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Preparation of Polymeric Composites from Polypropylene and Palm Fronds and the Study of Some of Their Physical Properties

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Abstract:

In this study a type of polymeric composites from melting poly propylene as a basic substance with Palm fronds powder were prepared. Evaluation of polymeric composites was done by studying some of its mechanical properties, which included: Yong modulus (E), Impact Strength (I.S), Brinell hardness (B.H) and Compression Strength (C.S). The polymeric composites were studied before and after reinforcement by comparing between them. There was an increase in resistance of Yong modulus (E), Impact Strength (I.S), Brinell hardness (B.H) and compression Strength (C.S). Also, the effect of some acids were studied such as (HCl, H₂SO₄, HNO₃) with concentrations of (0.5N; 1N and 1.5N) respectively. The physical properties of absorbance and poly propylene's diffusion coefficient were studied before and after reinforcement, The results showed an increase in values of these properties with increasing concentration of acid and time of polymer's immersion in the acidic solution.

Key words: Diffusion Coefficient, Palm fronds, Poly propylene, Polymeric composites.

Introduction:

Composite Materials are composed of two or more materials combined physically without chemical reactions, between them, So each material keeps Its properties .The resulting materials have new properties (1). Many studies indicate the importance of composite materials(2, 3, 4, 5, 6), One of these studies is the development of a LPGFS (Long Period Grating fiber Sensor) embedded into a polymer composite simulation model. In this way the polymer composite transforms into a “smart one”. The developed simulation model is a “must be accomplished” stage for a proper manner of engineering the smart polymer composite material fabrication and for improved designs of their applications in various fields. The LPGFS simulation model is developed considering the role of optic fiber birefringence induced by polymer embedment. After that, it follows the specific application stage in which it is analysed, the LPGFS response to loads applied to smart composite material by its environment (7).

Nano composites materials are currently in use as a replacement for traditional materials due to their superior properties, such as high strength-to-

weight ratio, cost effectiveness, and environmental friendliness(8), Nano composites with polypropylene/clay/wood flour were prepared by melt compounding. Thermal, mechanical and morphological properties were characterized. The addition of clay, compatibilizer and wood flour considerably improved the thermal stability (i.e., decomposition and melting temperatures) of the hybrids. The tensile modulus and strength of most hybrids were highly increased with the increase loading of clay, MAPP and wood flour, compared to the hybrids without wood flour. The wide angle X-ray diffraction (WAXD) patterns showed the increased d-spacing of clay layers, indicating enhanced compatibility between PP and clay with the addition of maleate polypropylene (MAPP). The transmission electron microscopy (TEM) photomicrographs illustrated the intercalated and partially exfoliated structures of the hybrids with clay, MAPP and wood flour. (9), by day. Natural fiber composites such as sisal polymer composites became more attractive due to their high specific strength, lightweight and biodegradability. Mixing of natural fiber with E-glass-Fiber Reinforced

Polymers is finding increased applications. In this study, sisal – glass fiber reinforced epoxy composites were developed and their mechanical properties such as tensile strength, compression strength and Hardness tests were evaluated. The results indicated that the incorporation of sisal fiber with E-glass can improve the properties, the fractured surfaces are evaluated by using Travelling and used as an alternate material for glass fiber reinforced polymer composites(10), natural fiber reinforced polymer composites are developed in two ways :treated and non-treated by using two different natural fibers and their mechanical properties such as tensile strength, flexural strength, impact strength and hardness test. At the end, properties of both strength of treated and untreated natural fiber reinforced polymer composite are compared and evaluated which one is the best and strengthen natural fiber reinforced polymer composite (11).

Materials and Methods:

Materials

Palm fronds were crushed as a powder after drying them in an oven at 90 C° for 3 hours, then the powder was put in metal molds made of iron locally (10 cm × 20 cm), The additional ratio was (32,22 and 12 %) of melting polypropylene at 165° C ,and pressure of 1.5 tons, The weight ratio was calculated from the following relationships (13):

$$\phi = \frac{W_p}{W_c} \times 100 \%$$

$$W_c = W_p + W_m$$

(ϕ) Weighted fiber fracture in composites

(W_c , W_m and W_p) Palm mass, substrate and composites respectively.

