Multifunctional Graphene Hybrid Hydrogels in 4D Biomimetic Designs

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The rapid advancement of nanomaterials over recent decades has opened new avenues in scientific research. Their remarkable properties offer the potential to transform a wide range of fields, including electronics, sensing, energy, and composite materials. In parallel with this growing interest in nanotechnology, three-dimensional (3D) structures have gained increasing attention in biomedical research. Conventional two-dimensional (2D) in vitro cell cultures are progressively being replaced by 3D models designed to better replicate physiologically relevant tissues.

In this talk, we will explore how nanomaterials contribute to the development of soft, biomimetic 3D systems. In our laboratories, hydrophilic polymeric networks are synthesized via in situ radical polymerization in the presence of two-dimensional materials or metal nanoparticles, resulting in three-dimensional nanocomposite soft scaffolds. While the primary function of the nanomaterials within the polymer network is mechanical reinforcement, we have demonstrated that they can also enhance key properties such as biocompatibility, sensing capabilities, and self-healing behaviour [1], leading to the formation of truly hybrid composites [2].

Furthermore, the ability to fabricate these systems using 3D printing techniques—employing concentric layers of different materials with tailored mechanical properties—enables the creation of advanced cell culture platforms that more closely mimic natural biological processes [3]. These systems are designed to go beyond traditional static scaffolds, as they can respond dynamically to external stimuli, such as magnetic [4] or electrical [5] activation, effectively transforming them into 4D scaffolds.

References

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Figures

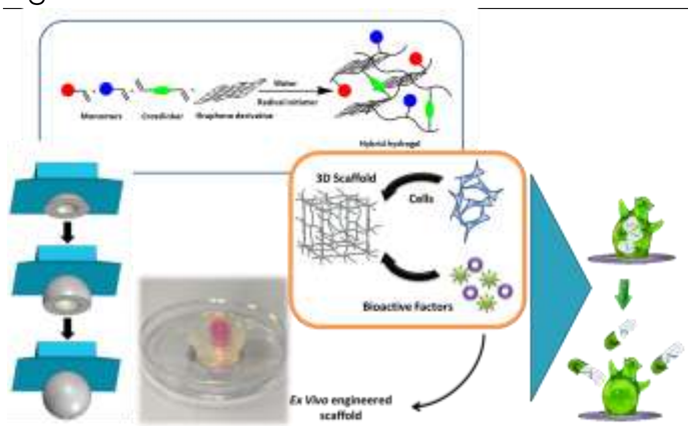

Figure 1: 3D Scaffold Designs