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The impact of different temperatures on NanoSilver Carbon manufacturing by Arc Discharge method

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ABSTRACT

The arc discharge process was adjusted by varying the temperature by two values The temperature, applied voltage, electrode shape, and kind of dielectric medium all have a significant impact on the mass production, stability, yield, and size and form. AgNPs-CNT with an average particle size of 13 nm was produced by the system (A) at a temperature of -10° C, but in system (B) the temperature was about 55° C and the production was spherical AgNPs/C with an average particle size of 30 nm. In both systems, the two electrodes were 99.9% pure silver as the anode with a diameter of 0.5 cm and 10 cm of length and carbon as the cathode with a diameter of 0.2 cm and 4 cm of length, the applied voltage was 30 A and the dielectric medium was ethanol. 1Energy-dispersive X-ray spectroscopy (EDX), Transmission Electron Microscope (TEM), and ultraviolet-visible spectrophotometer (UV-Vis) were used to characterize the yields. Every characterization demonstrates that the production of nanoparticles for both systems was successful.

Key Words:

arc discharge in ethanol, Carbon Nanotubes, and Nano-silver.

1. INTRODUCTION

The most important science in nanotechnology over the past 20 years has been applied research[1]. Connecting the essential gap between the atomic and molecular fundamental sciences and the microstructural scale of engineering is one of nanotechnology's many useful benefits[2]. The synthesis of metal nanoparticles is less complicated than that of ceramic nanoparticles[3], but it is still challenging because of the need to stabilize the metallic nanoparticles. Two major issues in the discharge method are oxidation and aggregation[4]. The present paper describes a novel physical methodology of preparation of nanosilver suspension in ethanol by the arc-discharge method in two systems at different temperatures, the difference in temperatures produced two different shapes of nanosilver. Arcing discharge is a physical process that circumvents the toxicity of chemical preparation and is the simplest way to synthesize nano-metal particles. The synthesis of nanoparticles using the arc discharge method seems straightforward, but achieving a high yield while maintaining a fine structure is challenging[5]. To do this, the experimental circumstances must be carefully controlled. The diameter, gap[6], and kind of media (gas or liquid) in which the electrodes are positioned[7] all have a significant impact on these conditions. In addition to these, other elements including cathode shape, voltage, temperature, power supply type, pressure, current [8], and temperature all have a significant impact on maximizing the yield [9]. Amir Hossein Sari, et al. [10] used an electric arc discharge method to synthesize multi-walled carbon nanotubes (CNTs). The simplicity, low-cost methods, and avoidance of multistep purification are all advantages of CNTs. Submerging graphite electrodes in deionized water and varying amounts of sodium chloride solution optimized the studies.

Al-Khatib et al. [11] studied the effect of current (between 30 and 110 A) on the production of copper nanoparticles, the result was in diameters ranging from 44 to 123 nm. In the results of carbon nanotube arc plasma, it was shown that employing smaller anode diameters increases the yield [12]. Various media (deionized water, ethanol, methanol, and acetone) are used to study preparation metal nanoparticles, which generate nanoparticles at 25, 31, 38, and 45 nm, respectively. The most stable collision is found in acetone, followed by deionized water, ethanol, and finally methanol [13]. One important factor in the creation of nanoparticles is electrode geometry [14]. To fully comprehend the function of electrode shape and geometry, more research is required [15]. This review demonstrates the necessity to clarify the precise mechanism involved in the creation of nanoparticles. Ali Eatemadi, et al. [16] Explained the importance of nanotubes and their uses in a variety of industries and disciplines, including medicine, nanotechnology, manufacturing, and construction. Silver-carbon nanoparticles serve as vaccine adjuvants, anti-diabetic agents, and biosensors. Also, Silver-Carbon nanoparticles are primarily utilized in antibacterial and anticancer therapies. They are also applied in the promotion of wound repair and bone healing. The production of carbon nanotubes (CNTs) from silver nanomaterial increases their antibacterial properties and reduces their biotoxicity. Therefore, the goal of adding Ag NPs to CNTs is to create a composite of silver-doped CNTs, which will optimally leverage the antibacterial benefits of both silver and CNTs. Also, CNTs used in thin-film electronics, automobile components, boat hulls, energy storage, water filters, coatings, actuators, and electromagnetic shields.