A pressure had been empowered on the casting to avoid presence of air vacuoles in it, and then was cut to pieces according to standard properties (ASTM American Society for Testing and Materials) for each test . Three samples for composites of palm fronds' fibers with polypropylene were prepared (Table 1)

Table 1. The change of the mechanical properties before and after reinforcement at (25 C°)

Samples	No. models	Size (µm)	weight of palm fronds (gm)	Weight of (polypropylene) (gm)
(PP) polypropylene	-	150	-	10
pp + palm fronds	1	150	1.2	8.8
pp + palm fronds	2	150	2.2	7.8
pp + palm fronds	3	150	3.2	6.8

Preparation of acidic solutions of (HCl, H₂SO₄ and HNO₃)

Preparation method of acidic solutions and polymer immersion in these solutions:

Acidic solutions of (HCl, H₂SO₄ and HNO₃) were prepared with different concentrations (0.5, 1.0 and 1.5 N) for each acid. For reinforced and non-reinforced samples with palm fronds, fibers have been cut to small cuboids and put in acidic solutions and all concentrations kept at room temperature, then samples were weighed after removing them from solutions, and the models re- weighed each 7 for 120 days.

Instruments used in study

Young's Coefficient was measured by Tri-points test which was provided by ELE-England company, a Shock had been measured by using Jar by Instrument which was provided by Tokyo Koki Seizosho, LTD company, using ing hydrokc piston (D-6700) provided by WOLPERT-Germany company for measuring Brinel hardness (Brinel HBr) and compressibility.

Results and Discussion:

Young's coefficient is one of the most important physical properties for all polymers. Change in polymer's dimensions are studied as a function of stress, when stress had been empowered on polymer's model at a constant speed and then deformation was measured in terms of size, length or area .Identifying polymer behavior under stress influence getting information of polymer properties in terms of strength, durability and flexibility from stress- strain curve, also the maximum stress and elongation obtained(13,14,15) .

Stress mean empowered force on cross-sectional area of unit for a model and has a symbol (σ) .

$$\sigma = \frac{F}{A} \text{ --- (1)}$$

(ϵ) Tensions represent the amount of elongation of model as a result of exposure to stress relative to original length

$$\epsilon = \frac{\Delta L}{L^o} \text{ --- (2)}$$

By using load triple point system, measurements were obtained which represents the relationship between stress and deviation polypropylene before and after supporting it with Palm fronds Young's coefficient was identified according to curve slop which represents the ratio between the stress and tension, as the following relationship:

$$E = \frac{\sigma}{\epsilon} \text{ --- (3)}$$

Figure 1 and 2 shows the relationship between stress and tensile strength of polymer before and after reinforcement at 25°C, 57°C respectively, where the stress was directly proportional to tension. When removing the empowered stress material it recaptures its nature.

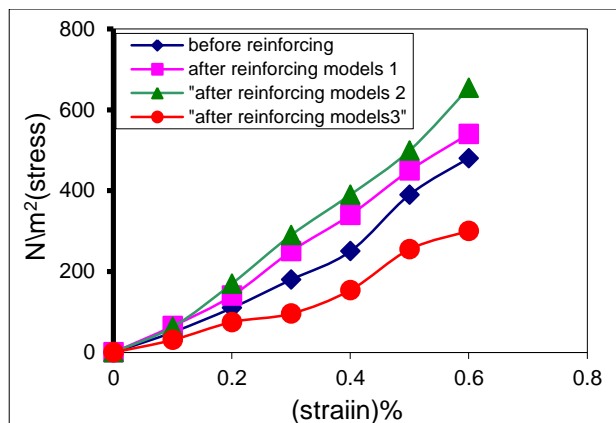


Figure 1. Shows the relationship between stress and tensile strength of polymer before and after reinforcement of 3 models at 25°C

