis of unsaturated polyester (UP) compositions with peach nuclei powder (PnP) treated at 51°C.

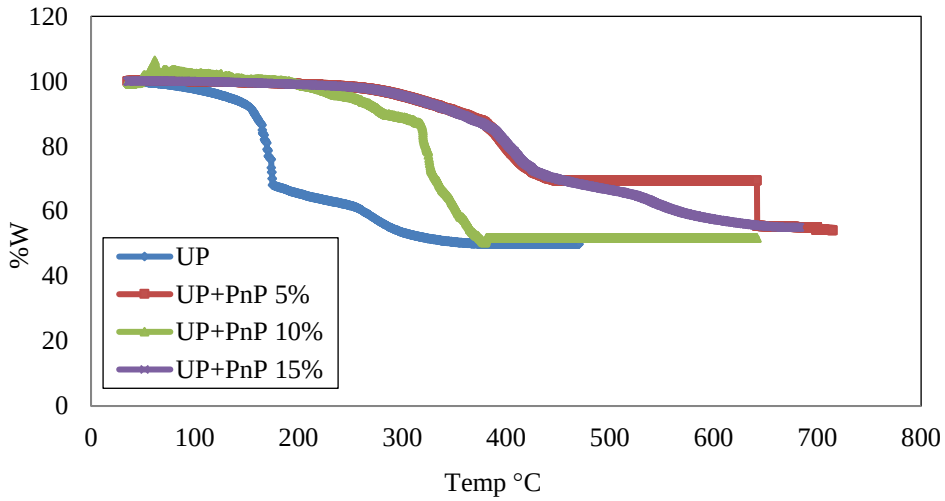

Figure 4. Thermogravimetric analysis of unsaturated polyester (UP) complexes with peach nuclei powder (PnP) treated at 81°C.

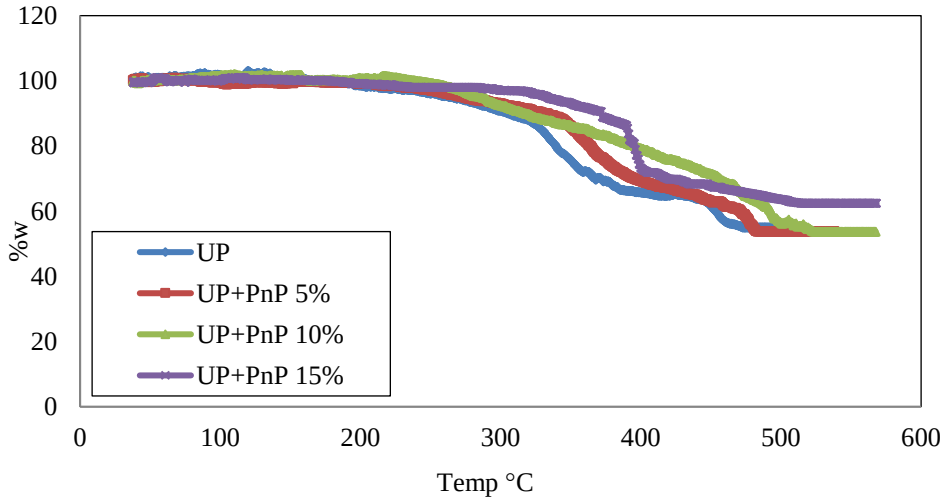

Figure 5. Thermogravimetric analysis of unsaturated polyester (UP) complexes with peach nuclei powder (PnP) treated at 121°C.

