Design of biofunctional nanostructures for theraregenerative medicine

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The implementation of a personalized therapy together a less invasive surgery for the restoration of human tissues is becoming an appropriate strategy to mitigate costs of the modern health care system and the maintenance of health and quality of life.
The design biomaterials endowed with therapeutic and regenerative (theraregenerative) properties are recently of particular interest. The selection of a suitable injectable technique is often based on material characteristics (including mechanical properties, drug release kinetics and degradation) that serve for the specific treatment function.
Micro or nano-structured materials in the form of gels, nanoparticles and nanocomposites have gained increasing interest in regenerative medicine because they are able to mimic the physical features of natural extracellular matrix (ECM) at the sub-micro and nano-scale levels [1]. 2D materials such as graphene oxide (GO) and exfoliated black phosphorus (2D BP) show important therapeutic and regenerative activities due to their physicochemical properties. Recent studies have shown the effectiveness of 2D BP and GO as photodynamic therapy (PDT) agents for cancer treatment [2]. This activity has been ascribed to their capability of generating singlet oxygen and acting as photosensitizers that, in presence of reactive oxygen species (ROS) and infrared light irradiation, constitute an essential component of PDT therapy. On the other hand, the oxygen-containing functional groups of GO and the phosphates ions (PO_4^{3-}) [3,4] derived by BP decomposition act as anionic ligands for positive calcium ions (Ca^{2+}), enhancing the attraction, binding, and aggregation of free Ca^{2+} in bone tissue, ultimately leading to the formation of calcium phosphate (CaP). In this way, GO and 2D BP represent bioactive signals able to promote osteogenesis. Here, we propose the *in vitro* use of 2D substrates (GO and 2D BP) to inhibit cancer cell proliferation and migration and at the same time to preserve the healthy cells [5]. Furthermore, we offer an overview of how these 2D materials may be used to develop nanostructured hybrid materials (*e.g.,* gels, nanoparticles) as a theraregenerative platform for bone tissue engineering in terms of bone cancer therapy and regeneration.

Acknowledgements

The authors thank the Project MIUR PRIN2017 – ACTION - Grant N. 2017SZ5WZB and the project PHOSMED - ERC-2020-PoC N. 963933 for financial support.

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