Porphyrins as self-destructive photocatalysts

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Introduction

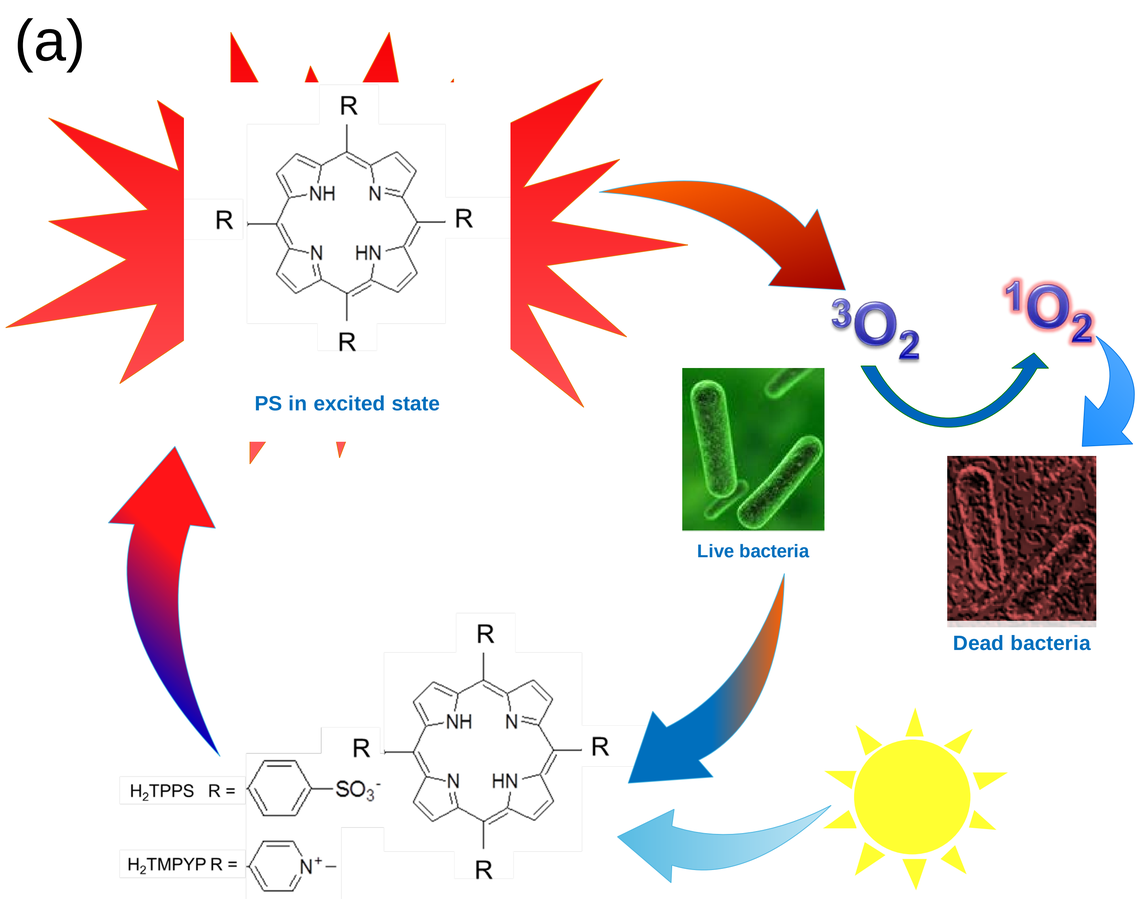
- Microorganisms cause high mortality rates in aquaculture [1].
- Common treatments (antibiotics, vaccination) are inappropriate for use in hatcheries [2].
- Singlet oxygen ($^1O_2$) treatment represents a promising and environmentally sustainable alternative for disinfection in hatcheries [1].
- Porphyrins are non-toxic photocatalysts, generating $^1O_2$ when exposed to visible light [1, 3] (Fig. 1a).

Aim

- This study investigates the "self-destructive" behaviour of two porphyrins in seawater. This desirable feature avoids costly removal of these photocatalysts at the end of the treatment.

