Drug Delivery Applications of Carbon Dioxide Responsive Hydrogels

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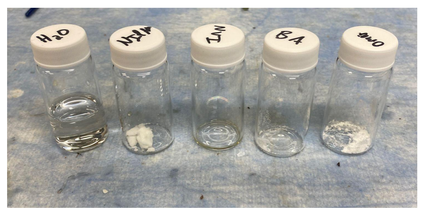
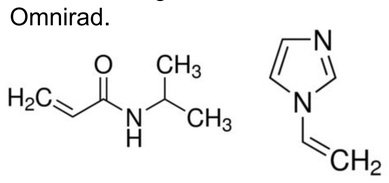
Abstract

Stimuli-responsive hydrogels are polymers that swell in the presence of water and alter their properties based on environmental conditions. Hydrogel applications utilize this ability to encapsulate and release a drug on command. In this study, we used a NIPAM-co-VI polymer to create a hydrogel that responds independently to temperature and CO_2. By sparging (bubbling gas through) hydrogels with CO_2, we are able to increase the rate and final amount of drug release from a hydrogel.

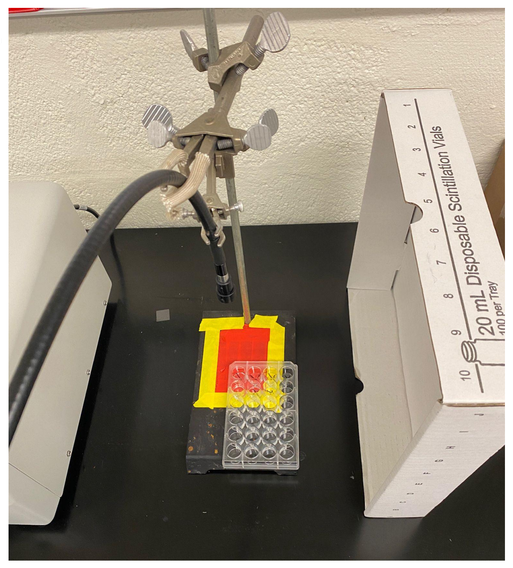
Hydrogel Synthesis



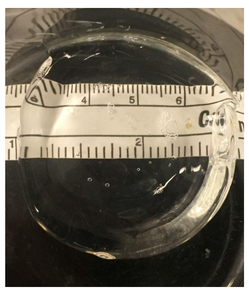
From left to right: DI, NIPAM, VI, BA, Omnirad.



When these chemicals are combined and cured under a UV light, they form a polymer that changes from hydrophilic to hydrophobic at its LCST (45ºC). Sparging with CO_2 activates the VI which decreases the surface tension of the gel. This allows it to absorb more water and expand to more than twice its size in its hydrated state.



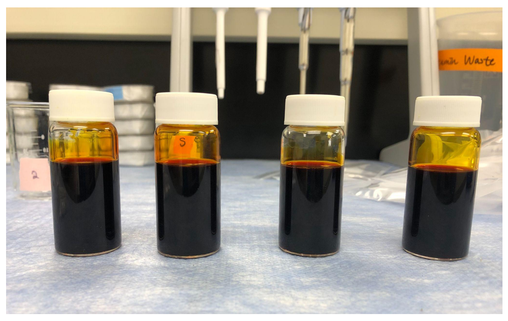
Gels positioned to be cured under UV light.



Hydrogel sparged with CO_2 in water.

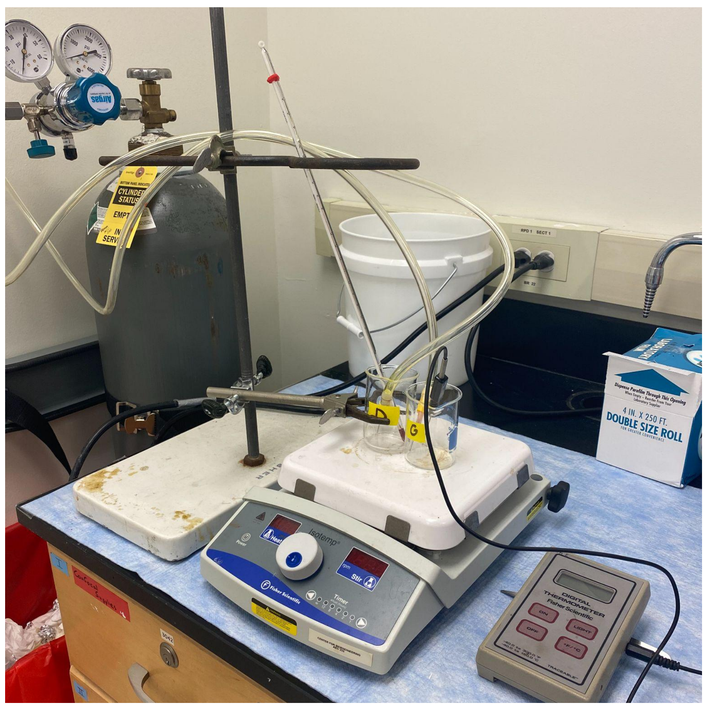
Dried hydrogel, ~1cm in diameter.

