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Study of the photolysis of polycarbonates in the presence of the prepared nickel oxide nanoparticles

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***Abstract*---**In this study, nickel oxide nanoparticles (NiONPS) were made using a plant extract from the bambar plant, and their identification and effects on the optical characteristics of polycarbonate flakes with a thickness of (60 ±5) microns were also studied. After numerous concentrations of the produced nanoparticles (0.03, 0.06, 0.12, 0.24, and 0.48) % were added to the polymer solution, the degree of photolysis of polycarbonate was evaluated. The prepared nickel oxide nanoparticles (NiONPS) were examined using an atomic force microscope (AFM), which revealed that the average diameter of the particles was 32.54 nm, a scanning electron microscope (SEM), which revealed the size of nanoparticles (17.80-19.08 nm), and X-ray diffraction (XRD), whose results were consistent with the standard reference (JCPDS, No.01-073-1523). Following the irradiation procedure on the polymeric films, the dissociation constant (Kd) and carbonyl group growth coefficient (FT-IR) were calculated using UV-Visible spectroscopy at the wavelength (300) nm, respectively (ICO). A viscometer was also used to calculate the polymer's molecular mass rate, degree of dissociation (α), and numerical rate of severing the polymeric chain (S). It was discovered that the rate of molecular mass reduces with increasing irradiation time while the rate of photo degradation of polycarbonate increases with increasing addition of nano-oxide on the polymer's surface.

***Keywords*---**polycarbonate, nickel oxide nanoparticles, photolysis, viscosity.

Introduction

A word of Latin origin, polymers, has two syllables: poly, which means many, and mers, which means binary units or molecules [1]. They are huge molecules created by joining numerous tiny molecules together. Monomers are the small molecules that interact with one another to generate repeating molecules, while polymerizations are the processes by which they do so. A polymer molecule can contain hundreds, thousands, tens of thousands, or even more monomer units bonded together [2]. Due to its great toughness and clarity, polycarbonate is regarded as one of the most significant technical polymers and is utilized in a variety of applications. The most common applications can be found in glazing and panel applications, such as transparent panels for greenhouses, electrical and electronic applications, such as computers and mobile phones, and optical media, such as CDs [3]. The research is interested in following up the effects of ultraviolet rays on the decomposition of polycarbonates, with the aim of understanding some of the relationships between the chemical and physical changes that occur in it and how the overall performance of the material is affected [4].

Materials with a Nano scale dimension limited to 1–100 nanometers are known as nanomaterial. The qualities of these materials are based on the concepts of nanotechnology. Nanotechnology is a broad and interdisciplinary field of research and development activities that has increased dramatically all over the world in the past few years and which has the potential to bring about new technologies that have had a significant impact in commercial fields [5]. Particles of nanomaterials usually have new and unique properties that are not available in large molecules such as increased strength, flexibility, magnetism, rigidity, small size, structure control and other properties, which allow them to obtain new and required properties and have very wide applications in different fields. The most important of these are the environment, agriculture, industry, food, health, and medicine [6, 7].

($NiON_{PS}$) belong to the cubic crystal system. Nickel oxide has a band gap of 3.6 to 4.0 eV [8]. Nickel oxide nanoparticles have a variety of specialized applications and are generally used mainly in the production of alloys, fuel cells, chemical cells, and photocatalytic activity [9, 10]. It has environmental applications in the field of adsorption of hazardous pollutants. and inorganic pollutants, and thus play a vital role in the cleanliness of the environment [11]. In this study, the extract of the leaves of the bambar tree (Cordia myxa) was used in preparing nano-nickel oxide ($NiON_{PS}$) by the green method and using nano-oxide as a catalyst that increases the speed of photodegradation of the polymer (polycarbonate) and studying the disintegration mechanism of the polymer through the use of UV-visible techniques. And infrared rays and study of the rate of change in molecular weight using a viscometer.

Materials and devices used

$Ni(NO_3)_2.6H_2O$, NaOH, Bambar extract, polycarbonate, chloroform as solvent, ethanol and double distal water. (SEM) and (XRD) were used. diffraction, (AFM), (FTIR), UV-vis spectroscopy, and Ostwald type viscometer.

Preparation of the plant extract

The plant extract was prepared from the leaves of the Bambar tree (Cordia myxa) by collecting samples of its leaves and washing them with tap water to get rid of the dirt stuck in them, and then washing with distilled water several times, drying in the shade and grinding using an electric grinder to obtain a powder that is sieved and kept in a container in Shade, weigh (4g) of it and put it in a glass beaker and add to it (400mL) of deionized water, taking into account the constant stirring using the magnetic motor, and heated up to a temperature of (80) ℃ for (30) minutes. The extract is brown, then is left to cool to room temperature and then filtered using filter papers. The resulting solution is placed in test tubes in a centrifuge at a speed of (1200) r/min in order to get rid of residual biomaterials and residual fibers and is stored in a glass vial at a low temperature. For the purpose of using it as a reducing agent for the preparation of ($NiON_{PS}$).

Preparation of $NiON_{PS}$

In order to make nano-nickel oxide, (2g) of $Ni(NO_3)_2.6H_2O$ is weighed and added to a glass beaker. Then, (50mL) of deionized water is added to it with constant stirring until complete dissolution is complete, and (50mL) of the prepared Bambar leaf extract is added using a burette in the form of drops gradually while stirring continuously at a temperature of (50) ℃. In the next step, the temperature of the solution is raised to (80) ℃, and then the acidity function is modified by adding sodium hydroxide at a concentration of (1) molar, where it is formed Colored precipitate (dark green). It is cooled to room temperature and then separated using a centrifuge to obtain the precipitate in the form of a gel, and it is washed several times with deionized water and absolute ethanol to get rid of impurities and dried in the oven at a temperature of (60) ℃ for two hours. Then the precipitate was collected and placed in an oven (Oven) at a temperature of 400℃ for two hours and then collected to perform the necessary tests on it [12, 13].

