Synthesis Of Silver Nanostructures: Reaction Parameters And Product Characteristics

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Silver nanostructures have been synthesized from solutions of silver sulphate through cementation on copper strips. It was found that the time and temperature affected obviously the properties of the precipitated silver powder.

Keywords: Silver nanostructures; XRD; SEM.

Silver, a metal with high electrical and thermal conductivity, has good malleability and ductility. [1] Various methodologies have been suggested and practiced for synthesis of silver and other metal nanostructures.[2,3] Reduction in solution can lead to the formation of either thin films or stable dispersions of silver nanoparticles if a suitable organic agent is present.[4] Among the techniques used, cementation is considered as an important chemical process. Cementation process has several advantages, such as recovery of metals in essentially pure metallic form, simple control requirements, low energy consumption and in general low cost process.[2,5]

This presentation will highlights on growth of some nanostructured of pure silver metal. In addition, this paper drew the attention to the cementation method as a promising, simple and attractive way to prepare metals nanostructures.

Reaction Time

When copper sheets are added to the solution of silver ions (silver sulphate), a very fast cementation reaction between copper metal and silver ions occurred. As a result of this reaction the colourless solution of silver sulphate is turned to a tint blue colour of copper sulphate solution mixed with a grayish colour of cemented silver nanostructures. In the following sections, the results of the study of the cementation of silver on copper are represented. The effect of different reaction parameters are also recorded and explored.

Fig.1. shows the variation of recovered silver nanostructures with reaction time at 20°C solution temperature, 1.2 pH of solution, 1X copper/silver ratio (X = stoichiometric amount of copper needed to deposit silver particles according to the balanced equation), 700 rpm stirring speed and 3.2×10^{-3} mol Ag_2SO_4. It is clear that, as the reaction time increased. , the recovery of silver increased from 14.5% after 2 min reaction time to about 50% after 30 min reaction time.

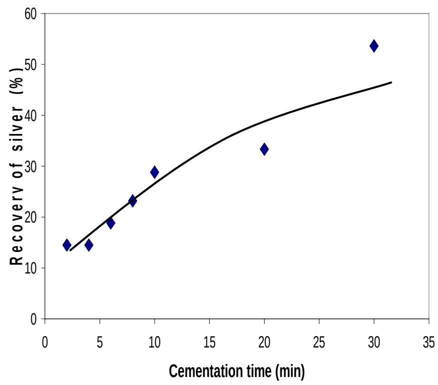

Fig.1.Variation in recovery of silver powder with cementation time at 20°C, 1.2 pH of solution,1X copper/silver stoichiometry, 700 rpm and 3.2×10^{-3} mol Ag_2SO_4.

Fig. 2. depicts the percentage of dissolved copper with the percentage of the recovery of silver nanoparticles at the above mentioned conditions. It illustrates that, there is a gradual increase in the recovery of silver with the amount of the dissolved copper. It shows, to some extent, a linear relation between the two factors. This is an indication of that; the dissolved copper is mainly involved in the cementation of silver nanoparticles rather than acidic dissolution of copper by the excess added acid (acid used to adjust the pH).

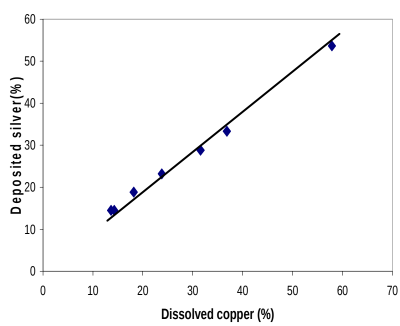

Fig. 2. Relation between percentage of dissolved copper and percentage of recovered silver particles at different time intervals.

XRD patterns of precipitated silver samples at various reaction time at the above mentioned conditions are shown in Fig. 3. It confirmed that the silver particles for all samples are precipitated in the form of metallic silver. All the diffraction peaks are ascribed to the silver metallic phase (silver, JCPDS card # 01-1167). No other diffraction peaks or phases such as silver oxide or silver sulphide or sulphates are detected in all patterns. This indicates that the precipitated silver particles are pure metallic silver. It is also obvious that, the peaks have low intensities and broad spectrum specially of that samples precipitated at short time period and have sharp spectrum from 2 to 6 min. The peak intensities and sharpness increased as the reaction time increased to 30 min.

