Stopping the Red Tide: Mitigation of *Karenia brevis* Harmful Algal Blooms

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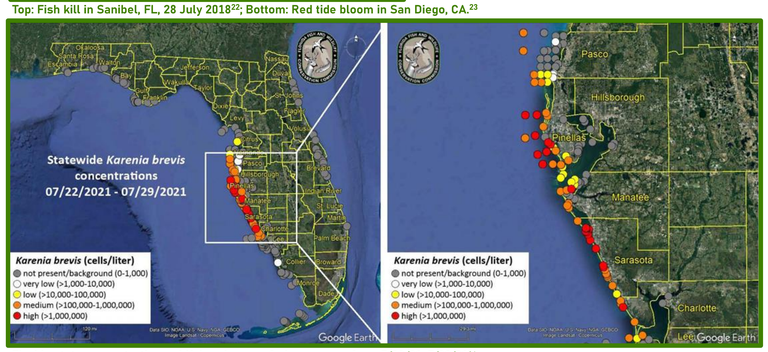
SMART SUMMER MATERIALS RESEARCH @ TULANE

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)***.

Top: Fish kill in Sanibel, FL, 28 July 2018[22]; Bottom: Red tide bloom in San Diego, CA.[23]



Florida state concentrations of *K. brevis* as an 8-day average from 7/22/21-7/29/21[21]

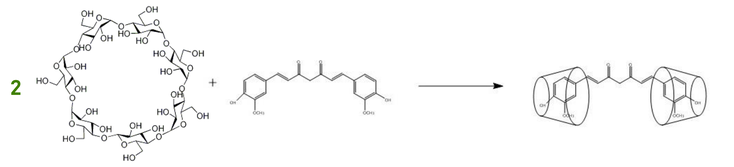
- *K. brevis* releases brevetoxins into the water which can be harmful to the central nervous system of fish and other vertebrates, resulting in large fish-kills[1].
- **Curcumin** is a chemical derived from the *Curcuma longa* species that has shown potent anti-algal properties against *Chattonella marina* (phytotoxin producing raphidophycea 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.

Sharks swim to refuge from red tide in Florida's Longboat Key Canals, 2 August 2021[25]

Objectives

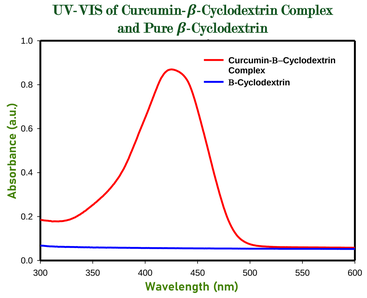
Demonstrate the anti-algal preparties of curcumin in β-cyclodextrin against *K. brevis*.

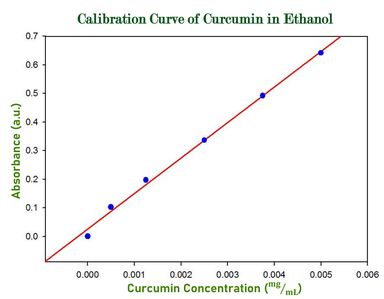
- Encapsulate curcumin in β-cyclodextrin to form inclusion complex.
- Characterize curcumin-β-cyclodextrin inclusion complex
- Investigate the anti-algal properties of curcumin-β-cyclodextrin inclusion complex against *K. brevis*



β-Cyclodextrin Curcumin Curcumin-β-Cyclodextrin Complex

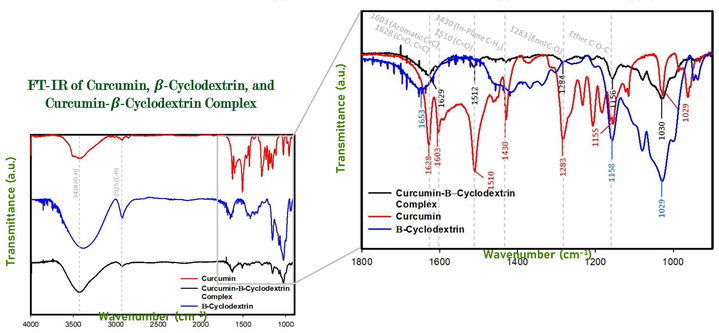
Characterization of Curcumin-β-Cyclodextrin Inclusion Complexes: UV-VIS Spectroscopy





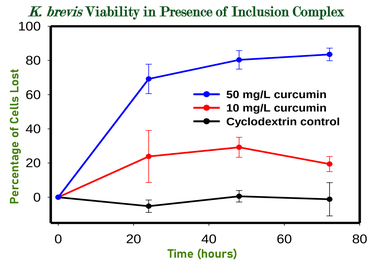
- β-cyclodextrin does not absorb light in the visible wavelength region.
- Absorption peak in the inclusion complex observed in the range of 300–600 nm is attributed to the absorption peak of curcumin, indicating inclusion complex formation
- The absorption peak at 420nm can be used to quantify the curcumin 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 1283cm^{-1} loses intensity, indicating insertion of curcumin into the β-cyclodextrin cavity. [6,7,8]
- 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.[9]

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

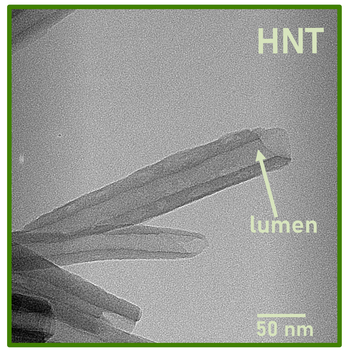


- The anti-algal properties of curcumin-β-cyclodextrin inclusion complex were tested against *K. brevis* over time.
- Compared to β-cyclodextrin control, viability of *K. brevis* cells decreased over time in the presence of inclusion complex.

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

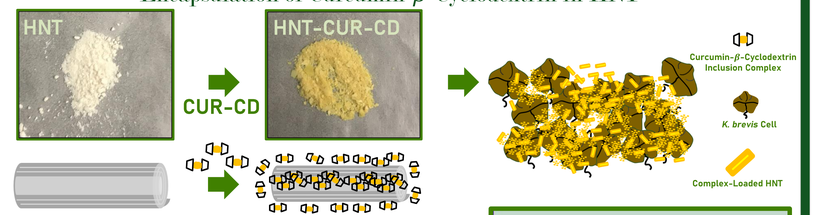
Future Work: Algal Bloom Flocculation Using Environmentally Benign Halloysite Nanotubes



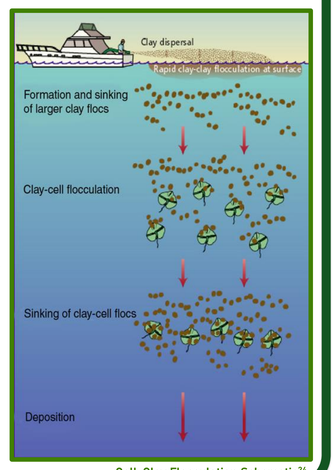
Morphology of HNT

- **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]

Encapsulation of Curcumin-β-Cyclodextrin in HNT



- 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 floc.
- Targeted algaecide delivery system for release to harmful algal bloom to be explored



Cell-Clay Flocculation Schematic[24]

Acknowledgements and References

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