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Ag– Au alloy Nanoparticles and Thin Filmproduced by Electro-Exploding Wire Technique in distilledwater

Hammad R. Humud [(1)] Aqeel M. Makkiyha [(2)], Mohammed A. Ghlem [(3)]
Department of Physics, College of Science, University of Baghdad, Baghdad, Iraq

Abstract: *The present work provides a simple technique for the production Ag–Au alloy nanoparticles based on the exploding wires in distilled by applying a high DCcurrent across two electrodes, one in the form of thin gold wire and the other in the form of silver plate and bring them to in touch mechanically. The obtained nanoparticles were characterized by applying X-ray diffraction (XRD),The X-ray data reveal the formation of nanoparticles,and localized surface plasmon resonance (LSPR) of Ag-Au alloy nanoparticles were studied by UV-Vis spectroscopy and it was found that the position of the LSPR band of the nanoparticles agrees with previous research, which could be tuned by the variation of D.C. current.The transmission electron microscopy (TEM) images show that the Ag – Au alloy nanoparticles have narrow particle size distribution ranged from 60 to 120 nm.*
Keywords: *Metallic Nanoparticles, Electro-Exploding Wire, Plasmon effect.*

I. INTRODUCTION

Nanoparticles have novel physical and chemical properties [1] and they have many applications; such as optoelectronic materials, magnetic fluids, composite material, fuel cells, pigments and sensors [2, 3]. Metal alloy nanoparticles are of great interest in surface science since they can exhibit electronic, optical and catalytic properties that are quite different from those of their constituents. Ag-Au alloy nanoparticles have received more attention due to their special characteristics and applications such as catalysis electronics Plasmonics devices [4], electrochemical sensing [5], and surface enhanced Raman scattering [6]. Considering the fact that Ag-Au alloy nanoparticles properties depend on their composition, tuning the composition is an outstanding facility for synthesis methods and there are many reports explaining this facility. The structure of Ag–Au alloy nanoparticles has generated a lot of interest since it is known that both Au and Ag have very similar lattice constants and are completely miscible over the entire composition range, forming homogeneous alloys in the bulk phase [7]. The choice of Ag and Au for many studies on metal nanoparticles is due to their full miscibility and high chemical stability, so that they can be used in almost any environment with no risk of rapid chemical reactions. Ag–Au alloy nanoparticles preparation has been achieved using various physical and chemical methods. For example (2001) have produced Ag–Au alloy nanoparticles of 10 nm sizes by using pulsed laser irradiation of bulk alloy metals in water. Similarly, $Ag_{53}Au_{47}$ of sizes about 22 nm have been prepared by laser vaporization controlled condensation [8]. He used laser irradiation ona mixture colloidof pure Ag and Au colloids with different volume ratios to produce alloy nanoparticles in varied compositions. In order to control the composition of the obtained alloy Ag-Au nanoparticles, the volume ratio of initial Ag and Au colloids were adjusted [9]. Chemically, Ag–Au alloy nanoparticles have also been prepared by co-reduction of HAuCl4 and AgNO3 uses various reducing and capping agents [10].Various compositions of these alloy colloids with a size range between 8 and 35 nm were also synthesized by the addition of silver ions to a polymer protected aqueous gold sol in the presence of a seeding agent followed by a heat treatment [11].The alloy composition was also achieved using a biochemical method in a foam matrix. Recently, electro-exploding wire (EEW) technique has been used for the fabrication of the metallic nanoparticles. Using the EEW technique, a high magnitude of current passes through a metal wire in a short time and converts the wire to a vapor state, The vaporized metal is then cooled down instantaneously to form nanoparticles [12]. This method has a positive feature as follows:

I) the produced particles range in size from 1 to 100 nm
II) The high nucleation rate and growth of a Nano particles
III) The toxic products such as CO are confined in the water
IV) Change the particle shape by changing the pH value of suspension [13]

Because of these advantages, nanoparticles produced by an EEW method are most broadcasted in the world market [14].

