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Electrical Conductivity of Carbon Nano Tubes Suspensions Prepared in Different Solutions

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ABSTRACT

Carbon nanoparticle was synthesis by pulse laser ablation of graphite target in different solution. Fourier Transform Infrared Spectroscopy (FTIR), Transmission electron microscopy (TEM) and Conductivity meter were used to study chemical composition, size, morphology and condectivity of suspensions. FTIR spectra exhibit the presence of C≡C, C═C, C-C bond which indicates the formation of carbon nanoparticles. The TEM show the formation of spherical nanoparticles, aggregation of the carbon nanoparticles, morphology of carbon nanotube ((141.6 nm length and 16.6 nm diameter) in ethanol, but high-quality of CNTs in Iso-propanol with (11.1–46.15 nm) diameter and (261.1- 592.3 nm) length and the CNTs are uniform diameters in deionize water with diameters (12.2-25 nm) and (500 - 708.3 nm) length). Study the electrical condectivity; determine the activation energy of suspension and the condectivity depended on geometry of carbon nanoparticles; electrical conductivity in ethanol suspension is more than Iso-propanol suspension and the electrical conductivity of deionize water is more than them.

Keywords: Carbon Nan tube, Laser Ablation, Conductivity of Suspension, Morphology of Carbon Nan particles.

التوصيلية الكهربائية لمعلقات أنابيب الكاربون النانوية المحضرة في محاليل مختلفة

الخلاصة

تم تحضير انابيب الكاربون النانوية بواسطة الاستئصال بالليزر النبضي لهدف الكرافيت في محاليل مختلفة, تم استخدام مطياف تحويلات فورير تحت الحمراء و المجهر الالكتروني النافذ و مقياس التوصيلية لدراسة الاواصر الكيميائية و حجم الجسيمات وتركيب وطوبغرافية انابيب الكاربون النانوية وتوصيلية المعلقات. قمم الامتصاص للأشعة تحت الحمراء الظاهرة تدل على C≡C , C═C و C-C| على التوالي شكلت الاواصر جسيمات الكاربون النانوية العالقة داخل المذيب. يظهرالمجهر الالكتروني النافذ تكوين جسيمات نانوية كروية و تكتل جسيمات الكاربون النانوية و طوبغرافية انابيب الكاربون النانوية بقطر يتراوح 16.6 nm وبطول141.6 nm في الايثانول لكن بجودة عالية لانابيب الكاربون النانوية في الايزوبروبانول بقطر يتراوح (11.1-46.15 nm) و بطول (261.1-592.3nm) وانابيب كاربون نانوية منتظمة في الماء الايوني وبقطر يتراوح (12.5 -25 nm) و بطول (500-708.3 nm) . دراسة التوصيلية الكهربائية

وحساب الطاقة الفعالة للمعلقات و اعتماد التوصيلية على الشكل الهندسي لجسيمات الكاربون النانوية ، التوصيلية الكهربائية لمعلق الايثانول اكثر من توصيلية معلق الايزوبروبانول والتوصيلية الكهربائية لمعلق الماء الايوني اكثر من كليهما.

INTRODUCTION

Silicon has been dominating the field of semiconductor industry for many years. Researchers are looking for alternative materials for semiconductor devices since long [1]. Therefore, it is imperative to find a new kind of clean and inexpensive energy resource in the 21" century. In the search for alternative materials, C is a group lV element existing in many forms with a wide range of optoelectrical properties is highly attractive for its possible application in optoelectric devices [2]. Carbon is cheap, non-toxic, and environment-friendly. which have very interesting physical , optical and electrical properties. The nature of the electrical conductivity of disperse systems is determined by the dispersed phase properties and the dispersion medium, the processes of aggregation of the particles which conduct electric current [3].

Laser ablation in liquid phase is a very unique approach for the nanostructure formation of refractory materials [4]. Carbon materials can be evaporated easily by laser ablation, since the energy densities of pulsed laser beam are high in small area and short time. The evaporated carbon particles form ablation plumes of the plasma state. The plume interacts with the background while diffusing, which is explained by Shock model or Drag model [5]. In gas phases, the evaporated particles are condensed, and Nano-particles, such as fullerenes C60, are synthesized [6]. In liquid phases, diffusions of the evaporated particles are intercepted therefore; the densities at the shock front are very high. Then, it was considered that larger particles would be formed by laser ablation in the liquid with the high solubility.