This work is aimed to study the preparation of AgNPs by arc discharge, with different parameters as a new method to prepare the AgNPs by DC-power supply with different temperatures. this work aims to show the effect of different temperatures in the preparation of Silver and carbon nanoparticles and study their characterization.

2. MATERIALS AND METHODS

In this work, AgNPs-CNT and spherical AgNPs/C were prepared in two systems (A) and (B) using the arc discharge method in ethanol as in Figure (1). To further the discharge process, a high-purity cylindrical carbon cathode and a 99.99% pure silver anode were used as electrodes, and a stabilized direct current was applied between the two rods by using a welding machine. To use the systems, the electrodes were submerged in ethanol, and system (A)'s cooling system was set to maintain a temperature of -10° C during the preparation process, whereas system (B) experienced a temperature of roughly 55° C. The anode electrode used a DC power supply with a low voltage of 80V and a high current of 30 A to travel progressively in the direction of the cathode electrode. The condensed vapor of carbon and silver in ethanol produces a stable aqueous suspension of nanoparticles. Chemical agents were not used in the process. Ethanol pure solutions were employed as the medium. There are three stages in the transformation of silver metal vapors into nanoparticles: nucleation, cluster growth, and condensation in ethanol. The silver clusters are promptly extracted from the medium to avoid sample aggregation. The nanoparticles were examined using energy-dispersive X-ray spectroscopy (EDX), by using a Quanta FEG 250 scanning electron microscope (FEI Companies, Hillsboro, Oregon-USA) At the Nawah Scientific Lab in Cairo, Egypt. Transmission electron microscopy (TEM) [JEM-2100F, JEOL, Japan], operating at 200 kV were obtained at the Alexandria University laboratory in Alexandria, Egypt, and UV-visible photometer Jenway 6305, Japan with a Xenon lamp with a wavelength range from 198 to 800 nm, a Resolution of 1nm, Accuracy of ±2nm, and A spectral bandwidth of 8nm, 6nm over UV range at the Nawah Scientific Lab in Cairo, Egypt. The UV-VIS spectrophotometer was used to evaluate the optical absorption spectra of the colloidal solution of silver Ag nanoparticles made by the electrical arc discharge method using ethanol. These characterizations were obtained to determine their structural characteristics.

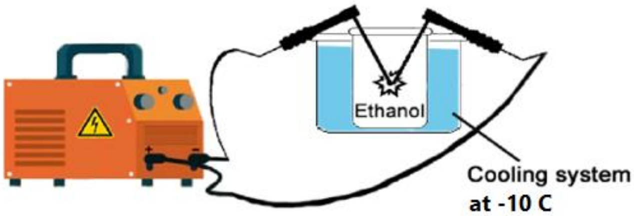


Fig (1) Experimental set for system (A), CNTS synthesis by arc discharge in ethanol with a cooling system at - 10°C

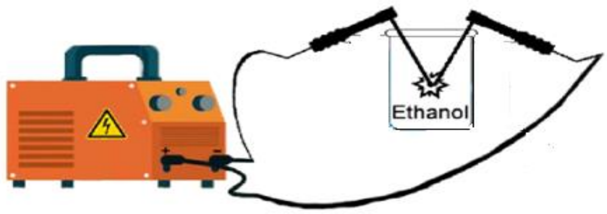


Fig (2) Experimental set for system(B), AgNps/C synthesis by arc discharge in ethanol at temperature from 25 to 55°C

Table 1: The key fixed parameters that are employed in the arc discharge method of synthesis.

Key parameters	Values for system (A)	Values for system (B)
Discharging voltage (average value)	80 V	80 V
Discharging current (average values)	30A	30A
Anode (diameter- length)	0.5cm,10cm	0.5cm,10cm
Cathode disk (diameter-length)	0.2cm,4cm	0.2cm,4cm
Discharging Duration time	30min	30min
Volume of solution	1 liter	1 liter
Pressure	atmospheric	atmospheric
The angle of discharge method	60°	60°
The solution temperature (before& After)	-10° C	25&55° C

3. RESULTS AND DISCUSSION

In system (A) the production was AgNPs-CNT and in system (B) the production was spherical AgNPs/C the results were characteristics by Transmission Electron Microscope (TEM), Ultraviolet (UV), and Energy-dispersive X-ray spectroscopy (EDX).