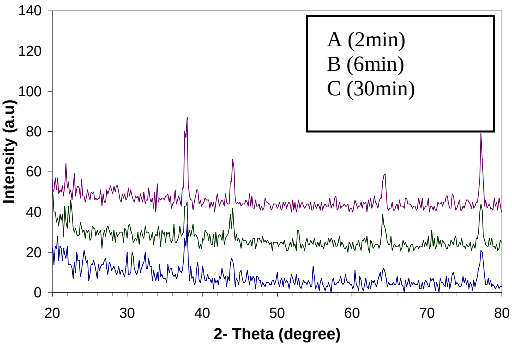

Fig. 3. XRD patterns of silver powders precipitated at different experimental conditions for solutions containing 3.2×10^{-3} mol of Ag_2SO_4, 20°C, 1.2 pH of solution, 700 rpm and 1X copper/silver stoichiometry.

Reaction Temperature

The variation of crystallite size of silver nanostructures at different reaction temperatures is illustrated in Fig. 4. It is clear that as the reaction temperature increased from 20°C to 100°C, the crystallite size increased from 32 nm to reach a value of about 70 nm.

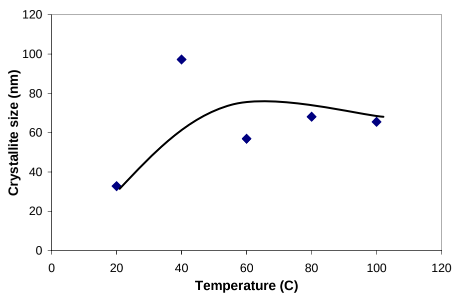

Fig. 4. Variation in crystallite size with reaction temperature at 6 min, 1.2 pH of solution, 1X copper/silver stoichiometry, 700 rpm and 3.2×10^{-3} mol Ag_2SO_4.

Morphology

SEM images of some selected precipitated silver nanoparticles are shown in Fig. 5 (a-d). The experimental conditions of these samples are shown there.

Crystallite Size

Fig. 4 and Table 1 show the variation in crystallite size upon changing the reaction time and reaction temperature (isothermally). In general the crystallite size increases as the time and temperature increase. In average the crystallite size of the precipitated silver nanostructures in the range from 40-60 nm. This particle size range is suitable for application in electronic device as conducting paste.

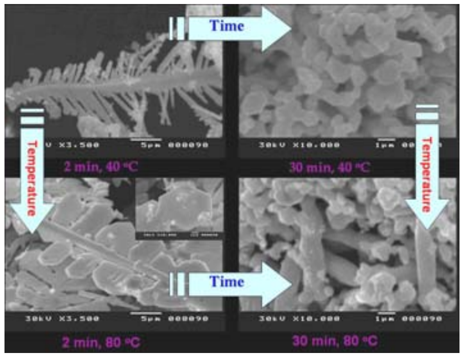

Fig. 5. SEM images of precipitated silver nanoparticles from solution containing 3.2×10^{-3} mol Ag_2SO_4, 1.2 pH of solution, 700 rpm, 1X copper/silver stoichiometry, at various experimental conditions.

Table 1. Crystallite size of silver particles precipitated at different reaction times and temperatures

Sample no.	Time (min.)	Temp. (°C)	Crystallite size (nm)
1	6	20	32.8
2	30	20	49.6
3	6	60	**56.9**
4	30	60	**78.5**
5	6	80	**37.9**
6	30	80	**71.2**
7	6	100	**65.5**
8	30	100	**63.9**

Conclusion

In conclusion, silver nanostructures have been synthesized successfully via a simple cementation process of silver on copper strips. The mean crystallite size of the precipitated silver nanoparticles was in the range from 40 to 80 nm under the studied experimental conditions.

References

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