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SC 320- Science Seminar III

February 12, 2014

Implementation of tetra-poly(ethylene glycol) hydrogel with high mechanical strength into microfluidic device technology

**Abstract:**

With the emergence of the polymeric substrates (Ocvirk), microfluidic technologies advanced substantially primarily due to cost effectiveness, compared to prior electrophoretic practices via glass chips. One of many reasons why Ocvirk and co-workers were successful with their newly developed poly(dimethylsiloxane) (PDMS) chip is because of its softness and deformity at room temperature. Softness is capable of resembling certain functions including valves and pumps, unlike harder plastics. But with further research, there will be more opportunities arising, more specifically, the newly introduced hydrogel polymer (Takehara). With characteristics such as inertness, permeability, and softness, hydrogel polymers are widely considered for biomedical applications, thus promoting further growth in microfluidic devices.

However, what may seem theoretically sound can actually be quite the cumbersome process. Moreover, there are some setbacks that hinder integrating hydrogels into microfluidic devices. Due to insufficient mechanical strength, hydrogels have a remarkably high water content and low surface friction bonding methods, limited fabrication and designing of the chip arise. Though this may seem as a barrier to the hydrogel endeavor, fortunately enough, the synthesis of tetra-poly(ethylene glycol) (tetra-PEG) overcame bonding-relating issues by providing chemically linked networks in the gel. Implementing an infused hydrogel and tetra-PEG gel is the essential topic of this study. Using the hydrogel reactive microbonding (HRMB) method—that is, interfacing the tetra-PEG sheet to link by chemical bonds and anchoring of macromonomers as the PDMS surface is only linked via chemical bonds—the formation of the bond between these two gels is what will be discussed as well as its success for furthering integrated microfluidic devices (Takehara).

Through experimentation, the bonding process caused problems such as microchannel clogging and dead volume, but was solved using a line-and-space pattern design in the microchannels. To test the properties of the tetra-PEG sheets as well as the strength of the bond between the PDMS and tetra-PEG sheets, applying pressure into the microfluidic device was conducted, known as the bulge test (Takehara). Furthermore, because continuous flow induces stimulation of cells, the chemical concentration modulation via hydrogels overcomes problems such as the pressure-driven flow known as the laminar effect—highly noted in prior experiments. On the basis of predicted mass transfer of solutes, in principle, chemical concentration modulation can be controlled. Because the tetra-PEG gel is not toxic to cells, it will open new doors for future experiments: studies such as monitoring the response of growing cells in variation of chemical concentrations by growing cells and allowing the chemicals to pass through from the cells to the detector and vice versa. The techniques conducted in this study provide essential methods that will allow future development of microfluidic devices for other natural science fields (Takehara).

Work Cited

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