Liquid-phase laser ablation has been used to produce carbon nanotube; this method has some advantages. The cost is comparatively low, because expensive instruments such as a vacuum apparatus are unnecessary. The recovery of the product is higher than that of laser ablation in the gas phase. Moreover, ablation surroundings can be easily changed by replacing solvent. The purpose of the present study is to produce carbon nanotube by laser ablation of graphite in different solution and study the structure, morphology and electrical properties by using FTIR spectroscopy TEM and conductivity meter.

EXPERIMENTAL

Carbon nanoparticles were produced by laser ablation of a pure graphite pellet (99.9 % from national spectroscopic electrodes co. diameter = 5 mm) was used in a glass Petri dish container filled with 5 ml of different solution. Both the target and Petri dish were rinsed with ethanol cleaner prior to preparation. The target was immersed in different solution to a depth of around 2 mm below the solution's surface during laser ablation. The target was rotated constantly during laser ablation.

The graphite target was irradiated by an Nd: YAG laser (system type HUAFEI) operating at a wavelength of 1064 nm as depicted in Figure (1). The repetition rate was 1 Hz. The laser energy was change from 20-200mJ with 25 laser pulse.

The chemical bonding studied by Fourier Transform Infrared Spectroscopy (FTIR) (8400S, SHIMADZU) and Transmission electron microscopy (TEM) (type CM10 pw6020, Philips-Germany) were used to study the particle size and the morphology. The conductivity measurements of the nanoparticles suspensions are done by using conductivity meter (HI 8033). The activation energy (E_a) which can be calculated using the equation (1) [7].

$$s = s_0 \exp\left(\frac{-E_a}{K_B T}\right) \qquad \text{... (1)}$$

Where σ_o is the high temperature limit of conductivity, E_a is activation energy and kT is the thermal energy associated with temperature variation in the measurement where k is Boltzmann constant and T is absolute temperature .

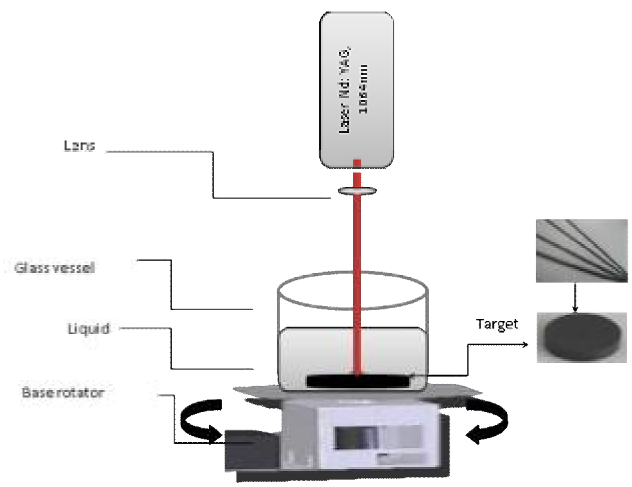

Figure (1) Experimental setup for Synthesis carbon nanoparticles by liquid Phase –pulse laser ablation.

RESULTS AND DISCUSSION

- **FTIR spectrum**

Figure (2) shows the FTIR spectrum of carbon nanoparticles suspensions prepared by laser ablation of graphite target in different solution at 80 mJ/pulse with 25 laser pulse. Figure (2a) shows the FTIR spectrum of carbon nanoparticles suspensions in ethanol, it is notice that the bond for all suspension is between (3000 - 3500 cm^{-1}) is due to the O – H stretching vibration. The peak between (3000 to 2800 cm^{-1}) is due to the C – H stretching vibration bond, asymmetric C – H stretching occurs at 2887.2 cm^{-1}, and symmetric C – H stretching occurs at 2974.0 cm^{-1}. A peak at 2368.4 cm^{-1} is due to the C ≡ C stretching vibration bond, while C = C stretching vibration bond appear at ~ 1640.0 cm^{-1}, suggests the formation carbon nanoparticles suspend in this solvent [8]. the peak between (1250 – 1500 cm^{-1}) is due to the symmetrical C – H stretching bonded also appear around the 881.4 cm^{-1}, a peak at ~ 1049.2 cm^{-1} is due to the C – O stretching bonds and peak around 1276.8 cm^{-1} is due to the C-C stretching vibration bond.

