The Effect of Network Properties on the Antifouling Properties of Amphiphilic Crosslinked Networks

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Statement of Purpose: Biofouling is a worldwide problem in marine systems and medical devices. Marine biofouling reduces the speed of ships, which carries economic implications by increasing fuel consumption and maintenance costs[1]. Biofouling in medical implants can modify the surface properties, which will alter the performance of the device and lead to failure[2]. Medical devices failure will not only affect the patient physically and emotionally but will also increase healthcare costs[3]. Hydrogels are widely used as antimicrobial coating due to their foul-resistant properties towards proteins and bacteria[4]. Common applications include contact lenses[5], catheters[6] and cardiovascular implants[7]. The strong interaction of the hydrogel surface layer with the water molecules inhibits adsorption of biomolecules and consequently cell attachment. Research on amphiphilic coatings has gain popularity recently due to surface ambiguity, which confuses and inhibits different protein adhesion mechanisms with the different chemical functionalities[8]. The incorporation of fluorinated groups into a hydrogel network will promote the amphiphilic character and in turn, increase the potential for antifouling coatings. Fluorinated polyurethanes demonstrated anti-fouling and fouling release properties as well mechanical stability[9]. Amphiphilic polyurethane coatings with tunable network properties were fabricated to target a greater range of organisms using environmentally friendly synthesis methods.

Methods: Epoxypropoxypropyl-terminated polydimethylsiloxane, PDMS, 5-Amino-1,3,3 trimethylcyclohexane methylamine, 3-(Acryloyloxy)-2-hydroxypropyl methacrylate were used to synthesize the crosslinker, non-isocyante urethane dimethacrylate (NIU-DMA). Amphiphilic hydrogels composed of 2-hydroxyethyl methacrylate (HEMA), hexafluorobutyl methacrylate (HFBMA) and NIU-DMA were copolymerized using ultraviolet (UV) light and Irgacure 651 as the photo-initiator, using different molar percentages of HFBMA and NIU-DMA. ^{1}H NMR and FTIR-ATR were used to monitor the synthesis of the crosslinker, NIU-DMA. The equilibrium water content *EWC* was calculated for all hydrogel compositions as an indication of the porosity of the gels. Tensile tests were conducted in the swollen state at room temperature to obtain the elastic modulus, tensile stress and strain at break. NIH3T3 mouse fibroblast attachment was investigated and with collaboration of Dr. Finlay from New Castle University, UK. *Ulva linza* attachment is being studied.

Results: The percent conversion of the NIU-DMA synthesis was greater than 82% in all steps and yields of no less than 83% were obtained. Tensile tests confirmed that the elastic modulus of these compositions is not statistically significant, however mechanical properties like the tensile stress and strain at break did change as the molar percent of NIU-DMA changed (Fig. 1). Modulus values range from 8 to 11 MPa and the EWC from 19 to 22-weight %. Preliminary DAPI staining results indicated a reduction of NIH3T3 mouse fibroblast attachment to the hydrogels compared to the glass coverslip control (Fig. 2).

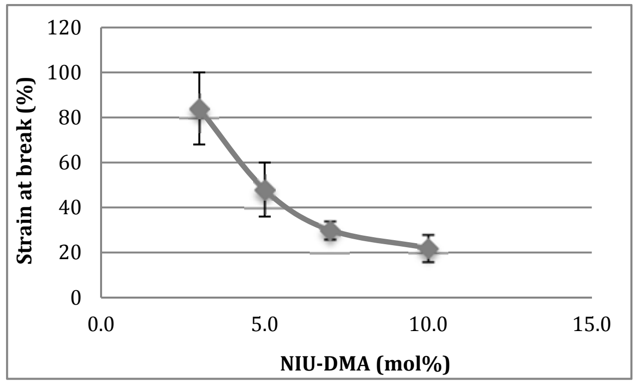

Figure 1. Strain at break decreases as the NIU-DMA molar % increases.

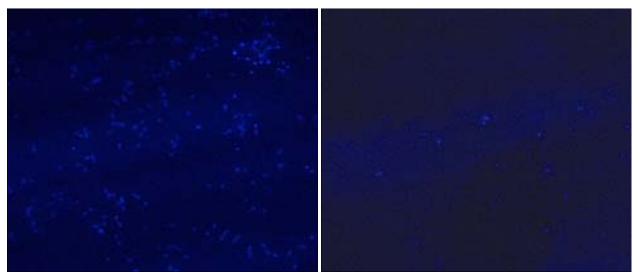

Figure 2. NIH3T3 cells were incubated for 24h on glass coverslip (left) and hydrogel with lowest mol % of HFBMA (right). Nuclei were stained blue with 4′,6′-diamidino-2-phenylindole dihydrochloride (DAPI).

Conclusions: The crosslink molar ratio influenced the mechanical properties of the network, which influences the mobility of the network. The change of network properties will influence the organisms' behavior and therefore affect their attachment to the surface. A reduction of NIH 3T3 fibroblast attachment to the hydrogels was seen in preliminary results. On going work is being done to test the effect of Ulva spores to these surfaces. Future work will focus in the surface properties of the crosslinked networks.

References:

1. Champ, M. A. *Mar. Poll. Bull.* 1999, *38* (4), 239–246.
2. Costerton, J. *Science* 1999, *284* (5418), 1318-1322.
3. Peleg, A. Y. *New Eng. J. Med.* 2010, *362* (19), 1804-1813.
4. Perrault, J. J. US6039940 A: 2000.
5. Kopecek, J. *J. Pol. Sci. Part A: Polymer Chemistry* 2009, *47* (22), 5929-5946.
6. Knudson, M. B. US5628730 A: 1997.
7. Mehta, B. US5258042 A: 1993.
8. Wang, Y. *J. Bioadh. Biofilm Res.* 2011, *27* (10), 1139-1150.
9. Brady, R. F. J. Robust nontoxic antifouling elastomers. 2003.