ANTIMICROBIAL PHOTODYNAMIC THERAPY AGAINST CLINICAL STRAINS OF STAPHYLOCOCCI WITH THE USE OF ORGANIC LIGHT-EMITTING DIODE

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THE DEFINITION AND NEED OF ANTIMICRIOBIAL PHOTODYNAMIC THERAPY

DEFINITION[1]

Antimicriobial photodynamic therapy (in short APDT) like other photodynamics therapies independently on the target (bacteria, virus, fungi) basis on three elements: light, photosensithzer and oxygen. A chemical compound, so called **photosensitizers,** undergoes activation via absorption of light at a specific length resulting in the generation of reactive oxygen species (ROS) consider as a main cidal agent. The energy transfers during photochemical reactions are usually presented in the Jablonski diagram. →

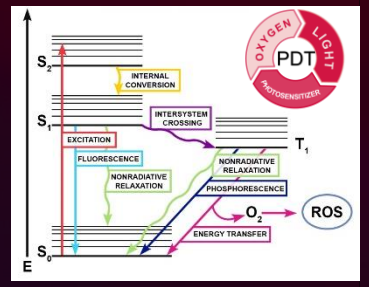

Fig. 1 Modified Jablonski diagram, the distribution of energy during photodynamic reactions.

NEED OF APDT[2,3]

ANTIMICROBIAL RESISTANCE & ANTIBIOTIC RESISTANCE
pose a great threat to public health and food security consuming huge financial outlays and resulting in thousands of deaths annually.

HEALTH-CARE ASSOCIATED INFECTIONS
affecting an average of eight percent of hospitalized patients. One of the major pathogens is here *Staphylococcus aureus*.

OPORTUNISTIC PATHOGENS INFECTIONS
pose a special threat for people with immunodeficiency disorders and immunosuppressed.

ORGANIC LIGHT-EMITTING DIODE AS A LIGHT SOURCE IN APDT[4]

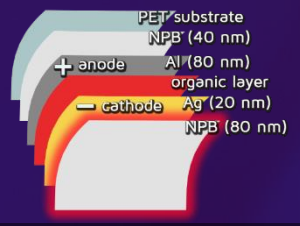

Fig. 2 The structure of red light emmiting OLED

As a light source in photodynamic therapy at all dominate lasers, LEDs, and lamps. In our research, we have chosen the organic light-emitting diode was used as a source of light energy. Its crucial component is Bis(2-methyldibenzo[f,h]quinoxaline)(acetylacetonate) iridium(III) [Ir(MDQ)2(acac)] in N,N'-Bis(naphthalen-1-yl)-N,N'-bis(phenyl)-benzidine (NPB) layer used as an emitting material. The device is characterized by surface-illumination nature and size-manipulable area. The whole device may be immobilized on the PET layer, the second one makes OLED highly flexible. The light irradiance was 5 mW/cm².

RESULTS

10 clinical STRAINS *Staphylococcus* ssp.

Irradiation PARAMETERS

- 3 HOURS
  OLED EXPOSITION
  54 J/cm²
- PHOTOSENSITIZER
  METHYLENE BLUE
  5 µg/mL
- 3 biological replicates
  9 technical replicates

All investigated *Staphylococcus* ssp. strains were obtained from medical specimens. Twelve species were isolated among which two (*S. aureus* and *S. caprae*) appeared twice in non-related samples. In the end, ten *staphs* strains were collected. The results of photoinactivation are presented in Figure 3 →
Beyond the APDT effect (blue empty bars; APDT), the influence of methylene blue in the dark was also examined (gray bras; MB). The basis of comparison was the non-treated control group (red bars; C).

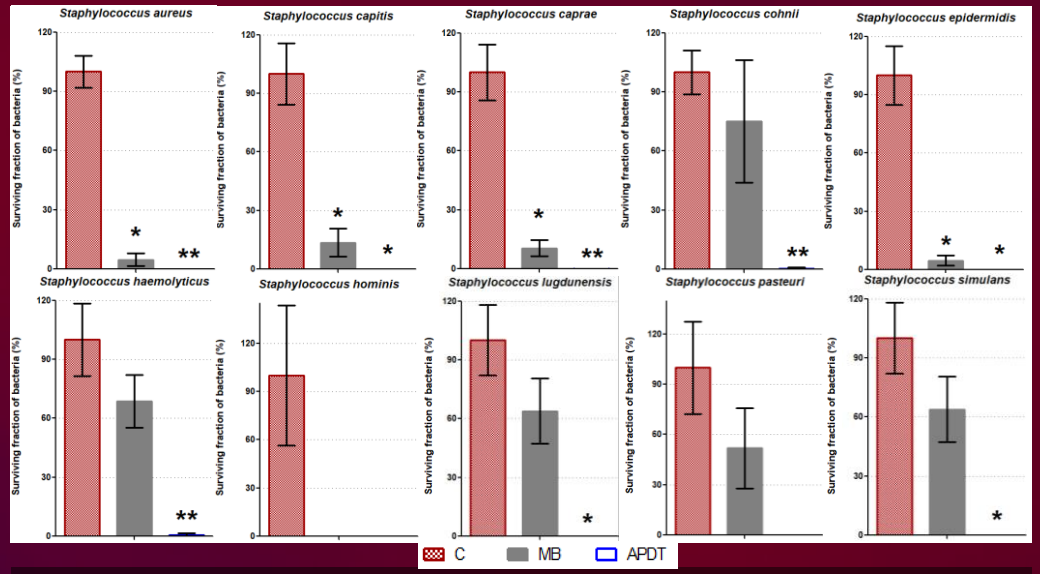

Fig. 3 The effect of antibiotic against Staphylococcus spp. clinical isolates presented as a percent of a surviving fraction of bacteria in comparison to control represenetd by the red bars, where 100% bacteria survived.

CONCLUSIONS

Antimicrobial photodynamic therapy showed high efficiency in the reduction of all clinical isolates of *Staphylococcus* ssp. causing at least a 99% decrease in bacteria fraction in compariconto the non-treated group. The toxic effect of non-photoactivated methylene blue is observed for all bacteria but the reduction is here always much lower than in the case of APDT. Interestingly APDT shows diverse effect which seems to be dependent on the strain of *Staphylococcus* ssp. . The highest reductions were obtained for *Staphylococcus hominins* (99,999999999% reduction of bacteria fraction). The lower sensitivity for APDT shown *Staphylococcus haemolyticus* with a reduction equal to 99.4%. The slight differences in bacterial cell wall structures are considered to play a crucial role in the photosensitizer affinity and its ability to penetration which is probably directly connected with ROS action and APDT effect.

REFERENCES:
1. Wilson Brian, Patterson Michael, The physics, biophysics and technology of photodynamic therapy, Physics in Medicine and Biology 2008 53 (9), 61-109.
2. WHO | WHO's first global report on antibiotic resistance reveals serious, worldwide threat to public health. WHO (2014).
3. B. A. Lipsky, A. R. Berendt, P. B. Cornia, J. C. Pile, E. J. G. Peters, D. G. Armstrong, H. G. Deery, J. M. Embil, W. S Joseph, A. W. Karchmer, M. S.Pinzur, E. Senneville, Clinical Infectious Diseases, 2012, 54, 132-173C.
4. Lian, M. Piksa, K. Yoshida, S. Persheyev, K. J. Pawlik, K. Matczyszyn and I. D. W. Samuel, npj Flexible Electronics, 2019, 3, 1-6.