Functionalized Nanomaterials Based on 2D Nanocrystals and Metal Nanoparticles Activated by Radiation for Antitumoral Therapy

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Cancer remains one of the leading causes of mortality worldwide, affecting millions of individuals and accounting for approximately 10 million deaths annually.[1] Traditional antitumor clinical approaches, such as Photodynamic Therapy (PDT) and Radiotherapy, often have limitations related to low efficacy and significant side effects, highlighting the need for more effective cancer treatments.
PDT traditionally relies on UV – near infrared light activation of a photosensitizer to generate Reactive Oxygen Species (ROS) that selectively destroy cancer cells. Recently, the use of X-rays as an external excitation source in PDT has proven effective due to their superior penetration capacity, extending the potential of conventional PDT to deeper tissues and overcoming the limitations of visible light penetration. Radiotherapy, on the other hand, kills cancer cells through the direct action of X-rays on biological tissues, leading to numerous side effects on healthy cells.[2]
In recent years, nanotechnology-based therapies have attracted growing interest, in particular, 2D nanomaterials are considered promising candidates due to their physicochemical properties, making them ideal platforms for radiation-based cancer treatments. [3, 4]
This study presents a novel biocompatible nanomaterial, consisting of functionalized 2D nanocrystals combined with metal nanoparticles, designed as radiosensitizer and PDT mediating agent, that can be activated by an external energy source (light, X-ray radiation), enabling to locally kill cancer cells and arrest their proliferation.
In vitro experiments were conducted on cancer cells to evaluate the cytotoxicity and efficacy of the novel nanomaterial. Cell viability, colony-forming ability, DNA damage, and cell cycle alterations were assessed at different time points before and after the treatment with increasing concentrations of the nanomaterial and irradiation doses. The optimal conditions to enable the highest efficacy were identified, as a range of treatment parameters that result in minimal cytotoxicity of the nanomaterial itself and maximum enhancement of irradiation-induced effects, able to induce a significant cell viability reduction. Our findings revealed that this nanomaterial amplifies the effect of radiation in cancer cells, acting as an effective radiosensitizer.

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