The TEM characterization photos[JEM-2100F, JEOL, Japan], operating at 200 kV were obtained at the Alexandria University laboratory in Alexandria, Egypt. They display uniformity, shape shapes, inner structure, and nano dimensions. The AgNPs-CNTs and AgNPs/c TEM micrographs, which were created using the arc discharge approach in ethanol, are displayed in Figures 2 and 3.

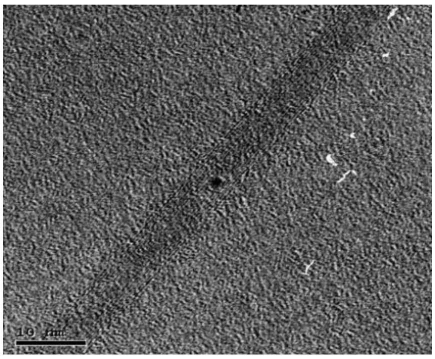


Fig (3) TEM micrographs of decorated CNTs with AgNPs synthesized by arc discharge method

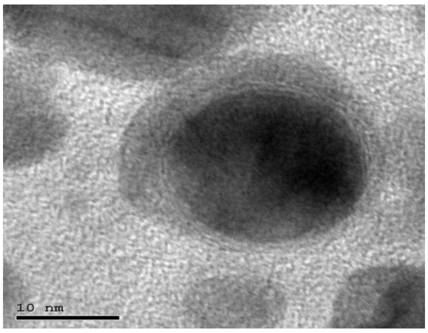


Fig (4) TEM micrographs of spherical shape AgNPs/C synthesized by arc discharge technique

The particles were prepared from the system (A), AgNPs-CNTs, have diameter ranges from 8.1 nm to 11 nm with an average size of 9.4 nm The CNT development along the sample that was analyzed and decorated with AgNPs appeared in Figure 2.

The AgNPs/c produced from the system (B) are often homogeneous and spherical with a diameter ranging from 9.6 nm to 19.1 nm and an average size of 12.41 nm, the size of nanoparticles determined by the ImageJ.

Additionally, EDX spectroscopy was used to verify the chemical makeup of the produced AgNPs-CNTs.

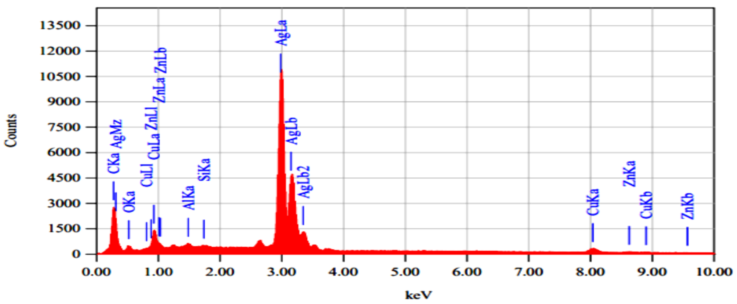


Figure (5): EDX diagram for AgNPs-CNTs synthesized by arc discharge technique.

From figure (4) Nearly 87.5%weight percent of the yield is made up of silver components, 7% is made up of carbon, and the remaining 5.5% is made up of contaminants, according to the area under the peaks found in the EDX curves. Edx was characterized using a Quanta FEG 250 scanning electron microscope (FEI Companies, Hillsboro, Oregon-USA) At the Nawah Scientific Lab in Cairo, Egypt.

By Using EDX spectroscopy, the chemical makeup of the produced AgNPs/C was also verified and shown in Figure (6).

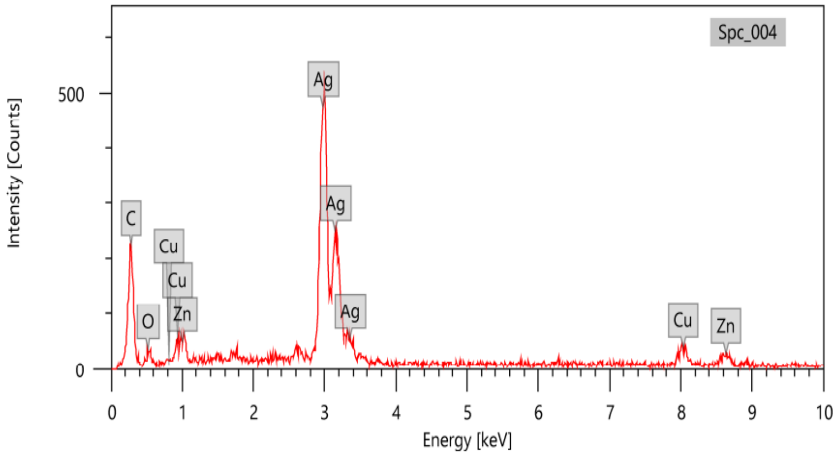


Figure (6): EDX diagram for AgNPs/C synthesized by arc discharge technique.