Preparation of a polycarbonate solution

To ensure perfect homogeneity, (7g) of pure polycarbonate was dissolved in 100 mL of chloroform solvent (7%W/V) and stirred continuously for an hour at room temperature using a magnetic stirrer [14].

Preparation of polymeric films

In order to make polycarbonate films, 2mL of the previously created polycarbonate solution were combined with the prepared nano-nickel oxide in the following weight ratios: (0.00, 0.03, 0.06, 0.12, 0.24, and 0.48) percent. The solution and oxide were then well combined to guarantee homogeneity. Then the mixture was placed in glass molds (locally made), made of slides glass installed on a piece of glass placed on a horizontal surface that was leveled with a level balance to obtain polymeric molds of equal thickness and making sure that there are no bubbles on the polymeric chips, then leave the mixture for 25 Delicate at room temperature to dry without exposure to sunlight. After that, the polymeric films were removed using a blade and forceps, and their thickness was measured using a micrometer, as the thickness of the polymeric films was (60 ± 5) μm. Then

the polymeric films were cut with dimensions commensurate with the cells of the spectrophotometers (UV-Visible, FT-IR) with a length of (3.5 cm) and a width of (1 cm).

Irradiation of samples

To irradiate the samples, a local manufacturer of irradiators was employed. The UV lamp utilized in this device had an output of (18) watts and a wavelength of (356) nm. The placement of the polymer films guarantees that they are equally exposed to radiation during predetermined irradiation times.

Follow-up of the optical fractionation of the polycarbonate

The optical fractionation of the polymeric film flakes was carried out using UV-Vis, FT-IR and viscometer techniques as follows:

UV-Visible Spectroscopy

The UV-visible device was used to calculate the absorbance value of the polymer films within the range (200-800) nm, where the Degradation rate constant (Kd) was calculated by the optical oxidation process of polymeric films according to the following equation:

$$\ln(A_\infty - A_t) = \ln(A_\infty - A_\circ) - K_d t \quad \ldots\ldots\ldots (1)$$

(Ao) represents the absorbance of the polymeric films before irradiation, (At) represents the absorbance at irradiation time (t) of the same chips, and (∞A) represents the absorbance of the films at infinity. A graphic relationship has been drawn between ln (a - x) with the irradiation time (t) as the slope represents the dissociation constant (- Kd).

Infrared spectroscopy

The optical fragmentation rate of the polymeric polycarbonate flakes is monitored by following the growth rate (I_{CO}) of the polycarbonate to know the intensity of the absorbed beams by measuring the infrared spectrum of these flakes within the range (400-4000) cm^{-1} before the irradiation process and after each period of irradiation. The carbonyl group adsorption site (C=O) was at 1765 cm^{-1}. Through which the carbonyl index (I_{CO}) growth factor was found, by applying equation (2) by adopting the band index method [15, 16] as in the following equation:

$$I_{(S)} = \frac{A_{(S)}}{A_{(R)}} \quad \ldots\ldots\ldots (2)$$

Since:
$I_{(S)}$: the growth factor of the group under study
$A_{(S)}$: absorbance of the group under study
$A_{(R)}$: Absorbance of the reference peak

Viscosity measurement

The average viscous molecular weight (MV) of the polymeric films before and after the irradiation process was calculated by applying the (Mark-Houwink) equation (17)

$$[\eta] = \mathbf{K}(\mathbf{M_V})^{\mathbf{a}} \quad \ldots\ldots\ldots (\mathbf{3})$$

Note that (K, a) are the experimental constants calculated for the polymer depending on the type of solvent and temperature, as the chloroform solvent was used in the study as a suitable solvent. From this information, we extract the intrinsic viscosity [η], which was estimated by using a viscometer, as follows: To calculate the relative viscosity, the viscosity of polycarbonates in the chloroform solvent is measured by following the solvent flow time (to) and the flow time of the pure polymer solution and the polymeric compound in the solvent after each irradiation time (t).

$$\boldsymbol{\eta_{rel}} = \frac{\boldsymbol{t}}{\boldsymbol{t_0}} \quad \ldots\ldots\ldots (\mathbf{4})$$

To calculate the specific viscosity [ηsp], equation No. (5) was used:

$$\boldsymbol{\eta_{sp}} = \boldsymbol{\eta_{rel}} - \mathbf{1} \quad \ldots\ldots\ldots (\mathbf{5})$$

From it, the intrinsic viscosity value is calculated using equation No. (6), and thus the viscosity of the disintegrated and non-disintegrated polymer can be calculated.

$$[\boldsymbol{\eta}] = \frac{\boldsymbol{\eta_{sp}}}{\boldsymbol{C}} \quad \ldots\ldots\ldots (\mathbf{6})$$

Since:
C: polymer concentration
ηsp: specific viscosity

The molecular mass of (PC) was also calculated in the presence of the additive ($NiON_{PS}$) and its absence at a temperature of 25 ℃ for PC, through measurements of the intrinsic viscosity of polymer films in chloroform using the equation below:

$$[\boldsymbol{\eta}] = \mathbf{3.01} \times \mathbf{10^{-4}}\ \mathbf{M_v}^{\mathbf{0.74}} \quad \ldots\ldots (\mathbf{7})$$

The weak bonds are randomly distributed along the polymeric chain, which breaks quickly at the beginning of the irradiation, which is calculated using the equation for the degree of dissociation (α).

