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Photodynamic inactivation of Microorganisms by Reactive Oxygen Species

Today the increasing resistance of bacteria against antibiotics is one of the most important clinical challenges. Beside the investigation and development of new drugs, it is necessary to focus also on alternative antibacterial approaches like antimicrobial photodynamic therapy (PDT). In the photodynamic process, visible light is absorbed in a harmless dye molecule (photosensitizer), which transfers the absorbed light energy mainly to adjacent oxygen molecules generating highly reactive oxygen species (ROS). Singlet oxygen is the most frequent generated species that can be directly measured by its luminescence in vitro. In case the photosensitizer is a cationic molecule, it can attach to the negatively charged surface of microorganisms. Then, ROS are generated directly at the bacterial cell wall upon light irradiation. The bacteria are killed via oxidative damage and killing efficacy is almost independent on the organisms and their antibiotic resistance pattern. Due to the simple oxidative mechanisms, the development of resistances against antimicrobial PDT is very unlikely. In another approach, the photodynamical produced ROS can be permanently applied on surfaces to kill bacteria which settle down on such a surface. In collaboration with the Department of Dermatology at the University Hospital of Regensburg we investigated several new photosensitizers which had been synthesized in the Department of Organic Chemistry of our University. We especially studied their efficiency against Gram-positive and Gram-negative bacteria under the influence of different cations and anions which are usually present on a natural skin. We developed a standardized protocol for the investigations and the presentation of the results. The outcomes are not only highly important for clinical applications but also for a principle understanding of the corresponding reactions inside the cells.