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Research Advance Of Polymer Hydrogels

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ABSTRACT

It is well known that super absorbent gels are three-dimensional network structure which can absorb a large amount of water. Therefore, polymer hydrogels have great advantages over traditional water-absorbing materials. Many researches on hydrogels have many possible and potential applications in industry, agriculture and biotechnology. In this paper, we review the recent decade year research advance of preparation of the hydrogels, hydrogels network structure, special properties and application of polymer hydrogels in industry, agriculture and science area.

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KEYWORDS

Preparation of gels;
Network structure;
Special properties.

INTRODUCTION

Hydrogels are formed by physically or chemically crosslinked three-dimensional polymer network capable of holding a large amount of water while at the same time maintaining their shape[1]. Because of their special physically and chemically properties what make them used widely in industry, agriculture and science area. Hydrogels have lots of kinds. And we generalize four kinds of hydrogels based on the ion of hydrogels holding. 1, neutral hydrogels; 2, anion hydrogels; 3, cation hydrogels; 4, amphoteric hydrogels. This paper expatiate the fabrication, network structure, special properties and application of hydrogels.

1. Fabrication method of hydrogels

There are lots of methods to synthesize the hydrogels. Base on the mode of crosslinked, the hydrogels are formed by chemically and physically. And the methods of chemically are generalized: radial initiation; chemical initiation, thermal initiation. N.Acar[2] fabricated poly(2-vinyl pyrimidine) gel used γ radial and discussed the effect of γ radial to vitrification point and molecular weight between two crosslink point of gels. M.Flemming[3] synthesized poly(viny ethylene glycol methacrylate) gel biomaterial what have slow release ability initiated by UV radial. And H.W.Jennifer[4] also fabricated the poly(vinyl ethylene glycol methacrylate) gel biomaterial initiated by UV radial. Inina N.Savina[5] using potassium diperiodatocuprate synthesized super macroporous polyacrylamide. Using Ce(IV) as initiator is a widely used approach for graft polymerization of various vinyl monomers onto hydrogels containing hydroxyl or epoxy groups[6–10]. And J. Chojnacka etc[11] using chemically initiator synthesized poly(nitryl acrylate) which have better ion conductibility than other gels. M.Kimilo prepared thermo-sensitive hydrogels poly(L-lysine NIPAAm PTA) using the method of interface polymerization. Li Jian etc[12] also fabricated thermo-sensitive hydrogels of polyethylene glycol/polyacrylic acid, but he introduced the method of thermal initiation and crosslinked. Wu Xuye, Zhuo Renxi etc[13] synthesized polyamidoamine dendrimer hydrogel via physically crosslinked.

2. Network structure of hydrogels

The physically property of hydrogel relate to network structure. Tanaka T and his coagent[14] found that the hydrogels occur continuously or discontinuously phase change in the surface when the gels swell. In the recent year, people have a lot of work about the instability of gels surface during gels swelling. T. Tanaka and K.Sekimoto etc[15] explained instability in theory. T.Tanaka thought that the instability could be due to the different swelling of the gel's two surface. First, the one side begins swelling and the other side does not swelling. And the gels press the layer of swelling. When the outside pressure is little, the gels press plumb to the surface. If the outside pressure is big, the counterforce makes the surface bend. But K.Sekimoto hold a different view, he deemed that the reason of the instability of gels surface could be instability of mechanics during the gels swelling, and educed a nonlinear elasticity network mode based on the nonlinear elasticity theory.

S.Panyukov[16-19] etc. expanded phenomenology theory of free crosslink polymer network structure and calculated the free crosslink gel's dispersion spectrum in the good solvent, bad solvent and θ solvent. In the bad solvent electrostatic effect and elasticity effect of polymer network compete one another resulting in network structure parameter deflect in the $\vec{q}$, so the energetics parameter change. S.Panyukov thought that not only elasticity effect affect the polymer's phase but electric charge also affects it in the bad solvent. H.Terence[20] also explain the mechanics instability during swelling from theory and experimentation. K.Sekimoto[21] found special area structure of gel's surface when he studied planar gel mode phase conversion. E.S.Matsuo[22] studied the asymmetric network structure used ray scatter method and generalized two reason.1, it can be due to the undulation of polymer solution before formed polymer gels. 2, it can be due to phase separate of polymer solution. A.M.Hecht[23] measured asymmetric network structure of polyacrylamide gel is 0.25nm~250nm. T.P.Hsu[24] and his co-operator considered that the asymmetric network structure effect pervasion rate of water in the gel, sosmosis of gels and swelling balance.

