Semi-Interpenetrating Network Photo-Responsive Hydrogels Containing Poly(Ionic-Liquid)s

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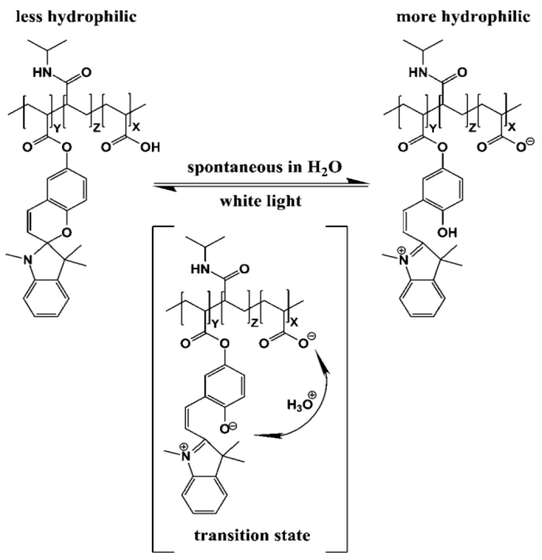
Introduction

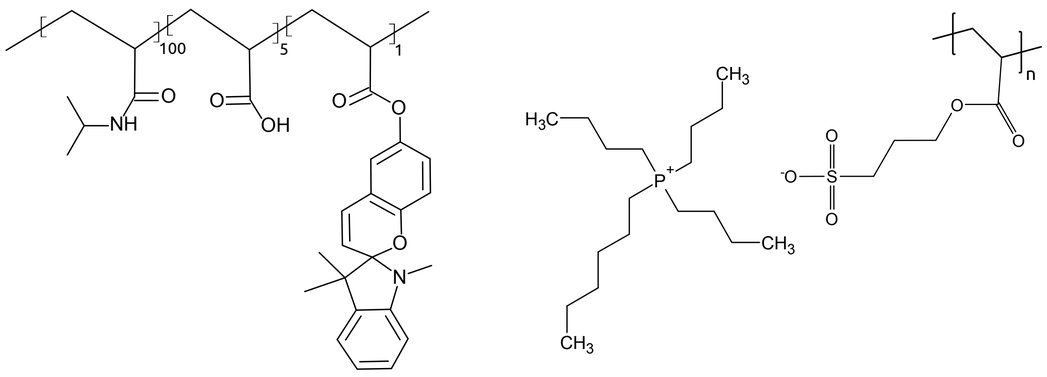
Semi-interpenetrating networks (sIPNs) are a type of polymer networks in which one polymer is crosslinked in the presence of a linear polymer solution. The materials used in this case are the poly(ionic liquid) (PIL), tributylhexyl phosphonium 3-sulfopropyl acrylate (PSPA) as the crosslinked matrix while the linear polymer is a poly(N-isopropylacrylamide-co-spiropyran-co-acrylic acid) p(NiPAAm-SA-AA) copolymer, which is both thermo- and photo-responsive.

The research described herein focuses on determining the influence of temperature and white light on the linear copolymer and also on the synthesis of sIPN hydrogels and quantifying their changes which occur in deionized water and in NaCl solutions of different concentrations under the influence of white light.

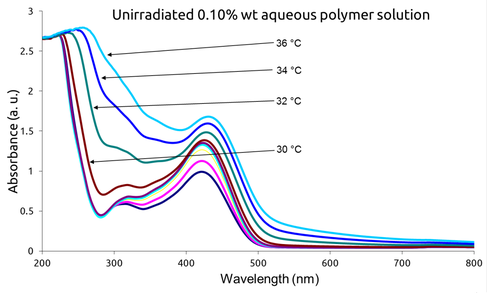


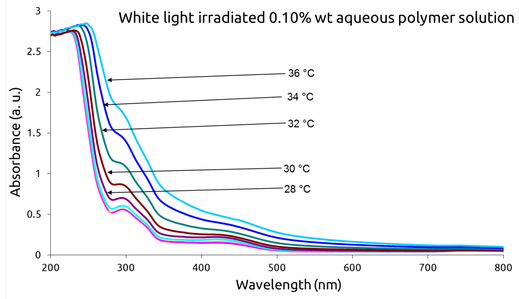
sIPN Constituents

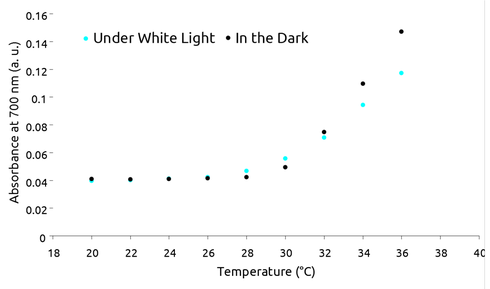
The structures of the linear p(NiPAAm-SPA-AA) copolymer (left) and the polymeric PSPA ionic liquid (cation and anion) are shown below.

