Hindawi Publishing Corporation
Advances in Materials Science and Engineering
Volume 2015, Article ID 624394, 2 pages
http://dx.doi.org/10.1155/2015/624394

Editorial

Silver Nanoparticles: Synthesis, Properties, and Applications

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Received 14 December 2014; Accepted 14 December 2014

Silver nanoparticles have been of interest since the IV century AD owing to their dichroic character when integrated into glass. For over centuries, silver based compounds have been used as nontoxic, inorganic, and antibacterial agents owing to their biocidal properties in many applications such as wood preservatives or for water purification in hospitals. Nanomaterials demonstrate unique and significantly modified physical and chemical properties, compared to their macroscaled counterparts, which make them of particular interest. For this reason, silver nanoparticles have become of major interest for their antibacterial properties and are already integrated into applications such as wound treatment, sterilization, food sanitation, antibacterial textiles, and more recently drug delivery. In fact, silver nanoparticles exhibit a broad spectrum of antibactericidal and antifungicidal activities making them extremely popular in a diverse range of consumer products, including plastics, soaps, pastes, food, and textiles, thus increasing their market value. In the present context, they have attracted increasing interest due to their unique physical, chemical, and biological properties compared to their macroscaled counterparts. Silver nanoparticles are also studied by material scientists who investigate their integration into other materials in order to obtain enhanced properties, as, for example, in solar cells where silver nanoparticles are used as plasmonic light traps. These properties make them valuable in applications such as inks, microelectronics, medical imaging, and waste management. Traditionally, metal nanoparticles are produced by physical methods like ion sputtering or pulsed laser ablation and chemical methods like solvothermal synthesis and sol-gel methods. More recently, however, environmentally friendly synthesis methods have been developed, called "green syntheses." Depending on the chosen method, silver nanoparticles with different morphologies, sizes, and shapes can be obtained. Nevertheless, one of the critical criteria remains the size distribution that should be as narrow as possible to target specific applications.

The following special issue focuses on works that emphasize silver nanoparticles in today's technologically advancing society. The contribution from K.-S. Chou and C.-H. Lee "Fabrication of Silver Interdigitated Electrode by a Stamp Method" proposes the fabrication of interdigitated electrodes via a stamp containing the imprint of the required electrode and employing silver ink. The stamping force required appears to be crucial in the reproducible printability of these electrodes. Further improvements in the printing can be obtained by changing the consistency of the silver ink, keeping in mind an ultimate automated method for such electrode fabrication. The method is attractive due to its cost-effectiveness and possible applications as sensors. On a different note, K.-H. Tseng et al. in their study entitled "A Study of Antibioactivity of Nanosilver Colloid and Silver Ion Solution" prepare the mood for a biomedical application of silver nanoparticles. Synthesis of the nanoparticles by nontoxic methods, such as electrical spark discharge without surfactants, is the appeal of the paper. Antibioactivity effectiveness of these ionic nanoparticles on yeast and bacteria is compared. Clearly, the study is of fundamental importance in

understanding the effect of silver ions on various bioactivities. In the same spirit, Y. Jeong et al. in "Assessment of Size-Dependent Antimicrobial and Cytotoxic Properties of Silver Nanoparticles" have studied not only antimicrobial activities of these silver nanoparticles but also their cytotoxicity. The size controlled synthesis of these nanoparticles further helped in assessing their size-dependent properties. Their work brings in new information on such materials as their experiments suggest that even though smaller nanoparticles tend to be more efficient antimicrobial agents, they also tend to present higher cytotoxicity for humans. In their work, they have studied antibacterial effect of Ag on *Methylobacterium* spp. and cytotoxicity on human peripheral blood mononuclear cells. They suggest that not only silver ions but also the nanosize of silver could be a factor in determining the antimicrobial activity.

The special issue also proposes review articles. The paper "Preparation of Silver Nanoparticles and Their Industrial and Biomedical Applications: A Comprehensive Review" by A. Haider I.-K. Kang, and as suggested by the title, is one such review article. The paper discusses the role of silver nanoparticles in industrial and biomedical applications. It describes various synthesis routes, including chemical and biological methods. Size of the nanoparticles and its effect on their cytotoxicity have been given a closer look along with their applications in textiles and plastic coatings, among others. Environmental consequences of releasing them into nature are also considered here. Furthermore, due to their antimicrobial properties, silver nanoparticles have also been an ingredient in wound dressings as presented by P. Uttayarat et al. in their research paper, "Radiolytic Synthesis of Colloidal Silver Nanoparticles for Antibacterial Wound Dressings." In this paper, the nanoparticles were synthesized by radiolysis where the precipitation of the silver nanoparticles depended on the gamma radiation dose. For a certain dose, the silver nanoparticles were efficient in inhibiting *Staphylococcus aureus* and *Pseudomonas aeruginosa*. They therefore prove to be good candidates as antiseptic agents in wound healing. Finally, a contribution from the guest editors entitled "A Review on the Green Synthesis of Silver Nanoparticles and Their Morphologies Studied via TEM" is part of this special issue. Since green synthesis is gaining importance and health and safety risks of other synthesis methods are continuously being assessed, the present review article by P. Rauwel et al. provides an overview of different green synthesis methods of silver nanoparticles using bacteria, fungi, yeast, and plant extracts. Furthermore, a review on the various particle sizes as a function of different plant extracts has been explored. In fact, even if organisms from bacteria to eukaryotes are used to produce silver nanoparticles, plant extracts possess the advantage of cost-effectiveness and abundance.

In conclusion, all the articles in the present issue present original research efforts in the field of the synthesis of silver nanoparticles, the study of their properties, and their integration in applications. This issue presents new research results developed in the field of interdigitated electrodes and their roles as antibacterial and antifungal agents. This issue also demonstrates the broad field of applications of silver nanoparticles via the two review articles that present the recent advances in industrial and biomedical applications and the development of new environmentally friendly methods for the synthesis of silver nanoparticles. Finally, we hope that this issue is useful and a reference for scientists, researchers, and teachers in the field of materials science and nanotechnology.

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