

Photodynamic inactivation of microorganisms water treatment process

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Abstract

The kinetics of the destruction of standard museum strains of microorganisms as a result of photodynamic action of red light and a number of non-toxic photosensitizers in the process of water conditioning has been studied experimentally. Prokaryotic cells of *Escherichia coli* ATCC 35218, eukaryotic cells of *Candida albicans* ATCC 24433 were used as the objects of the study. Eosin H, sodium fluorescein, methylene blue and riboflavin (vitamin B₂) in concentrations of 10 mg/l served as photosensitizers. A photodynamic effect was established with respect to microorganism cells, leading to their death in the presence of photosensitizers and red light. It has been shown that riboflavin and fluorescein are the most effective for eukaryotes (on the example of *Candida albicans* ATCC 24433), which help to reduce the number of colonies of cells in 2 hours of observations by more than 3.0 and 11.0 times, respectively. It was found that the death of prokaryotic cells in the case of *Escherichia coli* ATCC 35218 is most effective in causing methylene blue, riboflavin (vitamin B₂). For 2 hours of observations in their presence due to photodynamic action, microflora decreases in 36.0 and 90.0 times, respectively. The photodynamic effect of eosin against the microorganisms under study was the smallest, which is explained by the peculiarities of its chemical structure, including phenolic groups, which are known to exhibit an antioxidant effect. It is shown that fluorescein and methylene blue are most promising for effective lethal action against pathogenic microflora in pool water. Riboflavin is most effective for water treatment of drinking water used for cooking and drinking in public, including pre-school and school meals, which will allow not only to exclude the possibility of mass poisonings, but also to provide a daily intake of vitamin B₂ with a glass of water.

References

- [1] O.Z. Paab. Uber die Wircing fluorescender Stoffe auf Infusorien. *Biol.* **1900**. Vol.39. P.524-546.
- [2] Stoffen Von Tappeiner, H. H. Von Tappeiner, Jesionek A. Muench. Therapeutische Versuche mit fluoreszierenden. *Med. Wochenschr.* **1903**. Vol.47. P.2042-2044.
- [3] Photodynamic Action and Singential Oxygen Krasnovsky AA ml. *Biophysics.* **2004**. Vol.49. No.2. P.305-321. (russian)
- [4] Yu.A. Vladimirov, A.Ya. Potapenko. Physico-chemical basis of photobiological processes *M. Drofa.* **2016**. 285p. (russian)
- [5] Stoffen Jodlbauer A., Tappeiner H. Zur Behandlung der Hautcarcinome mit fluorescenzenden. *Detsh. Arch.Med.* **1905**. B.82. P.223-226.
- [6] Historical essay on the development of photodynamic therapy Stranadko, EF *Laser medicine.* **2002**. Vol.6. No.1. P.4-8. Historical essay on the development of photodynamic therapy Stranadko, EF *Laser medicine.* **2002**. Vol.6. No.1. P.4-8. (russian)
- [7] The main directions of photodynamic therapy in medicine Salmin R.M. *Surgery news.* **2008**. No.3. P.155-162. (russian)
- [8] K. Konopka, T. Goslinski. Photodynamic therapy in stomatology. *J Dent Res.* **2007**. Vol.86. No.11. P.1126-1132.
- [9] R. Andersen, N. Loebel, D. Hammond, M. Wilson. Treatment of periodontal diseases by photodisinfection in comparison with removal of calculus and smoothing of the root surface. *J. Clin Dent.* **2007**. Vol.18. No.2. P.34-38.