II. MATERIALS AND METHOD:

Ag and Au wires with high Purity (99.99%) from Blaybil Company in Al-Naher Street / Baghdad were used. Ag and Au wires were thinned using a rolling-mill with 0.3 mm diameters, and silver plate (70×30×2.5mm; purity: 99.99%)was cleaned using emery paper and followed by Acetone. Before the plate could be used for the explosion, its surface should be smooth and chemically etched. Etching was done withdiluted nitric acid with distilled water (10%). Then the plate was immersed i0n about2 minutes, then rinsed in distill water and dried. To synthesize the alloy nanoparticles, the Ag and Au wires were handtwisted together. The twisted wires were guided by a nozzle into the vessel and were installed between the high-current power supply.The wire guide was prepared from 30 cm glass rod of 1 cm diameter by cut into two equal halves. Two perpendicular holes were drilled through one and the portion was cut open to fix a 5 mm diameter glass bent tube (90° bent) in that place of one half piece of Teflon block which is an insulator as well as it can withstand the explosion conditions, as shown in Fig. (1). Two edges were grooved in the half piece of Teflon block to stuck metal plate with an adhesive agent. Water was poured almost to the edge. The metal plate was passed through the slides on one block and the wire was passed through the tube attached to the other block placed opposite to the previous one. Thick stranded copper wires was used for the purpose of conduction from the high current low voltage generator 's positive terminal to the metal plate by an ohmic connection, and from the negative terminal to the wire by another ohmic connection to complete the circuit .

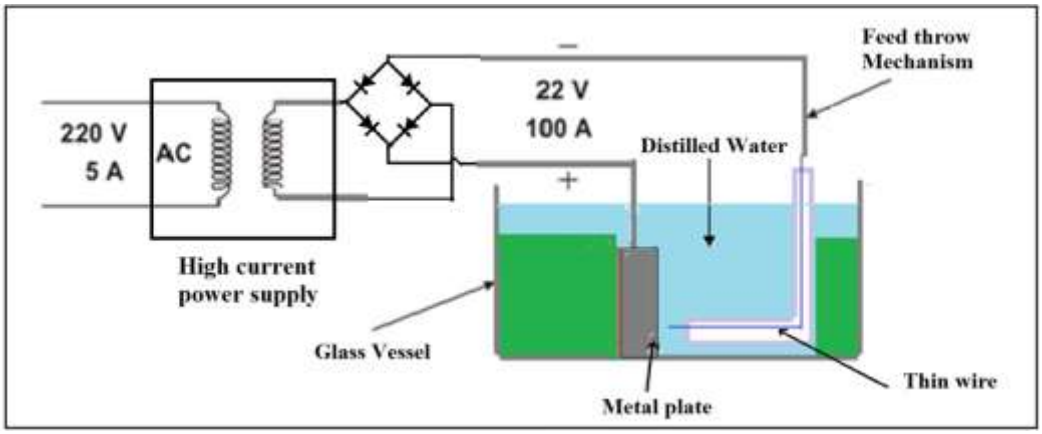

Figure (1): A schematic diagram of the electro-exploding wire (EEW)

In exploding wire technique oxygen or any other active is not suitable as a surrounding medium since with mobile carriers they form compounds. In general an inert atmosphere is suitable to the exploding wire. Also explosion can dounder water one which does not interact with the plasma formed during the explosion. The exploding wire under water have many advantages:

I) Experiments already reported in the literature have suggested that the initial stage of discharge is the same in water and air.

II) Water acts as a suitable medium for attenuating the speed of the metal ions during the explosion, hence controls the entire procedure.

III) Water is a good thermal conductor and therefore helps in temperature regulation of the process and it is easily accessible.

IV) Water also provides the necessary capping to prevent grain growth

IIV) After the collection of NPS in water, a technique which is suitable for the medium used should be employed to separate them from it.

A few drops from the nanoparticle suspension were dried on glass substrate for recording X-ray diffraction (XRD) data in the range 30^{o} –90^{o}. The XRD was performed with a PW3710 Philips analytical X-Ray diffract-meter using a Cu- Kα radiation (λ = 1.54056 Å) XRD patternswas achieved for Ag-Au NPS obtained from exploding Ag-Au wires with 0.3mm diameter in water media.