$$\boldsymbol{\alpha} = \frac{\mathbf{1}}{\mathbf{P_t}} - \frac{\mathbf{1}}{\mathbf{P_\circ}} \quad \ldots\ldots\ldots (\mathbf{8})$$

Since:
Pt: the numerical rate of the degree of polymerization at the time (t) of irradiation

Po: the numerical rate of the degree of polymerization before irradiation
The numerical rate of cutting the main polymeric chain (S) was calculated using Equation (9) [18].

$$S = \alpha p_0 \qquad \ldots\ldots\ldots (9)$$

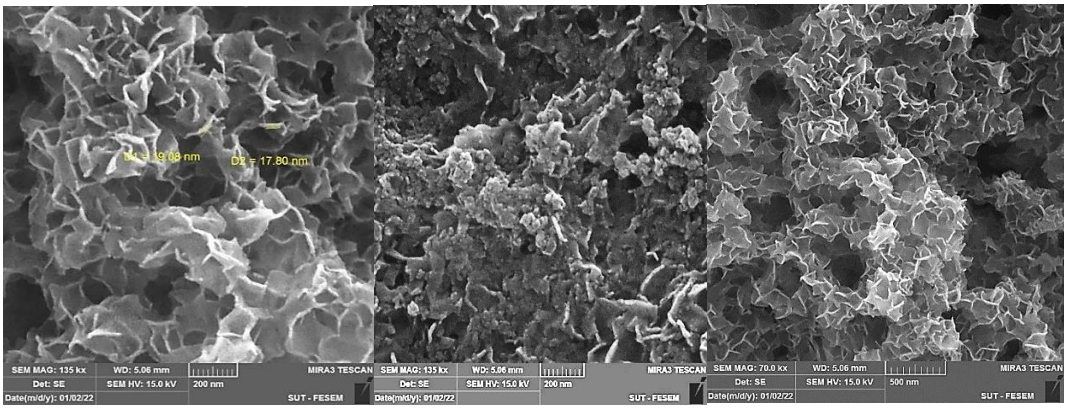
Since: α: the degree of dissociation.

Results and Discussion

Study of the structural properties of $NiON_{PS}$ prepared by the green method

SEM measurements

SEM is used to determine the morphology and shape of the particles, in addition to measuring the size of the minutes of the sample prepared by the green method. As shown in Figure (1), which shows the images of nickel oxide nanoparticles with different magnification strength for all images (A, B, C) by scanning electron microscope. The size of nanoparticles is in the range (17.80-19.08) nm.



C B A

Figure (1) (A, B, C) (SEM) images of the prepared $NiON_{PS}$

XRD measurements

The nature of the crystal structure of the nickel oxide nanoparticles prepared by the green method was identified by studying the XRD and knowing the locations of the peaks (Peaks) that appear when these rays are shined at different angles on the sample, Figure (2) shows the X-ray diffraction results of the nickel oxide nanoparticles compared with the standard reference (JCPDS, No.01 -073-1523). The diffraction peaks (111), (200), (220) and (311) are attributed at angles 37.26°, 43.34°, 62.87° and 75.40°, respectively. The standard reference and a comparison with the International Center for Diffraction Data (JCPDS) card. Join committee on power diffraction standards.

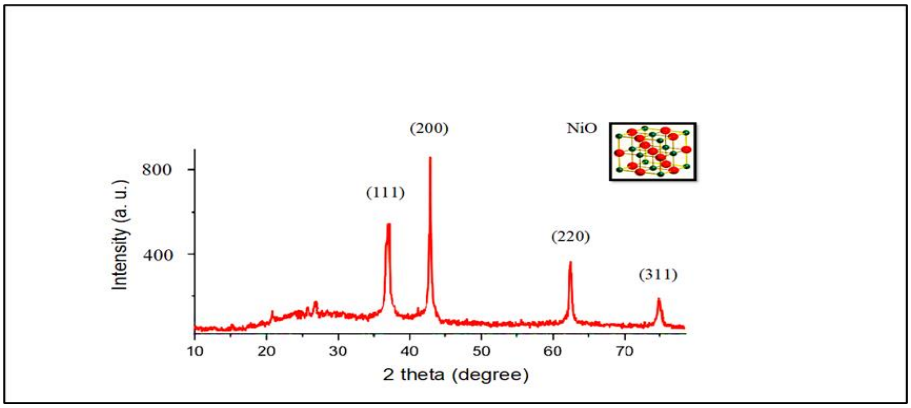


Figure (2) XRD of the prepared $NiON_{PS}$

AFM measurements

It is the microscope that gives information about the topography of the surface of the material with high accuracy up to the atomic level, as its sensors scan the topography of materials with infinitesimal precision, as well as gives information about the size of the particles and the texture of the surface. Figure (3) shows three-dimensional images of the surface of the nano-nickel oxide prepared by the method green, Also, Figure (4) shows the graph of the distribution rate of the prepared nanoparticles, in which the average diameter of the nanoparticles is 32.54 nm.