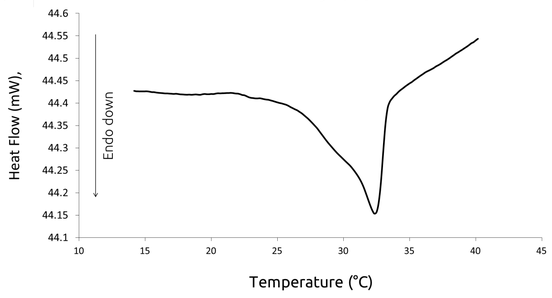


DSC and UV-Vis Analysis





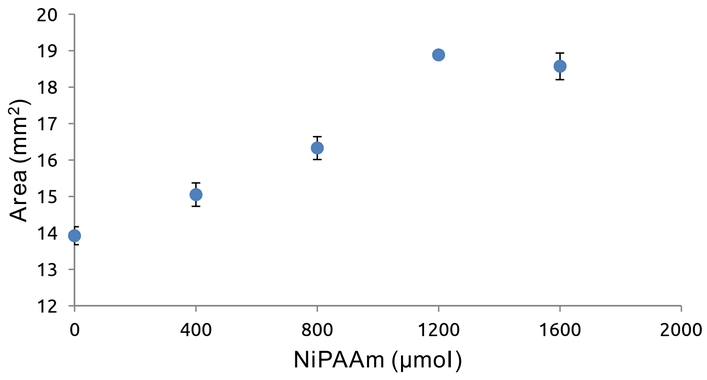




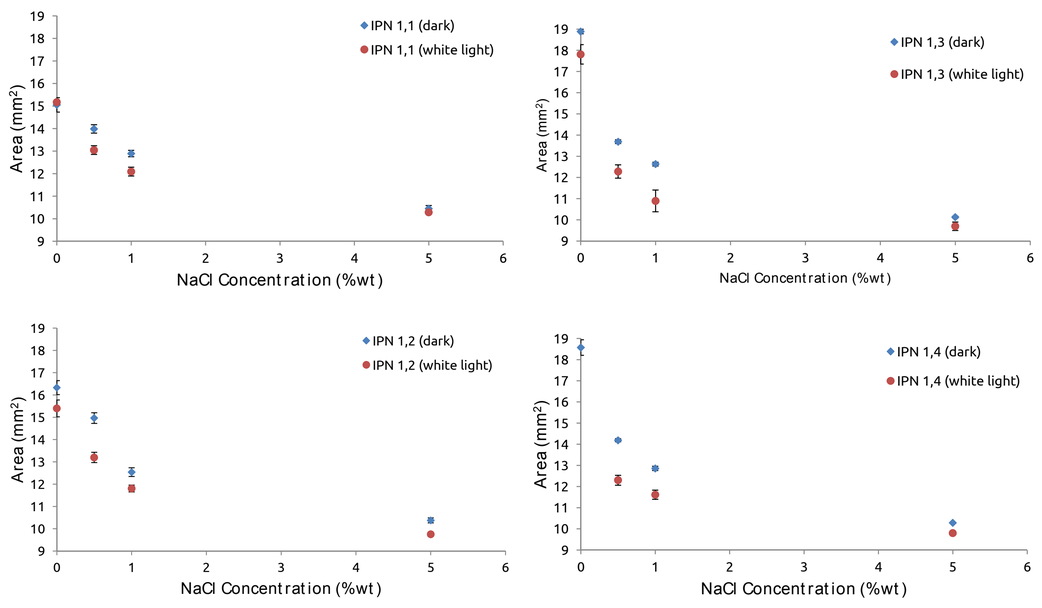
To determine the influence of temperature and white light on the absorbance of the solutions, the temperature was varied between 20 °C and 36 °C, in 2 °C/min steps, either in the dark or under white light irradiation. The endothermic peak which appears at approximatively 32 °C and the increase in absorbance, as seen in the UV-Vis spectra, indicate the presence of the lower critical solution temperature.

sIPN Hydration and Photo-Actuation

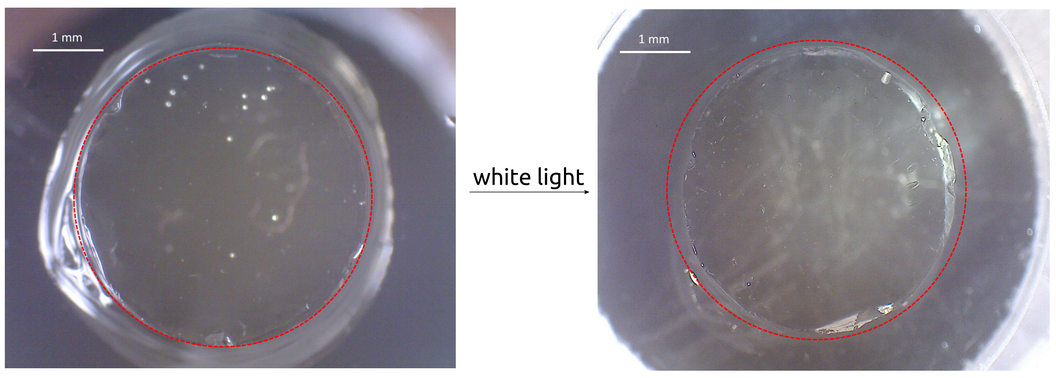
Four gels were synthesised covering the molar ratio from 1:1 to 1:4 PIL:p(NiPAAm-SA-AA) (IPN 1,1 to IPN 1,4). The influence of p(NiPAAm-SA-AA) copolymer on the hydration capabilities of sIPNs was investigated.



The resulting gels were hydrated for 18h in DI water and NaCl solutions of different concentrations - 0.5%, 1% and 5% (wt%). Measurements were made to determine the area of the hydrogel under varying illumination conditions.



The following pictures are an example of the photo-induced hydrogel shrinking. In this case, IPN1,2, which was hydrated in a 0.5 wt% solution, was exposed to white light for 30 minutes and shows a 12% area contraction.



Conclusions

A functional polymer has been synthesized by copolymerizing NiPAAm with SPA and AA. Its properties were investigated using thermal analysis and UV-Vis spectroscopy. Furthermore, this copolymer has been embedded into a PSPA matrix, creating a sIPN. Photo-induced shrinking was observed in the hydrated gels, with the optimal results appearing at 0.5% and 1% NaCl concentration, with an optimal area contraction of around 12% for IPN 1,2.

Acknowledgements

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