

Ultrasonic Spectroscopy of Cu/Pd Bimetallic Nanostructured Based Nanofluids and its Antimicrobial Properties

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Abstract: The present work is concerned about ultrasonic spectroscopy of Cu/Pd nanostructure based nanofluid and its antimicrobial behavior. Following the chemical routes, bimetallic Cu/Pd nanostructure has been synthesized. The average size, size distribution, surface morphology and structure of particles were determined by transmission electron microscope (TEM), acoustic particle sizer (APS) and X-ray diffraction (XRD), respectively. The formation of bimetallic nanoparticles is indicated by XRD analysis. TEM result shows the particle size distribution between 10 – 15 nm and well dispersed. Particle size of nanoparticles was also determined with the acoustic particle sizer (APS-100). APS measures the acoustic attenuation (dB/cm) vs. frequency (in the range 1-100 MHz). The particle size distribution is determined from the acoustic attenuation data. The results obtained by APS-100 were consistent with the TEM images. Further, this nanofluid was tested for antibacterial activity. Result of antibacterial activity reveals that this nanofluid exhibits good antibacterial activity against both gram positive and gram negative bacteria.

1. Introduction

In the recent years, metal nanoparticles have been of great interest and widely investigated due to their applications in wide areas such as optics, catalysis and biomedicine [1-3]. Bimetallic nanostructures exhibit unique electronic, optical and catalytic properties compared to pure metallic nanoparticles. The high surface-to-volume ratios of such nanostructures lead to dramatic changes in their properties. Among bimetallic nanostructures, Cu/Pd has drawn considerable attention due to its unique properties [4-5]. Various researchers have tried to prepare its stable nanoparticles. In the present study, bimetallic Cu/Pd nanoparticles have been prepared in aqueous solution. The prepared Cu/Pd nanostructure has been characterized by radiation microscopic and the ultrasonic methods for its structural and surface morphological properties. The obtained Cu/Pd nanoparticles had good stability and were well dispersed. Further, this nanofluid was tested for antibacterial activity against different bacteria and minimum inhibitory concentration (MIC) of the sample has been calculated by micro dilution method.

2. Experimental Procedure:

Bimetallic copper/palladium nanoparticles in aqueous solution have been prepared through the chemical routes. The characterization of the prepared Cu/Pd was carried out using the transmission electron microscopy (TEM), acoustic spectroscopy (APS-100) and X-ray diffraction (XRD). Antibacterial activity of synthesized nanoparticles was examined on different bacterial strains viz. *E. coli* and *S. aureus* using the agar disc diffusion method and their MIC values were determined by micro-dilution method using serially diluted test compounds according to the guidelines of National Committee for Clinical Laboratory Standards (NCCLS, 2000) [6].

3. Results and Discussions

The structure and crystallite size of the powdered material was analyzed with X-ray diffractometer using Cu-K α radiations as source with a wavelength of 1.5406 Å as shown in figure 1. The diffraction pattern shows a good agreement with the diffraction data from JCPDS 00-05-0681 (Pd) and 00-04-0836 (Cu). The XRD peaks observed at $2\theta = 39.6^\circ, 45.7^\circ$ and 67.8°

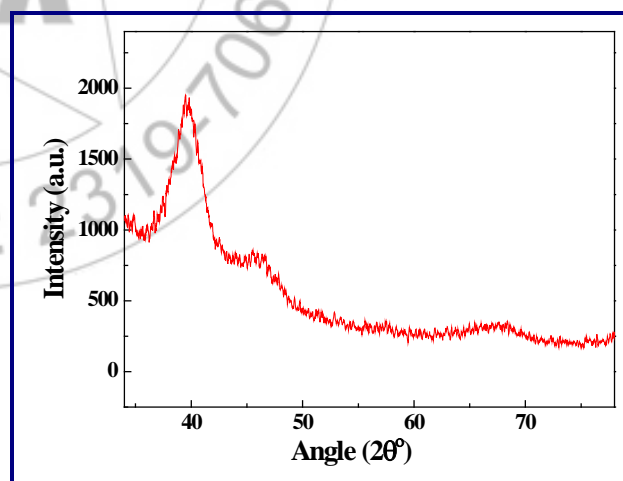


Figure 1: X-ray diffraction pattern of Copper/palladium nanoparticles

Correspond to the (111), (200) and (220) planes of Pd nanoparticles of a face centered cubic lattice, respectively. The other peaks at $2\theta = 43.6^\circ$ and 74.4° correspond to the (111) and (220) planes of Cu nanoparticles. The XRD result confirms the formation of bimetallic nanostructure.