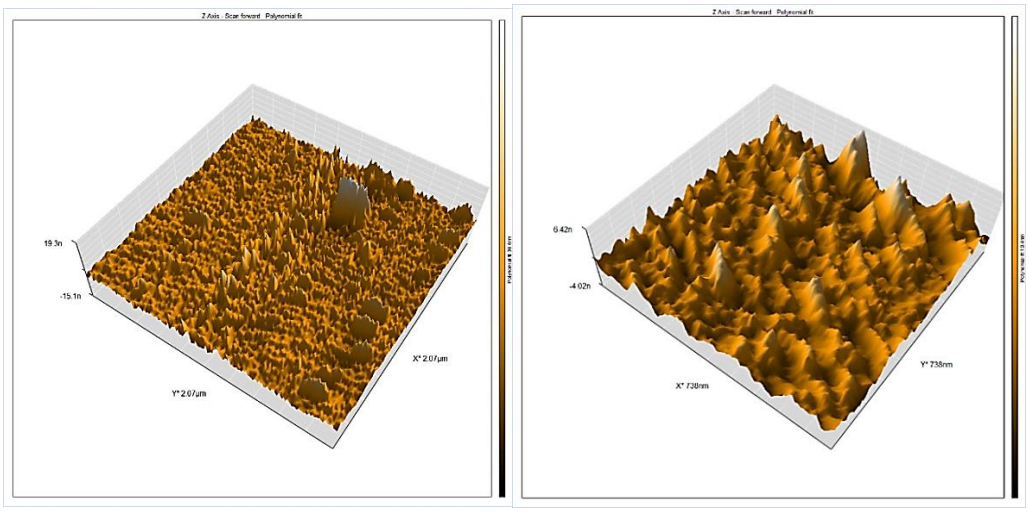


Figure (3) 3D (AFM) images of the prepared $NiON_{PS}$

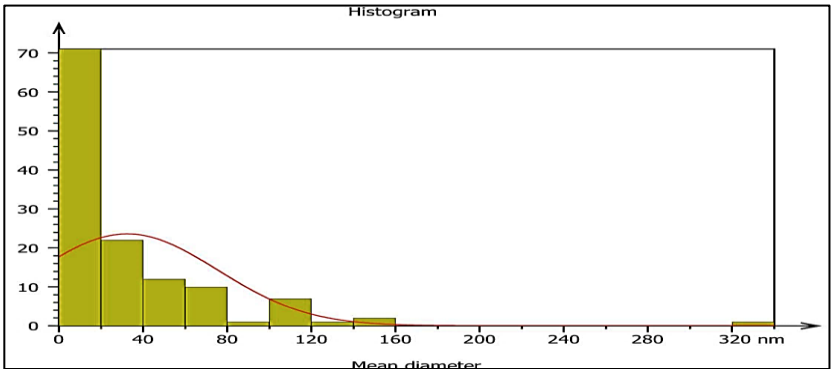


Figure (4) Graph of the distribution rate of the $NiON_{PS}$ with an average diameter of 32.54 nm

Follow-up of the optical fractionation of the polycarbonate

The optical fractionation of the prepared polymeric films with a thickness of (60±5) micron of pure polycarbonates containing different concentrations of nickel oxide nanoparticles was followed up to find out the effect of increasing the concentration of nanoparticles of NiO on the dissolution of the polymer during different irradiation times. UV-Vis technology, FT-IR infrared technology and viscometer were used as follows:

Uv-vis spectroscopy

The optical fractionation of pure PC films and films containing different weight ratios of $NiON_{PS}$ can be followed through the UV-visible spectrum. When PC films were exposed to UV rays for specific periods of time, this led to a change in the color of the films to a yellowish color. This change indicates the photolysis of the polymer as shown in Table (1) below. The photodissociation speed constant (Kd) was calculated through the absorbance values that we obtain UV spectroscopy after the irradiation process and at different times. It has been observed that the absorbance of the films varies with different irradiation times, as well as with the different concentration of the added $NiON_{PS}$.

Table (1) The absorbance values of polycarbonate films with a thickness of (60±5) micron, as well as for containing different concentrations of $NiON_{PS}$, calculated at the wavelength of 300 nm from UV-visible spectroscopic measurements

Irradiation time (h) / Chip type	Absorbance (A_t)				
	0.0	10	25	40	80
PC	0.143	0.259	0.363	0.518	0.614
PC + 0.03 % $NiON_{PS}$	0.166	0.296	0.439	0.560	0.667
PC + 0.06 % $NiON_{PS}$	0.168	0.400	0.549	0.628	0.764
PC + 0.12 % $NiON_{PS}$	0.170	0.465	0.607	0.663	0.864
PC + 0.24 % $NiON_{PS}$	0.173	0.540	0.683	0.808	0.924
PC + 0.48 % $NiON_{PS}$	0.191	0.612	0.764	0.956	1.217

The absorption spectrum of the prepared polymeric films with a thickness of (60 ± 5) microns and containing different concentrations varies according to the different irradiation times compared to the pure polymer film. The absorbance of the films increases with the increase in the concentration of the nano-material added to it due to the increase in the effective aggregates as in Figures (5) to (7). For the purpose of calculating the photodissociation constant of polymer films in the presence of the nano-added material, by drawing the relationship between ln (A∞ - At) with the irradiation time as shown in Figures (8) to (10). We get a straight line, and this indicates that the optical fractionation reaction of the nickel oxide nanoparticle is a first order reaction.

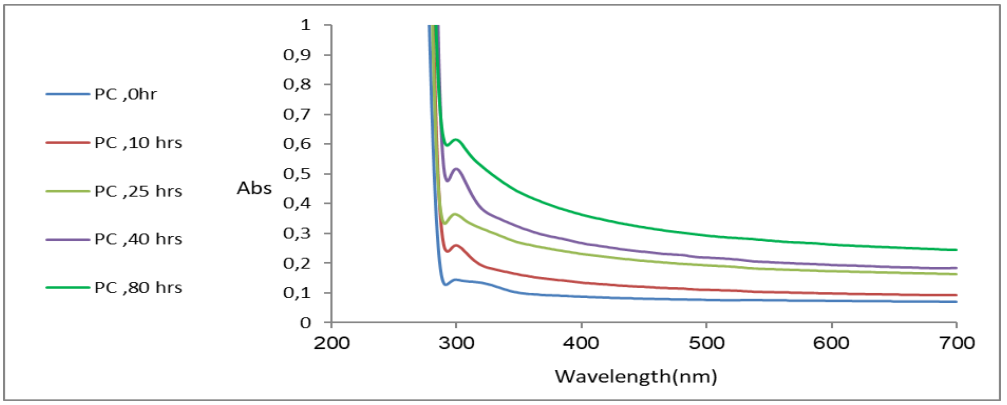


Figure (5): The change in the UV-visible spectrum of additive-free polycarbonate films with a thickness of (60±5) microns at irradiation times.

