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USING THE PHYSICAL EFFECT OF HEAT AS CATALYSTS TO TREAT THE PLASTIC WASTE FROM POLYSTYRENE

Ahmed Noori Mahmood[1]* and Ali Mohammed Ahmed[2]

College of Environmental Sciences and Technology, Depart. Of Environmental Sciences, University of Mosul., Iraq.

Abstract

Two groups of plastic waste manufactured from polystyrene (Ps) were used to manufacture samples, the first group of polystyrene (Ps) is not subject to recycling, while the second group was made of polystyrene (Ps), which was subject to recycling using the sulfonation method. and by (19.3%). The first group was called the saturated polystyrene group, while the second group was called unsaturated polystyrene. The manufactured samples were subjected to impact resistance tests, shear stress tests and compressive resistance tests before and after exposing them to a thermophysical effecter at temperatures (T = 60, 80 and 100) C^0). The results showed that the impact strength of the samples subject to a physical effect decreases with the increase in the time period of the treatment with this effect, and that the behavior of this decrease was closer to the exponential form than the linear formula, as the results showed that the amount of shear stress and resistance to compressive decreases in the first hours of treatment with the physical effect Thermal, and it reaches the maximum value after the passage of a critical period of time where the unsaturated polystyrene samples needed (2) hours of physical thermal effect treatment, while the saturated polystyrene samples needed (4) hours to reach the maximum value. The results also showed that, depending on the nature of the thermophysical effect (the treatment temperature), the response of both samples varies for impact resistance, shear stress, and compressibility resistance.

Key words : plastic waste, mechanical properties, heat treatment.

Introduction

Since the entry of plastic materials in the manufacture of household appliances that benefit in the kitchens, we have obtained a qualitative transfer in the prices of these tools, As the price of these tools decreased to (90%) from their value before they were made of plastic materials,, In addition to the availability of countless forms of these tools, colors and cosmetic inscriptions that can decorate these tools, The fact that the manufacture of these tools from plastic materials gives space and great freedom for the factory in choosing shapes, bodies, colors and additions that can complement these tools and bring them out very wonderfully.

Plastic materials did not suffice with this space of change, but it entered a new, broad and new form, which is the use in the field of household utensils and utensils represented by its ability to take the tasks of food utensils such as mugs, dishes, food spoons, forks, knives, etc., and that these tools are used for one time.. It generated a new culture and behavior among people in dealing with these daily requirements and needs, so that the use of these single-use tools has become common to most members of society and very broadly.

Although the new life behavior that plastic materials created in the cultures and customs of societies is considered positive behavior in many respects, it has created a large and cumulative problem with the passage of days, This problem was represented by the fact that these materials are used after the manner in which they were designed, it will generate hundreds of Tons of plastic materials as waste, and this plastic waste is increasing very significantly with the passage of days to reach a stage where it becomes a dilemma that may be difficult, as it was impossible at all, to solve it scientifically sound

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***Author for correspondence :** E-mail: ahmednoori@uomsul.edu.iq

without causing negative side effects on the environment in general and health The individual in particular (Worm *et al.,* 2017) and (Juhyeon *et al.,* 2019).

A number of methods and methods have been developed to address this dilemma, and the most important of these methods are: (Wilson *et al.,* 2012) ; (Vishal and Giridhar, 2002) ; (Kalliopi and Hrissi, 2017) and (Xinaliang *et al.,* 2007).

1. Burning Method.
2. Recycling Method.
3. Re-Polymerization Method.
4. Changing The Properties Of These Substances To Make Then Subject To Self-Degradation.

Burning plastic materials is an effective and almost inexpensive method in the treatment of plastic materials, but it is a method with a significant negative effect on the environment and the health of the peoples (Chang *et al.,* 2019), as burning such materials leads to the generation of extremely dangerous products that may lead to pollution rates to dangerous states which lead to effectively to cause negative side effect on the environment and the peoples and reaches the level of fatal negative side effect (Xinsheng, 1996), even if the burning process took place in a burner designated for this purpose or the energy resulting from this burning process was used in another application, the fact that the materials resulting from this process cannot be exceeded, and therefore are This process is like someone solving a problem by generating a bigger problem.