III. RESULTS AND DISCUSSION:

Fig. 2 illustratesthe X-ray diffraction patterns for Ag-Au particles produced by exploding wire technique using different current (75, 100, 125 and 150) A and dried on a glass slide. The indexing process of a powder diffraction pattern was done and Miller Indices (h, k l) to each peak were assigned. There is one peak at $2\theta = 38.2130^{o}$corresponding to (111) plane for cubic- Au structure at 75, 100 and 125 A. Another peak appears at 43.70^{o}corresponding to (111) plane at 150 A sample. All peaks appear abroad, which indicate on the creation of Nano particles, and being have more broadening, ie decreasing the crystalline size, with increasing applied

current in producing Nano particles. The peaks being more intense with increasing current as a result of increasing crystalline.Table (1) shows the full width half maxima, Miller indices and grain size of Ag-Au NPS and a comparison between calculated inter-planer distance (d_{hkl})with standard values from JCPD standard card No.96-901-2431.

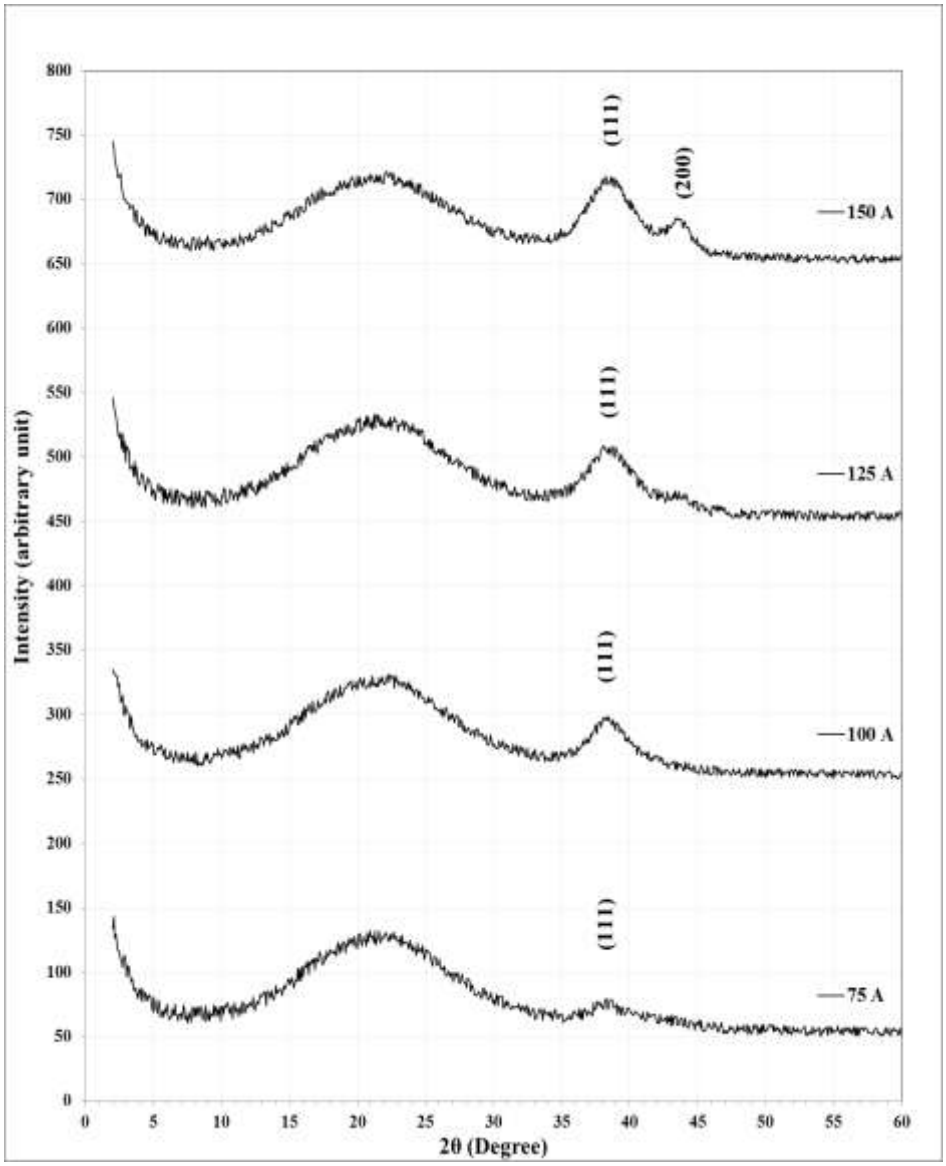

Fig.2: XRD patterns for producing Ag-Au Nano particles by exploding wire with different current

Table 1: Comparison between calculated (d_{hkl}) with standard values, full width half maxima, Miller indices and grain size of Ag-Au NPS produced by exploding wire with different current