The EDX curves' area under the peaks showed that around 62% of the yield's weight is made up of silver components, 30% is carbon, and the remaining 8% is made up of contaminants. This characterization was carried out using a Quanta FEG 250 scanning electron microscope (FEI Companies, Hillsboro, Oregon-USA) at the Alexandria University laboratory in Alexandria, Egypt.

For the optical characterization of silver nanoparticles, UV-visible spectroscopy is one of the most popular methods[2]. The nanoparticles' strong absorption peak is caused by the surface plasmon excitation, making it extremely sensitive to the presence of silver colloids. It is normal for silver nanoparticles to have an absorption band between 350 and 450 nm [17]. The red zone of the plasmon absorption shifts with increasing particle size.

The absorbance of the resulting solution was recorded and shown in Figure 7.

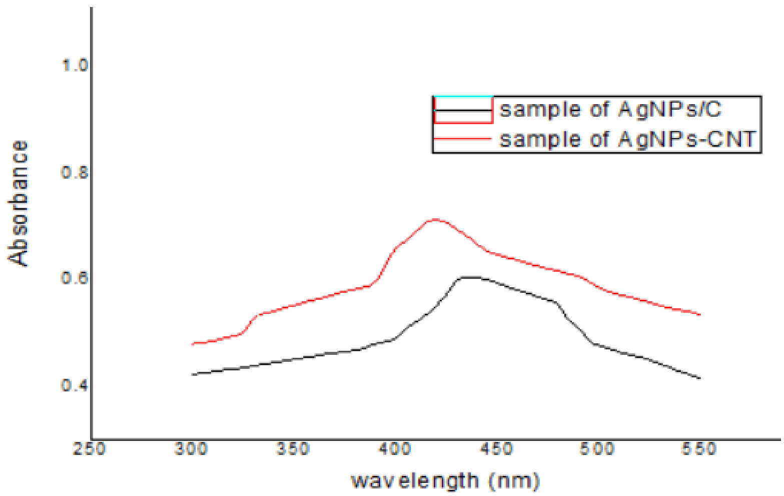


Fig (7) UV–Vis spectrum for AgNPs-CNTs.

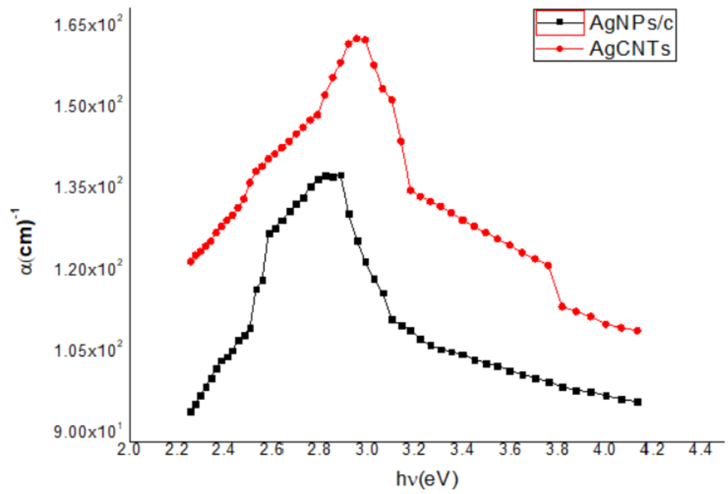
The two samples are contrasted in this UV visible spectrometer chart. Sample (A) contains AgNPs-CNTs, whereas sample (B) contains AgNPs/C. The absorbance peaks in Figure 7 demonstrate the significant differences in the maxima of the samples produced by systems A and B. The former has an absorption range of 380 to 420 nm and a maximum wavelength of 410 nm, while the latter has an absorption range of 410 to 470 nm and a maximum wavelength of 435 nm. As a result, AgNPS-CNT is absorbed in greater amounts [18], suggesting that the sample generated by system A has fewer nanoparticles than the sample generated by system B.