As for the recycling process, it is considered a temporary solution, as the recycled plastic material will return after a while to take the characteristic of plastic waste, and as a result we will be as nothing has been done (Schmidt *et al.,* 2011)**.** As for the re-polymerization of these materials, which is scientifically called (Repolymerization), it is economically not useful, since most polymeric materials have the advantage that re-polymerization is more difficult and much more expensive than the state of polymerization for the first time (Agarwal *et al.,* 2014)**.**

We now only have a way to change the properties of these materials and make them materials with properties that earn them the characteristic of self-degradation (Mohamed and Hamdani, 2000), *i.e.* making them materials with the ability to decompose and restore the basis or elements of their components to nature, which is originally coming from them. This characteristic is not present in most manufactured plastic materials, and it is almost the basis of the problem of these materials, in addition to the fact that these materials have the characteristics of inactivity, they are little interaction with the natural environment in which they are present (Wael *et al.,* 2019), so we find that they remain very long periods without happening, The ocean is an effective change in it. One of the most important methods that studies are conducted for the purpose of knowing its effectiveness and its ability to develop the characteristic of self-degradation in plastics is the use of physical effects, including thermal effects, Where it was found that some of the plastic materials when exposed to the effect of heat lose the ineffective property in interacting with the natural environment which present in it and one of the most important factors that increase the reactivity of these plastic materials with it are the weather factors, so this method may be one of the effective methods in treating these substances delivering the material to a situation in which weather conditions can influence and analyze it is definitely the solution we want (Hong and Jo, 2000).

Materials and Methods

Samples Preparation

Two groups of plastic materials circulated in the local market were collected. The first group is used as a single-use cup, fork or spoon and is made of polystyrene (Ps) not subject to recycling. While the second group is the same material as the first group, but it was subject to recycling by using the sulfonation method, at a rate of (19.3%) by treating it with methane dichloride with some additions in order to reduce the largest possible amount of the effects of the recycling process on the characteristics of The core article. The first group was called the saturated polystyrene group, while the second group was called unsaturated polystyrene, because the recycling process using the sulfonation method leads, in part, to a kind of change in the geometry of the arrangement of the polymeric chains. In order to fabrication samples, we used aluminum plates with a thickness of (1 mm), and in the form of closed template and open template which are used in the different stages of the sample fabrication process. The dimensions of samples are:

1. (60 x 10 x 5) mm. Used for impact strength test
2. (100 x 10 x 5) mm. Used for shear stress test
3. (30 x 30 x 5) mm. Used for compressive resistance test

Chloroform was used to dissolve polystyrene at various stages and with volumetric proportions of (10% & 5%) of the total percentage of the dissolved substance, and the method of manual annealing was used to ensure the consistency of the sample and its absence from manufacturing defects, and the samples were treated superficially after the casting and drying process to ensure dimensional control using the smoothing papers from Silicon carbide type and granular sizes{(400,1000,2000) # } respectively.

Technologies and Devices used

Samples were examined microscopically by using an optical microscope with a magnification force of (400) times, being the appropriate magnification force for the clearest comprehensive picture of the samples. The samples were photographed using a (HUAWEI) mobile digital camera with a resolution power (16 M Pixel). Use a german origin (BINDER) type convection oven that has the ability to supply thermal energy up to (300 C^0) for period of (72) hours.

The ability of manufactured samples to resist impact was determined by using the Charpt Impact Test, which depends on the basis of its theory of measuring the maximum amount of energy that can be supplied to the sample before causing a break in the body of the sample and in a batch of energy over a short period of time, This is done by using the Izod Charpy Tension Impact Test Instrument, manufactured by Testing Machines, Inc, Amityville New York.

In shear stress tests we used a three-point turn test was adopted, the parts of which consist of two cylindrical and well-supported armrests made of stainless steel placed on two sliders that allow the distance between them to be adjusted by a graduated ruler, where the sample is placed on the two predicates, and then is done gradually applying the load from the top by means of a cylinder having the same diameter and same quality, and hence shear stress is calculated using the relationship (1)

$$S=\frac{3\,\square\,\square}{2\square\square^{2}} \quad .... (1)$$

Whereas:

S: shear stress (MPa)

P: Applied load (N), which is the force required to break the sample.

L: distance between the two armrests (mm)

W: width sample

X: thickness of sample (Yasser and Kyong, 2020).

In compression resistance test, and due to the relatively weak mechanical properties of polymeric materials in general and the ability of these materials to resist compression in particular, a manual hydraulic press of the Graseby Spesac sample was used. As this type of press is used to prepare and compress a wide range of cylindrical samples at a maximum compressing strength of (15) Tons. After a simple modification on the plunger surface of the sample.

The maximum compression resistance value can be calculated from the following relationship (2).

$$\text{Compressive Strength}=\frac{\square\square\square\square\square\square}{\square\square\square\square}=\frac{(\square*\square)}{(\square\square\square\square\square\square*\square\square\square\square\square)}=(\text{N. mm}^{-2}) \quad .... (2)$$

Whereas:

W: mass equivalent to the pressure on the samples. Kgm

g: ground acceleration.