Current (A)	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	hkl	d_{hkl} Std.(Å)	Phase	Card No.
75	38.2130	2.120	2.3533	4.0	(111)	2.3500	Au	96-901-2431
100	38.3430	3.012	2.3456	2.8	(111)	2.3500	Au	96-901-2431
125	38.4320	3.650	2.3404	2.3	(111)	2.3500	Au	96-901-2431
150	38.4620	3.893	2.3387	2.2	(111)	2.3500	Au	96-901-2431
	43.7000	3.740	2.0697	2.3	(200)	2.0352	Au	96-901-2431

Fig. (3) Shows SEM Image for Ag-Au Nano particles, dried on glass slides produced by exploding of Ag and Au wires with different current. This figure displays that the produced particle diameter decrease from about 100 nm to about 10 nm with increasing applied current from 75 A to 150 A.

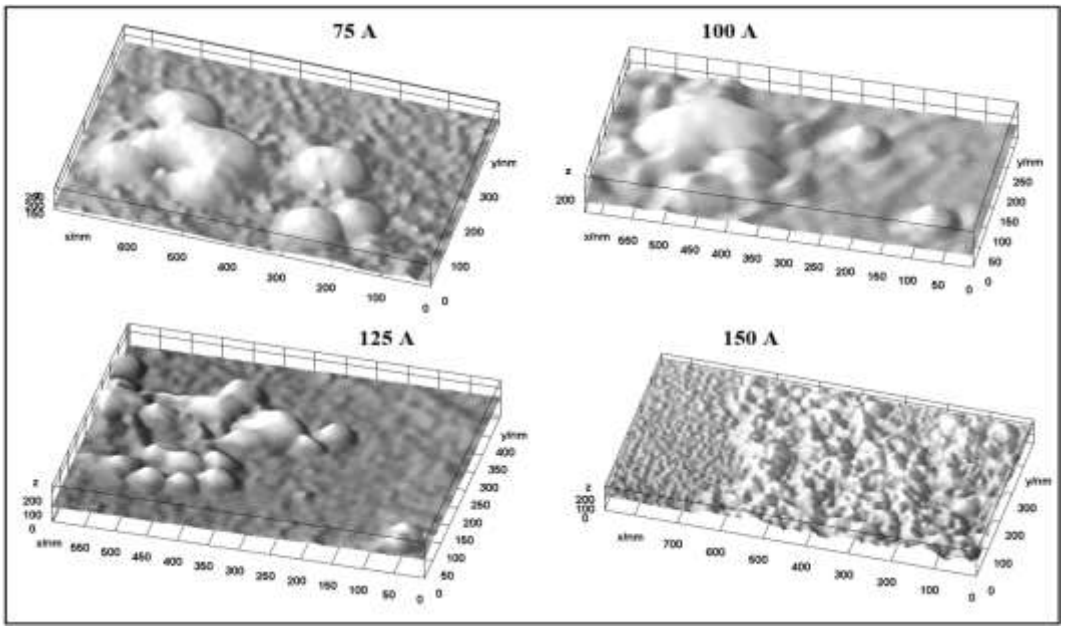

Fig.3: SEM images for the produced Ag-Au Nano particles by exploding wire with different current

Fig. (4) shows TEM Image, with 64000 magnification power, for Ag-Au Nano particles produced by exploding of Ag and Au wires with different currents and deposited on glass slides. Also, this figure indicates that the produced particle diameter decreased from 91.7 nm to 63.7 nm with increasing applied current from 75 A to 150 A.