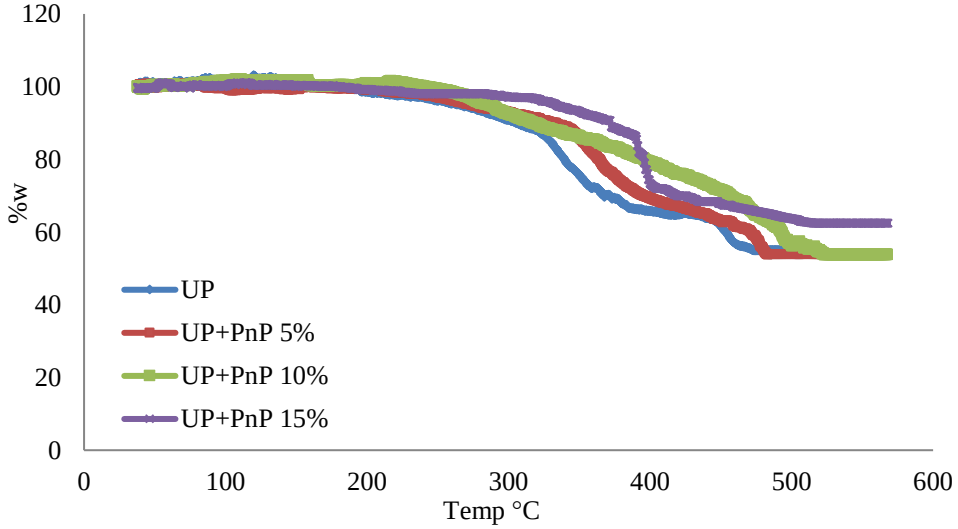

Figure 6. Thermogravimetric analysis of unsaturated polyester (UP) compounds with peach nuclei powder (PnP) treated at 151°C.

Table 1. Some values of the thermal stability of the onset of degradation of polymers taken from the analysis curves.

Polymeric composites	**Thermal degrees of the onset of decomposition**				
	21	51	81	121	151
UPE	312	312	312	312	312
UPE +PnP 5%	312	245	305	311	225
UPE +PnP 10%	332	291	299	305	307
UPE +PnP 15%	310	317	280	315	288

PnP, peach nuclei powder; UPE, unsaturated polyester.

Table 2. Some values of thermal stability for the end of decomposition of polymers taken from thermogravimetric analysis curves

Polymer composite	**Thermal degrees for the end of decomposition**				
	21	51	81	121	151
UPE	445	445	445	445	445
UPE +PnP 5%	435	547	438	423	416
UPE +PnP 10%	553	545	530	507	463
UPE +PnP 15%	511	484	460	451	436

PnP, peach nuclei powder; UPE, unsaturated polyester.

Table 3. Some values of the residual weight of the polymer (wt%) at 310°C for polymeric composites taken from thermogravimetric analysis curves treated at different temperatures.

Polymeric composites	**Weight remaining percentage (%) at 310°C**				
	21	51	81	121	151
UPE	81	81	81	81	81
UPE + PnP 5%	88	85	84	82	75
UPE + PnP 10%	95	93	90	87	86
UPE + PnP 15%	91	90	89	87	84

PnP, peach nuclei powder; UPE, unsaturated polyester.

By observing Table 2 and comparing the values of IDT, CDT, and Wt% for all the polymeric composites alone, a remarkable increase in these values is observed due to the presence of the peach seeds with the unsaturated ester [41]. By extrapolating the values of CDT in Tables 2 and 3, and for all the polymeric composites, the following is observed:

1. The IDT values of the polymeric composites containing peach seed powder at 10% were high.
2. A noticeable effect of increased curing temperature on the IDT values is observed, as the higher the curing degree, the lower its value.

Reviewing the CDT values in Table 2, the following were noted:

1. The CDT values of the polymeric composites containing peach seeds powder at 10% were high.
2. A significant effect of increased treatment temperature on CDT values is observed, as the higher the degree of treatment, the lower its value.

It was found that the treatment temperatures had a significant effect on the IDT and CDT values of the polymeric composites as their values decreased with increasing the treatment temperatures as well as the weight ratios.

The polymeric composites are in the form of polymeric chains intertwined with each other, where the fragility of the composites and the speed of rotation of their units with increasing heat leads to a

rapid softening and then decomposition. It is also noted that all the polymeric composites have high CDT values, so the polymeric composites are considered to have good thermal stability [42].

There is another phenomenon that attracts attention when comparing the values of IDT CDT, and $Wt\%_{330}$ for polymeric composites treated in temperatures from 21°C to 151°C, where there was a drop in these values due to the ease of separation and movement of their units as the treatment temperature increased. The results showed a clear indication of these values between the lowest degree of treatment (21°C) and the highest value (151°C). When the temperature decreases, the viscosity of the polymer increases and the movement of the polymeric chains is restricted, and the presence of peach seed powder as an interlocking material is an additional factor restricting the movement of the polymeric chains, and the interlocking increases. The fillers work in distributing the stress on a larger volume of the polymer, thus preventing the growth of cracks and thus increasing the degree of glass transition (T_g) and prevents its dissolution at low temperatures.

Thermal Stability of Networks Treated at Different pH Values

Figures 7, 8, and 9 show the TGA curves of polymeric networks treated at three different pH values. Reference values for the onset and end of the decomposition and the residual weight at 310°C were extracted and are presented in Tables 4, 5, and 6.

