A platform for antibacterial photodynamic therapy based on vaterite particles containing a porphyrin derivative as a photosensitizer

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The development of biocompatible and biodegradable carriers for the delivery of photosensitizers (PS) is one of the most significant tasks of modern antibacterial photodynamic therapy (APDT) [1]. To increase the efficiency of porphyrin loading, we used calcium carbonate particles containing the sulfonated β-CD. The porphyrin derivative TOEt4PyP (PP) was chosen as a PS [2]. The loading efficiency was 44% of the initial PP concentration in the loading solution for ordinary vaterite particles, and 83% for sulfo-β-CD-containing particles. The release (cumulative result) of an encapsulated PP from vaterite particles into a saline solution in time is shown in Fig. 1.

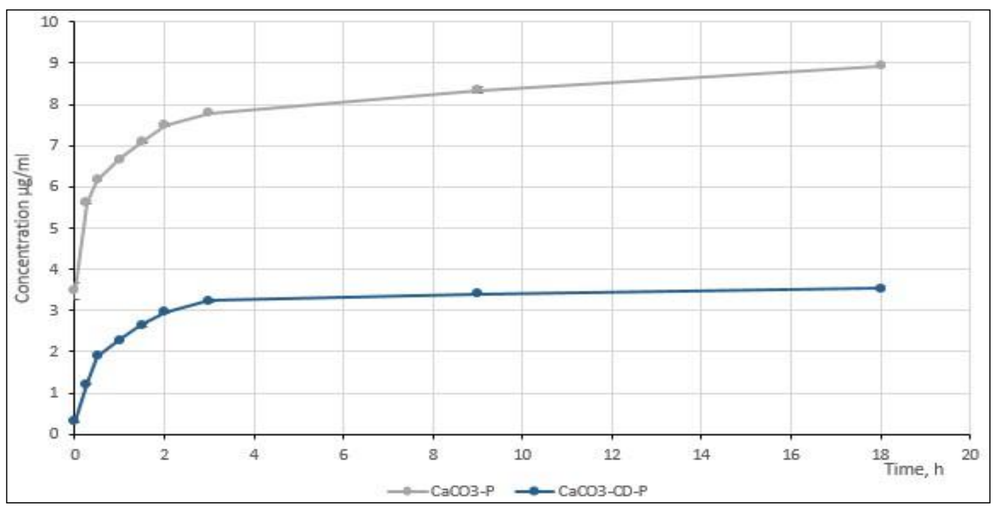

Fig. 1. Cumulative release

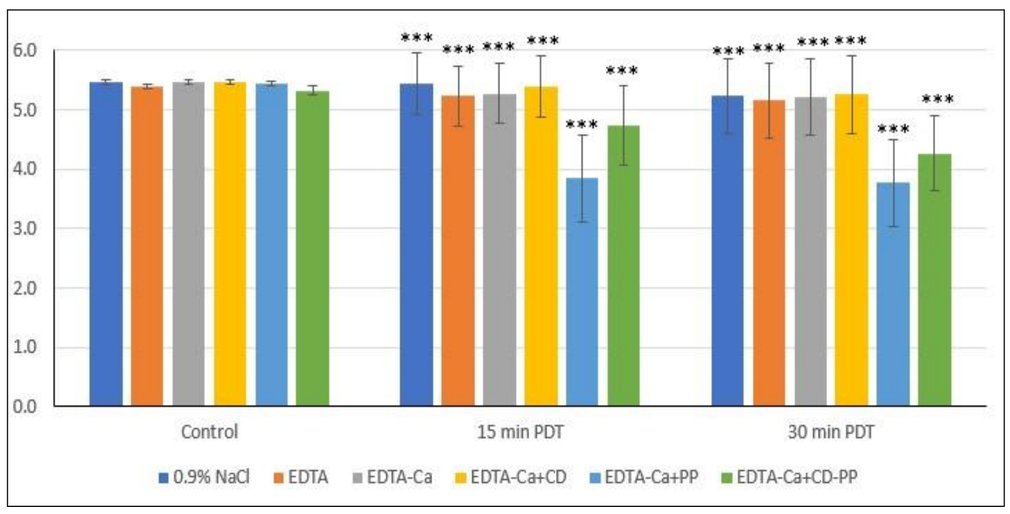

Fig. 2. Antibacterial activity

To study the APDT effect, the obtained particles were dissolved using ethylenediaminetetraacetate (EDTA) and the obtained solutions were investigated against the S. Aureus strain (L.A. Trasevich GISK, Moscow). A LED with a maximum emission spectrum λ=405±20 nm and a power density of 80 mW/cm^2 was used as a radiation source. Figure 2 shows a histogram characterizing the dark (control) and light toxicity of solutions obtained after the complexation of carrier particles with EDTA, that is, containing a PP, as well as other particle components (0.9% NaCl), EDTA, CD, Ca^{2+} ion complexes and EDTA (EDTA-Ca)) as controls. Treatment of cells with solutions obtained by complexation of particles containing porphyrin derivative (EDTA-Ca+PP) and porphyrin-sulfo-β-CD complex (EDTA-Ca+CD-PP) without irradiation does not affect the survival of the studied strain. However, the treatment of S. Aureus cells with a solution containing free porphyrin (EDTA-Ca+PP) and subsequent irradiation for 15 minutes ensured a reduction in the bacterial population to 3.8 LOG10K. A similar effect was observed at 30 minutes of irradiation, since the concentration of porphyrin did not change. The APDT effect of a solution containing the porphyrin-sulfo-β-CD (EDTA-Ca+CD-PP) complex is less pronounced, which may be explained by the difficulties of interaction of porphyrin in the "packaging" of sulfo-β-CD with a negatively charged cell membrane.

Conclusion: Vaterite particles with a size of 3-3.5 microns containing the sulfo-β-CD molecular complex with a photosensitizer (TOEt4PyP) were obtained and investigated as a promising platform for APDT. The use of β-CD provides significant loading efficiency compared to other approaches used.

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