Abstract

Hydrogels, as a complex fluid with evolving microstructure have unique applications in the areas ranging from tissue scaffolds to large volume sealants in geo-formations. This research deals with the formation of hydrogel layer with additional porosity induced by gas bubbles.

Nitrogen gas was bubbled in alginate using a fluidic arrangement to generate uniform and self-aligned bubbles in a monolayer on a petridish. The average diameter of bubbles was 500 μm prior to the cross-linking by $CaCl_2$. The cross-linked gel was dried in a vacuum oven at a constant temperature, and subsequently, soaked in Vitamin B_{12} solution. The image of the alginate film prior to crosslinking was acquired under digital microscope. The dimensions of the voids immediately after complete drying were obtained using a scanning electron microscope. The porosity of the gel was measured gravimetrically and volumetrically. The release of Vitamin B_{12} in brine solution on a shaker was studied. For comparison, the experiment was repeated with a scaffold that did not have any embedded void. The enhancements in uptake and release of Vitamin B_{12} due to the presence of voids are estimated.

The porous hydrogel structure with voids was also formed in thin layer, confined between two parallel plates. The foam gel prepared from polyacrylamide and N_2 gas was placed in its fluid state in the channel. A shut-in period allows the formulation to mature to its gel-state. The surfactant and the polymer in the aqueous phase helped in stabilizing the bubbles till the cross-linked network became immobile. A laser-based imaging device was used to track the changes in the bubbles at various stages of the experiment. The pressure differential along the channel was monitored. The formation of mono-dispersed bubbles and their self-alignment was observed on a petri-dish. In a sub-millimeter channel, some gravity drainage was observed after placement of completely immature gel. This can be avoided by some prior crosslinking of the formulation. The foam gel underwent a rupture at a threshold pressure for various injected fluids, e.g. water, nitrogen and carbon dioxide, followed by a hindered flow that is quantified here. Injected water travelled through the aqueous phase of the gel, where as the injected gas flowed through temporary interconnections of bubbles.

Keywords: Alginate, scaffolds, uptake and release, polyacrylamide, foam gel.