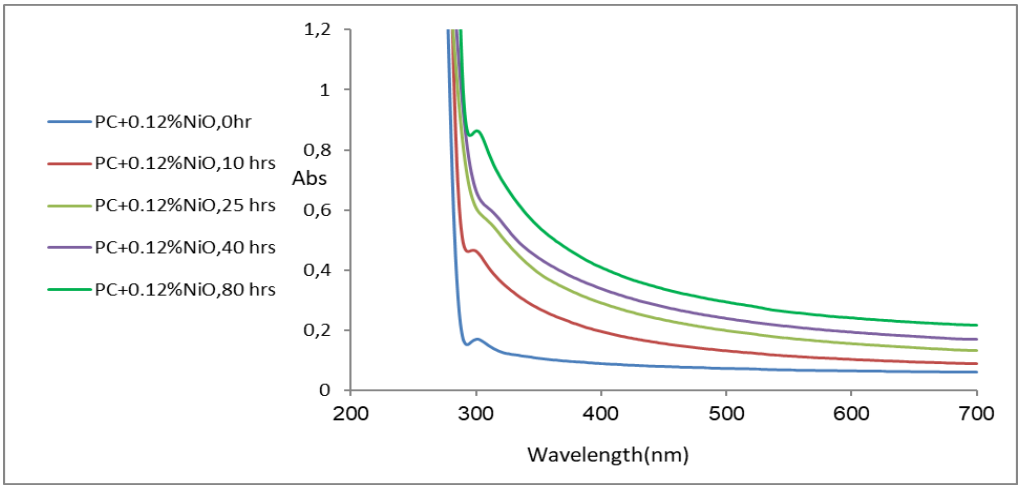


Figure (6): Change in the UV-visible spectrum of polycarbonate films containing concentration0.12% of $NiON_{PS}$ with a thickness of (60±5) microns at irradiation times

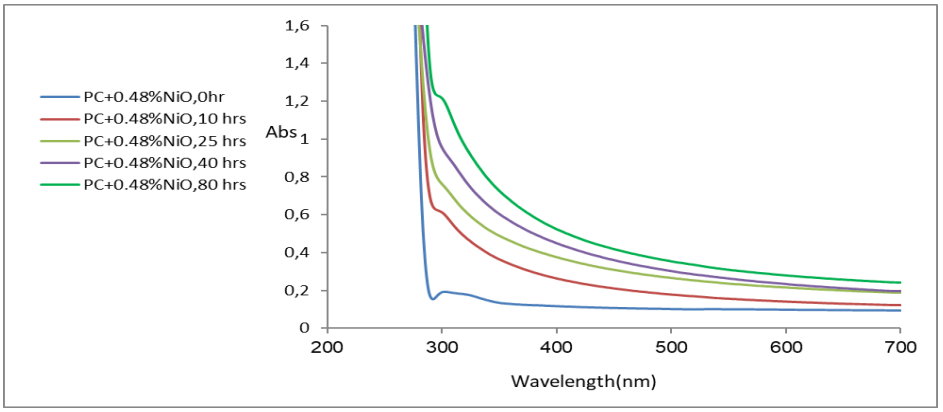


Figure (7): The change in the UV-visible spectrum of polycarbonate films containing concentration 0.48% of $NiON_{PS}$ with a thickness of (60±5) microns at irradiation times

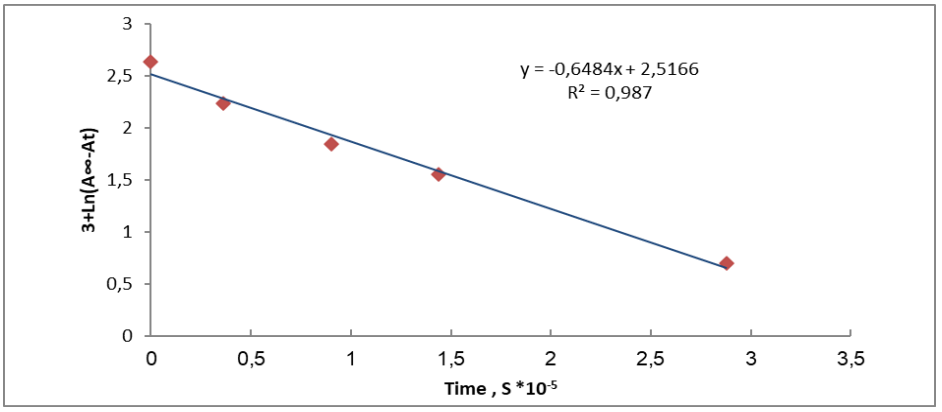


Figure (8): The relationship between the natural logarithm of the absorbance of $NiON_{PS}$ at a concentration of 0.06% in polycarbonate films of thickness (60±5) micron with irradiation time.

