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Gabriela Palestino*, Sergio Rosales-Mendoza, Ma. Estela Calixto-Rodriguez, and Enrique Quiroga-González

Functional mesoporous materials

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Preface

Functional mesoporous materials possess new properties as a consequence of their size, shape and microstructure, which give them high versatility for many applications. By controlling those parameters, new biological, photonic, catalytic, energy and environmental applications have been developed and successfully applied to provide emergent solutions to social, industrial and technological problems. One of the most exciting aspects of working with functional mesoporous materials and their applications is the need of knowledge exchange between different disciplines. Thus, this multidisciplinary character of functional materials science is the main characteristic of this special issue.

In this context, the special issue "Functional Mesoporous Materials" of the journal Mesoporous Biomaterials comprise three mini-reviews, one communication, and three regular papers. In these papers, cutting edge research regarding the synthesis of functional mesoporous materials and their impact in biological, photonic and energy applications is presented and discussed.

The prospective on using functional mesoporous hydrogels, porous silicon and porous-silicon composites in the biomedical field as drug delivery platforms is covered in the review by Rocha-García and co-workers. Through this mini-review it is shown that mesoporous biosystems can be designed with multi-functions to perform specific and selective tasks. The review covers recent studies focused on : i) improving the loading of drugs into the mesoporous carriers, ii) understanding the mechanisms of drug release and iii) generating new insights into the interactions between the host biological systems and the guest hybrid vehicles. In their work the authors highlighted the necessity to expand in-vivo trials and clinical translation to ensure the real application of these mesoporous biomaterials in the near future. The up-to-date interest of using porous silicon nanostructured materials as nanocarriers/adjuvants in vaccine formulations was also reviewed by Navarro-Tovar and coworkers. Multi-epitope vaccine formulations are given as examples in this minireview; particularly those requiring strong cellular responses, such as cancer and infections caused by intracellular pathogens, for which a limited number of effective adjuvants are in advanced developmental stage. In the same area, the communication by Gonzalez and coworkers demonstrates the effects induced by single walled carbon nanotubes (SWCNTs) on the airway smooth muscle tone, by using an isolated rat tracheal rings model and monitoring nitric oxide (NO) as a possible mediator involved in the effects. In this research it is shown that SWCNTs did not modify the smooth muscle tone per se.

Besides its prominent use in biomedicine, PSi mesoporous materials are widely used as templates for the development of photonic devices. In this sense, Gómez-Barojas and coworkers have studied the possibility of passivating the surface states of PSi by thermal oxidation. The rationale is the use of PSi photonic materials as non-interfering supports for luminescent dyes. Fluorescein was used as model molecule to show that thermal oxidation of the mesoporous nanostructure at low temperature minimizes the intrinsic photoluminescence of the PSi inorganic material, thus allowing a better detection of the fluorescent dye infiltrated into the porous network.

The prospects and recent advances of carbon based supercapacitors were reviewed by Cuentas-Gallegos and coworkers. In their review, the authors discussed the influence of surface area, porosity, surface modification (by doping or functionalization), and introduction of electroactive oxides into the porous templates on the intrinsic capacitance values of different carbon materials.

***Corresponding Author: Gabriela Palestino:** Faculty of Chemical Sciences, Universidad Autónoma de San Luis Potosí, Av. Manuel Nava No. 6, 78210 San Luis Potosí, SLP, México, E-mail: palestinogabriela@fcq.uaslp.mx, Tel.: 444-8262440+6439
Sergio Rosales-Mendoza: Faculty of Chemical Sciences, Universidad Autónoma de San Luis Potosí, Av. Manuel Nava No. 6, 78210 San Luis Potosí, SLP, México
Ma. Estela Calixto-Rodriguez, Enrique Quiroga-González: Institute of Physics, Benemérita Universidad Autónoma de Puebla, P.O. Box J-48, 72570 Puebla, México

The prospective of producing 1D $CuInSe_2$ (CIS) nanowires by the assistance of porous silicon (PSi) templates was investigated by S. De La Luz-Merino and coworkers. It was demonstrated that the type of substrate used as template highly influences the formation of CIS nanowires. In their work the authors showed that while CIS thin film on glass/TCO (Mo) substrates can be straightforward, its confinement into PSi templates opens the possibility of band gap tuning. In addition, the generation of nanostructured secondary phases based on Cu_xSe_y was achieved. Since Cu_xSe_y has been recently reported as biocompatible photothermal material for cancer therapy, the study has interesting implications in biomedical applications.

For the development of new biological applications, the synthesis of carbon nanostructures in liquid phase is currently another topic of great importance. An example of the current research in this area is presented by Quintana and coworkers, related with the production of graphene nanoribbon carpets. They have exhibited significantly higher sensitivity for the electrical detection of adenosine triphosphate (ATP) molecules respect to that of a single-walled carbon nanotube network [1]. Likewise, carbon nanoscrolls have been suggested as tunable water and ions channels, as well as synthetic pores for gene and drug delivery systems [2]. In these applications ultrasonic techniques have been essential for the synthesis, modification and manipulation of the studied carbon nanomaterials [3]. By using this novel technique, the production of three different carbon nanostructures (nanoribbons, squared sheets, and carbon nanoscrolls) has been reported. The authors claimed that the addition of small organic molecules during the ultrasonication process is a key factor for the formation of carbon nanostructures. They also demonstrated that the radical reactive species produced by the acoustic cavitation during sonication of graphite can be reduced as consequence of radical attack starting from small solvent molecules. The authors suggest that this strategy will allow the production of carbon nanostructures readily available for their chemical functionalization or for their incorporation into hybrid materials enabling the development of new advanced biological applications.

In conclusion, this special issue comprises a compilation of articles that exemplify the sustained research activity in the field of mesoporous materials, from the development of novel, optimized synthesis methodologies, to the application of the materials in diverse technological fields.

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