Figure (2b) shows the FTIR spectrum of carbon nanoparticles suspensions in Iso-propanol , it is notice that the bond for all suspensions is between (3000 to 3500 cm^{-1}) is due to the O – H stretching vibration, and a peak between (3000 to 2800 cm^{-1}) is due to the C – H stretching vibration bond; asymmetric C – H stretching occurs at 2887.2 cm^{-1} , 2885.3 cm^{-1}, 2860.2 cm^{-1} and 2856.4 cm^{-1}, while symmetric C – H stretching occurs at 2977.2 cm^{-1} , 2972.0 cm^{-1} and 2923.9 cm^{-1}. The peak at 2335.6 cm^{-1} is due to the C ≡ C stretching vibration bond, while C = C stretching vibration bond appear at ~ 1647.1 cm^{-1}, suggests the formation carbon nanoparticles suspend in this solvent. the peak between (1250 – 1500 cm^{-1}) is due to the symmetrical C – H stretching bonded also appear around the 881.4 cm^{-1}, while peak at ~ 1049.2 cm^{-1} is due to the C – O stretching bonds and peak around 1269.1 cm^{-1} is due to the C-C stretching vibration bond.

Figure (2c) shows the FTIR spectrum of carbon nanoparticles suspensions in deionize-water, it is notice that the bond for all suspensions is between (3000 to 3600 cm^{-1}) is due to the O – H stretching vibration. The peak at 2092.6 cm^{-1} and ~ 2150 is due to the C ≡ C stretching vibration bond, while C = C stretching vibration bond appear at ~ 1641.3 cm^{-1}, suggests the formation carbon nanoparticles suspend in this solvent. The peak between (800 – 1300 cm^{-1}) is due to the C - O stretching bonded**.** According to the results of figures, the relative intensity of FTIR absorption peak is change with change laser energy while the positions and width of observed peaks are well constant for the most part in each spectrum, it is inferred that the C ≡ C and C = C bonds was formed by laser ablation of graphite in different solution which referred to formation carbon nanoparticles suspend in this solvent [9].

