Porphyins as self-destructive photocatalysts

Danilo Malara\textsuperscript{a}, Lone Hoj\textsuperscript{b}, Michael Oelgemöller\textsuperscript{c}, Kirsten Heimann\textsuperscript{a}

\textsuperscript{a}College of Marine and Environmental Sciences, James Cook University, Townsville, QLD 4811, Australia
\textsuperscript{b}Australian Institute of Marine Science (AIMS) PMB 3, Townsville, QLD 4810, Australia
\textsuperscript{c}College of Science, Technology and Engineering, James Cook University, Townsville, QLD 4811, Australia

Email: danilo.malara@my.jcu.edu.au; kirsten.heimann@jcu.edu.au

Introduction

- Microorganisms cause high mortality rates in aquaculture [1].
- Common treatments (antibiotics, vaccination) are inappropriate for use in hatcheries [2].
- Singlet oxygen (\(1\text{O}_2\)) treatment represents a promising and environmentally sustainable alternative for disinfection in hatcheries [1].
- Porphyrins are non-toxic photocatalysts, generating \(1\text{O}_2\) 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\textsuperscript{1} (H\textsubscript{2}TMPYP) and anionic\textsuperscript{2} (H\textsubscript{2}TPPS) dyes were dissolved in filtered seawater in concentrations of 200, 20, 2 and 0.2 \(\mu\text{M}\).
- Absorbance wavelength scans showed that 20 \(\mu\text{M}\) of either porphyrin gave optimal absorbance peak profiles (Fig 2).
- For photodegradation experiments, 2 mL of 20 \(\mu\text{M}\) porphyrin in seawater solution was added to each well of a 24 well plate.
- Well plates were exposed to 8 \(\times\) 8W fluorescent tubes (Lower Intensity, (LI), 63.87 \(\mu\text{mol}\text{m}^{-2}\text{s}^{-1}\)) or a 150W LED flood light (Higher Intensity, HI, 262.2 \(\mu\text{mol}\text{m}^{-2}\text{s}^{-1}\)) for 20 days (Fig. 1b).
- Absorbance was measured daily over a 20 days time course.
- Black and light control were conducted simultaneously.

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).

Discussion

- Previous studies identified a Lowest Observed Effect Concentration (LOEC) of 5\(\mu\text{M}\) for both porphyrins to kill bacteria via \(1\text{O}_2\) treatment depending on light conditions.
- 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.

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References:


![Figure 1](image1.png)

![Figure 2](image2.png)

![Figure 3](image3.png)