Highly efficient graphene quantum dots/porphyrin photodynamic therapeutic agents for breast cancer

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Graphene quantum dots (GQDs), a zero-dimensional (0D) nanomaterial, present outstanding biological features, including low toxicity, biocompatibility, excellent photo stability, tuneable fluorescence, and water dispersibility, that make them ideal multifunctional nanoplatforms. So far, many ways have been tried to make GQDs successful in use as bioimaging agents as well as to carry large amounts of therapeutic drugs that can be released in a controlled way.

Tetrapyrrolic macrocycles, such as porphyrins, corroles, and phthalocyanines, have been explored for cancer photodynamic therapy (PDT) due to their high ability to generate ROS species, low toxicity, and unique optical and electronic properties. However, the poor water solubility of tetrapyrrolic macrocycles can lead to the formation of aggregates, compromising their therapeutic effect. Our research reported the successful synthesis of GQDs and functionalization with corrole or porphyrins. Our recent findings demonstrate that aminoporphyrins can be effectively covalently linked to GQDs via two distinct chemical routes, using either thionyl chloride ($SOCl_2$) or 1-ethyl-3-(3'-dimethylaminopropyl) carbodiamide (EDAC). It was reported that the functionalization of GQDs with aminoporphyrin promoted an efficient uptake in breast cancer cells (T-47D cell line) when compared with the free molecular porphyrin. The developed hybrids were further investigated in terms of phototherapeutic agents under white light irradiation, and a significant photocytotoxic effect was observed for concentrations up to 10 nM, which compared favourably with the photocytotoxic concentration of the isolated porphyrin. These results point out the relevance of the synergistic effects of the conjugation of the nanoplatform with the therapeutic molecules in terms of PDT efficiency against cancer cells. Even so, the effectiveness of the hybrid materials developed should be validated using highly complex in vivo models.