SEAS OF RENEWAL: VALORIZATION OF SEA URCHIN WASTE TOWARDS SUSTAINABLE AND INNOVATIVE BIOMATERIALS FOR REGENERATIVE MEDICINE

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Résumé

Sea urchins possess unique biological features, including Mutable Collagenous Tissues (MCTs), which have been shown to be a valuable and sustainable source of native collagen. Indeed, the MCT-derived extracted collagen fully retains its original fibrillar architecture and glycosaminoglycan (GAG) decoration. Furthermore, it can be obtained from edible sea urchin waste, aligning with Circular Economy principles, and has been employed in the development of innovative biomaterials for regenerative medicine.

In this work, we provide an overview of the various types of sea urchin collagen-based biomaterials produced to date through optimized protocols and technological advancements. These include a first generation of biomaterials, such as thin mesh-like films and porous sponge-like 3D scaffolds composed solely of sea urchin collagen (SC). A second generation of biomaterials has also been developed, comprising: (i) composite and multifunctional scaffolds combining SC with sea urchin-derived antioxidant molecules (polyhydroxynaphthoquinones, PHNQs), also extracted from sea urchin waste in a zero-waste valorization approach; (ii) hydrogels based on methacrylated SC to enhance stability and handling; and (iii) customized hydrogels fabricated via 3D bioprinting technology, further advancing their application in tissue engineering.

These biomaterials underwent extensive structural, mechanical, and degradation analyses, as well as in vitro and, in some cases, in vivo preclinical evaluations, which highlighted their promising potential for biomedical applications.

Overall, these valorization strategies emphasize the feasibility of harnessing sea urchin waste-particularly MCT-derived collagen-for the development of high-value, sustainable, and innovative products, thereby supporting the principles of the Blue Bioeconomy and Blue Growth.

Mots-Clés: sea urchin, fibrillar collagen, biomaterials, hydrogels, 3D printing, waste valorization

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