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Green valorisation of waste vegetable oil into thermo-responsive nanocomposites for enhanced oil recovery

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Abstract

Abstract

Introduction:

Although polymer flooding is an efficient chemical enhanced oil recovery (CEOR) method, the poor thermal and salinity stability of commonly used partially hydrolysed polyacrylamide (HPAM) hinders its implementation in reservoirs with extremely high-temperature and high-salinity (HTHS) conditions. Hence, the synthesis of environmentally sustainable polymers able to maintain stability under harsh reservoir conditions is of significant research interest for enhanced oil recovery (EOR) applications.

Methods:

In this research, oleic acid-enriched waste vegetable oil (WVO) was valorised to synthesise a green, thermo-responsive nanocomposite composed of very-long-chain fatty acid esters for EOR applications under harsh HTHS reservoir conditions. A sustainable transesterification approach was first applied to produce a fatty acid-based thermo-responsive oleic acrylate macromonomer from WVO. The obtained green macromonomer was subsequently copolymerised with acrylamide, 2-acrylamido-2-methylpropane sulfonic acid, and dimethylphenylvinylsilane via emulsion polymerisation. The structure, morphology and compositional properties of the synthesised nanocomposite were extensively characterised by FTIR, ¹H NMR, TEM, SEM and EDX. Furthermore, the thermal behaviour of the synthesised nanocomposite was assessed using TGA and DTA techniques.

Results:

The results demonstrated clear temperature-responsive thickening behaviour at a minimal polymer content of 0.04 wt.%, with viscosity increasing as the temperature rose from 25 to 110 °C and salinity increased from 1,000 to 250,000 ppm, including deionised water systems. This thermo-responsive thickening behaviour demonstrates enhanced mobility control and improved sweep efficiency during polymer flooding. Flooding experiments indicated that the acrylated oleate-g-terpolymer/silica nanocomposite is a promising polymer flooding candidate and achieved recovery factors of 15.4 % and 21.2 % at concentrations of 0.04 wt.% and 0.05 wt.%, respectively, assessed under harsh conditions of 100 °C and a salinity of 250,000 ppm. Moreover, the synthesised nanocomposite demonstrated significant resistance factor (R_f) values of 5.9 and 8.1 using nanocomposite concentrations of 0.04 wt.% and 0.05 wt.%, respectively. The nanocomposite altered sandstone wettability from oil-wet to water-wet, which improved the oil recovery.

Conclusions:

These results suggest that waste vegetable oil-derived thermo-responsive nanocomposites offer a sustainable, high-performance polymer flooding solution capable of delivering significant oil recovery under ultra-high-temperature and high-salinity reservoir conditions at remarkably low polymer concentrations. The findings highlight the strong potential of these green, thermo-responsive nanocomposites as promising candidates for large-scale EOR applications in HTHS oil reservoirs worldwide.

Keywords

Free radical polymerisation, Waste valorisation, Enhanced oil recovery, nanocomposite.

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Abstract pending approval

Reviewer 1

Reviewer comments: The abstract is pretty good. The topic is novel and interesting for me. I guess the readers will like it

Author response: Thank you for your kind and encouraging comment. We are glad that the novelty and relevance of the topic are appreciated, and we hope the work will be of interest to the readers.