Photophysical properties of porphyrins as a selection criterion of porphyrins for study of their effectiveness against microorganisms

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ABSTRACT

• Photodynamic inactivation (PDI) of some microorganisms (S. aureus, E. coli) was investigated and their dependence on photophysical properties of photosensitizers (cationic porphyrins and metalloporphyrins) was shown.
• Singlet oxygen is the main cytotoxic agent in phototherapy of cancer tissues and in PDI of microorganisms.
• Photophysical properties (quantum yields of singlet oxygen generation) of 16 new porphyrins and metalloporphyrins has been investigated.
• The quantum yield of singlet oxygen of metalloporphyrins containing Zn significantly higher than of metal-free porphyrins (85-87% and 77-79%).
• Experiments with Gram (+) and Gram (-) microorganisms confirmed that the highest degree of photodynamic inactivation possess Zn-metalloporphyrins.

PHOTOACTIVATION OF PORPHYRINS AND PHOTOTHERAPY OF TUMOR

Fig. 1. Injection of PPS
Fig. 2. Light action
Annealing of tumor

• Photosensitizers (PSs) under the injection of PSs contributes to the generation of reactive oxygen species (ROS) (Fig. 1).
• After injection of PSs in blood they accumulate in tumor and after action of light the tumor destroys (Fig. 2) (the same mechanism for bacteria).

Cationic porphyrins and metalloporphyrins

• New cationic porphyrins and metalloporphyrins were synthesized
• Compounds with the pyridyl ring and the active hydroxyethyl-, butyl- or allyl- peripheral groups (-R) bound in the 3rd (A) or 4th (B) position were synthesized (over 100)

The quantum yields of singlet oxygen generation by porphyrins

One of the most important criteria for the effectiveness of the PSs is the quantum yield of singlet oxygen generation (\(\Phi_{\text{S}}\)). \(\Phi_{\text{S}}\) of new porphyrins and metalloporphyrins were compared with known cationic porphyrins 5,10,15,20-tetra(N-methyl-2-pyridyl)porphyrin (H2TM2PyP)(\(\Phi_{\text{S}}(\text{H2TM2PyP})=0.18\)) and 5,10,15,20-tetra(N-methyl-4-pyridyl)-4- (pyridyl)porphin (\(\Phi_{\text{S}}(\text{H2TM2PyP})=0.51\)) [1].

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CONCLUSIONS

• Zn-containing new cationic metalloporphyrins have significantly higher quantum yield of singlet oxygen generation in comparison with other porphyrins.
• New cationic metalloporphyrins have a high photodynamic activity against both Gram (+) and Gram(-) microorganisms.
• At the concentration of 0.1 µg/ml the highest efficiency is observed of metalloporphyrin Zn-TBu3PyP.
• Irradiation by LED (405 nm) for 30 min completely inactivates Gram (+) microorganisms (St. aureus 209 P and methicillin-resistant strain S, aureus meticillin-resistant (MRSA))