Methods

- Cationic[I] (H_2TMPYP) and anionic[II] (H_2TPPS) dyes were dissolved in filtered seawater in concentrations of 200, 20, 2 and 0.2 µM.
- Absorbance wavelength scans showed that 20 µM of either porphyrin gave optimal absorbance peak profiles (Fig 2).
- For photodegradation experiments, 2 mL of 20 µM porphyrin in seawater solution was added to each well of a 24 well plate.
- Well plates were exposed to 8×8W fluorescent tubes (Lower Intensity, (LI), 63.87 µmol*m^{-2}*s^{-1}) or a 150W LED flood light (Higher Intensity, HI, 262.2 µmol*m^{-2}*s^{-1}) for 20 days (Fig. 1b).
- Absorbance was measured daily over a 20 days time course.
- Black and light control were conducted simultaneously.



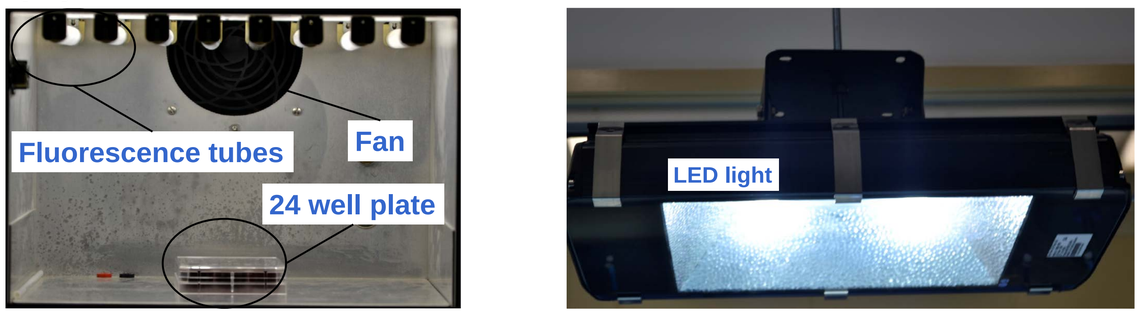


Figure 1: (a) schematic representation of singlet oxygen production by a photosensitiser (PS). (b) light sources: 8×8W cool white fluorescent tubes (left) and 150W cool white LED flood light (right).

[I] 5,10,15,20 - Tetrakis (1-methyl-4-pyridinio) porphyrin tetra (p-toluenesulfonate)

[II] 4,4′,4″,4‴ - (Porphine-5,10,15,20-tetrayl) tetrakis (benzenesulfonic acid) tetrasodium salt hydrate

