Self-healing hydrogels

Hydrogel or aquagel is a complex network of cross-linked hydrophilic polymer chains found as a colloidal gel with water as the dispersion medium. Polyacrylamide hydrogels formed by the hydrophobic interaction between the stearyl groups existing in a solution of the sodium dodecyl sulfate (SDS) exhibits two different faces that are dependent on the their state. Noteworthy, in the presence of SDS, the gels assume the slow relaxation mode while subjected to the dynamic light scattering (DLS) effects and elastic moduli. This concludes that the gels with SDS have a temporary nature estimated at a rage of seconds to milliseconds.

On removal of SDS, the gel exhibits characteristics similar to those of the chemically cross-linked gels. Their time-depend elastic moduli are similar, alongside with the high degree of inhomogeinity they present. They too show a single relaxation mode in the dynamic light scattering (DLS). The structural changes experienced on gels incorporated with SDS made the physical gels become insoluble in water which had a gel fraction of close to one. The gels that had the surfactant had a large proportion of the physically cross-links dissociating under force, but irreversibly reforming on removal of the force. The reforming of the hydrophobic units resulted in a self-healing efficiency of close to 100%, which is unattainable on removal of SDS.

The objective of this conduct test is to explain what gives toughness and reforming characteristics to the gels containing surfactants. The experiment also aims at explaining the contradiction outcome that a critical gel could remain stable in water. The importance of the explanation is to give future scientists essential ideas required in the designing of self-healing soft materials.

Pure solutions of hydrophobically modified hydrophilic polymers have soft materials with exceptional rheological properties. The hydrophilic group is responsible for the breakable and reversble cross-links within such a gel. A simple, free radical micellar technique makes such a gel. A monomer dissolved in the micelle undergoes copolymerization with acrylamide. The high level of concentration of the hydrophobe in the micelle makes the hydrophobic monomers to be distributed along the hydrophilic polymer backbone as randomly positioned blocks. However, the inefficiency of this method is the fact that larger hydrphobes with more than 18 carbon groups are insoluble in the micelle group, because of their low level of solubility in water.

The problem of the insolubility of hydrophobes wit larger chains of carbon atoms finds a solution on incorporation of SDS. The method works on addition of a substance that promotes the growth of the micelle, such as a salt solution of NaCl. The gels incorporated with surfactants using C18 blocks showed unique characteristics such as insolubility in water and solubility in SDS solutions. They showed nonergodicity, high degree of toughness and self-healing characteristics. Removal of SDS shows a fragile gel.

To show this trend of characteristics, this experiment incorporates two series of physical gels. The first series is a gel with SDS, and the second series is a control experiment of a gel where the SDS micelles are removed after their preparation. Methods used to test the parameters include the DLS, rheometry and uniaxial elongation.

The experiment required, among others, acrylamide, sodium dodecyl sulfate, ammonium persulfate and sodium chloride. Stearyl methacrylate acted as the C18 chain. The copolymerization of acrylamide with stearyl methacrylate took place at a temperature of 25 degrees for 24 hours in the presence of 0. 25% v/v of ammonium persulfate. The concentrations of NaCl solution and stearyl methacrylate were set at 0. 5M and 0. 24M respectively. The stearyl methacrylate content of the monomer mixture was 2 mol % but ranged from 5% to 15% in the total monomer concentration. The copolymerization took pllace in the plastic syringes of 4 mm, while determining their swelling and mechanical measurements. The samples were immersed in water set at 24 degrees for 15 days. Water was replaced daily to extract all soluble species. The DLS measurements were conducted in light scattering vials after filtration of the gel with a 0. 2µm nylon membrane. The test was carried out at 25 degrees using a using ALV/CGS-3 compact goniometer instrument. A UV-spectrophotometer was used to quantify the solubilzation of the C18-NaCl solution. This was achieved by running of sample of different concentrations and drawing a transmittance versus concentration graph. Rheological tests took place using a rheometer system with a cone angle of 4 degrees and 40 mm diameter.

The results showed a large swelling-ratio of the cells of the gel containing SDS at short swelling times. This is because of the osmotic pressure of the SDS counter ions within the gel. Removal of SDS showed the reduced swelling ratio, as the gel converted to a nonionic form. The dynamics of the gelatin and physical gels were conducted before and after the addition of NaCl and C18, as well as before and after the removal of SDS. The ICF of the

SDS showed fast and slow relaxation modes. NaCl merges the relaxation into one mode. Removal of SDS micelles leads to the disappearance of the slow mode. Rheological results showed a time dependent dynamic moduli for a SDS gel indicating a temporary nature of the hydrophobic association. Extraction of SDS resulted in a time independent, dynamic moduli. The mechanical results showed an unchanged modulus of gels containing SDS on subjection to strain. The modulus decreases rapidly with strain upon extraction of SDS.

In conclusion, numerous, essential characteristics of self-healing hydrogels disappear upon removal of SDS. Among the important characteristics achieved on introduction of SDS, include a structural relaxation and temporary nature of hydrophilic association and reversibility of its cross-links.