Length & width: the dimensions of the sample (Yana *et al.,* 2019).

Results and Discussions

Impact Strength Tests

Fig. 1 and 2 represent the amount of change in the impact resistance (Impact Strength) values of unsaturated and saturated polystyrene, respectively, as a function of the time period of the heat treatment.

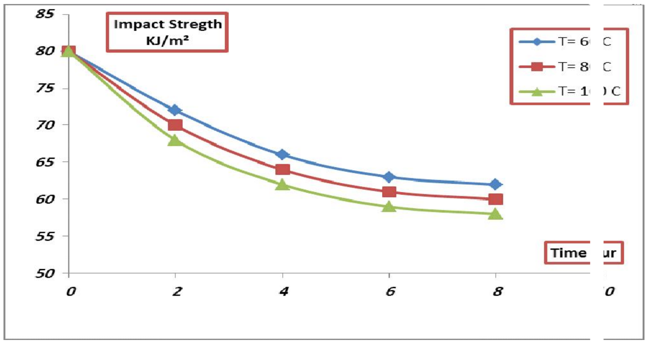

Fig. 1: Impact strength of unsaturated polystyrene as a function of time of heat treatment.

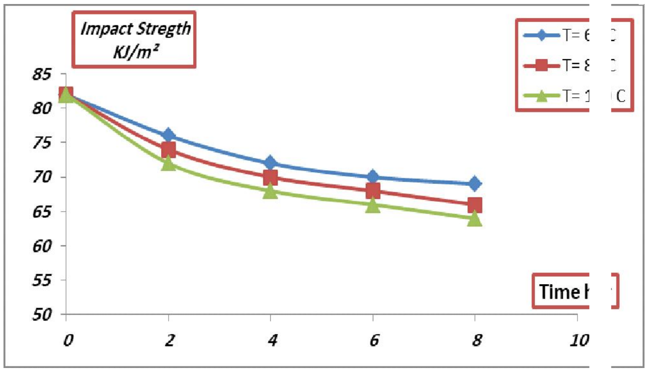

Fig. 2: Impact strength of saturated polystyrene as a function of the heat. treatment time.

Where it is observed from the two figures above that the value of the impact strength for both samples decrease with increasing the time period of the heat treatment and that the behavior of this decrease is closer to the exponential form than the linear formula, As the amount of decrease in the values of impact strength at the first hours of thermal treatment is greater than the amount of decrease in the values of impact strength when there is a time of thermal treatment at large values and for all degrees of heat treatment, where it was observed that in the case of unsaturated polystyrene, for example, the amount of decrease in the value of impact strength reaches approximately (13%) at the first two hours of the thermal treatment, while at the last two hours of the thermal treatment the amount of decrease in the value of impact strength reaches about (3%) When the treatment temperature (T = 80^0C), It is also noted from the previous two figures that the amount of decrease in the value of impact strength depends on the nature, degree of treatment, of the physical effect causing the decrease, which in turn will be reflected in the extent of the effect on the sample, In other words, we find that the effect of the physical effecter when the treatment temperature is (T = 100^0C) is greater than the effect of the physical effect that is in the treatment temperature (T = 80^0C) and that the latter is greater than the value of the physical effect in which the temperature is (T = 60^0C), Indeed, for example, we find that the amount of decrease in the value of impact strength at the first two hours of the thermal treatment of the unsaturated polystyrene sample is about (6.25%) when the physical effect temperature (T = 60 C) while it is within (12.5%) when the temperature The physical effect (T = 80 C) and the decrease in the value of the impact strength reaches (15%) when the physical effect temperature (T = 100 C). Finally, from Fig. 1 and 2 it is noted that the total decrease in the impact strength value of the unsaturated polystyrene sample is greater than the decrease in the impact strength capacity of the saturated polystyrene sample over all the treatment period, Where it was observed that the overall decrease in the impact strength of the unsaturated polystyrene sample reaches limits (25%) along the treatment period, while it is within the limits (17%) of the saturated polystyrene sample and along the same time period of the treatment. And for the purpose of explaining the behavior that the samples took in causing the change In the ability of the material to resist impact, we must understand that impact strength is in fact represent the ability of the material to resist cracking and fracture under the influence of the forces acting on it, and that this resistance is often little when the material has a brittle hardness (Brittle) due to the inability of this material to contain the energy produced by the effector and distribute external stresses on it. And its lack of localization at specific points, while we find that the greater the plasticity of the substance (Ductile), the impact strength increases in order to enhance the characteristic of the material's ability to transfer the external energy projected at it at a specific point and distribute it to the rest of the body (Yang *et al.,* 2008) and since the polystyrene (saturated and unsaturated) is a solid resin with molecular chains that are not able to separate and respond to rapid mechanical stress (Hemn *et al.,* 2020)**.**Therefore, we find that the fracture produced by the impact is of the brittle type. It is observed Fig. 3, which represents the microscopic examination of the unsaturated polystyrene as it is observed from the figure that the type of fracture obtained in the material is of the type of brittle fracture, but the degree of brittle of the fracture can be considered in the low grades, in other words the resulting fracture can be considered a simple brittle fracture.