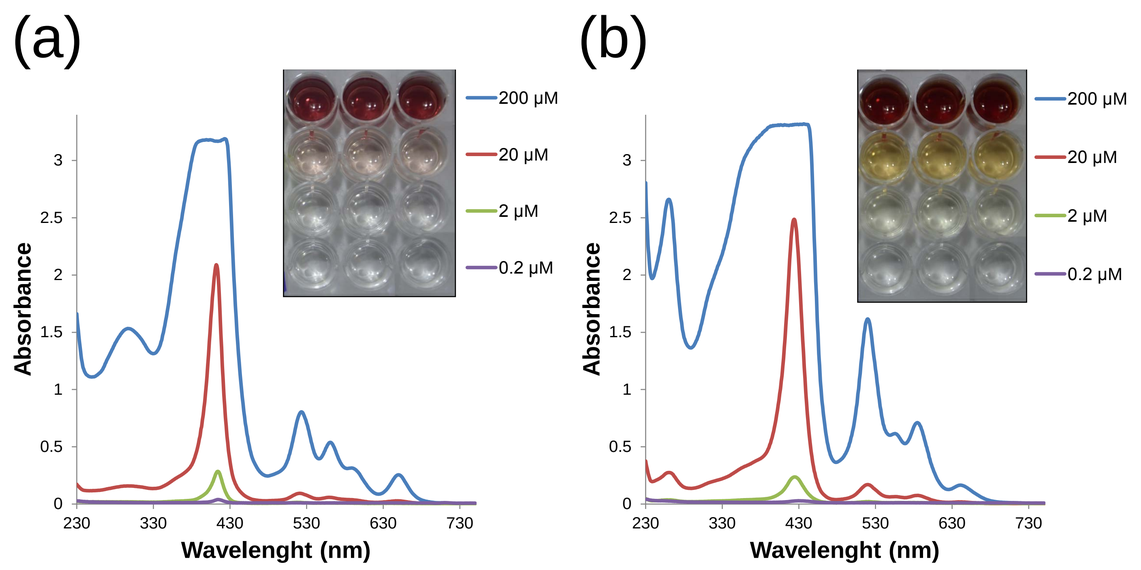


Figure 2: Anionic **(a)** and cationic **(b)** absorbance spectra at different concentrations (~200, 20, 2 and 0.2 µM)

Results

- Time-course experiments revealed complete photodegradation of both porphyrins after 12 and 18 days of exposure to LI (Fig 3a).
- Photodegradations induced by HI showed no measurable UV-Vis absorptions after 2 and 5 days for either porphyrins (Fig. 3b).
- The cationic porphyrin was found more photostable than its anionic counterpart under either irradiation conditions (LI and HI).

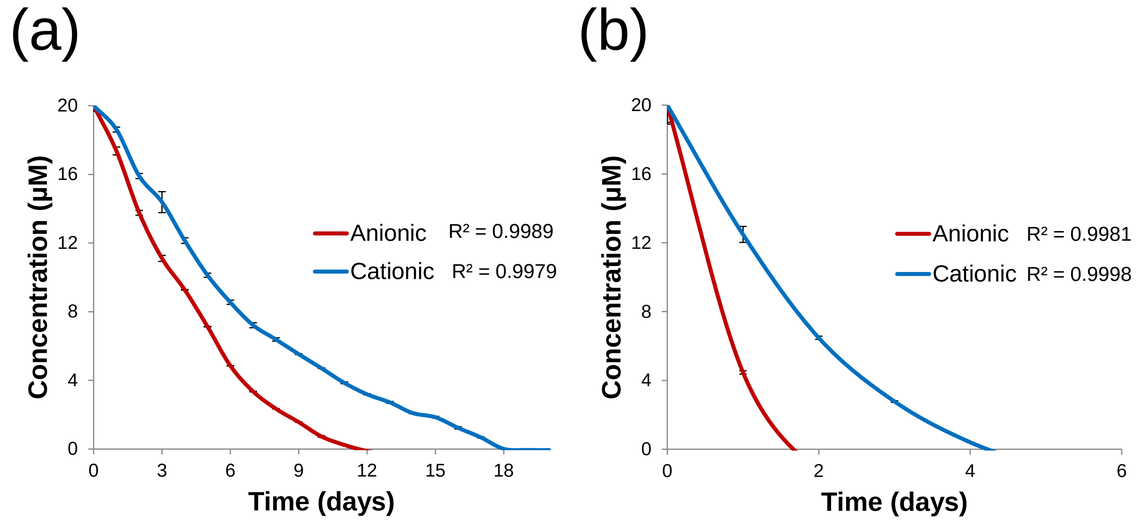


Figure 3: Porphyrins concentration in time course experiment and photo-induced degradation with LI (a) and HI (b) over 20 days. Error bars means Standard Errors (SE). R^2 is based on the Grade 3 polynomial fitting curve.

Discussion

- Previous studies identified a Lowest Observed Effect Concentration (LOEC) of 5µM for both porphyrins to kill bacteria via $^1O_2$ treatment within 2-10 days [4].
- Photobleaching naturally self-destructs these materials, thus avoiding their costly removal at the end of the treatment period.
- Self-destruction processes are slow enough to allow for efficient disinfection.

Conclusion

- Porphyrins are promising materials for disinfection applications.
- The different photostability of the porphyrins allows for time- and task-specific applications with potential treatment windows of 2 to 18 days depending on light conditions.

Acknowledgements

The authors thank James Cook University and AIMS@JCU for their financial support

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