Chemical Data Collections 13–14 (2018) 60–72

Contents lists available at ScienceDirect

Chemical Data Collections

journal homepage: www.elsevier.com/locate/cdc

Data Article

Experimental investigation on effect of alkali, salts on the rheological properties of polyacrylamide and mixed assembly of polymer-surfactant

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ARTICLE INFO

Article history:
Received 20 December 2017
Revised 9 January 2018
Accepted 24 January 2018
Available online 31 January 2018

Keywords:
Shear rate
Inorganic salts
Enhance oil recovery
Shear thinning and intermolecular interaction

ABSTRACT

An experimental study was conducted to evaluate the effect of addition of alkali, salts and surfactants on the rheological properties of polyacrylamide (PAM) solution by rheometry. The results show the addition of inorganic salts (NaCl, Na_2SO_4, $MgCl_2$), alkali (NaOH) and surfactants (CTAB, Gemini-5 and Gemini-6) strongly influence the rheological behavior of polyacrylamide solution. The shear thinning behavior of the solution at low shear rate was observed. The scope of this experimental work also includes the measurements of viscoelastic behavior, transient shear stress response and yield stress. The results are quite interesting and the mixed systems can be used as ASP flooding in Enhance oil recovery.

Specifications Table

Subject area	*Chemical Engineering*
Compounds	Polyacrylamide, Cetyltrimethyl Ammonium bromide, Gemini 5, Gemini 6, Sodium hydroxide, Magnesium Chloride, Sodium Sulfate, Sodium Chloride.
Data category	*Synthesized, physicochemical.*
Data acquisition format	*Elemental analysis.*
Data type	*Analyzed*
Procedure	The rheological measurements were carried out on a modular compact rheometer (MCR 102 SN 81270415 FW3.70). The experiments for alkali and salts with polyacrylamide and mixed assembly of the polymer-surfactant system were performed at a temperature 30 °C. The flow curves recorded at fix shear ($\gamma = 100\ s^{-1}$) and varying shear ($\gamma = 0$ to $500\ s^{-1}$) rate.

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https://doi.org/10.1016/j.cdc.2018.01.004
2405-8300/

1. Rationale

The alkali surfactant polymer (ASP) process is considered as the one of the most beneficial method for enhancing the oil recovery from highly acidic crude reservoirs. In a recent year, the alkali surfactant polymer process has attracted much interest of researchers [1,2]. Some experimental studies reported that the ASP process increases the oil recovery comparison to other chemical processes and also increase the life of the reservoir [3]. Alkali can react with acids in the crude oil reservoir and form soap by In-situ saponification process, which increases the performance of the injected surfactant and lowers the oil/water interfacial tension [4]. Alkali includes sodium hydroxide, sodium carbonate, sodium phosphate etc. which produces OH^- ions and can generate high pH value. The viscosity of the polymer solution is also affected by alkali. For a polymer-alkali system, the viscosity is a function of concentration, type and also the time after the mixing [5]. The ASP flooding has a benefit that it increases the viscosity of the injected fluid to improve the sweep efficiency, reduces the oil/water interfacial tension, improves the mobility ratio and increases the capillary number. The capillary number is an important parameter in enhance oil recovery, which is directly proportional to displacement efficiency and restricts the residual saturation [6]. The small quantity of salt will also affect the rheological properties of polymer. The addition of salt reduces the hydrophobic size of the polymer molecule and changes the viscosity [7]. Also, the presence of inorganic salts in a solution can dramatically change the properties of the polymer and surfactant and effect the interaction between them [8,9]. Salt shields the charges on the backbone chains of polymer; thereby modify the conformation of the polymer chains from that of a stiff to a flexible chain. Consequently, the polymer network is disrupted due to the degradation of mechanically active junctions, which leads to the formation of more intra-molecular associative junctions [10].

The ASP flooding is a complex process and the knowledge of the properties of the injected fluid is important factors for the success of enhance oil recovery. In this work, the solution behavior of polyacrylamide solution was studied in presence of alkali (NaOH) and of inorganic salts (NaCl, $MgCl_2$ and Na_2SO_4) to see the effect of these on polyacrylamide solution. In this experiment, we introduce the Gemini surfactant to investigate its effect on rheological properties of polyacrylamide because of its low critical micelles concentration (CMC) value. Also, these surfactants usually have better surface-active properties than corresponding conventional surfactants (CTAB) of equal chain length.

2. Procedure

2.1. Materials and methods

The polyacrylamide (PAM) with the molecular weight of 150,000 (M.P > 200 °C), purchased from Sigma-Aldrich and used as received. The conventional surfactant CTAB (molecular weight 364.46, Sigma-Aldrich) used as received. Gemini (16-5-16) and Gemini (16-6-16) were synthesized and characterized as per detail described elsewhere [11]. Sodium hydroxide is alkali (mol. wt. 40), purchased from central drug house (New Delhi) used as received without any further purification. Mineral salts ($MgCl_2$ and Na_2SO_4, central drug house, New Delhi) and NaCl (Merck India Limited, Mumbai) used as received.

2.2. Preparation of solutions

The preparation of polyacrylamide solution with alkali, salts and surfactants required a special care. The polyacrylamide solution at various concentrations was prepared by dissolving a known amount of polyacrylamide in distilled water having a specific conductivity of $1–2 \times 10^{-6}$ S/cm under constant stirring for about 2 hours. Alkali, salts and surfactants solution were then prepared by adding a known amount of alkali/salts/surfactant in a polyacrylamide solution prepared described elsewhere [12]. During the preparation of the solution, it is found that the solution gets precipitated at higher concentration of alkali and salts. Which limits the NaOH concentration from 0.05 to 0.1 wt.% in a 1.0 wt.% PAM + 20 mmol surfactant. Formation of precipitate at room temperature was also observed