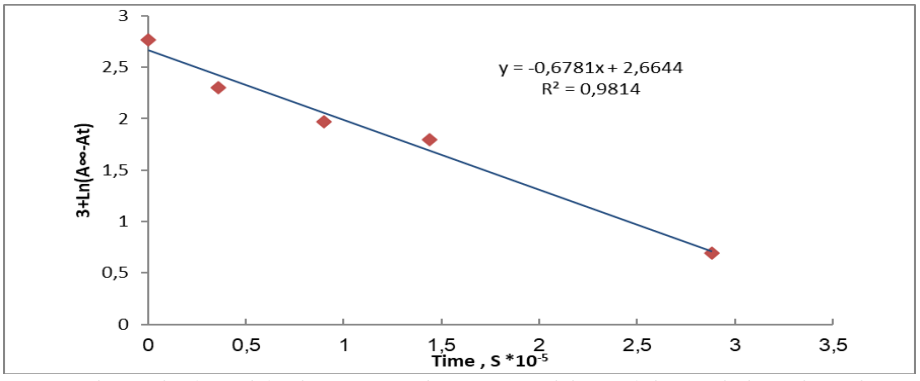


Figure 9: The relationship between the natural logarithm of the absorbance of $NiON_{PS}$ at a concentration of 0.12% in polycarbonate films of thickness (60±5) micron with irradiation time

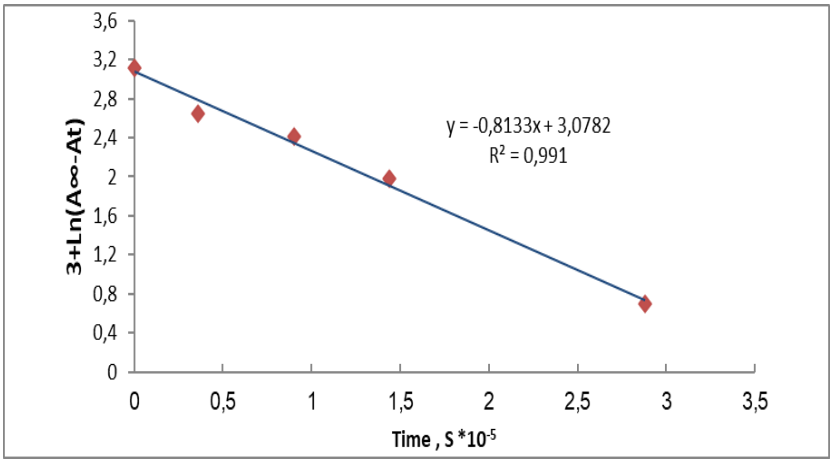


Figure 10: The relationship between the natural logarithm of the absorbance of $NiON_{PS}$ at a concentration of 0.48% in polycarbonate films of thickness (60±5) micron with irradiation time

From calculating the slope of the straight line (Slop) from the above figures, the values of the photodissociation speed constant Kd for the nickel oxide nanoparticle added to the PC polycarbonate are calculated according to the mentioned concentrations [19]. As it turns out that the photodissociation speed constant is directly proportional to the concentration of the nano-material added to the polymer. As shown in Table (2). This indicates that the $NiON_{PS}$ increases the speed of light reaction with the polymer.

Table (2) values of the dissociation velocity constants Kd for $NiON_{PS}$ in polycarbonate films

Concentration%	constant disintegration velocity K_d $(Sec.)^{-1}x10^{-5}$
PC + 0.03 % $NiON_{PS}$	0.628
PC + 0.06 % $NiON_{PS}$	0.648
PC + 0.12 % $NiON_{PS}$	0.678
PC + 0.24 % $NiON_{PS}$	0.782
PC + 0.48 % $NiON_{PS}$	0.813

Infrared spectroscopy

Infrared spectroscopy (FT-IR) was used to follow the optical fractionation of pure polycarbonate films containing different concentrations of nano-nickel oxide during different irradiation periods. Where the optical fragmentation was followed up by the reaction of the polymer with photons in the presence of oxygen for the carbonyl group (C = O) at (1765 cm^{-1}) [20]. This band and in the presence of nano-nickel oxide disintegrate the polymer as the nano-NiO behaves as a disintegration accelerator. Calculating the values of the carboxyl group absorption coefficient (I_{CO}) is important to follow the chemical activity of pure polymer films containing different concentrations of nickel oxide nanoparticles, where the highest value is

in the case of high concentration, which was calculated using the baseline method [21].

By following the FT-IR measurements of pure PC films with thickness (60 ±5) µm, it was observed that there were changes in the infrared spectrum in conjunction with different irradiation times compared with the infrared spectrum of pure PC before irradiation as shown in the figure (11) Infrared spectrum of pure polycarbonate before the irradiation process, while Figure (12) shows the infrared spectrum of polycarbonate after 120 hours of irradiation. The difference in the carbonyl aggregate bands peaks before and after the irradiation process for pure PC is noted.

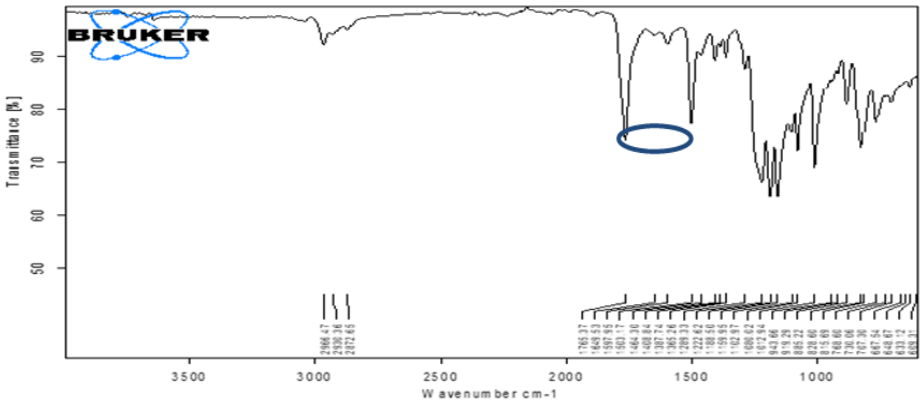


Figure 11: FT-IR spectrum of an additive-free polycarbonate thin film before irradiation

