

Nano-Colloidal Silver Suspension: Fabrication and Characterization

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Abstract

Silver is powerful natural antibiotic noble metal has been used for thousands of years with no harmful side effect since have being observed, today colloidal silver is rapidly gaining favor in the medical community and water treatment reflecting a kind of revival in the public health community sector. We made design of colloidal silver generator (CS) by using pulsar DC. power supply to get electrical arc discharge between two high purity silver rods., AFM, UV-Visible Spectrometry, OM, AAS, and electrical conductivity were applied to each sample. Results showed that CS prepared with (ADT) indicate good efficiency in producing colloidal silver with size ranging (40-560) nm. Variation in optical properties , color and electrical conductivity could be related to practical size distribution and to ionic/particle(Ag^+/Ag^0) silver concentration which in the rang (3-10)ppm.

Key words: Nano technology, colloidal silver and arc discharge

عالق الفضة النانوميتري: تحضير وخصائص

صبيحة عبد الجبار بدن حسن اسماعيل دمبوس رياض ابراهيم عطية
وزارة العلوم والتكنولوجيا / دائرة بحوث المواد
بغداد - العراق

الخلاصة

الفضة هي مادة مضادة بكتيرية حيوية طبيعية استخدمت منذ الاف السنين في عمليات حفظ السوائل لخلوها من الاعراض الجانبية عند الاستخدام. يستخدم عالق الفضة بشكل واسع وباهتمام كبير في المجال الصحي وتنقية المياه ومجالات الاستخدام البشري الصحي. في هذا البحث تم بتصميم مولد لعالق الفضة النانوميتري باستخدام مبدا الحصول على شرارة التفريغ الكهربائي بين قطبي فضة مغمورين بالماء ومربوطين بمجهاز عالي القدرة مستمر ونبضي و دراسة الخصائص الفيزيائية لعالق الفضة المحضر حيث استخدمت التقنيات (AFM, OM, AAS, UV-visible and electrical conductivity) اظهرت النتائج ان عالق الفضة المحضر بتقنية التفريغ الكهربائي (ADT) ذات كفاءة جيدة للحصول على عالق فضة بحبيبات ذات توزيع حجمي (40-560) نانومتر. التغير في الخصائص البصرية واللونية والتوصيلية الكهربائية قد يعزى الى التوزيع الحجمي للعالق وتركيز ايونات /حبيبات (Ag^+/Ag^0) الفضة والتي بحدود (3-10)ppm.

الكلمات المفتاحية: تكنولوجيا النانو ، عالق الفضة و التفريغ الكهربائي

Introduction

Colloidal silver (CS) is a natural antibiotic which has been used throughout the world for centuries as a means to destroy microbes for all kinds and to correct many health problems. The use of colloidal silver is spreading rapidly throughout the medical community in the healing of burn victims. (Hong, et al., 2006) and (Fumo, et al., 2004). CS are extremely minute silver particles suspended with particle size at a range (1-1000 nm) in water, with a positive electric charge. The smaller the particles, the more effective CS has proven to be. The best colloid silver produced at a molecular level. A small DC current is passed through an electrolytic medium (distilled water) with silver electrodes. Minute, molecular size particles are drawn from the positive electrode, having a positive electrical charge. This electrical charge is of primary importance to healing and antibacterial qualities (Sondi, et al., 2004).

The charge slowly dissipates, especially when exposed to light (Sterns, et al., 1998) and (Aymonier, 2002). The body's ability to process the tiny atoms

In principle, current techniques for nanometer-sized particles preparation can be divided into two categories: physical and chemical. Many researchers have tried to develop new effective antimicrobial reagents free of resistance and cost. Such problems have led to the use of Ag-based antiseptics that may be linked to broad-spectrum activity and for lower propensity to induced microbial resistance than antibiotics (Aslan, et al., 2005)

The chemical methods are usually expensive and potentially dangerous for the environment.

Material and Methods

Our study concentrated upon a physical method for colloidal silver (CS) formation where the pulsar DC voltage between silver electrodes in pure water was a good alternative method, and was not only a cheap process, but also

environmentally friendly. During arc discharge, the temperature between the Ag electrodes can reach several thousands (Tsung, et al., 2003) and the Ag rods etched in water medium. Ag narrow range Nano-size colloidal in water seem to be thermodynamically stable for long time (especially if kept in cold and dark place). Silver wires (99.99% purity, 1-1.5 mm in diameter), distilled water (pH 5.1), DC pulsar power supply, magnetic stirrer.