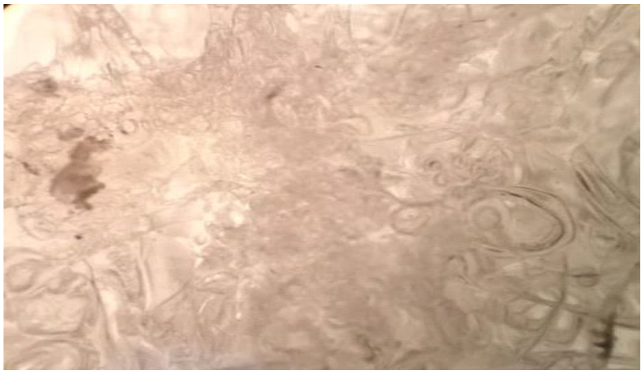

Fig. 3: Microscopic examination of the fractional section obtained in the unsaturated polystyrene sample, which was not exposed to the thermophysical treatment, as it shows that the fracture is a simple brittle fracture type. *(x*400*)*

While we notice from Fig. 4, which represents the microscopic examination of the fracture site of unsaturated polystyrene subjected to the thermal physical effect at a temperature (T = 100 C) for two hours, the resulting fracture is a brittle fracture with a degree of brittle higher than the previous state, that is, the degree of brittle of the material Increased two hours after exposure to thermal physical effect.

At the same time, we notice from Fig. 5, which represents the microscopic examination of the fracture site of the unsaturated polystyrene sample exposed to the thermophysical effect after (8) hours of thermal treatment and at a degree (T = 100 C) that the degree of brittle of the fracture increased significantly and became The fracture is almost completely brittle. For this we find

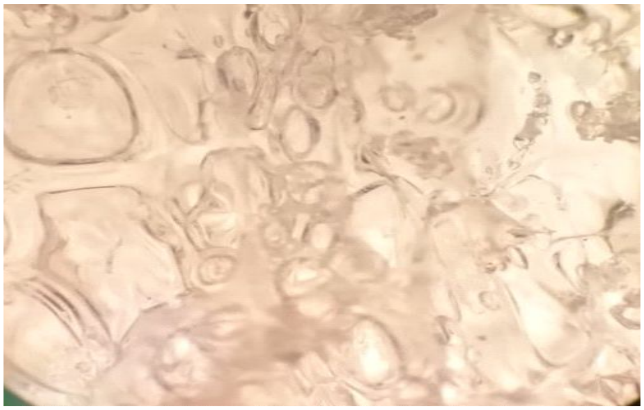

Fig. 4: Microscopic examination of the fractional section obtained in the unsaturated polystyrene sample exposed to the thermal physical effect at a temperature (T = 100 C°) for a period of two hours shows that the fracture is of a brittle type (medium Brittle). *(x*400*)*

that the ability of the material to resist fracture or the ability of the material to resist impact decreases with the increased exposure of the material to the thermophysical effect, as the effect of this factor is centered around making the material more brittle and as a result less able to resist the impact.

Fig. 5: Microscopic examination of the fracture section obtained in the unsaturated polystyrene sample exposed to the thermal physical effecter at a temperature (T = 100 C °) for period of (8) hours, showing that the fracture is of a brittle type (completely brittle). *(x*400*)*

As for the failure of the samples subjected to the impact strength tests to be linear behavior and their tendency to exponential behavior so that the amount of decrease in the impact strength is large during the first hours of the thermal treatment compared to the decrease in the ability of the material to resist the impact at the hours that follow and in which the amount of decrease is relatively less until samples reach a stage in which the value of the material's ability to resist the impact is stable and can be explained on the basis that there are some substances that are transferred figure the ductile state to the brittle state by stages, *i.e.* the material is ductile and then separates into a semi-brittle material and then moves to brittle . That is (Yang *et al.,* 2005)**.**

Ductile ——— semi Ductile or semi Brittle ——— Brittle

Among these materials are polymeric materials, as these materials also have the advantage that at the same mechanical state they can be at different levels, and that their presence at any level depends on the nature of the material's and working conditions.so that these materials can be descript as brittle in general, but It is may be present in the level of simple brittle, medium Brittle, or heavy brittle (Noda *et al.,* 2019)**.**

Light Brittle —— Med Brittle ———— Deep or Heavy Brittle Simple Or

When the material reaches the higher levels of the mechanical state, the properties of these materials are almost fixed, so that they take constant values to describe their state. Therefore, we find that the effect of the thermophysical effecter used in its resulting coefficient has moved the material from a specific mechanical level to a higher mechanical level so that the material of the sample was transformed from a simple or weak brittle material into a high brittle material and by treatment with the thermophysical effecter and that the time and nature of the physical effect coefficient was Sufficient and effective events of this transition.

