Can porphyrinoids defeat cancer?

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Nowadays, malignant disorders are the second leading cause of death worldwide and are induced by the uncontrolled growth of abnormal cells resulting from DNA mutations. Despite the recognized advances in cancer treatments, alternative strategies are still required to overcome some drawbacks of the current treatments, such as severe radiation damage, limited applicability, lack of specificity, and acute side effects. In this sense, Photodynamic Therapy (PDT) has been pointed out by the scientific and medical communities as one of the most promising approaches for the treatment of malignant diseases. Among the organic-based photosensitizers (PS), porphyrinoids are the most studied, and some were already approved for clinical use.

Our group developed several strategies to improve the efficiency of meso-tetraarylporphyrins PS against malignant diseases. Water-soluble 5,10,15,20-tetrakis(1-methylpyridinium-4-yl)porphyrin (TMPyP) and its tetracationic pyridinium inverted analog showed to be efficient PS to kill MCF-7 breast cancer cells via autophagic flux and necrosis (Fig. 1-left). TMPyP and its metallo complexes are also able to stabilize DNA G-Quadruplexes (G4), thus inhibiting the telomerase activity, which is a useful approach in anticancer drug design (Fig. 1-right). Furthermore, non-charged reduced porphyrin derivatives can be considered as PS when incorporated into micelles. This strategy allows to improve their water-solubility and retain their PS properties, enabling apoptosis-mediated death of PC-3 prostate cancer cells (Fig. 2). Another approach involved the immobilization of both neutral and cationic porphyrin derivatives in graphene oxide (GO) and graphene quantum dots (GQDs). The porphyrin@carbon nanomaterials displayed enhanced PS ability against T24 bladder and T47D breast cancer cells, demonstrating the potential of graphene-based nanomaterials as platforms to deliver porphyrin-based PS without compromising their photosensitization capability (Fig. 2).

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FIGURE 1
PDT approach towards MCF-7 breast cancer cells (left) and G4 stabilization/telomerase inhibition by cationic meso-tetraarylporphyrins (right).

FIGURE 2
Incorporation of porphyrin derivatives into micelles and immobilization into carbon-based nanomaterials as effective strategies to deliver PS for PDT.