Graphene and New 2D-Nanomaterials for Cancer Phototherapy and Tissue Regeneration

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Abstract

Photothermal therapy (PTT) using two-dimensional nanomaterials (2DnMat) has emerged as a promising alternative strategy for cancer treatment. Their high surface area, strong absorption in the near-infrared (NIR) region, and versatile surface functionalization make 2DnMat highly suitable for PTT applications. Although efficient and selective *in vitro* and *in vivo* cancer ablation using lasers has been widely reported, key challenges remain, such as demonstrating truly selective treatments that kill only cancer cells while leaving normal cells unaffected [1]. Our group has developed novel pharmaceutical formulations incorporating 2DnMat for photothermal treatment of skin, gastric, rectal, and breast cancers, combined with custom-built NIR LED systems. These systems enable the induction of mild hyperthermia and selective effects, in contrast to laser-based approaches reported in the literature [1, 2]. Our platforms effectively eradicate cancer cells while preserving healthy tissue and demonstrate the ability to permeate biological barriers such as human skin. We further developed a partial reduction strategy for graphene oxide that enhances NIR photothermal conversion while maintaining water stability [2]. Additionally, MoS_2-based hydrogel formulations showed selective photothermal killing of A-431 skin cancer cells under NIR irradiation, without affecting fibroblasts. Recent advances include the development of water-stable, magnetically responsive 2DnMat enabling both PTT and magnetic hyperthermia therapies, as well as magnetically triggerable 3D-printed scaffolds. A perspective on graphene and 2DnMat for bioapplications explored in our laboratory will be presented, seeking industrial and clinical translation, as well as academic partnerships.

References

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Figures