Injectable Microporous Alginate Nano/micro Composites: Controlling Gelation Kinetics and Functional Properties

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In situ-gelling materials have many advantages for therapeutic and sensing applications due to their minimally invasive nature. Control of gelation kinetics and physical properties of the gels are paramount to the function of the gels in various application sites in vivo. Here, we show how internal gelation kinetics of microporous alginate hydrogel composites (MPACs) can be controlled in a facile manner through polyelectrolyte multilayer (PEM) deposition and relative concentrations of CaCO$_3$ used in fabrication. Increasing the diffusional barrier on the CaCO$_3$ particles by increasing numbers of layers of polyelectrolytes increases the gelation time of the composite by up to 600 percent. Changes in particle concentration used in the fabrication also strongly influences the gelation time, inducing increases of up to 500 percent. Furthermore, the use of carbonate-templated capsules in this system serves a dual purpose of allowing for the formation of functional microdomains within the hydrogel that can house a variety of encapsulants including nanoparticles, macromolecules, proteins, etc, which can be used for therapeutics or diagnostic purposes.

In Vivo Molecular Contrast OCT Imaging of Methylene Blue in a Zebrafish Embryo

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Optical coherence tomography (OCT) is a rapidly developing medical imaging technique that obtains tomographic images with micron scale resolution in three dimensions and high speeds. The addition of molecular contrast to the available morphological information holds great promise for extending OCT’s impact in clinical practice and beyond. However, fundamental limitations prevent OCT from directly taking advantage of powerful molecular processes such as fluorescence emission and Raman scattering. In order to overcome these limitations, standard OCT can be hybridized with spectroscopic techniques. Pump-probe absorption spectroscopy is a well-known and well-established technique used to measure molecular dynamics. Pump-probe absorption spectroscopy detects the molecular energy level change in absorption of one light field (probe) induced by molecular excitation from a second light field (pump). Pump-probe absorption spectroscopy is compatible with OCT and can serve to provide molecular contrast. We have developed a Pump-Probe OCT (PPOCT) system that integrates a 663 nm diode pump laser into a typical 830 nm spectral-domain OCT system. This has enabled in vivo PPOCT imaging using the FDA approved dye/drug methylene blue (MB). A zebrafish embryo was immersed in a 0.01 percent solution of MB for six hours. Volumetric PPOCT images show accumulation of MB in the pronephric ducts, which is the primodial filtration organ. Molecular contrast in OCT images from an FDA approved dye such as MB could find use both as a research tool and clinically to enhance the contrast of OCT images.