Binding Properties of Polymer Nanoparticles Encapsulating Porphyrinic Photosensitizers

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The concept of photodynamic therapy (PDT) for anticancer treatment is based on the formation of highly reactive singlet oxygen ($^1O_2$) via energy transfer from a light excited photosensitizer ultimately leading to localized cell death. Due to their intrinsic phototoxicity and high tumor accumulation, porphyrinic compounds including porphyrins and chlorins have evolved as important family of photosensitizers in PDT. However, one of their drawbacks originates from a high aggregation tendency of most porphyrinic compounds. Polymer systems have been identified as an elegant and simple way to cope with the undesired effects of aggregation. As an example, Photolon®, which is a polyvinylpyrrolidone (PVP) - chlorin e6 (Ce6) complex, has been approved for medical application in PDT. [1]

Previously, we have reported and characterized a series of naturally derived porphyrins by NMR spectroscopy keeping the focus on their aggregation models, propensity to form aggregates, carrier systems and their interactions with membrane models. [2, 3]

The aim of this study is to investigate the efficacy of different polymer systems regarding their disaggregating capability and binding strength of porphyrin compounds using NMR and UV spectroscopy as main techniques. A step towards understanding the loading efficiency of the polymer matrices can be accomplished by characterization of parameters such as the association (binding) constant of porphyrin-polymer ensembles. Particularly, we have calculated and compared the binding constants of polymer matrices either based on block copolymer micelles (BCMs) or PVP with a chlorin (SerCe) and a deuteroporphyrin IX derivative (DPIXDSME). The results indicate different binding motives of the polymer matrices with respect to the porphyrinic compounds. Moreover, the stability and reactivity of the polymer-encapsulated porphyrins were probed by NMR spectroscopy mimicking physiological conditions. They were found to be different for BCMs and PVP and correlated with the association constants. The protective role of the polymer carrier system towards blood plasma proteins plays an important role in the drug delivery process. The binding differences reported in this contribution may have a considerable impact on the pharmacokinetic properties of the corresponding delivery systems.

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