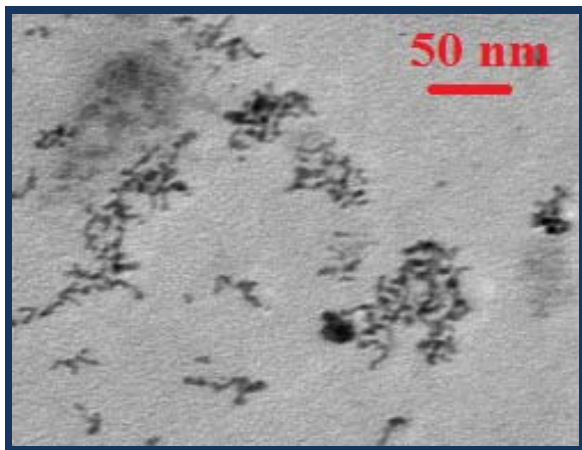


Figure 2: TEM image of Copper/palladium nanoparticles.

TEM was used to determine the size distribution and morphology of the synthesized nanoparticles as shown in Figure 2. The TEM image shows that the size distribution of the synthesized bimetallic Cu/Pd nanoparticles is in the range 10 - 15 nm. The acoustic particle sizer was, then, used to measure the particle size. The result is shown in Figure 3. APS measures the acoustic attenuation (dB/cm) vs. frequency (in the range 1-100MHz). The particle size distribution is determined from the acoustic attenuation data using software based on Epstein

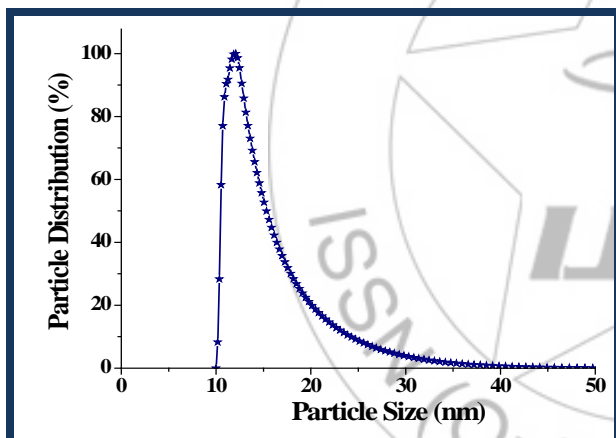


Figure 3: Particle size distribution curve of copper/palladium nanoparticles measured with acoustic particle sizer.

and Carhart theory [7]. This analysis confirms that the Cu/Pd nanoparticles are in the range 10–15 nm. The size determined by APS was in good agreement with the TEM results.

We have further tested the nanoparticles against different bacteria for its antibacterial activity. The result of antibacterial activity in the form of zone of inhibition and their MIC values

Table 1: Antibacterial activity of the compound in terms of inhibition zone (mm)		
Microbial species		
Sample	<i>E. coli</i> (ATCC 35218)	<i>S. aureus</i> (ATCC 25323)
Cu/Pd	12.54 ± 0.47	11.91 ± 0.43
Ciprofloxacin	28.06 ± 1.30	29.93 ± 0.49

Table 2: Antimicrobial activity expressed as MIC (µg/ml)		
Microbial species		
Sample	<i>E. coli</i> (ATCC 35218)	<i>S. aureus</i> (ATCC 25323)
Cu/Pd	46.98	93.97
Ciprofloxacin	6.25	6.25

are shown in table 1 and table 2. From these results, we can see that zone of inhibition produced by the nanoparticle against *E. coli* than *S. aureus* bacteria is 12.54 mm and 11.91 mm at a low concentration of 46.98 and 93.97 µg/ml, respectively. Results of antibacterial activity reveal that nanofluid exhibits excellent antibacterial activity against *E. coli* and *S. aureus* bacteria. On conclusions, bimetallic Cu/Pd nanoparticles can be synthesized using reduction in the presence of PVP and characterized by XRD, TEM and APS for their structural and surface morphological properties. Prepared nanoparticles are stable in suspension. It is very important that the particle size distribution determined by ultrasonic spectroscopy method using cost effective APS-100 is in good agreement with that of TEM analysis. Hence this technique can be considered a very useful tool for the non-destructive characterization of bimetallic nanoparticles. Also the nanoparticles solutions exhibited excellent antibacterial activity against both gram positive and gram negative bacteria at a very low concentration.

4. Acknowledgment

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References

- [1] Y. Mizukoshi, T. Fujimoto, Y. Nagata, R. Oshima, Y. Maeda, *J. Phys. Chem. B* 104 (2000) 6028-6032.
- [2] M. Sastry, A. Swami, S. Mandal, P.R. Selvakannan, *J. Mater. Chem.* 15 (2005) 3161-3174.
- [3] S. Chen, H. Zhang, L. Wu, Y. Zhao, C. Huang, M. Ge, Z. Liu, *J. Mater. Chem.*, 2012, 22, 9117-9122.
- [4] L. Zhang, F. Hou, Y. Tan, *Chem. Commun.* 48 (2012) 7152–7154.
- [5] N. Tushima, Y. Wang, *Langmuir* 10 (1994) 4574-4580.
- [6] National Committee for Clinical Laboratory Standards NCCLS, Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically: approved standards- fifth edition. NCCLS document M7-A5. NCCLS. 2000: Wayne, PA, USA.
- [7] P.S. Epstein, R.R. Carhart, *J. Acoust. Soc. Am.* 25 (1953) 553-565.