3. Special properties

Polyelectrolyte gels have a lot of special properties. Tanaka pointed out that hydrogels occur phase conversion continuously or discontinuously when the outside factor (temperature, pH, concentration of monomer) change and thought the structure of gels was the result of ion effect, Vander Waals forces and hydrogen bonding. At the same time he also thought the reason which polyacrylamide gel occurs phase conversion is the gel's crosslink density changing when the polyacrylamide gel is irradiated by visible light. Xian-Zheng Zhang[25]etc fabricated microgel-impregnated thermosensitive PNIPAAm hydrogels. And the PNIPAAm/PEG-DA microgel was used as an additive during the polymerization and gelation process of PNIPAAm hydrogels at room temperature for the purpose of improving thermosensitive property of PNIPAAm hydrogels without the expense of their mechanical property. The microgel impregnated PNIPAAm hydrogels exhibited a tighter and more constrained porous network than pure PNIPAAm hydrogels without microgel additives. He Jiangchuan etc synthesized a series of fast-responding microporous thermosensitive hydrogels P(NIPA-co-SMA) through the free radical polymerization of NIPA and a small quantity of SMA as anionic comonomer in aqueous solution with calcium carbonate as the pore forming agent. It was found that the porous gels presents nearly the same transition point as the analogous non-porous ones, while their their SR increases about 50%, and the thermo-sensitivity of the gels increase as the content of pore-forming agent increases, while SR decreases when that of the crosslinking agent increases. Liu Qiong, Fan Xiaodong[26] prepared a novel pH-sensitive soy protein-based hydrogel. It was found that denaturation and acylation are effective ways are effective ways to increase SPI solubility, and when the EDTAD amount is less than 10% protein amount, with the increasing amount of EDTAD, the swelling ratio of the hydrogel greatly increases, and the highest SR value can reach 4. The pH-sensitive value of the hydrogels is pH 5 corresponding to the isoelectrical point of SPI, and the protein-based hydrogel is also ionic strength-sensitive. Inina N.Savina[2] synthesized supermacroporous polyacrylamide. The most interesting property of AAC-grafted pAAm cryogels was a drastic nearly three-fold increase in lysozyme binding when grafting degree increased from 60% to 70%. This behaviour was explained as tentacle-like binding of protein to the polymer.

4. Application of hydrogels

Hydrogels have many possible and potential applications in industry, agriculture, biomaterial. It can absorb a large amount of water while at the same time maintaining their shape. A low interface tension and hydrophilic properties make hydrogels highly biocompatible allowing their numerous applications in biotechnology and biomedicine including their use as chromatographic materials, carriers for immobilisa tion of molecules and cells, matrices for electrophoresis and immunodiffusion, scaffolds for cultivation of microbial and mammalian cells, implants and drug delivery systems[27]. Jian-Tao Zhang prepared a novel temperature-sensitive poly(N-isopro pylacrylamide) hydrogels containing water-soluble b-cyclodextrin polymer by forming semi-interpenetrating polymeric networks. Compared to the conventional poly(N-isopropylacrylamide) gel, the b-cyclodextrin-incorporated hydrogels showed the same lower critical solution temperature due to the independence of the b-cyclodextrin polymer in the networks. The release time of ibuprofen from the novel gel was significantly prolonged, which was presumably attributed to the formation of the inclusion complexes between the cyclodextrin groups and the drug molecules. New thermo- and pH-sensitive hydrogels[28-34] were obtained by graft copolymerzation. M.Tetsu etc[35] made a small engine using aluminum foil which had a lot of pore and wrapped hydrogels. The moving rate is 77mm/s and rotate speed is 394r/min. In addition, hydrogels are used to fabricate nanometer material or observe Brown moving of solo molecule in their micropore.

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