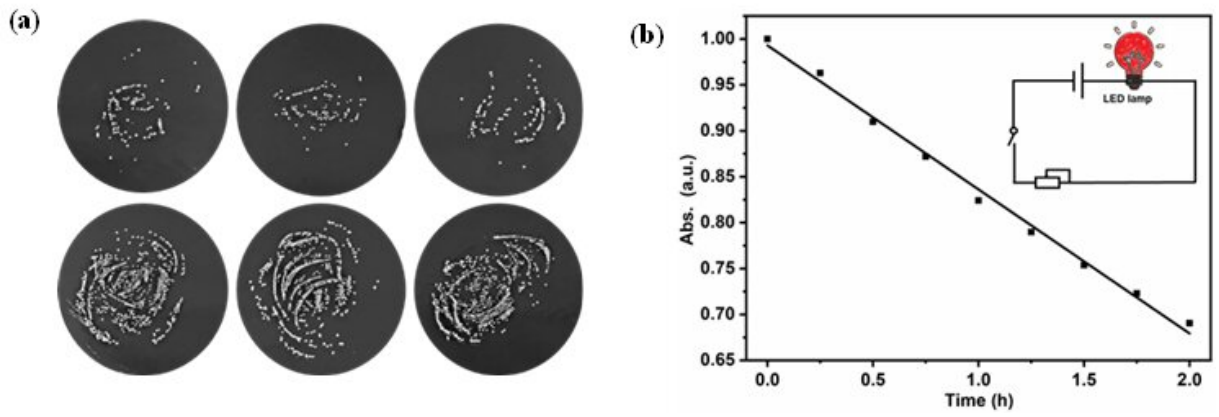
Film photosensitizer: Highly efficient singlet oxygen generation

April 8 2020



(a) Photos of colony-forming units (CFU) for S. aureus incubated on LW-PBI-based films under white light irradiation (90 mW/cm2, 10 min). (b) Plot of absorbance recorded at 291 nm of the UA solution in PBS buffer versus time using a home-made conceptual device. Inset: A schematic representation of the proof-of-concept device. Credit: ©Science China Press

Photosensitized generation of singlet oxygen has attracted a great deal of interest reaching applications in various fields owing to its high biological activity and strong oxidation, including organic synthesis, wastewater treatment, and photodynamic therapy (PDT). Although singlet oxygen can be produced in a variety of ways, triplet state energy transfer from some organic molecules under light illuminations is one of the most efficient and controllable way to produce the active oxygen

species, where the organics are called photosensitizers.

Therefore, the performance of photosensitizers plays a vital role in the production and application of singlet oxygen. Till now, coordinated compounds based on polypyrrole are the most commonly used and studied photosensitizers. However, these photosensitizers are usually used in solution or suspension state, and hardly used in solid state. In addition, they also suffer from low photochemical stability and low absorption efficiency of visible light, which may further limit their practical applications. Therefore, developing high performance, solid state usable photosensitizers of molecular oxygen still remains a challenge.

In the past two decades, the Fang group from Shaanxi Normal University has been devoted to the creation of fluorescence sensitive film materials and the relevant film devices. A series of fluorescent films have been created and applied to sensor/detector developments. In this work, they developed a unique film-based photosensitizer, where a nonplanar spirofluorene-containing perylene bisimide (PBI) derivative was synthesized and used as the active layer.

Photophysical properties and singlet oxygen production performance demonstrated that the ACQ effect is effectively avoided due to the intentionally introduced steric effect, leading to ideal fluorescence emission in solid state. The film also shows great photochemical stability and high absorption efficiency in the visible light region, laying the foundation for them to be used in solid state. Meanwhile, the film depicts great efficiency in light production of singlet oxygen, and thereby may be successfully used in sterilization.

The high performance is partially ascribed to the presence of a richness of molecular channels within the adlayer of the film due to the non-planar structure of the as synthesized fluorophore, which is believed to

be necessary for mass transfer, a pre-requirement for efficient singlet oxygen production.

Compared to routine photosensitizers used in solution or suspension state, the film-based one possesses a number of advantages. It is: (1) reusable, (2) contamination-free, and (3) allows for device-making, which must bring convenience for practical applications. Further studies revealed that the effective photo-production of singlet oxygen can also be realized via utilization of a tiny and low-price LED lamp as a light source and as a film support. The conceptual device is expected to be usable for PDT, water purification, sterilization, antisepsis, etc.

More information: Wenjun Xu et al, A new spirofluorene-based nonplanar PBI-dyad and its utilization in the film-based photo-production of singlet oxygen, *Science China Chemistry* (2020). DOI: 10.1007/s11426-019-9676-y

Provided by Science China Press