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Investigating the mechanism behind the radiation-induced photochemical properties of photo-active substances

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Photodynamic therapy (PDT) is a clinical treatment that uses light to activate a photosensitizer which produces reactive oxygen species (ROS) able to destroy tumor cells. Photosensitizers are nontoxic in dark until they are activated by a specific wavelength of light and then generate different ROS, such as singlet oxygen 1O2, superoxide anion (·O2-) and hydroxyl radicals(·OH), which are quite cytotoxic to tumor cells. However, PDT has several drawbacks such as low yield of ROS and short tissue penetration depth of light which reduces the treatment effectivity. Similar to photosensitizers, photocatalysts such as TiO2 and ZnO are also able to generate ROS when exposed to light.
It has been recently suggested that such photocatalysts can also be activated by ionizing radiation and exert anti-tumour effect which is very promising because this implies that there is much less penetration issues allowing treatment of deeper situated tumours.
In this study, we attempted to determine the photochemical mechanism of TiO2 and ZnO NPs when exposed to ionizing radiation. First, we systematically studied the interaction between ionizing radiation, such as X-rays and gamma-rays and photocatalysts like TiO2 and ZnO in aqueous suspensions. Two fluorescence probes SOSG (specific for detection of 1O2) and APF (specific for detection of ·OH) were applied to evaluate the ROS generation after radiation exposure. According to our results, ionizing radiation can strongly activate the photocatalytic properties of both TiO2 and ZnO since dramatic increase could be seen in the yields of ROS compared to water alone. However, TiO2 and ZnO nanoparticles exhibited quite different photochemical response upon radiation exposure. TiO2 could mainly generate 1O2 either under X-ray or gamma-ray radiation while ZnO nanoparticles mainly generated ·OH. Further attempts were made to figure out the dominant species which are responsible for the increased generation of ROS. Different scavengers were applied to quench different species contributing to the generation of ROS. Research so far demonstrated that O2 played the most important role in generating 1O2. More efforts will be devoted to further clarify the generation process of interesting ROS and to determine the photocatalytic effect of different radiation types.

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