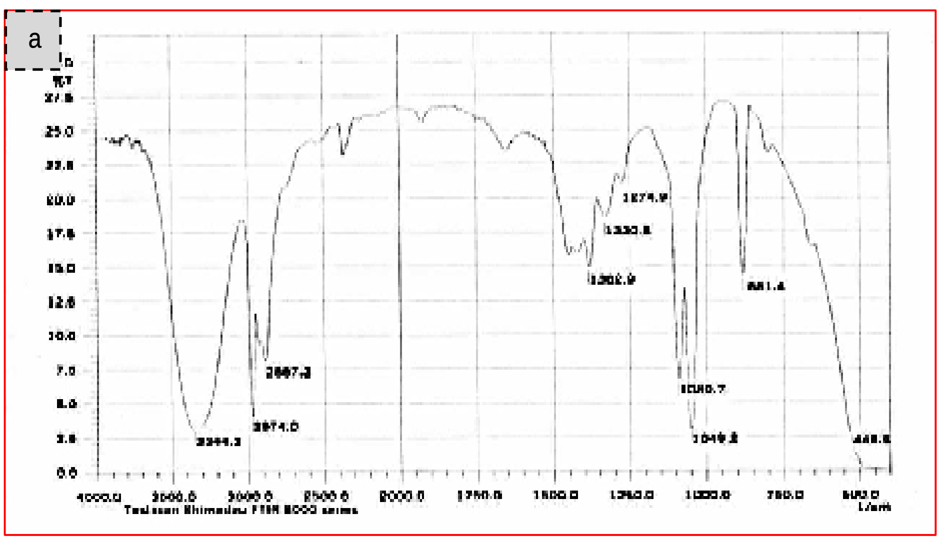

Figure (2) To be continued

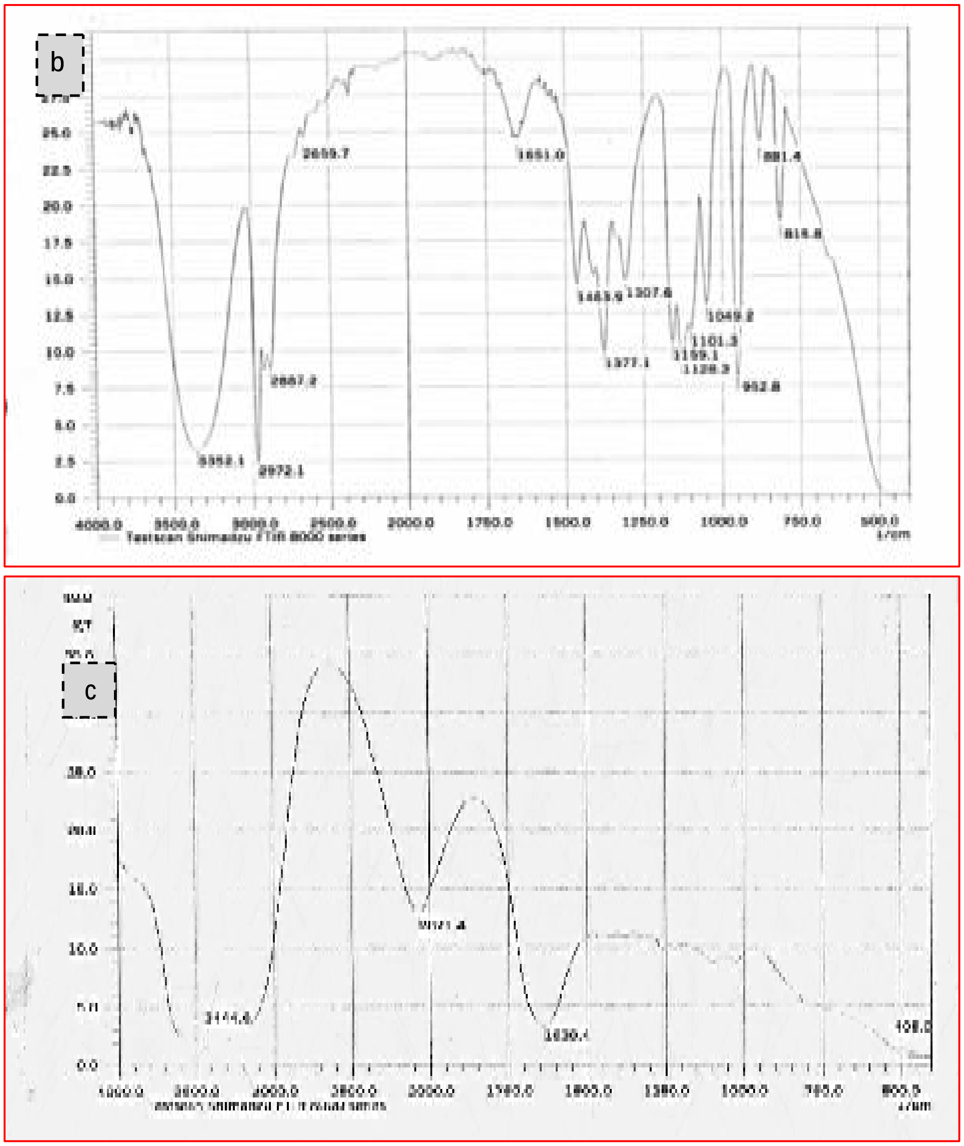

Figure (2) FTIR spectrum of CNPs suspensions produced at 80mJ in different solution a)Ethanol b) I so-propane c) deionize water.

