Influence of Biopolymers on the Efficiency of Photodynamic Treatment with Methylene Blue Dye on Cell Cultures and Model Wounds

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Laser therapy is a highly effective physiotherapeutic method of treating patients with various diseases. Laser sources have recently been widely used to treat a wide variety of medical conditions, primarily in surgery, oncology, ophthalmology, dermatology, dentistry and other areas. One of the types of laser therapy and recognized treatment strategies in oncology [1], as well as an alternative to antibiotic therapy in the treatment of local infectious inflammations is photodynamic therapy (PDT). Two participants are needed to carry out PDT: a photosensitizer (PS), a substance that increases the sensitivity of tissues to light and selectively accumulates in cancer cells and pathological microorganisms, and light with a wavelength that coincides with the absorption band of the PS. Light is crucial for PDT, since it excites the photosensitizer, which then leads to the formation of active oxygen species. Photosensitisers can undergo two types of photochemical reactions, both using triplet oxygen ($^3O_2$) as a reagent (Fig. 1). A laser, *i.e.* monochromatic radiation with a wavelength corresponding to the absorption band of PS, is usually used to excite the photosensitizer *in vitro* and *in vivo*.

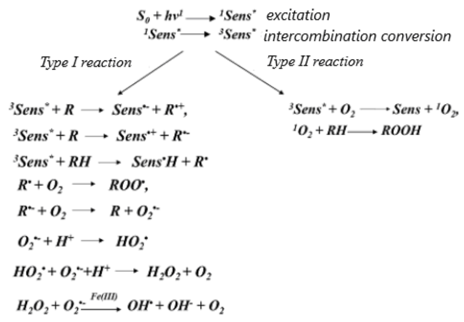

Figure 1: Two types of photochemical reactions. 1Sens* and 3Sens* are the excited states of the singlet and triplet photosensitizer, respectively; R is the substrate; Sens– and Sens+ are the anion and radical cation of the photosensitizer

However, the unique feature of laser radiation, namely its coherence, is not required for PDT, so a number of other light sources are also suitable for PDT. Nevertheless, in practical medicine, when carrying out PDT procedures, more accessible LED radiation of the same wavelength, but with a slightly wider radiation band is used. along with the laser. In this case, effective excitation of the absorption band of the photosensitizer molecules is achieved [2,3]. Traditional photodynamic agents are porphyrins and their derivatives (Photoditazine, radochlorin). Cationic PS (porphyrins, chlorins, dyes), which are believed to penetrate the cell wall of gram-positive and even the most resistant to bactericidal drugs gram-negative bacteria more easily than uncharged PS [4], are primarily used in aPDT. A positive charge on the photosensitizer molecule increases the efficiency of interaction between the photosensitizer and the bacterial cell (the target) [5]. Methylene blue (MB) is one of the actively studied cationic photosensitizers for aPDT [6]. This dye absorbs in the region of 660 nm. Due to the ease of production, low cost, bactericidal properties and photostability, MB is approved and recommended as a PS in the aPDT treatment of periodontal disease, nail plate and cardiosis [7,8]. It should be noted that for the complete cure of local infectious diseases by the aPDT method, it is necessary not only to effectively inactivate pathogenic microorganisms, but also to initiate regenerative processes in the wound.

In our work, we have shown that PDT using a LED light source and a non-porphyrin photosensitizer (methylene blue) in combination with an amphiphilic polymer can be effective in in vitro experiments when treating cultures of pathogenic bacteria, cancer cells, and in vivo during PDT of model wounds in laboratory animals.

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