HYDROTHERMAL SYNTHESIS OF ZnO NANOSTRUCTURES WITH DIFFERENT MORPHOLOGIES AND THEIR ANTIMICROBIAL ACTIVITY AGAINST *Escherihia coli* AND *Staphylococus aureus* BACTERIAL CULTURES

A. Stanković[1], Lj. Veselinović[1], S. Marković[1], S. Dimitrijević[2], S. Škapin[3] and D. Uskoković[1]

[1] Institute of Technical Sciences of Serbian Academy of Science and Ars, Belgrade, Serbia
[2]Faculty of Technology and Metallurgy, University of Belgrade, Serbia
[3] Jožef Štefan Institute, Ljubljana, Slovenia

ABSTRACT

Nanoparticle metal oxides represent a new class of important materials that are increasinglly being developed for use in research and health-related applications. Zinc oxide is currently being investigated as an antimicrobial agent in both microscale and nanoscale formulations. Results have indicated that ZnO nanoparticles show antibacterial activity apparently greater than for microparticles. In this study, we generally attempt to examine influence of size and particularly shape of ZnO nanoparticles synthesized through a controlled hydrothermal method, on the antibacterial activity toward *Escherihia coli* (Gram-negative bacteria) and *Staphylococcus aureus* (Gram-positive bacteria). Apart from different forms of prepared ZnO nanoparticles, antimicrobial tests showed impressive antibacterial properties, above 99 % microbial cells reduction, toward gram positive bacteria *S. Aureus* and gram negative bacteria *E. Colli*.

SYNTHESIS

ZnO powders with different particles morphology were prepared by a low temperature hydrothermal processing of a precipitate. Starting materials, zinc acetate dihydrate ($Zn(CH_3COO)_2{\cdot}2H_2O$, Merck p.a.), sodium hydroxide (NaOH, Kemika p.a.) and PVP (PVP 99%, Sigma-Aldrich Chemie GmbH, Germany), PVA (PVA 99 %, Sigma-Aldrich Chemie GmbH, Germany) and PLGA (PLGA 99 %, Guilin Peptide Technology Limited, China) as a stabilizing agents were directly used as a received without special treatment. The morphology of the nanostructures was controlled by adjusting the initial pH values of the reactants solution. In a typical procedure, 0.5 M of the solution of NaOH was added drop-wise into a 0.2 mM of a water solution of $Zn(CH_3COO)_2{\cdot}2H_2O$ with 5 wt% appropriate stabilizing agent at 60 °C under constant stirring at 2000 rpm. About 1.5 l of the as-prepared suspension was thermally treated in a two-liter *Parr* stainless steel stirred reactor under non-equilibrium conditions up to 120 °C at a constant heating rate of 2 °C/min, under constant stirring at 400 rpm. The reaction time was 72 h.

RESULTS

The typical XRD patterns of the ZnO powders synthesized through a hydrothermal procedure starting from zinc acetate dihydrate ($Zn(CH_3COO)_2{\cdot}2H_2O$) and sodium hydroxide (NaOH) as the reaction precursors with the addition of different types of stabilizing agents are presented in Fig. 1. The morphologies of the hydrothermally prepared ZnO particles, as well as of the commercial ZnO powder, were examined using FE SEM Fig. 2. In addition, the particle size distribution over volume was measured by a laser PSA and the particle size distribution curves for all ZnO samples are presented on the right side of the Fig. 3.

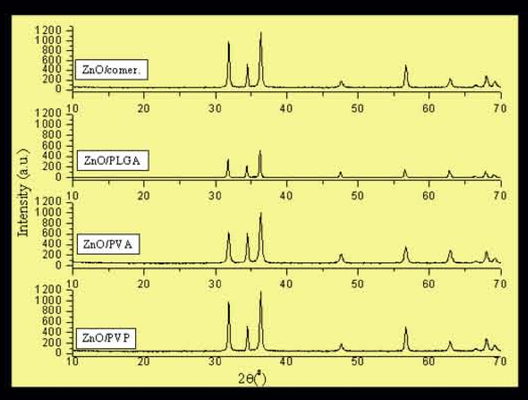

Fig.1 The typical XRD patterns of the ZnO powders

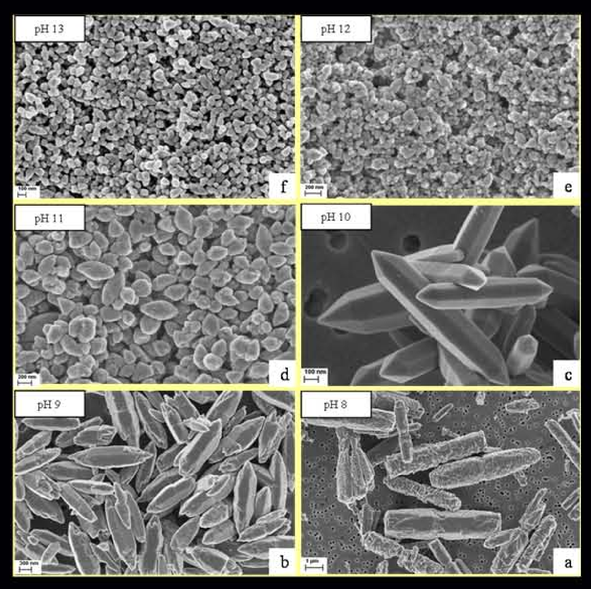

Fig.2 The FE SEM images of prepared ZnO powders using a PVP as a stabilizing agent