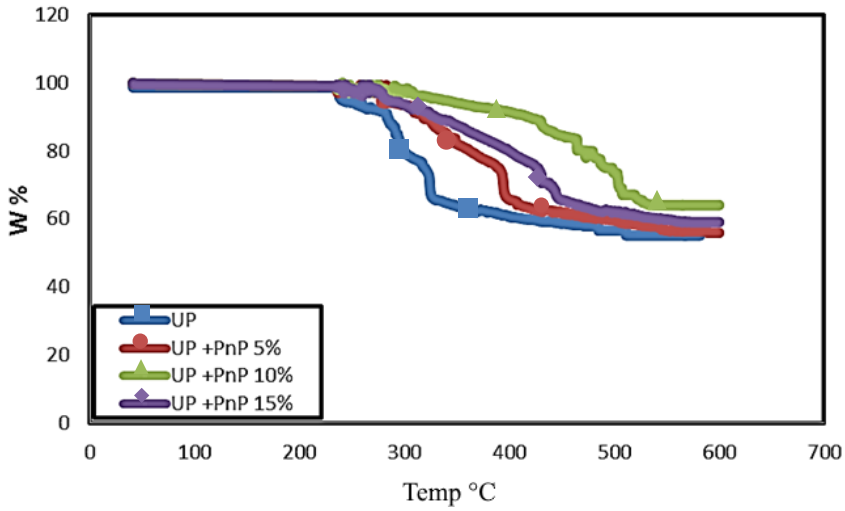

Figure 7. Thermogravimetric analysis of the unsaturated polyester (UP) before consolidation and after treatment at pH 4. PnP, peach nuclei powder.

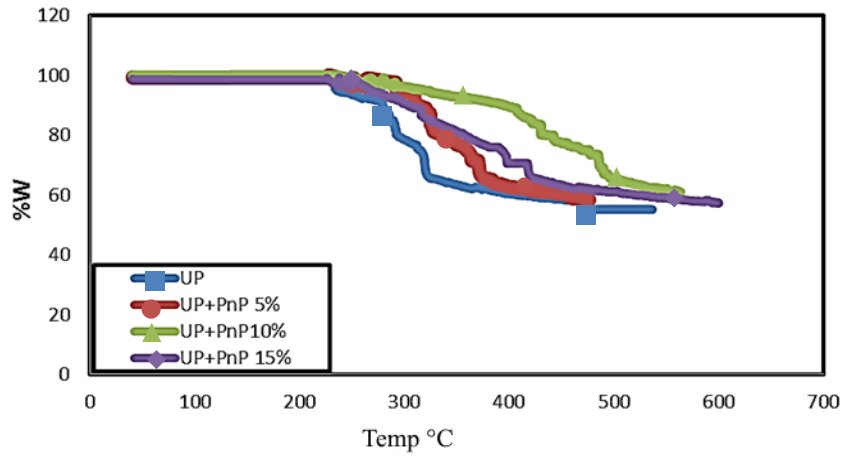

Figure 8. Thermogravimetric analysis of unsaturated polyester (UP) complexes with peach nuclei powder (PnP) treated at pH 7.

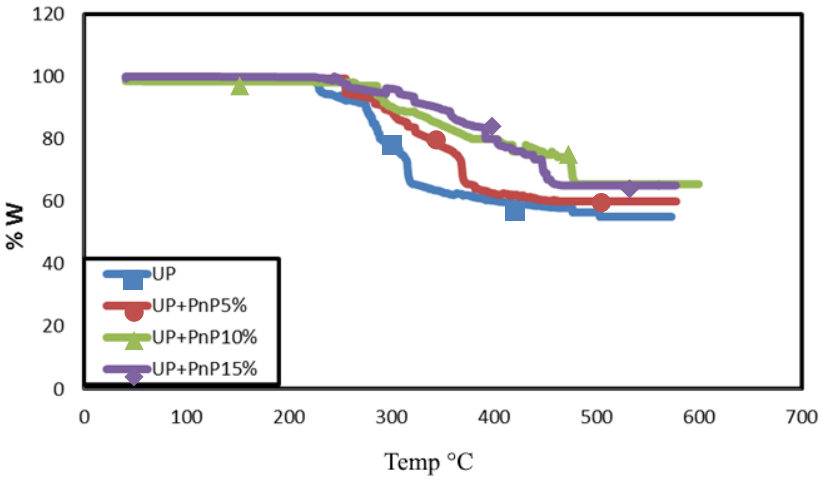

Figure 9. Thermogravimetric analysis of unsaturated polyester (UP) compositions with peach nuclei powder (PnP) treated at pH 10.

Table 4. Some values of the thermal stability of the onset of degradation of polymers taken from analysis curves treated at different pH values.

