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Perspective

Cell/Drug Nanodelivery and Bioceramics: Platforms for Oro-Dental Applications

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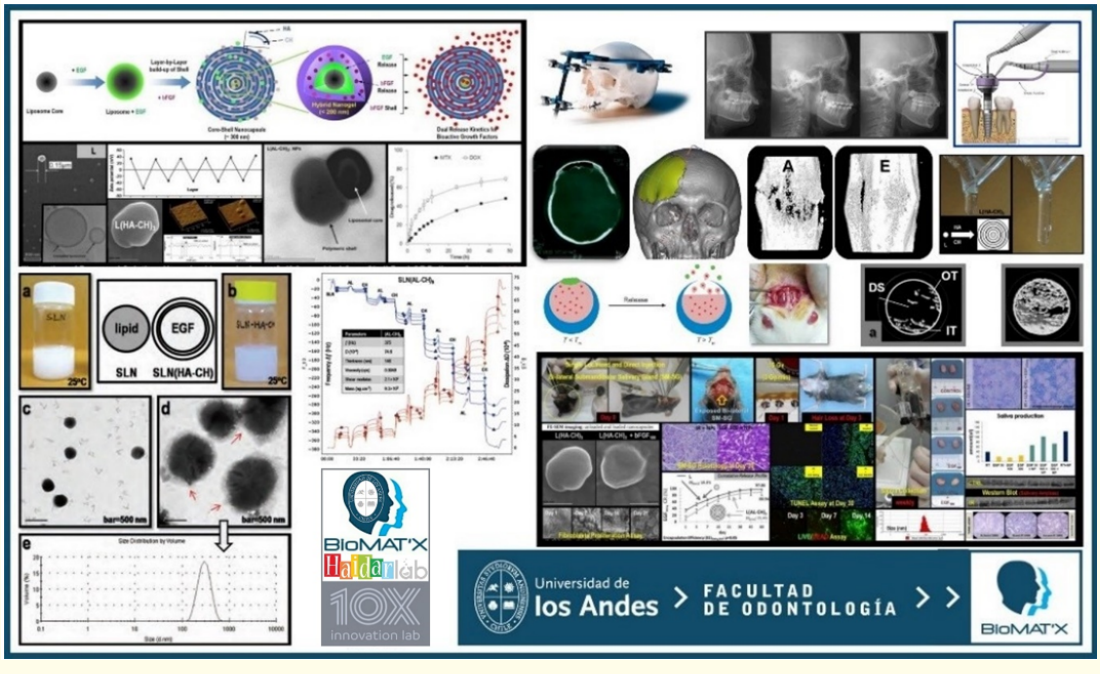
Graphical Abstract



Innovative tissue engineering and regenerative medicine solutions that incorporate nanobiotechnology, advanced biomaterials, computer assistance, three-dimensional printing and robotic systems can offer a wide-ranging potential for augmenting and improving the functional and esthetic cranio-maxillo-facial and oro-dental health profile of patients. Indeed, the biomaterials field, in general, is one of the largest and fastest growing research areas both in the scientific community as well as in the industry. Novel biomaterials often result

from collaborations between different disciplines, not limited to, chemistry, medicine, pharmacology, engineering and biology. The overall objective is to lead the implementation of new solutions and devices for repairing and restoring form and function of the human body and eventually improving quality of life (QoL) and longevity successful ageing. Emphasis on the physico-chemico-mechanical and bio-characteristics and -interactions between the biomaterials and living tissues is hence, critical and evident.

Herein and for over 100 years, R&D&I efforts have focused on optimizing drug delivery. In recent years, cells, micro- and nano-particles, and combinations thereof as carriers, have emerged, mainly for facilitating superior encapsulation and controlled release pharmacokinetics. Indeed, most cells and drugs require an appropriate formulation for their successful application as pharmaceuticals. In this, the use of polymer-based hydrogel biomaterials for the delivery of drugs and recruitment of cells to promote tissue regeneration in the body is of growing interest and currently a hot research topic in pharmacology, pharmaceutics and bio-material science; a multi-/intra-disciplinary research field. For example, hydrogels are cross-linked three-dimensional polymeric networks with unique properties such as affinity for biological fluids, tunable porosity, high water content and uptake, ease of preparation, flexibility, malleability, biocompatibility and biodegradability. Hence, while biomimetic hydrogels have been popular for tackling pharmacological, biomedical and clinical limitations of the existing drug delivery systems, injectable hydrogels have been recently gaining more attention due to the potential spatio-temporal control, tunability and stimuli-responsiveness capacities, offering significant innovative solutions in the delivery controlled and targeted delivery of therapeutics such as cells, genes, proteins and drug molecules, amongst others, with versatile platform applications in tissue engineering, regenerative medicine, implantology, functional and aesthetic surgical interventions, cancer, disease prevention and/or treatment and beyond.

Another prevalent R&D&I topic is bioCeramics. The use of ceramics in biological environments and biomedical applications is of enduringly-increasing importance, as is the understanding of how biology works with minerals to develop strong materials suitable for the clinic. Herein, bioCeramics have been revolutionizing the biomedical field in the form of bone grafts, fillers, implants and metal implant surface coatings for use in humans. Likewise, efforts are focusing on understanding and improving the biocompatibility, physico-chemical and mechanical properties of such materials and devices, with the attention directed towards the development and potential use of ceramic/ceramic composites, at micro-, nano- and pico-scales. Indeed, exciting and potential opportunities are associated with the design, development and use of nanobioceramics as tissue- and body-interactive materials, facilitating healing and repair, or promoting the regeneration of tissues, therefore restoring physiological functions. Ceramic-based and/or ceramic-incorporated biomaterials are being biologically evaluated through numerous *in vitro*, *in vivo* and clinical tests. Safety of ceramic components and mechanical stability (preventing deformation under physiological conditions) and strength upon loading are major issues.

Current challenges and opportunities in field: Despite recent advances that continue accruing, including that several Injectable Hydrogels and bioCeramics have already received US-FDA approval, are understudy in clinical trial stage and/or are already commercially-available in the market, limitations (and therefore, opportunities for R&D&I) exist. Such, whether based on natural or synthetic (or hybrid) polymers and constituents, include challenges in structural chemistry, phase transition, synthesis, cross-linking, mechanical stability, visco-elasticity and porosity, in situ load release profile and pharmacokinetics over time, biodegradability, immunological compatibility, host-immune responses, lack of molecular-level studies; formulation and fabrication costs, administration route (injectable vs implantable), data analysis from quality clinical trials, GMP (good manufacturing practices) scale-up processes or strategies and/or application-specific regulatory obstacles; topics that still entail more extensive research and funding [1-12].

Conflict of Interest

The author of this article declares having no conflict of interest of any form or nature with any platelet concentrate product, protocol, technique or company.

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