As for the explanation of the difference in the decrease of the impact strength ability of the samples exposed to the tests with the difference in the nature of the physical effect, it can be explained on the basis that each material has the ability to contain the effect of the external effecter and that this ability is affected differently according to the difference of the material with the different nature of the effecter in general. And that most of the materials in which this characteristic appears are plastic materials, due to the sensitivity of its molecular structure (Davies and Irving, 2020), to external influences in general and thermal effects in particular, as differences can be considered simple in temperatures that can lead to noticeable differences in their composition or molecular structure. The physical effecter that influenced the samples under examination when the value of the effecter temperature (T = 60 C) was less than the effect caused by the effecter whose temperature was its value (T = 100 C) is on the same sample and for the same exposure time. Where it is observed figure the two figure (6) and (7) that represent images of microscopic examination of unsaturated polystyrene subjected to thermophysical influences, the value of the first (T = 60 C) and the second (T = 100 C) for a period of (6) hours for both.

Fig. 6: Microscopic examination of the fracture section of the unsaturated polystyrene sample exposed to the thermal physical effecter at a temperature (T = 60 C °) for a period of (6) hours. *(x*400*)*

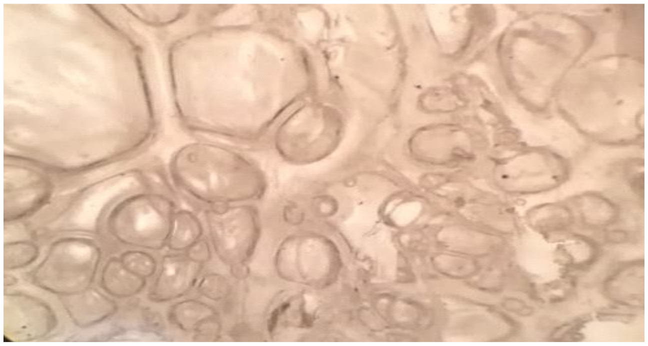

Fig. 7: Microscopic examination of the fracture section of the unsaturated polystyrene sample exposed to the thermal physical effect at a temperature (T = 100 C°) for a period of (6) hours. (*x*400)

Where it is observed from the two figures that the fraction obtained in Fig. 7, which represents the fracture of the exposed sample to a thermophysical effect whose value (T = 100 C) is more brittle than the fraction occurring in Figure (6), which represents the fracture of the exposed sample to a thermal physical effecter whose value (T = 60 C) Therefore, we find that the nature of the physical effect has a noticeable role in changing the properties of the substance subject to this effect when the materials subject to this effect are highly sensitive to this type of effecter.

Finally, for the purpose of explaining the response differences of the unsaturated polystyrene sample from the saturated polystyrene sample, it is possible to rely on some facts of polymeric materials, the most important of which can be considered as the consolidation of polymeric chains and a unifying trend. Whereas, the more compact polymeric chains, the greater the continuity property of these materials, which in turn will lead to an increase in plasticity and elasticity of the polymeric material (Piorkowska *et al.,* 1992)**,** and this increase will affect the ability of the material to contain the impact (Zenkiewicz and Dzwonkowski, 2007). Since in the case of unsaturated polystyrene, the molecular structure of this type of polymer is less compact than saturated polystyrene, and thus we find that the saturation is more without its saturated than saturated and thus the ability to resist the impact is greater than the unsaturated without it and less able to resist the impact. Another fact is that the greater the agglutination of polymeric chains, the greater the ability of the material to maintain its general characteristics in general and mechanical properties in particular. Therefore, we find that the ability of unsaturated polystyrene to maintain the characteristic of impact strength is less than the ability of saturated polystyrene, and that for the stacking difference and orientation between them.

Shear Stress Tests

Fig. 8 and 9 represent the shear stress of unsaturated and saturated polystyrene samples, respectively, as functions of the time-period of the physical-thermal treatment and of different temperatures.

