Elaboration of core-shell nanostructures by sono and electrochemical synthesis: Particular case of Cu-Ag and Cu-Pt nanopowders

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Nanoparticles have been extensively studied in the last decade because of their high surface-to-volume ratios and their potential applications in magnetic recording, catalysis, medical, etc. Recently, new type of nanoparticles, composed of a core and a shell of two different materials, has been synthesized. Here, we present an original synthesis mode based on pulsed sonoelectrochemistry (for core elaboration) followed by a chemical displacement reaction (for shell formation). Our first results concern the Cu-Ag and Cu-Pt core-shell nanopowders to test their bactericide and catalytic properties respectively.
In the first step, the core synthesis was achieved by the electrolysis of a copper solution onto a titanium sonotrode (Fig.1) via the reduction (1)

$$Cu^{2+} + 2\ e^- \rightarrow Cu \qquad (1)$$

followed by an ultrasound crenel applied just after the end of the electrolysis time. These actions were repeat until to obtain enough nanopowder. Very short times (some milliseconds decades) were chosen for electrodeposition and ultrasound pulses. Therefore only copper germs with nanometric size appear on the cathode during electrolysis and were expelled from the sonotrode when ultrasounds were applied (Fig.2).

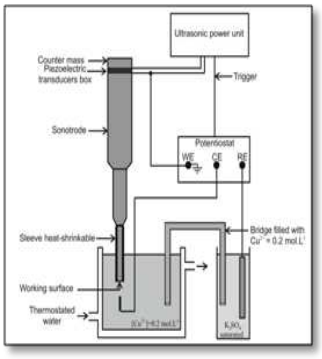

Fig. 1

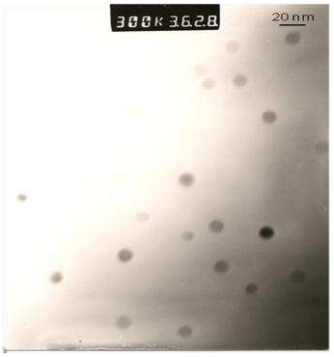

Fig. 2

For the second step (shell synthesis), the powder was collected, rinsed and immerged in the displacement solution (silver or platinum bath) in manner to produce the shell structure following reactions (2) or (3) respectively:

$$2\ Ag^+ + Cu \rightarrow 2\ Ag + Cu^{2+} \qquad (2)$$
$$Pt^{4+} + Cu \rightarrow Pt + 2\ Cu^{2+} \qquad (3)$$

The reaction kinetics of displacement (i.e. variation of the particles composition versus time) were achieved for Cu/Ag and Cu/Pt nanopowders by energy dispersive analysis. Moreover X-ray diffraction exhibited only distinct peaks of the two metals, proving that no alloy was obtained and no contamination of the particles by titanium horn erosion was observed. The morphology and the particles size were defined by scanning electronic microscopy and electron energy-loss spectroscopy. At least, the bactericide properties of Cu/Ag will be presented.