Arc Discharge Technique

The DC arc-discharge system in figure (1) consists of a DC pulsar power supply providing a pulse voltage of (70 - 100) V for 2 ms and (20 - 40) V around 10 μ s. The electrical current could reach during that moment (4-10 A) where the etching current caused arc-discharge pulse etched Ag wires (anode and cathode) as in figure (1). Ag wire evaporated and condensed in water. A control system keeps the gap between the Ag electrodes in a few microns. Other parameters should be controlled during this technique such as the speed of stirring - time of process, water volume, distance of the gap, arc-discharge current as in figure (2) and other parameters. The transparent solution converts to a characteristic pale yellow color as in figure (3)

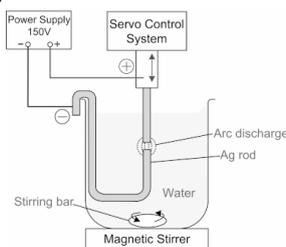


Figure (1) The arc-discharge system

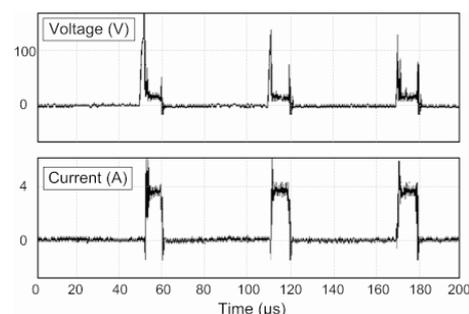


Figure (2) Current-Voltage pulse during arc-discharge duration for Nano-colloidal Ag suspension



Figure (3) Samples of Ag colloidal particles suspended in water (pale yellow color).

Characterization of Ag Nano Colloidal (CS)

The Ag colloid solutions were examined optically using UV-Visible spectrophotometer (type Shamedzo 20). Silver solutions were sprayed on glass substrates using thermal spray paralysis as in figure (4)

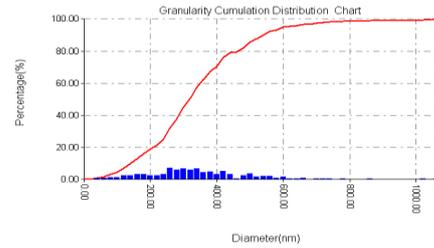


Figure (4) Thermal spray paralysis

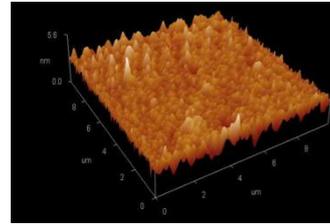
for size distribution determination; AFM (Angstrom advanced - type AA3000) and OM were used; electrical conductivity(COM 83 – Radiometer Copenhagen), PH , Ag concentration by AAS (AA Spectrophotometer phoenix - 986) were also examined for each sample.

Result and Discussion

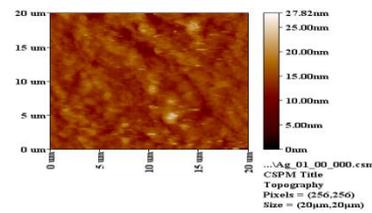
Silver thin films were prepared according to diagram (1) using thermal spray paralysis system (figure4) for particle size distribution as shown in figure(5).



(a)



(b)



(c)

Figure (5)(a) AFM size distribution of Ag colloidal, (b and c) surface morphology and 3D. Image of silver thin film on glass substrate

Figure (5 a , b and c) showed the AFM image of semi- spherical Ag particles with size distribution about (40-560) nm. During the preparation process; it was noticed that the effects of light and temperature on colloidal silver solutions, where the agglomeration process detected by UV analysis and color appearance; so we concentrated on right preparation parameters and storage conditions of silver samples. During silver Nano particles production, water decomposition (e.g electrolysis) was observed. This result in generation of gaseous hydrogen and oxygen, which appear in the water medium. Hydrogen and oxygen start to interact with newly prepared silver Nano particles as was shown in figure (6). Since Hydrogen (molecular or atomic forms) did not adsorb on silver particle surface at room temperature and also is not significantly dissolved in water.

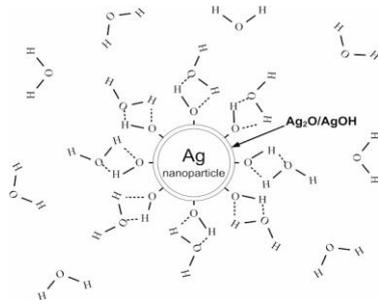


Figure (6) model scheme of charged Ag particles suspended in water

It was ultimately removed from water suspension to gas phase while oxygen (especially atomic) could adsorb and react with silver surface at room temperature, Ag cluster could easily create bonds with water particles in water environment. Finally negatively or positively charged Ag narrow range Nano particles can be create in water as was shown in the model (figure 6). Figure (7) showed the silver powder samples were subjected to x-ray diffraction technique and it showed the crystalline pattern of silver powder with characterized peak position 2θ at (33.0337 degree) with high relative intensity (100%) to plane (111) and second peak position 2θ at (43.9817 degree) with relative intensity (52%) to plane (200) and this results were agreed with other study (Revathi *et al.* 2009). Figure (8) showed typical UV-Vis spectrometer analysis for the silver colloidal suspension, and this method showed maximum surface Plasmon resonance in Nano silver solutions at about peak $\sim 420\text{nm}$ wavelength.