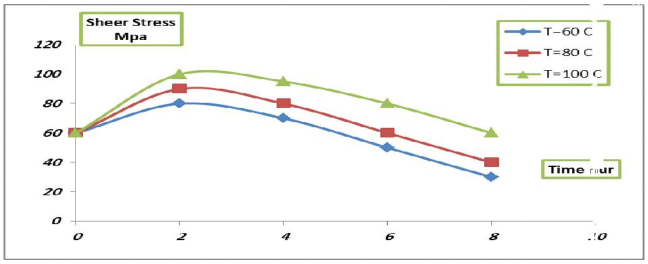

Fig. 8: Shear stress of unsaturated polystyrene as a function of the heat treatment time and of different temperatures.

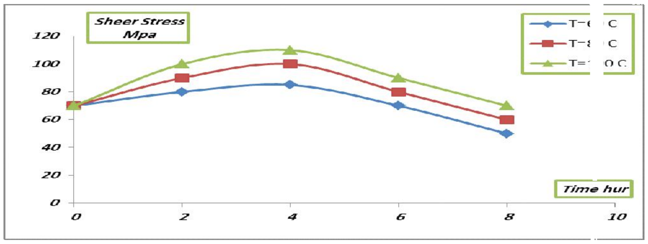

Fig. 9: Shear potential of saturated polystyrene as a function of the heat treatment time and of different temperatures.

Where it is observed from the two figures above that the shear stress increases with the increase of the time period of the treatment to reach a maximum value, and then the shear stress of the samples decreases with the increase of the time period of the treatment with the physical effecter. It is also noted from the two figures above that the highest shear stress reached by the unsaturated polystyrene sample is after two hours of treatment with the physical effecter and for all the temperatures used while the saturated polystyrene sample needs (4) hours to reach the maximum value of the shear stress. As noted from the two figures above, the shear stress of both samples is affected by the change in the nature of the thermophysical effect used. Finally, it is noted from the two figures above that the decrease in the shear stress of the unsaturated polystyrene sample reaches limits of (38%) after the passage of (8) hours of treatment with the thermal effecter when the effect temperature (T = 60Cp), while finding that the amount of decrease in the Shear stress of the saturated polystyrene sample is up to (11%) after (8) hours of treatment with the thermal effect when the effecter temperature is (T = 60Cp). For the purpose of interpreting the results obtained after treating the samples with the thermophysical effecter, we have to return to the basics and principles of shear resistance or shear stress, as the precise definition of this characteristic is the ability of the material to resist yield resulting from the effect of external stress which leads to moving parts of the material in one direction and the other part in another direction, which leads to the occurrence of two states. The first is a fracture in the substance or what is known as shear, and the second is yield, which is the response of the substance to stress, and the sample subject to stress is distorted. Shear resistance is a characteristic of the material that makes it resist the shear stress on it, so it will not break or yield to it (Yao *et al.,* 2018) and (Poblete and Zhu, 2019).

Thus, we find that the increase in the shear resistance of both samples may be caused by an increase in the interconnection of the parts of the samples due to the energy provided by the external influence that leads to raising the efficiency of the shear stress resistance, but that with increasing the supply of energy to the sample will lead to a surplus in the energy in the sample And that this additional energy will lead to a kind of negative side effect to the structure of the sample, which leads to a weak in binding of the parts of the sample and thus a decrease in stress or resistance to shear (Manjun *et al.,* 2020) and (Ahmed *et al.,* 2020).

As for the difference in the time period to reach to maximum shear resistance for both, the reason for it is due to the nature of the composition or structure of the material where there are materials that are able to contain a higher energy amount due to the availability of storage sites in the structure of the sample and often these sites are either free radicals or the separation between the polymeric chains as the increased energy content leads to the convergence of the polymeric chains from each other.The difference in response to the nature of the effector is now considered a truism, since with the difference in the temperature of the effector and with the stability of the time period of the thermal treatment is in fact a difference in the amount of energy supplied to the sample, and this difference will lead to the possibility of obtaining all the above-mentioned possibilities.

Fig. 10 and 11 represent the microscopic examination of the fracture section obtained in the saturated polystyrene sample exposed to the thermal effecter at a temperature (T = 60Cp) for a period of (4) and (8) hours, respectively.