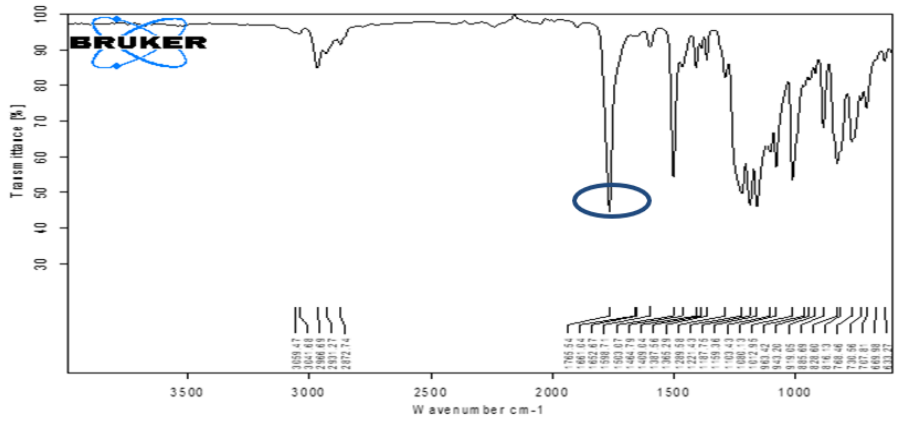


Figure (12): FT-IR spectrum of a polycarbonate film without additives with an irradiation time of (120) hours

As for the polycarbonate film containing a concentration of 0.48% of nano-nickel oxide with a thickness of (60 ±5) µm, the change can be observed as in Figure (13) which shows the infrared spectrum of the polycarbonate containing a concentration of 0.48% of nano-nickel oxide after the irradiation process. for 120 hours

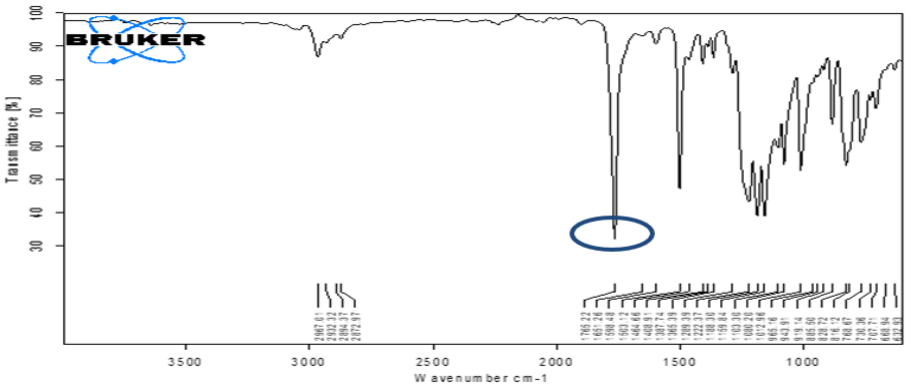


Figure (13): FT-IR spectrum of a polycarbonate thin film containing $NiON_{PS}$ with a concentration of (0.48%) and an irradiation time of (120) hours

The values of the carbonyl group absorption coefficient (I_{CO}) were calculated for the pure PC film in addition to the films containing different concentrations of nickel oxide nanoparticles as shown in Table (3).

Table 3: The values of the carbonyl group absorption coefficient (I_{CO}) with the irradiation time for polycarbonates containing different concentrations of $NiON_{PS}$

Irradiation time (hour) / percentage for	I_{CO}				
	0.0	40	80	120	160
PC	1.302	1.467	1.62	1.823	1.975
PC + 0.03 % $NiON_{PS}$	1.412	1.602	1.783	1.999	2.188
PC + 0.06 % $NiON_{PS}$	1.418	1.687	1.952	2.187	2. 345
PC + 0.12 % $NiON_{PS}$	1.421	1.856	2.209	2.367	2.503
PC + 0.24 % $NiON_{PS}$	1.433	1.968	2.398	2.568	2.666
PC + 0.48 % $NiON_{PS}$	1.438	2.211	2.606	2.782	2.861

From the observations of Table (3), it appears that the values of the carbonyl group absorption coefficient (I_{CO}) for pure polycarbonates increase with the increase in the irradiation time, meaning that the carbonyl group is proportional.

Viscosity measurement

When the polymer is exposed to ultraviolet rays, several sequential processes occur, including cross-linking, secondary oxidation reactions, in addition to chemical reactions that result in the breaking of weak bonds, i.e. chain-scission [22]. The measurements in Table (4) showed that the viscous molecular weight of the pure polycarbonate films is inversely proportional to the irradiation time due to the increase in the rates of polymer dissociation with the irradiation time as well as due to the cutting of the polymer chains and crosslinking, which leads to a decrease in the molecular weight of the polymer.

Table (4): Calculated values from the viscous molecular weight measurements of pure PC chips

Ava. Chain Scission (S)	Deg. Degree $a\ x\ 10^{-3}$	$\frac{1}{P}x10^{-3}$	Degree of Polymerization P	$\frac{dM_v}{dt} = \frac{M_{v0} - M_{vt}}{t}$	$(M_v)^2x10^9$	$\overline{(M_v)}x10^3$	Time Irradiation (hrs.)
0.0	0.0	1.629	613.662	∞	24.349	156.042	0
0.289	0.472	2.101	475.876	0.486	14.642	121.006	20
0.578	0.943	2.572	388.752	0.397	9.771	98.852	40
1.307	2.130	3.759	265.978	0.306	4.574	67.633	80
2.017	3.287	4.916	203.401	0.241	2.675	51.721	120

Table (5) shows the values calculated from the viscous molecular weight measurements of polycarbonates containing 0.12% of the prepared $NiON_{PS}$.