- **TEM image**

Figure (3) shows TEM image of CNTs suspend in ethanol. From this image Spherical particles have two size distributions lie in the range of 16.6 – 25 nm with 20 nm average diameters and 8.3 – 41.6 nm with 23 nm average size. Spherical particles are assembled in the linear manner and make rod shape nanostructure of 141.6 nm in length and 16.6 nm diameter. Figure (4) shows that most of the obtained CNTs are not very straight with 30.76–46.15 nm in diameter and a 592.3 nm in length. Some carbon nanoparticles with spherical geometry are contained in the middle of these spiral helicine CNTs.

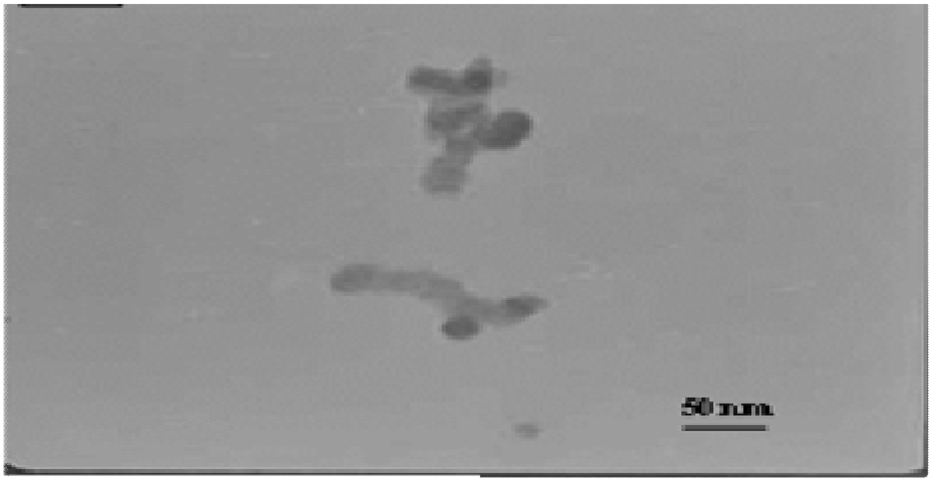

Figure (3) TEM image shows the morphology of CNPs suspend in ethanol solution at laser irradiation with 25 pulses and energy of 200 mJ/pulse.

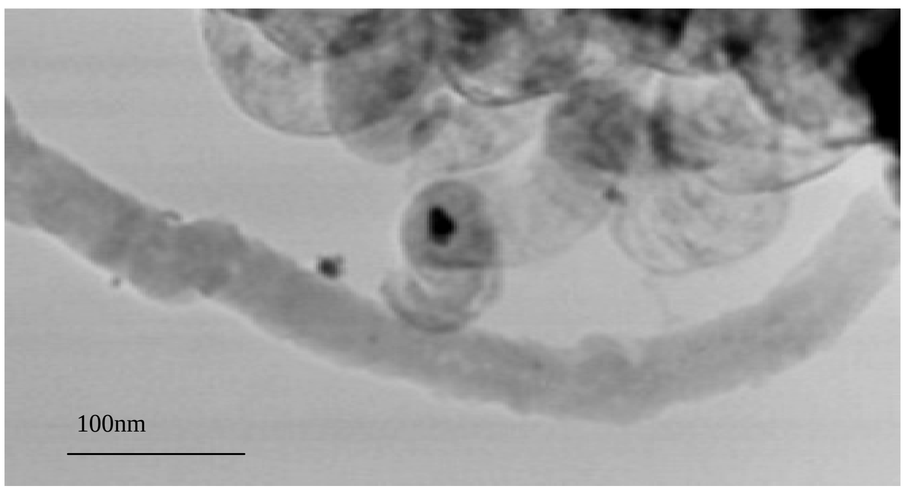

Figure (4) TEM image of CNTs prepared in Iso- propanol at 200mJ with 25 pulses

Figure (5) shows the CNPs suspensions in deionize water at laser pulse energy 80 mJ/pulse and 25 laser pulse. The CNTs are of uniform diameters, some of the CNTs aggregated to gather and some carbon nanoparticles with spherical geometry are contained in the middle of these CNTs. The nanotube can be observed with diameters 25 nm and a 708.3 nm in length for a wide nanotube and a thin nanotube with diameters 12.5 nm but of a 500 nm in length.