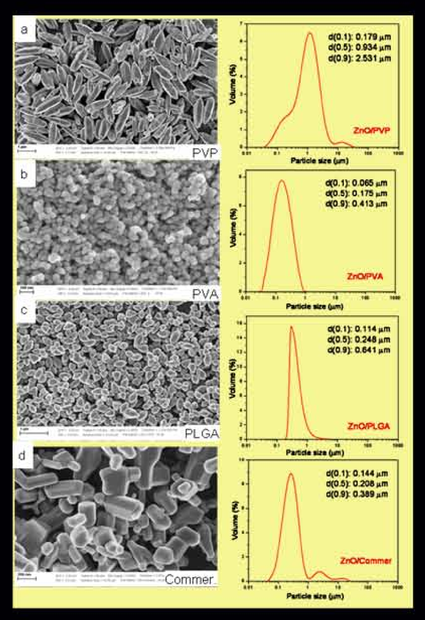

Fig.3 The FE SEM images of prepared ZnO particles using a different stabilizing agents and proper particle size distribution on the right side.

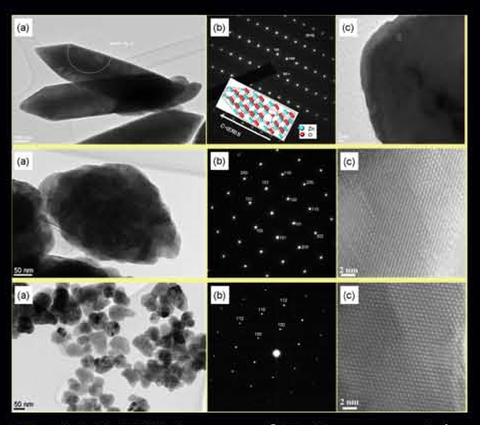

Fig.4 HR TEM images of ZnO nanoparticles of different morphologies.

HR TEM images and the selected area electron diffraction (SAED) patterns of hexagonal prism micro-rods, sub-micro ellipsoids and nano-spheres, synthesized at pH 10, 11 and 13, respectively are presented at Fig. 4. The antibacterial activity of pure ZnO powders consisting of particles of different morphologies and dimensions was investigated at different concentrations 5, 10 and 20 mM for a variety of times 15, 30 and 60 min. Results of the antibacterial activity of prepared ZnO particles of different morphology toward *E. Coli* and *S. Aureus* are presented on Fig. 5.

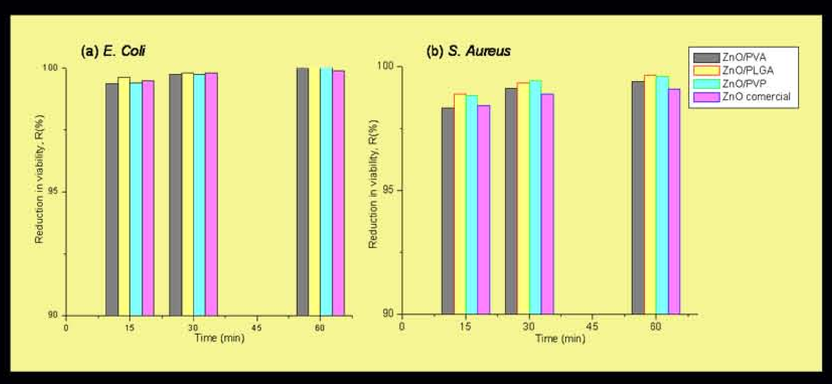

Fig.5 Antibacterial aci Reduction in cell viability for (a) *E. coli* and (b) *S. aureus* bacteria after the action of the synthesized and commercial ZnO particles of different sizes and morphologies for 15, 30 and 60 min. The concentration of ZnO dispersions for all samples in the presented charts was 5 mM.

CONCLUSIONS

Apart from different forms and dimensions of the prepared ZnO nanoparticles, antimicrobial tests showed impressive antibacterial properties: a 99-percent reduction of microbial cells of gram positive bacteria *S. aureus* and gram negative bacteria *E. colli*. These results are in complete agreement with the results related to the antimicrobial activity of the commercial ZnO powder, which was also tested in our experiments. No significant change in the antibacterial activity depending on the morphology and size of ZnO nanoparticles was observed. This indicates that the size of the tested ZnO particles is not of a major significance for their antibacterial activity. Therefore, the results from this study can be used in further research related to possible applications of ZnO powders in food packaging industry and water purification process.

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