Iranian Polymer Journal (2020) 29:445–453
https://doi.org/10.1007/s13726-020-00809-5

ORIGINAL RESEARCH

Temperature resistance of AM/AMPS/NVP copolymer microspheres

Meiqin Lin[1] · Qian Zhao[1] · Shuangmin Dang[1] · Zihao Yang[1] · Zhaoxia Dong[1,2] · Juan Zhang[1]

Received: 15 October 2019 / Accepted: 12 March 2020 / Published online: 25 March 2020

Abstract

Functional monomers, such as 2-acrylamide-2-methylpropionic sulfonic acid (AMPS), *N*-vinylpyrrolidone (NVP), and acrylamide (AM), were copolymerized into terpolymer microspheres by inverse suspension polymerization. The structure, morphology, swelling, and temperature resistance of the microspheres were comprehensively characterized through several means, including a ^{13}C nuclear magnetic resonance spectroscope, scanning electron microscope, optical microscope, and laser particle size analyzer (LPSA). The results showed that the AM, AMPS, and NVP monomers were initially polymerized to form smooth and uniformly dispersed terpolymer microspheres. The particle size distribution of the microspheres ranged from 60 to 90 µm at a stirring speed of 300 rpm. The microspheres fully absorbed water and swelled to 21.9 times at 120 °C compared with dry powder microspheres. The ternary copolymer microsphere/water dispersion system can only withstand a 120 °C temperature for 19 days. However, this temperature resistance of the microspheres can be effectively improved by adding the appropriate stabilizer solution. The microspheres can be stabilized for at least 42 days and 120 days in 0.1% thiourea--cobalt chloride composite stabilizer solution and 0.025% LY stabilizer solution, respectively, at 120 °C. It can be seen that the microspheres, water, and stabilizer systems have excellent long-term thermal stability. The AM/AMPS/NVP microspheres with temperature resistance will have broad application prospects in high-temperature reservoirs.

Keywords Ternary copolymer microspheres · Swelling property · Temperature resistance · Stabilizer concentration · Morphology

Introduction

An oilfield enters a stage of high heterogeneity and water cut during the later stage of its development. Deep profile control of injection wells in an old oilfield can effectively improve water injection, thus economically and effectively improving oil recovery from the oilfield despite the high water cut [1–3]. The conventional granular profile control agent has high strength and can effectively plug high permeability zones; however, its granular size is large, deep profile control effect is small, and the consequent enhancement of oil recovery is not ideal [4–6]. In contrast, cross-linked polymer microspheres have good water absorption, swelling, deformability, and controllability of particle size, which enable them to migrate deep through fractures and pore paths to conduct profile control along the formation which it would enhance oil recovery [7–9]. Generally, the preparation methods for cross-linked polymer microspheres include inverse suspension polymerization, inverse emulsion polymerization, and inverse microemulsion polymerization. A series of polymer microspheres with controllable sizes can be prepared through different polymerization methods to meet the needs of different reservoir conditions [10–12]. Because acrylamide has a wide range of sources, excellent water solubility, low activation energy, and low price, it has become a common main monomer in the preparation of polymer microspheres for deep profile control [13–15]. However, polyacrylamide microspheres can only be stable at 90 °C aqueous solutions for about 10 days [16]. The lactam group in the acrylamide molecule easily hydrolyzes at high temperatures, affecting the temperature resistance of the cross-linked polymer microspheres as a whole. This makes it particularly unsuitable for use in high temperature reservoirs

✉ Meiqin Lin
13910509321@163.com; zoyicup@126.com

[1] Unconventional Petroleum Research Institute, China University of Petroleum, Beijing 102249, People's Republic of China

[2] China University of Geosciences (Beijing), Beijing 100083, People's Republic of China