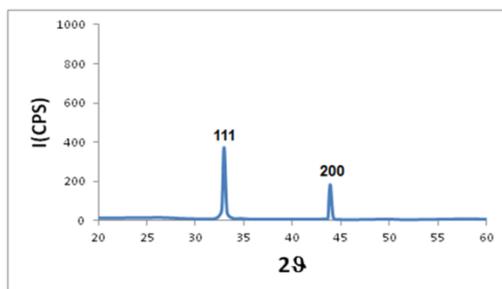


Figure (7) XRD diagram of silver thin film

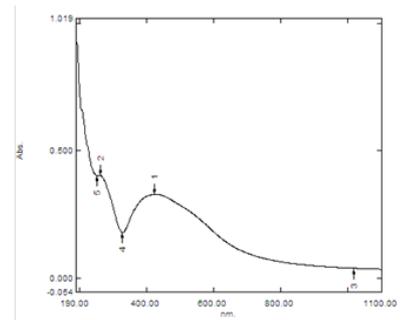


Figure (8) The UV-vis spectrum of Nano-CS samples

The band at higher energy was reported to be due to the formation of various types of silver ions. Such presence of silver ions in the present study confirms of formation of Nano particles (Khanna *et al.* 2007). The Ag Nano narrow range particles due to hydrogen bonding were suspended in water without any stabilizers or surfactants. Positively charged particles Ag Nano particles surrounded by water molecules having (4-34.6) ppm and electrical conductivity about (2.99-28.1) μs with

