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Advanced nanostructured materials: Turning scientific discoveries into health

Advanced multi-functional ceramics, like nano hydroxyapatites containing Mg, Zn, Sr and Si within hydroxyapatite (HAP) lattice, noted HAP-Mg-Zn-Sr-Si, are of a major interest for hard tissue engineering and biomedical applications, particularly due to their similarity with biological HAP from bone structure. Among the innovative strategies, the ionic substitution represents an intelligent tool to improve the biological efficiency of nanobiomaterials based on HAP, as a new generation of advanced bioceramics based on multi-substituted hydroxyapatites, ms-HAPs. Series of these advanced ceramics were synthesized in our Physical Chemistry Center by innovative strategies, including wet chemical precipitation method, without surfactants or template molecules, by thermal processing, lyophilisation and calcination. Thus, nano ms-HAPs, containing divalent cations of Mg, Zn and Sr, as well as with Si as orthosilicate, were synthesized and thoroughly characterized. Particle size, crystallinity, morphology, specific surface area of obtained advanced multi-functional bioceramics were investigated by XRD, ICP-OES, SEM-EDX, FT-IR and FT-Raman spectra, HR-TEM, AFM and BET measurements. The obtained data confirmed a unique nanostructured phase of the highest compositional purity for all synthesized biomaterials. Results also showed a distinct change in shape and size of nanoparticles, and in crystallinity of lyophilized powders, non-calcined or calcined, with ionic substitutions. The substitution effect on biological performance of these bioceramics was investigated on primary human osteoblasts in culture media. Therefore, innovative scaffolds were fabricated by supramolecular engineering approach from advanced HAP-Mg-Zn-Si and HAP-Mg-Zn-Sr-Si bioceramics self-assembled alone or with collagen: COL on solid/liquid interface. Human osteoblasts response on doped HAPs was assessed by viability tests, like MTT assay, adhesion and proliferation, and protein expression for osteoblast markers, such as collagen type 1, osteopontin, osteonectin and osteocalcin. Moreover, the investigation of alkaline phosphatase activity and F-actin stress fibers indicated the highest biological performance for advanced functional bioceramics compared with pure HAP scaffolds, particularly in promoting the formation of mineralized bone matrix. The enhanced biological performance of these advanced nanomaterials recommends them for medical applications, as bioactive coatings for smart orthopaedic and dental implants and as bone substitute for bone repair and regeneration. Certainly, these results demonstrate benefits of turning these discoveries into health, with multiple uses in clinical applications for bone tissue repair and regeneration as well as in the treatment of osteoporotic bone fractures. Consequently, multi-substituted hydroxyapatites can be a promising multi-functional bioceramic platform for nanomedicine applications.

Speaker Biography

Maria Tomoaia-Cotisel completed Ph.D. at the Babes-Bolyai University of Cluj-Napoca, Romania, and postdoctoral studies from London University, King's College, UK. She is a corresponding member of the Academy of Romanian Scientists. She was the visiting scientist at Philipps University of Marburg, (1989/1990), Germany, State University of New York at Buffalo (1990/1991), US, National Institutes of Health, (1991-1993) and Molecular/Structural Biotech., Inc., (1994-1997), Bethesda, MD, USA. She is the founder and director of Research Center in Physical Chemistry (2007-) at BBU, STAR research institute. She published over 250 original research papers, 5 patents, and 10 books in physical chemistry, including thermodynamics, chemical structure, biophysics, bionanomaterials, colloids, and interfaces. She got important awards, e.g., Gheorghe Spacu Award (1983, from the Academy in Romania), Alexander von Humboldt Award (1986, Germany), Japan Society for Promotion of Science and Technology Award (1986, Japan) and Fogarty Award (1991, USA) for science and technology. She is a leader and supervisor for Ph. D. students in Doctoral School of Chemistry at BBU, in physical chemistry, biophysics and material science.

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