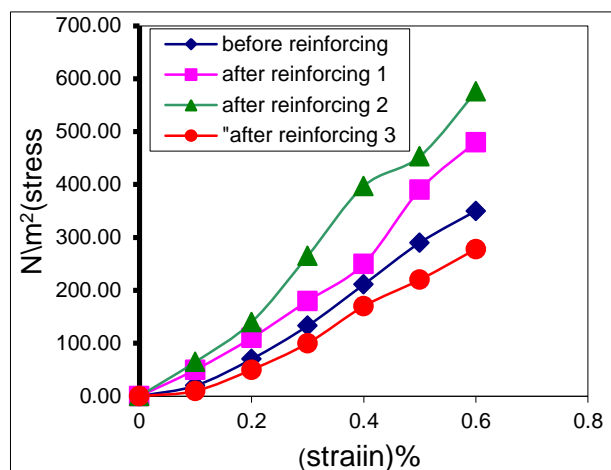


Figure 2. The relationship between stress and tensile strength for polymer before and after reinforcement of 3 models at 57°C

The flexibility coefficient was decreased with the increasing temperature

Table 2. Changes of the values of Young's Coefficient before and after reinforcement at (25,57)°C .

Young's Coefficient	Polymer before reinforced	Polymer after reinforced (model 1)	Polymer after reinforced (model 2)	Polymer after reinforced (model 3)
At 25°C	807.1429	925	1090.714	509.6429
At 57°C	618.2143	807.1429	986.0714	490.7143

Composites material reinforced with Palm fronds powder of (12 and 22) % have Young's coefficient higher than polymer before reinforcement, because palm fronds powder tolerates a great part of empowered stress on composites material, the palm fronds fibers work as barriers this obstruction depends on interface between fibers and polypropylene (16), weight ratio of fibers powder and distribution method through substrate. Young's coefficient at 32% was less than polymer before reinforcement because the substrate was not enough to link the particles and distribute them within the composites polymer at this concentration, that led to weak composites. Increasing temperature of model caused the bonds between the molecular chains of substrate to fall apart causing flaccidity. Great emotion and weakness of resistance of substrate occurred and led to decrease Young's coefficient at 57°C.

Impact resistance

Impact force test is one of practical methods, which gives fracture description picture about strength of material and its resistance at high velocities(17). Impact resistance was calculated by equation 4.

$$\text{Impact Strength (I.S)} = \frac{\text{Fracture Energy(Joule)}}{\text{Area(m}^2\text{)}} \text{-----(4)}$$

Area = Area of model at fracture.

The energy required to fracture sample before reinforcement was (0.20 kg. m), while the results in table (2) showed when reinforcing polymer with Palm fronds,, the energy required to fracture increased due to the presence of flexible emotion energy fibers in composites material , because of the fibers tolerance to stress compared with composites material. Fiber had worked to distribute the stress on bigger size and had decreased concentration of stress at a point, also it worked as barriers to fracture and prevented the presence of small pores which occurred as a result from impact(18,19, 20).

Hardness (B. Hr) Hardness

Hardness is defined as a resistance material to scratch or pervasion .There are different universal method to determine hardness of plastics, such as Brinell and Rockwell hardness pervasion occurs at a slow ratio of model's surface during exertion of force for test that leads to topical crawling .After removing the effecting force, slow recovery occurs in test which leads to changes in the dimension

depending on hardness calculation, to prevent that it must be time-bound to shed strength on model surface(20). Hardness is one of the surface mechanical properties, polymers maybe exposed to pervasion or scratch by other tools through using them in applied fields (21). Brinell method was used to calculate hardness of the composite material by using function 5 (22, 23, 24).

$$B. Hr = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2})} \quad \text{--- (5)}$$

P = slaughtered stress (kg)

D= radius of ball steel (mm)

D= radius of impact on surface (mm)

π = ratio fixed

t = depth of impact

Table (2) has improved values of hardness after reinforcing polypropylene with fiber due to increased tangles resulting from stacking between polypropylene bonds with palm fronds, fibers which decrease movement of polymer molecules and then

increase its hardness and resistance for scratching(25).

Compressive Resistance (CS):

Compressive resistance shows tolerance of material when exposed to static compression before breaking. High value indicates enlarged forces of cohesion between particles of materials. Compressed test is one of the important tests which gives whole picture about polymer's strength and its tolerance.

