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An Economic Way to Toughen Poly Acrylic Acid Superabsorbent Polymer Using Hyper Branched Polymer

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Abstract : Superabsorbent hydrogels (SAP), as an enviro-sensitive material have been widely used for industrial and biomedical applications due to their unique structure and capabilities. Poor mechanical properties of SAPs - which is extremely related to their large volume change – count as a great weakness in adopting for high-tech applications. Therefore, improving SAPs' mechanical properties via toughening methods by mixing different types of cross-linked polymer or introducing energy-dissipating mechanisms is highly focused. In this work, in order to change the intrinsic brittle character of commercialized Poly Acrylic Acid (here as SAP) to be semi-ductile, a commercial available highly branched tree-like dendritic polymers with numerous –OH end groups known as hyper-branched polymer (HB) has been added to PAA-SAP system in a single step, cost effective and environment friendly solvent casting method. Samples were characterized by FTIR, SEM and TEM and their physico-chemical characterization including swelling capabilities, hydraulic permeability, surface tension and thermal properties had been performed. Toughness energy, stiffness, elongation at breaking point, viscoelastic properties and samples extensibility were mechanical properties that had been performed and characterized as a function of samples lateral cracks' length in different HB concentration. Addition of HB to PAA-SAP significantly improved mechanical and surface properties. Increasing equilibrium swelling ratio by about 25% had been experienced by the SAP-HB samples in comparison with SAPs; however, samples swelling kinetics remained without changes as initial rate of water uptake and equilibrium time haven't been subjected to any changes. Thermal stability analysis showed that HB is participating in hybrid network formation while improving mechanical properties. Samples characterization by TEM showed that, the aggregated HB polymer binders into nano-spheres with diameter in range of 10–200 nm. So well dispersion in the SAP matrix occurred as it was predictable due to the hydrophilic character of the numerous hydroxyl groups at the end of HB which enhance the compatibility of HB with PAA-SAP. As the profused -OH groups in HB could react with -COOH groups in the PAA-SAP during the curing process, the formation of a 2D structure in the SAP-HB could be attributed to the strong interfacial adhesion between HB and the PAA-SAP matrix which hinders the activity of PAA chains (SEM analysis). FTIR spectra introduced new peaks at 1041 and 1121 cm-1 that attributed to the C–O(–OH) stretching hydroxyl and O–C stretching ester groups of HB polymer binder indicating the incorporation of HB polymer into the SAP structure. SAP-HB polymer has significant effects on the final mechanical properties. The brittleness of PAA hydrogels are decreased by introducing HB as the fracture energies of hydrogels increased from 8.67 to 26.67. PAA-HBs' stretch ability enhanced about 10 folds while reduced as a function of different notches depth.

Keywords : superabsorbent polymer, toughening, viscoelastic properties, hydrogel network
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