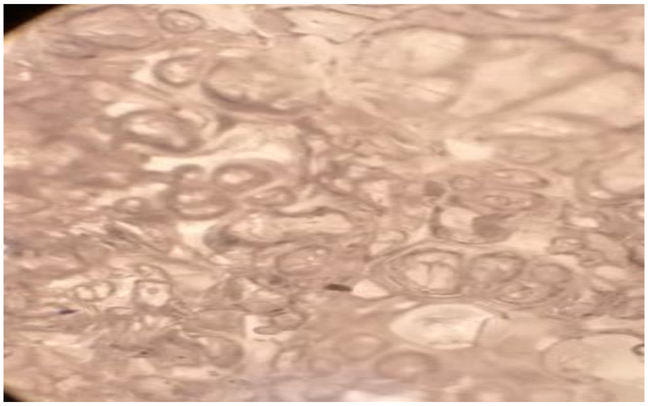

Fig. 10: Microscopic examination of the fracture section obtained in the saturated polystyrene sample exposed to the physical thermal effect at a temperature (T = 60 Cp) for period of (4) hours. *(x400)*

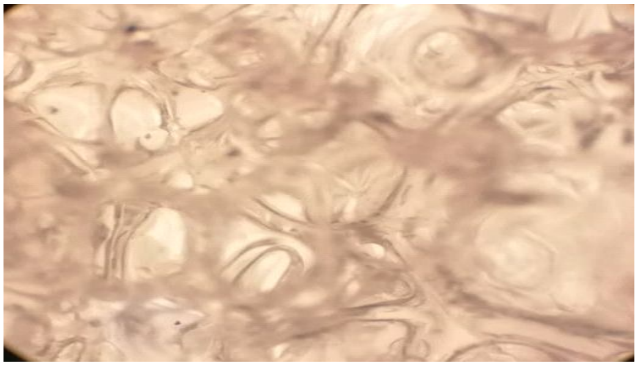

Fig. 11: Microscopic examination of the fracture section obtained in the saturated polystyrene sample exposed to the physical thermal effect at a temperature (T = 60 Cp) for period of (8) hours. *(x400)*

Where it is noticed Fig. 10 the convergence of the regions of the polymeric chains and that the general characteristic of the cross section is a substance with binding in the shape and structure of the material, while it is noted Fig. 11 that the substance and structure of the material have become less degree of binding in the shape and structure of the material.

Exposing the samples to the thermal effect led, in general, to diminishing the ability of the material to resist shear, and in more accurate words it led to a decrease in the ability of the material to maintain is a binding body and structure, which made it a material less able to resist external stresses, and that one of these effects are environmental influences, and therefore the material exposed to the thermal effect is a material that is less able to resist environmental conditions and it is more disintegrating than the material that is not exposed to the thermal effect. Therefore, environmental conditions in such a case can be an effective factor affecting the dismantling and annihilation of this material.

Compressive resistance Test

Fig. 12 and 13 represent the compressive resistance of the unsaturated and saturated polystyrene sample, respectively, as functions of the time period of the physical-thermal effect and to different temperature degrees.

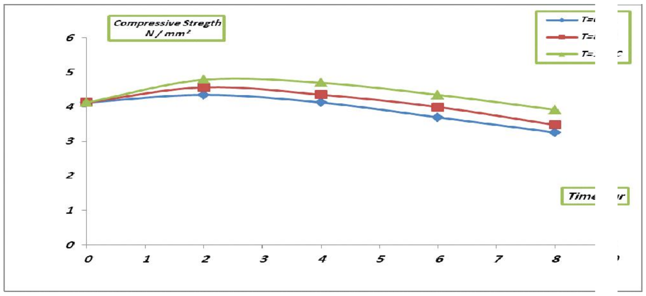

Fig. 12: Compressive strength of unsaturated polystyrene as a function of heat treatment time.

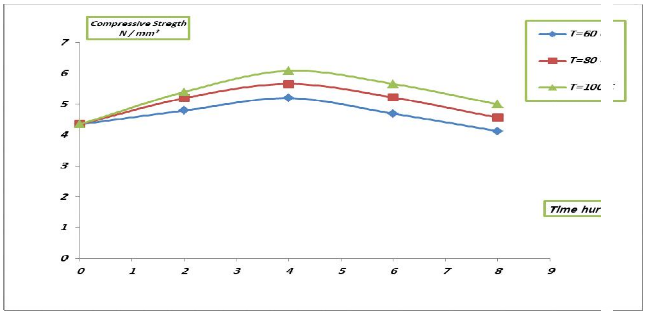

Fig. 13: Compressive strength of saturated polystyrene as a function of heat treatment time.