Methods



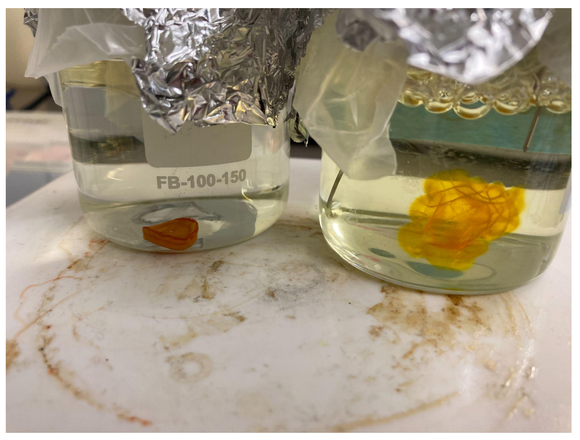
Gels were loaded in a PEG/PBS curcumin solution. PEG was used to dissolve the curcumin due to curcumin's high solubility in PEG, and PBS was used to make the otherwise hydrophobic solution more readily absorbed by the hydrophilic gel.

The sparging setup for two gels is shown on the right. Beakers are kept at the LCST (~45ºC) under careful observation using a hot plate, a temperature probe, a thermometer. The CO_2 is sparged using hoses with needles. The beakers are covered with aluminum foil to prevent evaporation and splashing. At set intervals, the gels are weighed to assess swelling and the release sink is measured to determine curcumin release.



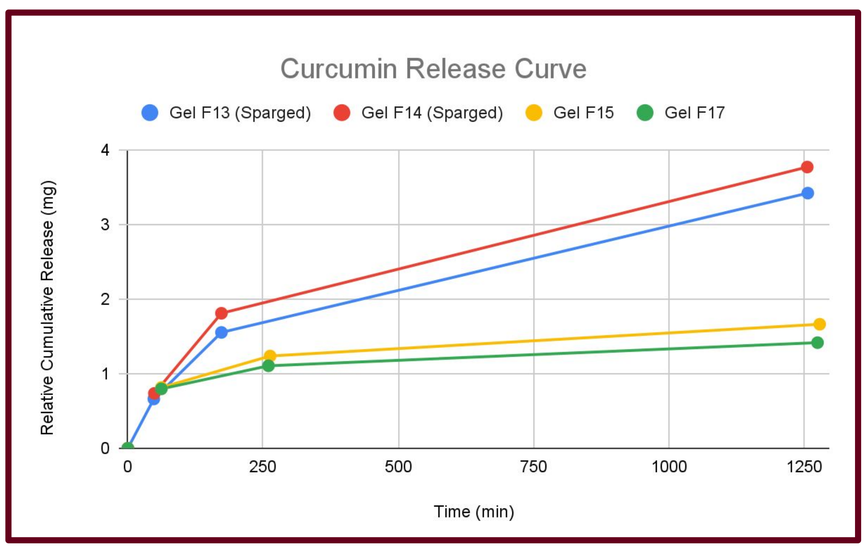
Curcumin release was calculated by taking the absorbance of the dyed water in the sink after each trial at curcumin's peak wavelength. This effectively gives us a metric of "orangeness".

Results



Unsparged (left beaker) and sparged (right beaker) curcumin-loaded hydrogels. Note how the sparged gel exhibits far more swelling -- this is because the CO_2 raises the LCST of the gel, causing it to become hydrophilic and take on water. Subsequently, more curcumin is released. This is evident from the orange coloration of the sink, which we are able to quantify with an absorbance reader (see release curve below).

During a 45°C release trial, the CO_2 sparged gels released significantly more curcumin than unsparged gels. This supports the use of CO_2 responsive hydrogels for drug delivery applications.



References

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Acknowledgements

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