Stopping the Red Tide: Mitigation of Karenia Brevis Harmful Algal Blooms

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Harmful Algal Blooms: The Red Tide

The discoloration of the water during the red tide occurs as a result the formation of large blooms of the dinoflagellate Karenia brevis (KB).

- K. brevis releases brevetoxins into the water which can be harmful to the central nervous system of fish and other vertebrates, resulting in large fish-kills1.
- Curcumin is a chemical derived from the Curcuma longa species that has shown potent anti-algal properties against Chattonella marina (phytotoxin producing raphodiphyce flagellate).4
- Curcumin is poorly water soluble (11 ng/mL). Inclusion complex formation with cyclodextrins has been reported as a means to enhance its aqueous solubility.5
- β-Cyclodextrin’s hydrophilic exterior and hydrophobic interior make it a desirable compound to aid in dissolving hydrophobic chemicals.

Characterization of Curcumin-β-Cyclodextrin Inclusion Complexes: UV-VIS Spectroscopy

- β-cyclodextrin does not absorb light in the visible wavelength region.
- Absorption peak in the inclusion complex observed in the range of 300–600 nm is attributed to the absorption peak of curcumin, indicating inclusion complex formation.
- The absorption peak at 420 nm can be used to quantify the curcumin encapsulated in β-cyclodextrin.

Characterization of Curcumin-β-Cyclodextrin Inclusion Complexes: FT-IR Spectroscopy

- Disappearance of Characteristic Curcumin Peaks: Enolic C-O stretch peak at 1283 cm⁻¹ loses intensity, indicating insertion of curcumin into the β-cyclodextrin cavity.4,7,8
- Electron Donor Peak Shifts: Possible hydrogen-bond formation between curcumin and β-cyclodextrin cavity electron donor (hydroxyl) groups shifts β-cyclodextrin peaks to lower wavenumbers.

Harmful Algal Bloom Mitigation Using Curcumin-β-Cyclodextrin Inclusion Complex

- The anti-algal properties of curcumin-β-cyclodextrin inclusion complex were tested against K. brevis over time.
- Compared to β-cyclodextrin control, viability of K. brevis cells decreased over time in the presence of inclusion complex.

Conclusions

- Encapsulation of curcumin in β-cyclodextrin was achieved and characterized through UV-VIS spectroscopy and FT-IR spectroscopy.
- Curcumin-β-cyclodextrin inclusion complex displayed anti-algal properties against K. brevis compared to β-cyclodextrin control.

Future Work: Algal Bloom Flocculation Using Environmentally Benign Halloysite Nanotubes

- Halloysite is an environmentally benign clay mineral with a tubular morphology that has allowed it to previously be used for controlled release of pharmaceuticals and oil spill dispersants.10,11
- Flocculation of algae cells with clay is a well-researched method of algal bloom mitigation.24
- Curcumin–β-cyclodextrin will be loaded into halloysite nanotubes (HNTs).
- Algaecide-loaded HNTs increase local concentrations of curcumin-β-cyclodextrin to flocculate.
- Targeted algaecide delivery system for release to harmful algal bloom to be explored.

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Objectives

Demonstrate the anti-algal properties of curcumin in β-cyclodextrin against K. brevis.
- Encapsulate curcumin in β-cyclodextrin to form inclusion complex.
- Characterize curcumin-β-cyclodextrin inclusion complex.
- Investigate the anti-algal properties of curcumin-β-cyclodextrin inclusion complex against K. brevis