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 CO₂. By sparging (bubbling gas through) hydrogels with CO₂, we are able to increase the rate and final amount of drug release from a hydrogel.

Methods

The standard curve to the left represents curcumin in water. However, due to curcumin’s low aqueous solubility, we loaded our gels in the PEG/PBS solution above. Gels were released in DI water. Thus, the standard curve was not used in the final calculations, and volume - adjusted absorbance readings were instead used to obtain the relative release profile in the section below. While absolute measurements are not required for our research, further work in this area would allow us to assess the difference in final percent of loaded curcumin release in sparged versus unsparged gels.

Results

During a 45°C release trial, the CO₂ sparged gels released significantly more curcumin than unsparged gels. The mass of the cumulative release was determined by recorded absorption values and volumes of each sink by a cumulative standard curve. The slope of the standard curve relates absorbance values with concentration, so the mass of curcumin release in each sink can be calculated with the final sink volume.

Hydrogel Synthesis

Materials
- Deionized Water
- Poly(N-isopropylacrylamide)
- 1-Vinylimidazole
- Methylene(bis)acrylamide
- Omnirad 2959

Combining and curing under a UV light, causes the gel to change from hydrophilic to hydrophobic at its LCST. Sparging with CO₂ causes the gel to swell, allowing it to absorb more water and expanding its hydrated state.

Applications

Optimization of drug release is promising for a number of hydrogel-related applications. For example, water bath treatment for diabetic foot ulcers, and water treatment for the removal of toxic dyes. Foot ulcers are non-healing wounds that appear chronically, especially with diabetic patients. Frangez et. al. also cites in their research that VEGF (vascular endothelial growth factor) is effective at stimulating angiogenesis. It is possible that VEGF release at the wound site using hydrogel encapsulation may complement the CO₂ bath treatment. A second potential application utilizes the capability of NIPAM-co-VI hydrogels to absorb toxic dyes from water. Garg et. al. synthesized hydrogels that were able to selectively absorb dyes such as methyl orange and methyl violet, implicating their use in wastewater treatment plants. The gels absorbed dye well, and upon release and redrying demonstrated their ability to function over multiple trials. This is similar to the reusability found by Garg et. al. with their gels, thus it is possible NIPAM-co-VI gels could provide a similar functionality with an alternate material.

References


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