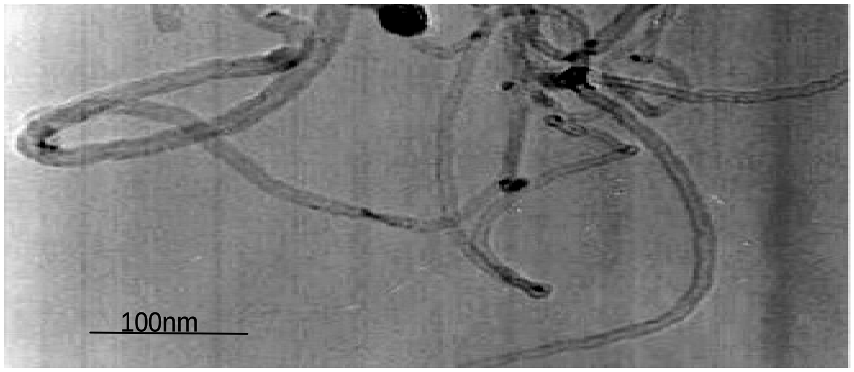

Figure (5) TEM image of CNTs prepared in deionize water at 80mJ with 25 pulses

- **Conductivity measurement**

Figures (6 , 7 , and 8) show the electrical conductivity σ of CNPs prepared at different laser energy (20 to 200)mJ/pulse with 25 laser pulse suspension in different solution: ethanol, isopropanol and deionize water respectively. The electrical conductivity increases sharply even at laser energy from (20-60 mJ) then decreases gradually and then increases. It reflects the existence of a strong aggregation between the carbon nanoparticles and formation of a highly interconnected network between the particles of an isotropic geometry [10, 11] .The electrical conductivity of CNPs suspension depended on the particle aggregation [12]. Also the figure explains the change of conductivity with temperature; notice that the conductivity is reduced as the temperature increased. The behavior is similar to conductive solution; the electrical conductivity of CNPs suspensions changes little with temperature[14]; from 20-40 c˚ the suspensions start to heating the electrical conductivity decreases and after the suspensions completely heating the electrical conductivity stabilized [13,15].

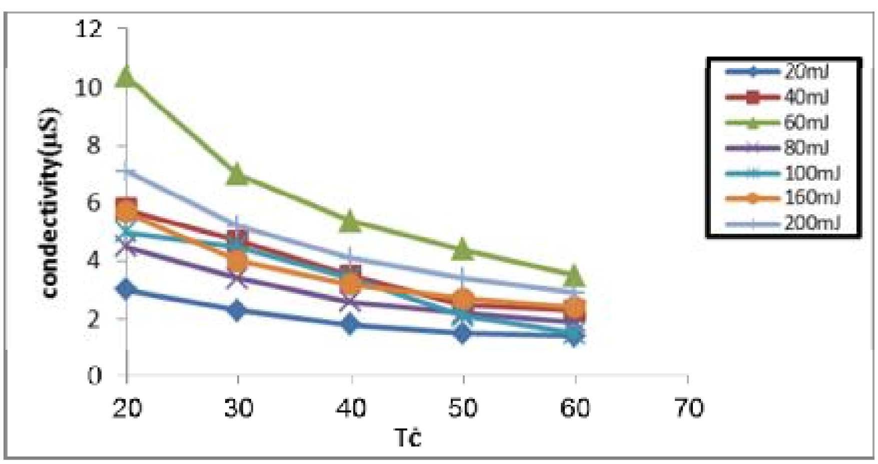

Figure (6) The relationship between conductivity and temperature for CNPs in Ethanol suspensions at different laser energy.