Reinforcing polymers with fibers leads to increasing resistance value for composite materials as in Table (3), This depends on type of reinforcing materials with substrate(26), distribution lead on fibers and strength of adhesion of polypropylene with Palm fronds fibers. Generally, Compressive resistance was defined as the maximum stress which solid materials tolerate under vertical pressure (27).

$$\text{Compressive Resistance(C.S)} = \frac{\text{maximum load}}{\text{cross section area}} \quad \text{--- (6)}$$

Table 3. Change of mechanical properties before and after reinforcement At (25° C)

Mechanical properties	Polymer before reinforcing	Polymer after reinforcing (Model 1 12% wt)	Polymer after reinforcing (Model 2 22% wt)	Polymer after reinforcing (Model 3 32% wt)
Impact Strength	3.486 Joule/m ²	3.956 Joule/m ²	4.739 Joule/m ²	6.891 Joule/m ²
Hardness Test	31.4 kg /mm ²	67.8 kg /mm ²	70.7 kg /mm ²	82.6 kg /mm ²
Compression Test	kg /mm ² 39823.	5.1709 kg /mm ²	8.2907 kg /mm ²	11.6513 kg /mm ²

Effect of acidic solutions on physical properties of polypropylene with Palm fronds fibers before and after reinforcing with fibers of palm fronds randomly:

Polymer's resistance depends on the nature of the polymer and the type and nature of media it is flooded in. The purpose of study analysis of polymers to identify the effect of different solutions on it. Absorption of different polymers and composite materials by flooding them in water or solutions or exposure to humidity have followed law of Figs, 3,4,5,6,7,8 of spreading that means mass of water or absorbed solution increase linearly with square root of time gradually till saturation (28). Absorbed solution is concentrated within the substrate which causes swelling in polymer and change in its dimensions because this solution had represented plasticizing agents for polymer(29). It was noticed the weight of models increase with immersion's time due to nature of polymer (when they were in contact with liquid directly) especially when the molecules try to pass through. Polymer quickly, beginning with filling gaps that stay away of polymer's chains. First law of Figure was applied

in diffusion stable state, that means concentration does not change with time (30, 31).

Calculate the percentage increase in the cluster (weight gain %) using equation (7)

$$\text{Weight Gain \%} = \frac{M_2 - M_1}{M_1} \times 100 \quad \text{-----(7)}$$

M₁= mass of the sample before flooding (gm)

M₂= mass of the sample after flooding (gm)

Diffusion coefficient was calculated from the graphical relationship between increase mass and square root of time, according to second law of Fig,1 using equation(8)

$$D = \pi(k b / 4M\infty)^2 \quad \text{-----(8)}$$

K= slop of linear part curve of increase in mass with square root of time.

b = thickness of sample

M ∞ =highest value for-profit in weight

All shapes showed relationship between increasing percentage in absorption mass and square root of time for polypropylene samples, reinforced and non- reinforced which were submerged in acidic solutions of (H₂SO₄, HCl, HNO₃). There was increase in mass of polymer reinforced with fibers than the non- reinforced with increasing submerging

time, due to polymer analysis which has worked on destructing interconnections between poly propylene and palm fronds. The series had represented centers of penetration of solutions during reinforced polymer. The absorption of composite polymer more than non-reinforced and the increase of absorption increased with evaluated concentration of acidic solution (30, 31).

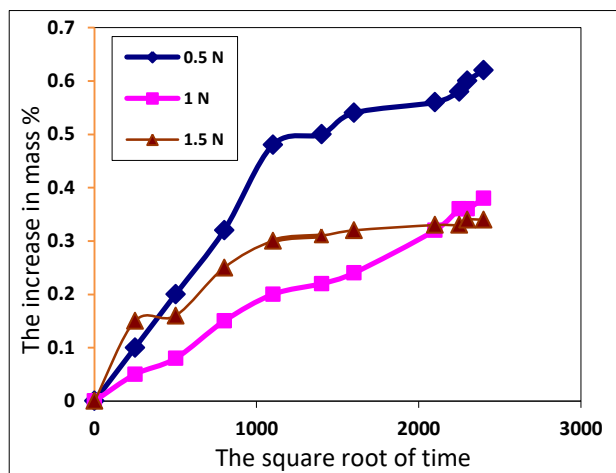


Figure 3. Relationship between increase percentage of mass with square root of time for non – reinforced polypropylene after immersion in H_2SO_4