Table (5): Values calculated from the viscous molecular weight measurements of the containing PC wafers At a concentration of 0.12% of $NiON_{PS}$

Ava. Chain Scission (S)	Deg. Degree $a\ x\ 10^{-3}$	$\frac{1}{P}x10^{-3}$	Degree of Polymerization P	$\frac{dM_v}{dt} = \frac{M_{v0} - M_{vt}}{t}$	$(M_v)^2x10^9$	$\overline{(M_v)}x10^3$	Time Irradiation (hrs.)
0.0	0.0	1.629	613.662	∞	24.349	156.042	0
0.417	0.680	2.309	432.999	0.638	12.122	110.103	20
0.730	1.190	2.819	354.734	0.457	8.136	90.202	40
1.793	2.923	4.552	219.651	0.347	3.119	55.853	80
2.706	4.411	6.040	165.557	0.263	1.772	42.098	120

Through the values of the numerical average of the cut-off of the polymeric chain (S) computed using equation No: (9) and proven in Tables (4) and (5) and its relationship with the irradiation time, which was shown by Figure (16) that the relationship is linear, and this confirms the existence of weak bonds that are distributed randomly along the polymeric chain.

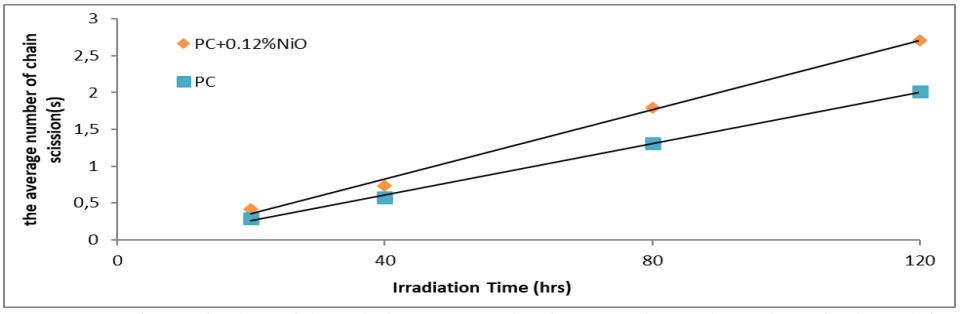


Figure (16): The relationship of the numerical rate of cutting the chain with the irradiation time of the PC chips with and without a concentration of 0.12% of $NiON_{PS}$

And through what is shown in Figure (16), which confirms the dissolution of pure polycarbonate films that contain different concentrations of nickel oxide nanoparticles at random. The degree of dissociation α for pure polycarbonate films containing 0.12% concentration of $NiON_{PS}$ was calculated through equation No: (8) whose values were listed in Tables (4) and (5), which show that the degree of dissociation increases in conjunction with the irradiation process. As shown in Figure (17), the highest value was recorded at the highest irradiation time of 120 hours.

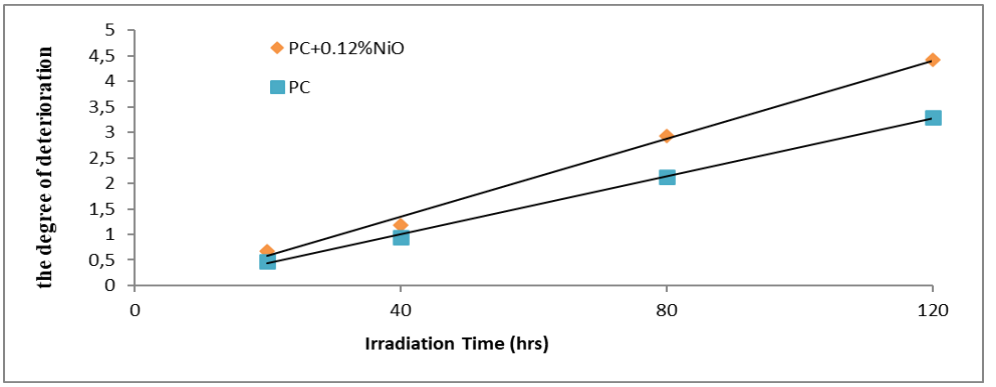


Figure (17): The relationship of the degree of fragmentation with the irradiation time of the PC chips with and without a concentration of 0.12% of $NiON_{PS}$.

From tables (4) and (5), it is clear that the values of the degree of dissociation α for polycarbonate films containing 0.12% concentration of the prepared $NiON_{PS}$ are higher than in the pure polymeric films.

Conclusions

After the results we obtained in our research were presented and discussed, we now review the most important conclusions we reached:

1. (SEM) images that show that the NiONPS are in the form of nanosheets. XRD measurement that the $NiON_{PS}$ conform to the standard reference. (AFM) and the graph of the distribution of nanoparticles of $NiON_{PS}$, which shows the average diameter of the particles equal to 32.54 nm.
2. The optical fractionation of polycarbonate films was studied after adding different weight percentages of the prepared $NiON_{PS}$. The results obtained show the following. The dissociation velocity constant (Kd) and the growth coefficient of carbonyl groups (I_{CO}) are directly proportional to the added nickel oxide nanoparticle concentration and the irradiation time. By calculating the degree of fragmentation (α) and the numerical rate of cutting the chain (S), it was found that the presence of $NiON_{PS}$ reduces the viscous molecular weight, and therefore it is considered an accelerator for the photofragmentation process, and the photodissociation process of the polymer takes place randomly.
3. $NiON_{PS}$ increases the absorption of light and thus can be used for the purpose of getting rid of environmental pollutants.

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