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ORIGINAL RESEARCH

# A polyacrylamide hydrogel for application at high temperature and salinity tolerance in temporary well plugging

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## Abstract
In addition to conventional approach to ensure the successful application of polymer hydrogels in maintaining temporary well plugging, exact analysis of gel formation and gel strength properties in wellbore are necessary. In this work, bottles and rheology tests are used to investigate the polymer hydrogel gelation time and cross-linking kinetics of sol–gel systems which consist of polyacrylamide and chromium acetate hydroxide as a cross-linker. The effects of temperature of 90 °C and pressure of 3000 psi (typical Iranian oil well condition) were studied in relation to gelation time, strength and the mechanical properties of the hydrogel. The average molecular weight of the polymer chains between cross-link ties was evaluated using an oil-well laboratory system and compressive strength test. Differential scanning calorimeter (DSC) analysis of dried gel and the effect of temperature on the kinetics of the gel swelling in different solutions such as distilled water, tap water, formation water and oil were studied. The results showed that the number of tie points between each entanglement has not much reduced under pressure. Therefore, the prepared hydrogel can maintain its chemical structure under the Iranian oil well pressure and can be proposed to field studies. The degree of sol–gel reaction of prepared hydrogel and the activation energy based on the Arrhenius equation were calculated to be 1.5 and 274 kJ/mol, respectively.


**Keywords** Polymer hydrogel · Gelation time · Rheology · Activation energy · Swelling · Network mesh size

## Introduction

Today, temporary well plugging are essential for some oil and gas wells in the world because of their long life, which may cause problems such as deterioration of equipment and internal problems [1]. One of the newest methods in well plugging is putting up polymer gel because of its safety and commercial cost [2]. Hydrogels are tri-dimensional structures containing hydrophilic polymer network and water. During the gelation process, the polymeric macromolecules in the presence of metal ions such as $Cr^{+3}$, $Al^{+3}$ and $Zr^{+4}$ as cross-linkers are formed from low viscous liquid termed as "gelant" into weak or strong three-dimensional cross-linked structure. The mechanical strength of hydrogel is improved depending on the formulations and during time [3, 4]. Gelation process is irreversible and consists of ionic bonds between anionic groups in polymer chains with metal cations [5]. The polymer chains hold together and form insoluble polymeric networks. Cross-link density of gel affects the network structure and controls the physical properties of hydrogels [6, 7]. The most desirable polymer for obtaining a gel in petroleum fields is based on polyacrylamide. Some of this polymer applications are used for water shutoff agent, improved recovery of oil (IOR) and enhanced oil recovery (EOR) from oil reservoir [8, 9]. In addition, it can be stable at reservoir temperature and water salinity (formation water) [10]. The presence of hydrophilic groups in hydrogels help to absorb hydrophilic solvent in an aqueous solution [11, 12]. Performance of temporary gel plugs depends on gelation time and cross-link density of gel to isolate the desire zone in a well [13]. An important

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