	Thermal degrees of the onset of decomposition		
	pH 4	**pH 7**	**pH 10**
UPE	232	232	232
UPE +PnP 5%	260	278	240
UPE +PnP 10%	273	280	276
UPE +PnP 15%	273	244	277

PnP, peach nuclei powder; UPE, unsaturated polyester.

Table 5. Some values of thermal stability end of degradation for polymers taken from thermogravimetric analysis curves treated at different pH values.

Polymeric composites	**Thermal grades for the end of decomposition**		
	pH 4	***pH 7***	***pH 10***
UPE	353	353	353
UPE +PnP 5%	385	355	370
UPE +PnP 10%	494	470	446
UPE +PnP 15%	431	407	441

PnP, peach nuclei powder; UPE, unsaturated polyester.

Table 6. Some values of the residual weight of the polymer (wt%) at 310°C for polymeric composites taken from thermogravimetric analysis curves treated at different pH values.

Polymeric composites	**Weight remaining percentage (%) at 330**		
	pH 4	***pH 7***	***pH 10***
UPE	65	65	65
UPE +PnP 5%	79.8	79.8	81
UPE +PnP 10%	92	92	87
UPE +PnP 15%	83	83	90

PnP, peach nuclei powder; UPE, unsaturated polyester.

By extrapolating the IDT values in Table 4 for all the composites, it was found that these values in the neutral medium are relatively higher than in the acidic and basic mediums. This effect can be attributed to the effect of the network and the speed of rotation of its units with increasing temperature

leads to its softening and then disintegration. Undenatured peach seed powder increases the crosslinking of the polyester as it increases the hardness of the polymer and reduces its flexibility because peach seed powders are one of the fillers that restrict the movement of polymeric chains and increase the resistance of the polymer and prevent its disintegration at high temperatures as well as acidic and basic medium.

It is noted from this context that the thermal stability of the compositions containing peach powder was high, especially for the compounds containing 10%. The reason is that the latter acted as nuclei, which increased the crosslinking process of the base material, and the higher the proportion of the peach powder, the lower the thermal stability. Inside the substrate and the bond between the support material and the base material at high concentrations [43–45].

By extrapolating the CDT values of the composites (Table 5), it is noticed that these values are relatively higher in the neutral medium than in the acidic and basic mediums and by reviewing the residual weight values of $(Wt\%)_{310}$, it is noticed that the highest values were in the neutral medium compared to the other two mediums as well.

By comparing these values with the CDT values, IDT values converge 310 (% Wt) with the CDT values in neutral environment. This observation indicates that the IDT values do not necessarily determine the context of polymer dissociation.

CONCLUSION

The hardness of the overlays prepared from unsaturated polyester resin changes with the change in the concentrations and quality of the peach seeds powder added to it. It increases with the increase in the weight fractions of all the overlays, because the reinforcement materials have high hardness and durability compared to the base material. The homogeneous distribution of the reinforcement materials within the base material provided an opportunity to increase the entanglement and compaction between the components of the overlay and thus work to increase the hardness. For all the polymeric composites alone, a remarkable increase in these values is observed due to the presence of the peach seeds with the unsaturated ester. The following observations were made:

1. The IDT values of the polymeric composites containing peach seeds powder at 10% were high.
2. A noticeable effect of increased curing temperature on the IDT values is observed, as the higher the curing degree, the lower its value.
3. The CDT values of the polymeric composites containing peach seeds powder at 10% were high.
4. A significant effect of increased treatment temperature on CDT values is observed, as the higher the degree of treatment, the lower its value.
5. It was found that the treatment temperatures had a significant effect on the IDT and CDT values of the polymeric composites as their values decreased with increasing the treatment temperatures as well as the weight ratios.
6. There is another phenomenon that attracts attention when comparing the values of IDT CDT, and % Wt_{330} for polymeric composites treated in temperatures from 21°C to 151°C, where there was a drop in these values due to the ease of separation and movement of their units as the treatment temperature increased. The results showed a clear indication of these values between the lowest degree of treatment (21°C) and the highest value (151°C).
7. The IDT values for all the composites, it was found that these values in the neutral medium are relatively higher than in the acidic and basic medium.
8. The thermal stability of the compositions containing peach powder was high, especially for the compounds containing 10%.
9. It was observed that the CDT values of the composites are relatively higher in the neutral medium than in the acidic and basic mediums and by reviewing the residual weight values of $(Wt\%)_{310}$, it is noticed that the highest values were in the neutral medium compared to the other two mediums as well.
10. By comparing these values with the CDT values, IDT values converge $(\%\ Wt)_{310}$ with the CDT

values in neutral environment. This observation indicates that the IDT values do not necessarily determine the context of polymer dissociation.

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