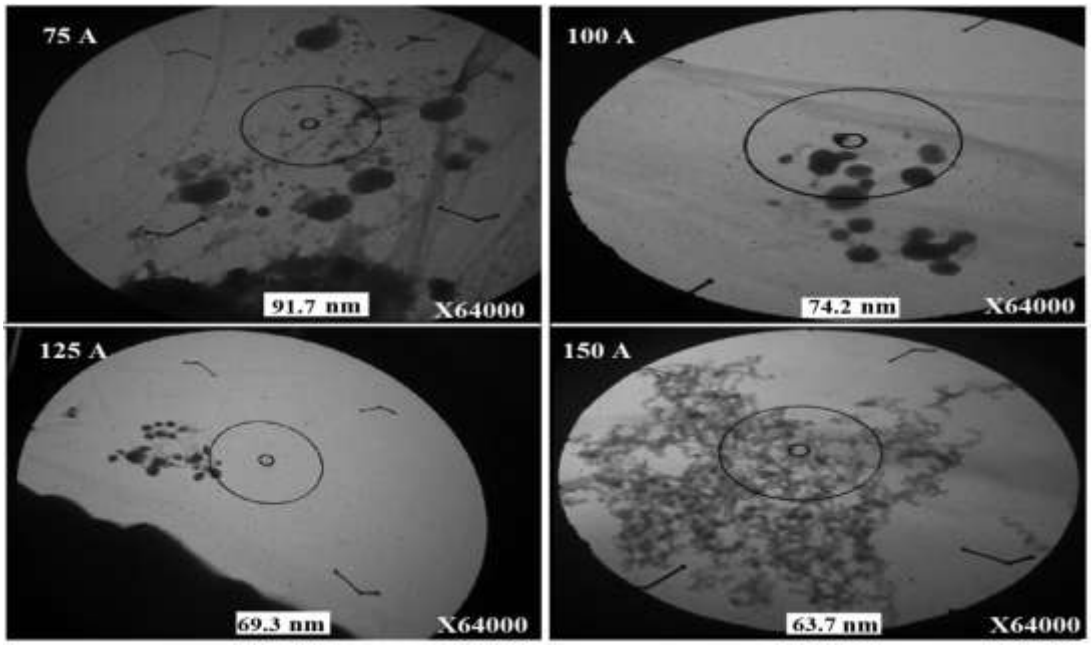

Fig.4: TEM images for the produced Ag-Au Nano particles by exploding wire with different current

Fig. (5) Illustrates absorption spectrum for Ag-Au particles collide in distilled water. It seems that the absorbance increase with increasing current as a result of the increasing number of the produced particles in water. Plasmon peaks appear at about 440 nmfor sample produced at 75 A (light passing near particles with diameter in the range of sub wavelength,loses its intensity by scattering). The absorption peak experiencea blue shift (to 385 nm)with increasing current up to 150 A, caused by decreasingmetal Nano- particle size which leads to slightly changing the resonance frequency[*]. This result agrees with Huang et al. (2010) [**].

[*]Daniel L. Feldheim and Colby A. Foss, "*Metal Nano Particles Synthesis, Characterization and Applications"*. United state, New York: Marcel Dekker, Inc., P.147, (2002).

[**] X. Huang and M. A. El-sayed, "Gold nanoparticles : Optical properties and implementations in cancer diagnosis and photothermal therapy," pp. 13–28, 2010.

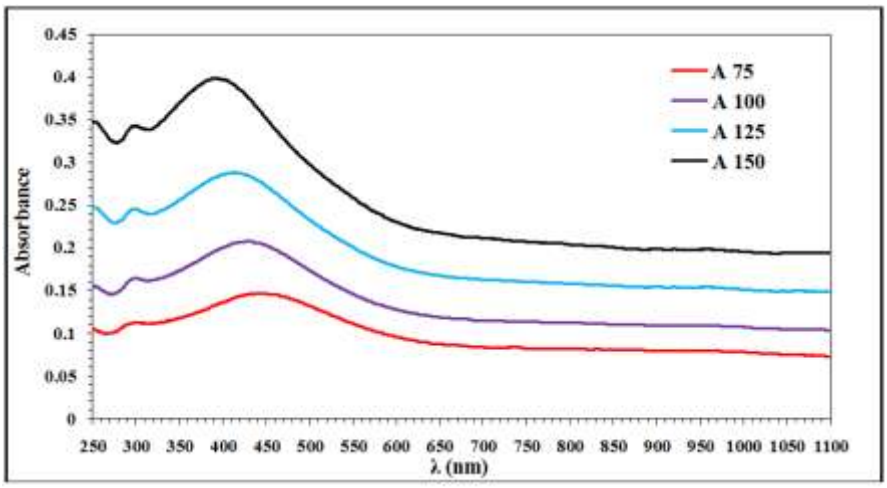

Fig. 5: Absorbance spectrum for colloidal Ag-Au Nano particles produced by exploding wire with different current.