The samples were subjected to ultraviolet–visible (UV–Vis) absorption measurements to identify any changes in the band structure and ascertain the optical band gap. The materials' UV spectra were recorded at room temperature[19]. One can use the optical absorption approach to investigate the optically induced transition and subsequently to investigate any changes that may have occurred in the band structure [20], so the absorption coefficient must be examined [21]. The absorption coefficient (α) of an optical material measure how much light it can absorb, It is a fraction of power absorbed in a unit length of the medium.

The following formula was used to determine the absorption coefficient[19,20]:

$$\alpha = (2.303/d) \times A$$

where A is the absorption data and d is the sample thickness. The optical absorption coefficient vs photon energy is seen in the Figure for AgCNTs and the figure for AgNPs/C

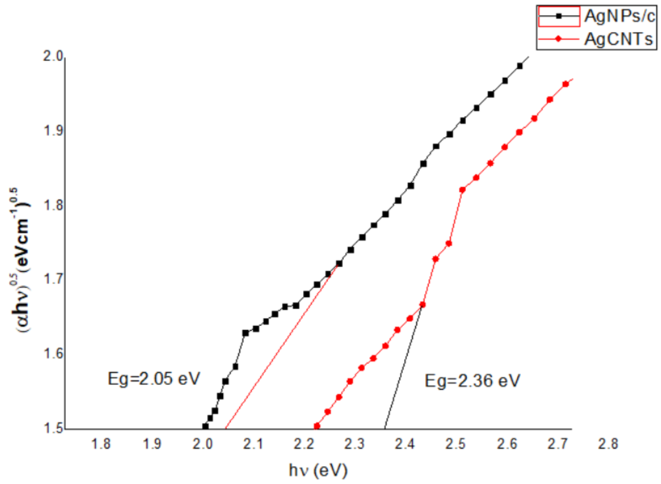


Figure(8) the absorption coefficient versus photon energy for AgCNTs and AgNPs/C.

there is one peak in each of the two plots in Fig (8), AgNPs/C the peak is at 2.83 eV with an absorption coefficient of 1.38×10^{2} cm^{-1}, and for AgCNTs the peak is at 2.96 eV with an absorption coefficient of 1.65×10^{2} cm^{-1}. The absorption coefficient enhanced for AgCNTs.To determine the energy gap Use Tauc's formula, the relationship between photon energy, hυ, and $(\alpha h\upsilon)^{1/2}$ is determined. The electronic transitions between bands are studied using this relation, and the energy gap for amorphous semiconductors is given as[21]:

$$\alpha h\upsilon = A(h\upsilon - E_g)^n$$

where A is a constant, *n is* equal to 3/2 and 1/2 for allowed and direct transitions, and values of 3 and 2 for indirect and allowed transitions. The optical gap is denoted by the symbol *Eg*. As seen in Figure 9, the matching value of *n* is approximately 2, and the transition is indirect[22].



Figure(9) The plots of $(\alpha h\upsilon)^{0.5}$ versus (hυ) for AgNPs/C and ACNTs.

The energy gap for AgCNTs and AgNPs is 2.36 eV and 2.05 eV, respectively. As shown in the figures below, the energy gap increases as nanoparticle size decreases which indicates that the size of AgCNTs is less than that of AgNPs/C.

4. CONCLUSION

The use of two different temperatures in preparing silver nanometals by using the arc discharge method produced two types of silver nanoparticles. The first production was AgNPs-CNTs were produced by using a cooling system that kept the temperature at about -10° C, the second production was AgNPs/C were produced at temperatures from 25° C to 55° C. The nanoparticles produced were characterized by an ultraviolet spectrometer (UV), Transmission electron microscope (TEM), and Energy-dispersive X-ray spectroscopy (EDX), all characterization shows that both nanoparticle manufacturing was successful. It was found that the average size of spherical nanoparticles was 12.4 ± 3 nm and for CNTs the size was 9 ± 2 nm in case of usage cooling system. According to the statistical errors the results are in fair agreement. the absorption coefficient and the energy gap were determined for two productions and it found that the energy gap increases as the size of nanoparticles decreases

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