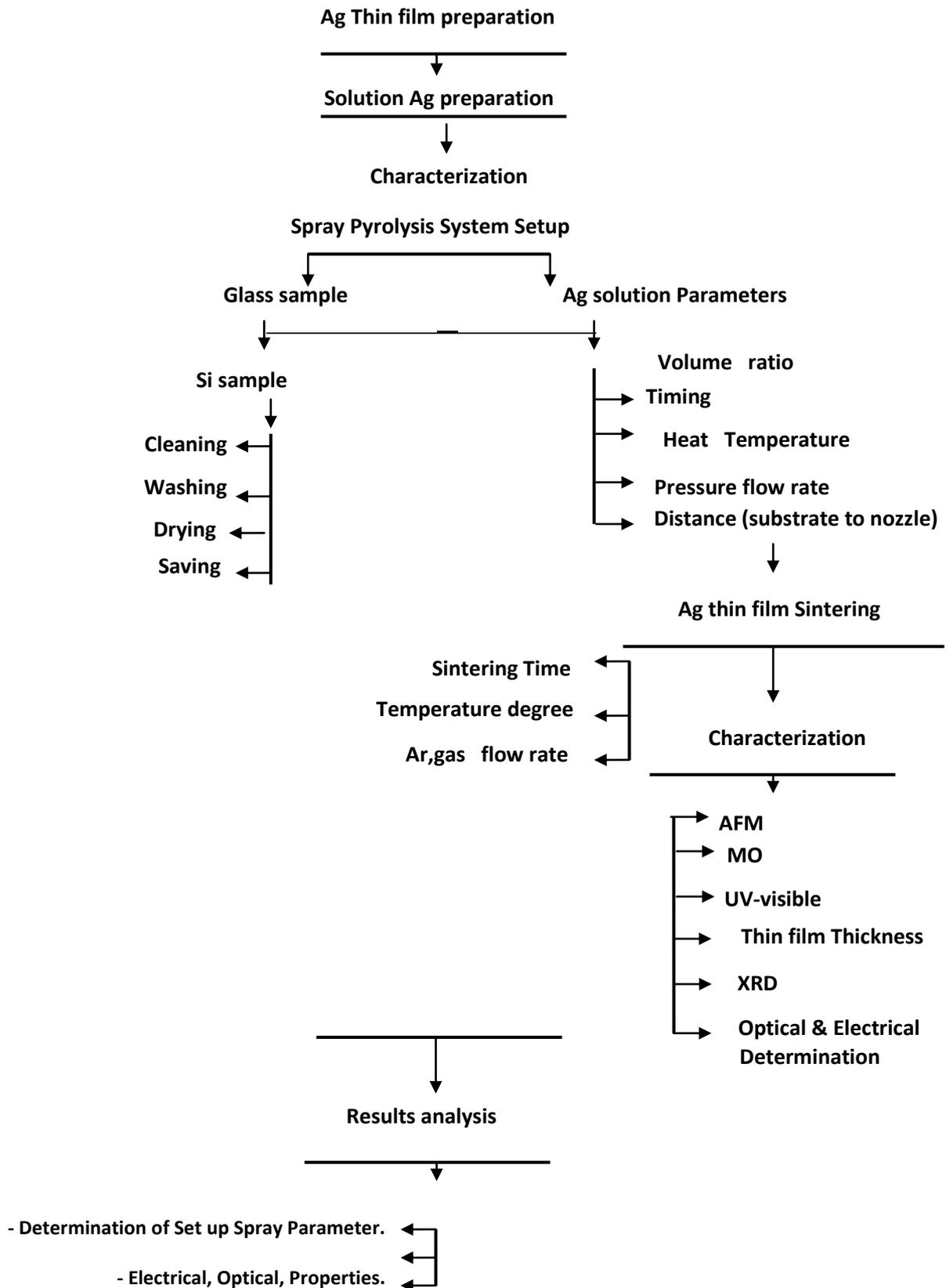


Diagram (1) Scheme of Ag thin film preparation and Determination of their electrical and Optical Properties.

pH (5.81-8.05).Ag (CS) could be heated to 30-40 °C without affecting its structures. The DC method based on pure components, e.g metal rods and deionizer water, seems to be promising alternative for metal noble metal such as Nano gold and Nano titanium since the high surface - area to volume ratio of Nano particles can create their unique physical chemical, mechanical, and quantum size effected proprieties .That lead to their potential application such as catalysis for plants , animals and human (Pal et al. , 2007 ; Murata, et al .2005; World Health Organization (WHO), 2008) Optionally; the (CS) could be followed by filtration process and centrifugation technique many times in different ways and processes.

Conclusion

1- The current DC method in pure water to prepare (CS) has been successfully developed for narrow range Nano particles Ag production.

2- The present work prepares low cost effective scientific route to form Nano silver powders by controlling (I,V,T, and pH.)parameters .

3-Silver Nano particles were formed in water has characteristic x-ray diffraction peak at plane (111 and 200).

4-Colloidal silver solution had characteristic UV-Vis spectrometry with UV band at resonance peak about 420nm.

5- According to AFM and OM , silver particle solution had semi spherical shape with size distribution 40-560 nm.

6- The silver Nano particles less than 50 nm could be obtained using arc discharge technique followed by filtration and centrifugation process.

References

Aslan, K.;Leonenko, Z. and Lakowicz, J.R. ,(2005)Geddes,C.O.,9-S.A.Jones,

Aymonier,A.U.,Schloher,B.L. and Antonie, O. , (2002) Chem.Commun. 24,309,18-9.

Fumo, F.; Morly, K.S. ;Wong, B.; Sharp, B.L. and Amold, P.L.,(2004) J.Antimicrob Chemother,54,19-24.

Hong, K. ; Lpark, L.; Sal, I. H. and Kang T. , (2006)Polymer Physics ,44,2468-2474,

Lok, C.N.,HO C.N. Chen, R. He , Q.Y. ,(2007)J.Biol.Inorg.chem.12,527-534

Murata, T.; Kanao, K. ; Oshikawa, M. and Takamtsu T. ,(2005) Water Air Soil Pollution; 164,103-118.

Pal, S. ; Tak, Y.K. and Song, J.M. , (2007) Appl. Environ. Microbiol, ,73 1712-1720,

Khanna , P.K. ; Narendra, Singh ; Deepti, Kulkarni ; S. Deshmukh ; Shobhit Charan and P.V. Adhyapak , (2007) Water Based Simple Synthesis of Re-dispersible Silver Nano-Particles. Elsevier Material Letters 61,3366-3370.

Revathi, Janardhanan ; Murugan, Karuppaiah ; Neha, Hebalkar and Tata, Narsinga Rao , (2009) Synthesis and Surface Chemistry of Nano Silver Particles . Elsevier , Polyhedron 28 2522-253

Sondi, I. and Salopek –Sondi, B. J. , (2004)Colloid Interface Sci.275:177-82.

Sterns ,Z.G. and Jr, S.E. ,(1998)Biometa. ,511,27-32.

Tiem, D.C. ,(2008) Novel Technique for Preparation Nano Silver Suspension Byarc-discharge, Rev. Adv. Mat. Sci., 8, 750-756.

Tsung, T.T. ; Chang, H.; Chen, L.C.;Han, L.L.;Lo H. ; Lin, M.K. and Mater, T. ,(2003) The Japan Institute of Metals ,44,1138-1147

World Health Organization (WHO) ,(2008) Silver and Silver Compounds Environmental Aspects, Biomaterial, 11,26-33, :http://www.who.int/ipcs/publications/cicad/en/cicad44.pdf,