Iran Polym J (2017) 26:323–330
DOI 10.1007/s13726-017-0523-3

ORIGINAL PAPER

POEGMA hydrogel cross-linked by starch-based microspheres: synthesis and characterization

Caiya Qi[1] · Huiyong An[1] · Yinan Jiang[1] · Panpan Shi[1] · Chang Liu[2] · Ying Tan[2]

Received: 7 October 2016 / Accepted: 17 March 2017 / Published online: 6 April 2017

Abstract Hydrogels with high mechanical strength and controllable stimuli responses are highly desirable in the biomedical field. Herein, starch-based microspheres were used as macrosized cross-linkers to synthesize a series of extremely tough and thermosensitive poly[2-(2-methoxyethoxy) ethyl methacrylate-*co*-oligo (ethylene glycol) methyl ether methacrylate] (POEGMA) hydrogels. Scanning electron microscopy and confocal laser scanning microscopy showed that the starch-based microspheres were uniformly distributed in the hydrogel network. Compression test results indicated that the POEGMA hydrogel exhibits strength of 3.0 MPa, which is ten times greater than that of conventional hydrogels cross-linked using small molecules. This improvement in mechanical strength is attributable to the even distribution of the cross-linking points in the hydrogel, because of which the length of the flexible polymer chains between the microspheres was similar. As a result, the polymer network can readily dissipate stress. Moreover, the mechanical strength of the POEGMA hydrogel can be regulated efficiently by varying the amount of microspheres used. In addition, the POEGMA hydrogel exhibited a lower critical solution temperature (LCST) of 37°C when the 2-(2-methoxyethoxy)ethyl methacrylate (MEO_2MA)/oligo(ethylene glycol) methyl ether methacrylate ($OEGMA_{300}$) mass ratio was 70/30. Further, the LCST of the POEGMA hydrogel can also be adjusted by adding salt or ethanol. The LCST decreased in the presence of sodium chloride but increased in the presence of ethanol.

Keywords Hydrogels · Starch-based microspheres · Cross-linker · Mechanical strength · LCST

Introduction

Polyoligo(ethylene glycol) methyl ether methacrylate (POEGMA) is a thermoresponsive polymer that consists of a hydrophobic hydrocarbon main chain with numerous hydrophilic oligo(ethylene glycol) side chains. POEGMA is an uncharged, water-soluble, nontoxic, and non-immunogenic polymer. Therefore, it is the most suitable synthetic polymer for biomedical applications [1, 2]. The oligo(ethylene glycol) side chains in OEGMA can be varied to form various poly(ethylene oxide) macromonomers with different degrees of hydrophilicity. More importantly, the lower critical solution temperature (LCST) of POEGMA can be tuned by copolymerizing the OEGMA macromonomer with oligo(ethylene glycol) side chains of different lengths without introducing side chains with different chemical properties [3].

Recently, POEGMA hydrogels have also attracted significant attention because of their high biocompatibility [4]. However, POEGMA hydrogels suffer from a lack of mechanical strength and are brittle and prone to damage even under low deformations; this significantly impedes the applicability of POEGMA hydrogels as biological materials. Liu et al. copolymerized OEGMA with 2-vinyl-4,6-diamino-1,3,5-triazine (VDT) to fabricate a thermosensitive hydrogel with a moderately high mechanical strength, which was attributable to the self-hydrogen-bonding of the VDT moieties, which resulted in a strong hydrogel network

✉ Huiyong An
ahy46@sina.com

[1] College of Chemistry, Chemical Engineering and Environmental Engineering, Liaoning Shihua University, Fushun 113001, People's Republic of China

[2] Key Laboratory of Polymer Ecomaterials, Changchun Institute of Applied Chemistry, Chinese Academy of Science, Changchun 130022, People's Republic of China