Switchable Coatings

Dynamic Surface Topographies in Polymer Hydrogel Networks

Sander Kommeren, Cees W.M. Bastiaansen

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Introduction

Marine biofouling, the unwanted colonization of marine organisms on surfaces immersed in seawater has a huge economic and environmental impact in terms of maintenance requirements for marine structures, increased vessel fuel consumption, operating costs, greenhouse gas emissions and spread of non-indigenous species.

Figure 1: Examples of marine biofouling.

Aim

The objective of this research is to investigate switchable hydrogel systems with a surface relief structure which can be used as anti-fouling and/or hydrodynamic drag reducing coatings. For instance, it is expected that switching the surface relief structure with autonomous triggers such as temperature prohibits the adhesion of marine organisms

Thermal Responsive Hydrogels

The hydrogel coatings are based on thermal responsive crosslinked poly(N-Isopropylacrylamide) (PNIPAAm). This crosslinked polymer is able to switch its surface relief Below the LCST the PNIPAAm chain absorbs water (by formation of ntermolecular hydrogen bonds and it expels water bove the LCST i.e. it forms intramolecular hydrogen bonds between C=O and N-H groups.

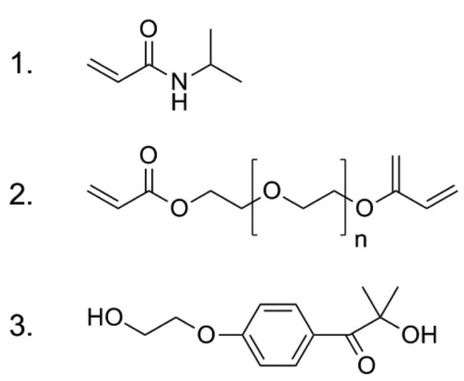

Figure 2: The PNIPAAm hydrogel is made from 1. Monomer N-Isopropylacrylamide (NIPAAm), 2. Crosslinker Polyethylene glycol diacrylate (PEGDA), 3. Photo initiator Irgacure 2959. [1]

Polymerization Induced Diffusion

By irradiation through a mask, polymerization is initiated in the exposed areas. Differences in the polymerization rate between the two polymerizing components, NIPAAm and PEGDA, creates a difference in the ratio between these components in the exposed and dark areas. [1]

This process is called polymerization- induced diffusion. A schematic representation of the irradiations steps are shown in Figure 3.

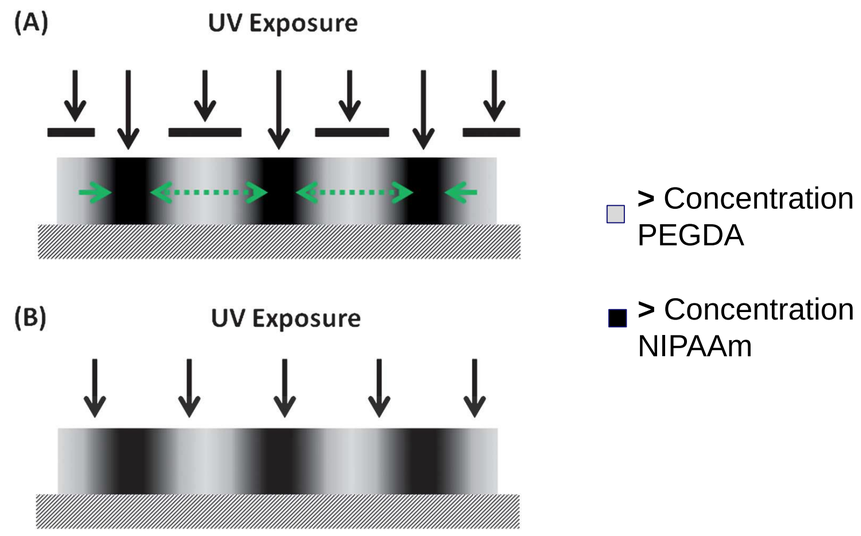

Figure 3: Fabrication steps of hydrogel coatings with switchable surface topologies. (A) Maskwise exposure. Green arrows indicate NIPAAm diffusion to the exposed area. (B) All remaining acrylates are polymerized during flood exposure. [2]

Switchable Surface Relief Structures

The local degree of swelling of the hydrogel is depended on the crosslink density. The surface relief structures can be tuned, for instance, by employed complex hierarchal masks An example of a rather straightforward and simple switchable grid type structure is shown in Figure 4.

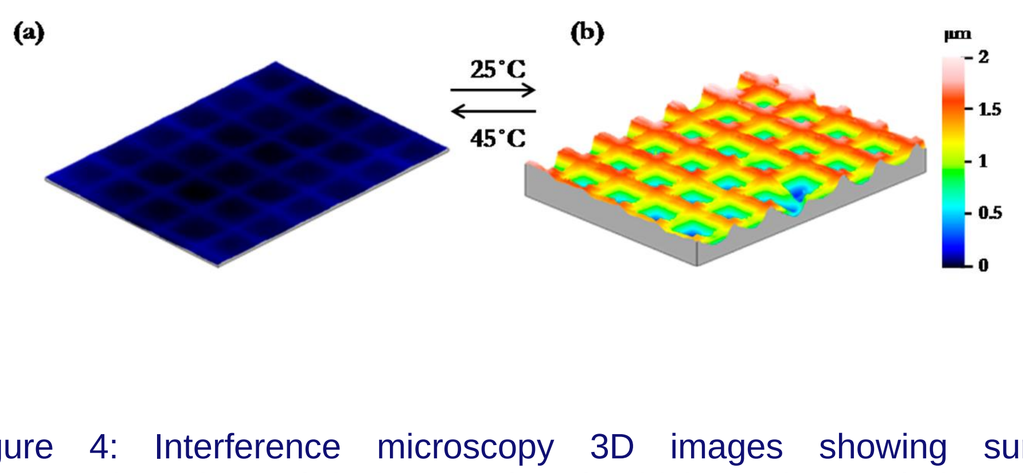

Figure 4: Interference microscopy 3D images showing surface topographies of a poly(N-isopropylacrylamide) coating cycled between warm(a) and cold(b) water. [1]

Conclusion

Switchable surface relief structures were successfully made by making crosslink density variations during the fabrication of the PNIPAAm hydrogel network.

References:
[1]: Liu, D., Bastiaansen, C.W.M., Toonder, J.M.J., Broer, D.J., *(Photo-)Thermally Induced Formation of Synamic Surface Topographies in Polymer Hydrogel Networks*, Langmuir, 2013, 29, 5622-5629.
[2]: Liu, D., Bastiaansen, C.W.M., Toonder, J.M.J., Broer, D.J., *Single-Composition three dimensionally morphing hydrogels*, Soft Matter, 2013, 9(2), 588-596.