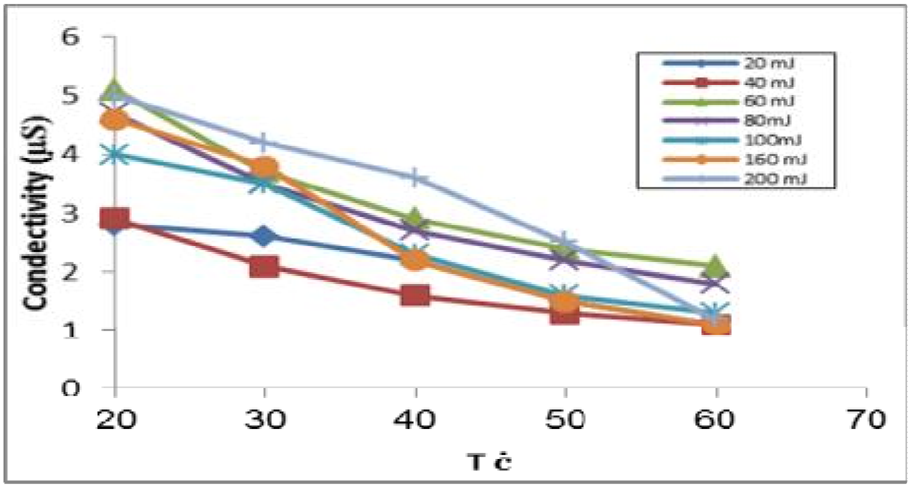

Figure (7) The relationship between conductivity and temperature for CNPs in Isopropanol suspensions at different laser energy.

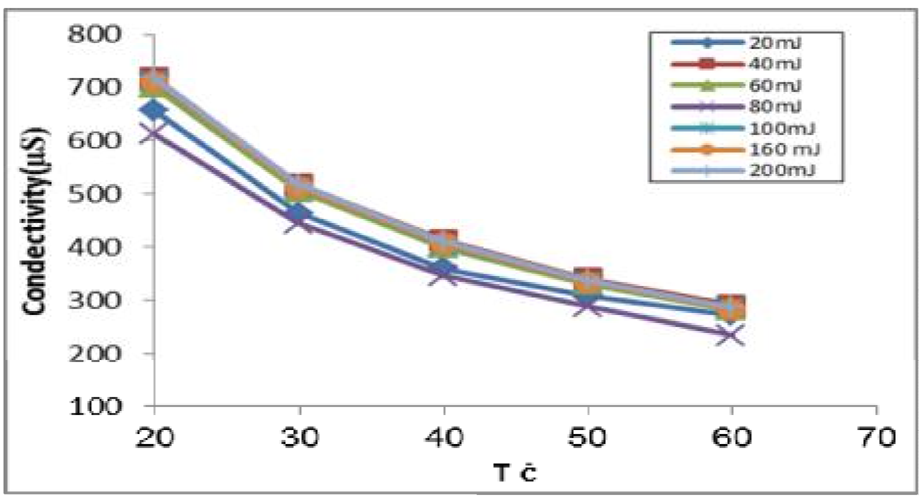

Figure (8) The relationship between conductivity and temperature for CNPs inDeionize water suspensions at different laser energy.

The activation energy E_a of these suspensions can be calculated from the equation (1). Table (1) shows the activation energy of carbon nanoparticles suspensions prepare at different laser energy with 25 laser pulse.

Table (1) The activation energy (E_a) of the carbon nanoparticles in different solution prepare at different laser energy with 25 laser pulse.

liquid	Activation energy (eV)					
	Different laser energy					
	20mJ /25	40mJ /25	60mJ /25	100mJ /25	160mJ /25	200mJ /25
Ethanol	0.215	0.165	0.186	0.351	0.264	0.215
Isopropanol	0.273	0.156	0.264	0.286	0.43	0.625
Deionize water	0.206	0.156	0.215	0.206	0.198	0.198

CONCLUSIONS

The formation of carbon nanoparticles (carbon nanotube) has been observed in the laser ablation of graphite target in different liquids. LP-PLA ensures a very simple and effective met hod to produce carbon nanotube in solution. The results of FTIR absorption peak which referred to formation carbon nanoparticles suspend in this solvents. TEM show formation of CNPs with prefect spherical geometry and carbon nanotube. The electrical conductivity of carbon nanoparticles suspension depends on the particle aggregation and temperature.

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