Fig. (6) shows the FTIR patterns for the Ag-Au Nano particles produced by exploding wire with different current. This figure indicates that that only the produced nanoparticles with 150 A current contain to Ag-O peaks located at 620 and 1650 cm^{-1} correspond to Ag-O stretch and deformation vibrations respectively [*], and additional peaks corresponding to gasses adsorbed on sample surface.

[*] H. Kumar and R. Rani, "Structural Characterization of Silver Nanoparticles Synthesized by Micro emulsion Route," Int. J. Eng. Innov. Technol., vol. 3, no. 3, pp. 344–348, 2013.

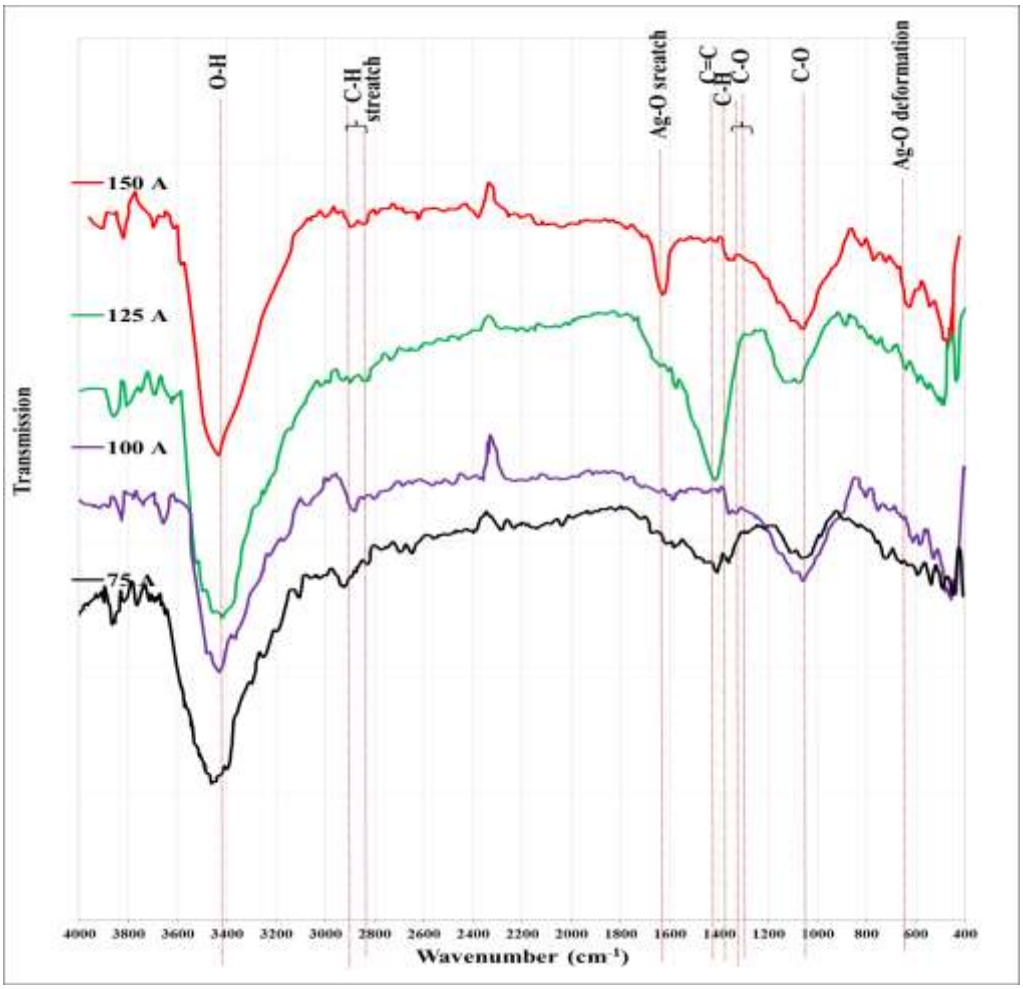

Fig. 6: FTIR patterns for Ag-Au Nano particles produced by exploding wire with different current.

IV. CONCLUSIONS

Our results, in a study the electro-exploding wire technique and the effect of applied current on Ag– Au alloy Nanoparticles size shows that this technique is a simple way to achieve metal alloys Nano particles and the ease of adjusted its size by changing applied current, where the particle size decrease with increasing current. The produced particles were characterized by SEM, XRD and by studying the plasmon effect peak position in absorbance spectra (shifted toward blue region with decreasing particle size).

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