Where it is observed from the two figure above that the compressive resistance of the samples increases with the increase of the time period of the treatment to reach the maximum value after a specified period of time for the treatment to return to decreasing with the increase in the time period of the treatment with the physical effect where it is noted figure the two figure above that the unsaturated polystyrene sample needs up to (2) hours of thermal treatment and all temperatures to reach the highest compression resistance, while the saturated polystyrene sample needs (4) hours to reach the maximum value of the compression resistance. It is also noted from the previous two figures that the compression resistance is sensitive to the change in the nature of the thermophysical effect, as it was observed that the treatment of both samples with the thermal effect at a temperature (T = 100 Cp) in which the response of the samples is greater than the treatment with the thermal effect when the temperature of the effecter (T = 80 Cp) Which, in turn, will result in a greater compression resistance in both samples than the treatment of the samples with the thermophysical effecter at a temperature (T = 60 Cp). It is also possible, through the previous two Figures, to note that the decrease in compressive strength of the unsaturated polystyrene sample treated with the thermophysical effect at a temperature of (T = 60 Cp) and for a period of (8) hours up to the limits of (28%), while we note that the amount of decrease in the saturated polystyrene sample With the same effect and for the same period of time the thermal treatment is (16%).

For the purpose of explaining the behavior of samples in resisting compression and the effect of the thermal effecter on them, we must remember that one of the most important factors that enhance the ability of the material to resist compression is the compact structure with a continuity characteristic in the nature and body of its formation and that this property can be subjective, that is, there are substances It is by its nature a compact textured structure or is an attribute that can be developed through forming operations or additions.

One of the most capable materials to improve the properties of compressive resistance is the plastic materials, due to the nature and structure of its installation and its broad ability to host other materials consisting of a semi-stable system with distinctive characteristics or affected by an external factor that has a positive impact on the quality of its continuity (Wang *et al.,* 2020) and (Krundaeva *et al.,* 2016). Therefore, the thermal effect has strengthened the continuity characteristic of both samples in the first hours of treatment, and therefore an improvement in the material's ability to resist compression was observed.

With the increase in the period of time for the thermal effect treatment, these substances despite the enhancement of the continuity feature in them, but they suffer from the problem of energy accumulation and which are unable to find suitable storage places in them and that this excess of energy will lead to a kind of disassociation of the link between the parts of the material (Moayyer *et al.,* 2020),this lead to makes it unable to preserve its appearance and shape when exposed to an external pressure factor, which means as a result the loss or diminution of the material's ability to resist compression. This is due to the decrease in the ability of the material to resist compression with an increase in the time period for thermal treatment and because of the sensitivity of the plastic materials to heat, we find that the change in the nature of the thermal effect through a change in its temperature resulted in a change in the response of the material to resist compression (Abdalla *et al.,* 2019). The heat of the supply to the energy, therefore changing the nature of the stimulus will lead to a change in the response of the material to resist compression.

Fig. 14 and 15 represent microscopic examination of a section in the saturated polystyrene sample exposed to the physical effect at a temperature (T = 60 Cp) for a period of (2) and (4) hours, respectively.

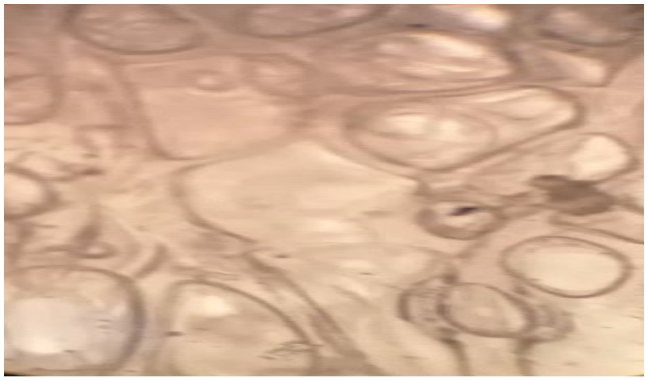

Fig. 14: Microscopic examination of a section in a saturated polystyrene sample exposed to the thermophysical effect at a temperature (T = 60 Cp) for a period of (2) hours. *(x400)*

Fig. 15: Microscopic examination of a section in a saturated polystyrene sample exposed to the thermophysical effect at a temperature (T = 60 Cp) for a period of (4) hours. *(x400)*

Where it is observed from the two figures, the continuity characteristic of the sample exposed to the physical effect is enhanced by a temperature of (T = 60 Cp) for a period of four hours, which was reflected on the ability of the material to resist compressibility while we observe Fig. 15, and despite the beginning of the emergence of the continuity property in the sample, It is still incomplete in the remaining parts of the sample, which made its ability to resist compressibility less than the previous case.

The treatment of the samples with a simple physical effect for a specific period of time led to the loss of the substance and its ability to resist compressibility, in other words, it led to weak material cohesion and its loss of agglutination and cohesion property, which made it lighter in ability to resist external influences and thus became a substance with greater susceptibility to the environment and its factors, including factors The environment is different, and in general, the material has become more abele to degradation.

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