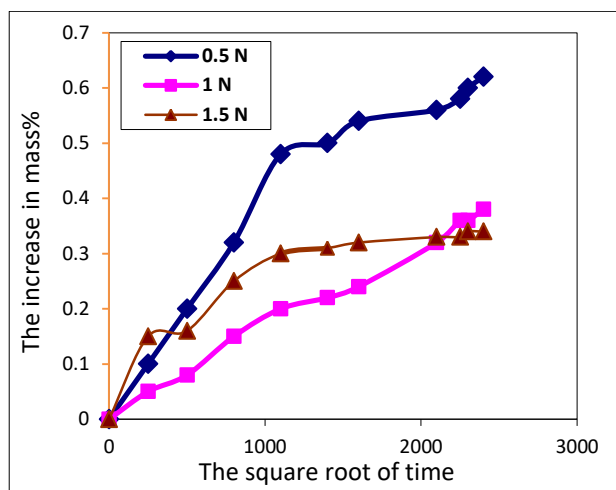


Figure 4. Relationship between the increase of the percentage of mass with the square root of time for reinforced polypropylene after immersion in H_2SO_4

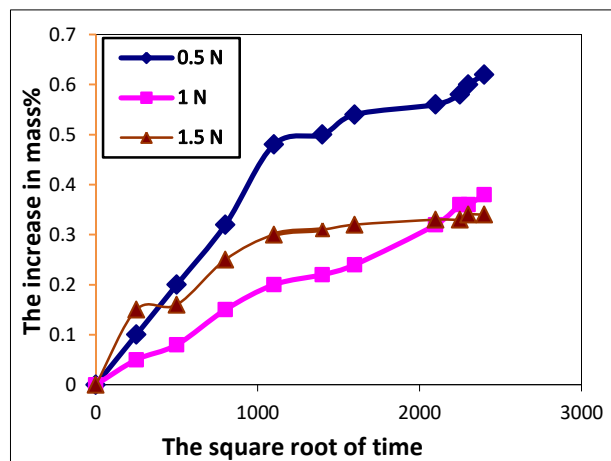


Figure 5:- Relationship between the increase of the percentage of mass with the square root of time for non- reinforced polypropylene after immersion in HCl

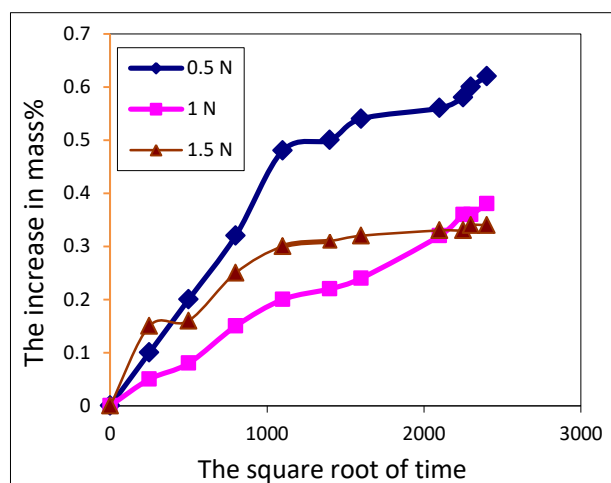


Figure 6. Relationship between the increase of the percentage of mass with the square root of time for reinforced polypropylene after immersion in HCl

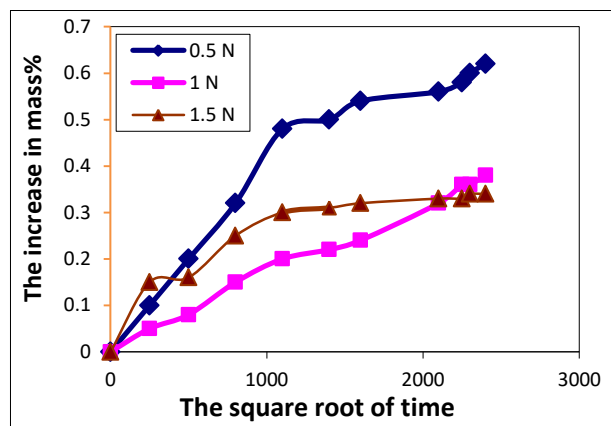


Figure 7. Relationship between the increase of the percentage of mass with the square root of time for non- reinforced polypropylene after immersion in HNO_3

