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ORIGINAL RESEARCH

Amphiphilic microblock tough cationic hydrogels with reduced permeability of the fluid channels: synthesis and properties

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Abstract

The high permeability channels would reduce the ultimate oil production resulting from excess water flooding. The objective of this paper is to prepare and evaluate a novel tough gel that can be used to significantly reduce the permeability of the fluid channels. We synthesized the hydrophobic associated hydrogel composed of poly(acrylamide-*co*-diacryl quaternary ammonium salts) (G(AM/DiAC)) by simple aqueous solution copolymerization method. Here, three diacryl quaternary ammonium salts are cation surfmer with different alkyl lengths (DiAC, carbon chain length = 6, 8, 10, respectively). The gel properties, including the mechanical performance and swelling property, as well as its influencing factors were investigated. The results showed that G(AM/DiAC) hydrogel has excellent mechanical properties. It was found that its mechanical properties were dependent on the alkyl length and dosage of surfmer. When carbon chain of DiAC was C_8 and the dosage of $DiAC_8$ reached 0.5 mol%, G(AM/$DiAC_8$) hydrogel showed the most excellent mechanical performance (tensile strengths = 58.97 kPa, elongation-at-break = 3712% and compressive strengths = 100.01 kPa). The toughness mechanism derived from the increase in the sequence length and number of hydrophobic micro-blocks in the molecular chains of hydrogels. Furthermore, the hydrogels exhibited slow swelling property, in favor of deep migration and plugging high permeable layer. The swelling equilibrium time of hydrogels was prolonged by 10 days when the dosage of $DiAC_{10}$ reached 0.9 mol%, by reason of the intermolecular dissociation between hydrophobic micro-blocks.

Keywords Tough hydrogels · Hydrophobic association · Hydrophobic micro-blocks · Tensile strength · Compressive strength

Introduction

Macromolecular hydrogels are a type of three-dimensional functional soft materials formed through intermolecular chemical covalent bonds or non-covalent bonds [1–3]. However, the application of these hydrogels is limited by the weak mechanical strength, low stability and slow response [4]. Thus, studying the preparation of high-strength ultra-drawn hydrogels is of high significance. The existing tough hydrogels are mainly co-cross-linked via covalent or covalent–non-covalent bonding [5] including double-network hydrogels [6–8], macromolecular microsphere composite hydrogels [9, 10], slip-ring hydrogels [11, 12] and supramolecular hydrogels [13–15]. The reversibility of non-covalent bonds usually endows supramolecular hydrogels with high processability and reusability. In particular, hydrophobic association hydrogels outstand with high tensile performance and compressive strength. The unique mechanical performance makes the hydrophobically modified polyacrylamide hydrogels be widely used in the field of tertiary oil recovery [16–18]. The ultra-drawn performance contributes to high resistance of hydrogels to flushing and passing through the pore by elastic deformation under differential pressure, and the high-strength performance greatly increases dimensional integrity of hydrogels, contributing to

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