- [10] S. Jepsen, A. Braun, C. Dehn, F. Krause. Short-term clinical effects of complex antibacterial and photodynamic therapy in periodontal treatment: a randomized clinical trial. *J Clin Periodontol.* **2008**. Vol.35. No.10. P.877-84.
- [11] M. Wilson, J. Dobson, S. Sarkar. Sensitization of pathogenic bacteria in periodontal tissues when they are destroyed by laser radiation of low power. *Oral Microbiol Immunol.* **1993**. Vol.8. No.3. P.182-187.
- [12] R.R. Oliveira, H.O. Schwartz-Filho, A.B.Jr. Novaes, M.Jr. Taba. Antibacterial photodynamic therapy with conservative treatment of acute periodontitis: a pilot randomized controlled clinical study. *J Periodontol.* **2007**. Vol.78. No.6. P.965-973.
- [13] F. Foschi, C.R. Fontana, K.Ruggiero, R. Riahi, et al. Photodynamic inactivation of *Enterococcus faecalis* in dental root canals in vitro. *Lasers Surg. Med.* **2007**. Vol.39. No.10. P.782-787.
- [14] A. Rios, J. He, G.N. Glickman, R. Spears, E.D. Schneiderman, A.L. Honeyman. Evaluation of photodynamic therapy using a light-emitting diode lamp against *Enterococcus faecalis* in extracted human teeth. *J Endod.* **2011**. Vol.37. No.6. P.856-859.
- [15] A. Kishen, M. Upadya, G.P. Tegos, M.R. Hamblin. Efflux pump inhibitor potentiates antimicrobial photodynamic inactivation of *Enterococcus faecalis* biofilm. *Photochem Photobiol.* **2010**. Vol.86. No.6. P.1343-1349.
- [16] N.A. Kuznetsova, O.L. Kaliya. Photodynamic disinfection of water. *Chemical Journal.* **2013**. Vol.54. No.2. Iss.1. P.100-109. (russian)
- [17] V.I. Ipatova V.Yu. Prokhodskaya, A.G. Dmitrieva. Investigation of the toxicity of substances - sensitizers of photodynamic disinfection of the aquatic environment in a two-species test system Materials of the international conference "The current state of aquatic biological resources of marine and fresh water ecosystems in Russia: problems and solutions. *Rostov on the Don.* **2010**. P.86-92. (russian)
- [18] V.A. Perkhvanidze, Yu.G. Simakov, N.V. Batkayeva. Comparative analysis of toxicity of methylene blue and proflavine for saprophytic bacteria and photodynamic water disinfection. *General Biology. A Series of Natural and Technical Sciences.* **2017**. No.6. P.3-9. (russian)
- [19] D.A. Makarov. Physicochemical basis of sensitized phthalocyanine and acridine derivatives of photoinactivation of microorganisms in aqueous media. *Abstract. Ph.D. M.* **2012**. 25p. (russian)
- [20] Z.V. Zaporozhtseva, V.A. Podsonny, V.S. Zrodnikov. Method of photodynamic inactivation of bacteria. The patent of the Russian Federation 2316366. publ. **10.02.2008**. (russian)
- [21] N.A. Kuznetsova, L.K. Slivka, G.M. Pleshkov, D.A. Makarov. The method of water disinfection. The patent of the Russian Federation is 2358909. publ. **20.06.2009**. (russian)
- [22] M.D. Mashkovsky. Medicines, in 2 tons *Moscow: New Wave LLC.* **2002**. 608p. (russian)
- [23] Platonov A.E. Statistical analysis in medicine and biology. Tasks, terminology, logic, computer methods. *Moscow: RAMS.* **2000**. 51p. (russian)
- [24] N.M. Strozok, M.G. Perevozkina, G.A. Nikiforov. The relationship between the chemical structure and the inhibitory effect of sterically hindered phenols in the oxidation of methyloleate in a homogeneous and microheterogeneous system. *Izvestiya Akademii Nauk. A series of chemical.* **2005**. No.2. P.323-328. (russian)
- [25] N.M. Storozhok, N.P. Medyanik, A.P. Krysin, A.P. Pozdnyakov, S.A. Krekov Interrelation of the chemical structure and antioxidant properties of *N*-substituted amides of salicylic acid. *Kinetics and Catalysis.* **2012**. Vol.53. No.2. P.170-180. (russian)