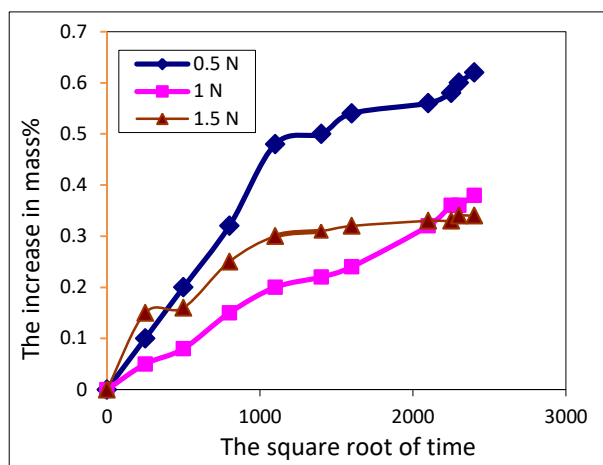


Figure 8. Relationship between the increase of the percentage of mass with the square root of time for reinforced polypropylene after immersion in HNO₃

Table 4. The diffusion coefficient values for reinforced and non-reinforced polypropylene with palm fronds and submerged in different concentration of acids.

Type of acid	Diffusion coefficient $\times 10^{-12} \text{ m}^2/\text{sec}$					
	PP polypropylene non-reinforced			PP polypropylene reinforced		
	0.5 N	1 N	1.5 N	0.5 N	1 N	1.5 N
H ₂ SO ₄	28.54	33.06	42.24	29.03	36.53	42.05
HNO ₃	33.19	40.70	42.41	36.94	37.35	45.82
HCl	24.6	26.01	38.08	35.64	37.91	39.05

Diffusion coefficient values for non-composite poly propylene was less than composite poly propylene (Table 4), Diffusion coefficient was elevated with increased acid concentration because of increased effects of the acid on bonds of polymer and palm fronds, fibers which was leading to increase disintegration of bonds that connect its molecules(31,32, 33,34).

Conclusion:

Note the increase in the value of the Young coefficient after the reinforcement with powder palm fronds, while decreasing by increasing the temperature, It also showed improvement of the mechanical properties of Yong modulus (E), Impact Strength (I.S), Brinell hardness (B.H) and compression Strength (C.S) of material for reinforced by powder palm fronds when compared with their pre-reinforcement, The value of both the absorbance and the propagation factor of the polymer supported by palm powder was also higher than its value in the unsupported polymer due to the chemical effects on the overlapping substances which depended on their chemical composition, And there was a difference between the values of

the propagation coefficient of the polymer before and after the increase by increasing the concentration of acid in the solution to increase the effect of acid on the bonding material in the polymer and powder palm also, which leads to disintegration.

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Mosul.

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تحضير متراكبات بوليمرية من البولي بروبيلين وسعف النخيل ودراسة بعض خواصه الفيزيائية

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الخلاصة:

تم في هذا البحث تحضير نوع من المتراكبات البوليمرية من البولي بروبيلين المنصهر كمادة أساس مع مسحوق سعف النخيل كمواد مدعمة وقد تم تقييم المواد المتراكبة من خلال دراسة بعض خواصها الميكانيكية والتي شملت مقاومة الصدمة (I.S) ومعامل يونك (E) ومقاومة الانضغاط (C.S) ومعامل المرونة وصلادة برينيل (B.H) وقد تمت المقارنة بين المتراكبات البوليمرية قبل وبعد التدعيم. ولوحظ زيادة مقاومة الصدمة وصلادة برينيل ومقاومة الانضغاطية وتمت دراسة تأثير بعض الحوامض (HNO_3 و H_2SO_4 و HCl) وبتراكيز (1.5 N و 1N و 1.5N) وتمت دراسة بعض الخصائص الفيزيائية كالامتصاصية ومعامل الانتشار للبولي بروبيلين قبل وبعد التدعيم وقد أظهرت النتائج زيادة واضحة في قيم هذه الخصائص بزيادة تركيز الحامض وزمن غمر البوليمر في المحلول الحامضي.

الكلمات المفتاحية: المتراكبات البوليمرية، بولي بروبيلين، سعف النخيل، معامل الانتشار.