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Partially Aminated Polyacrylamide Hydrogel: A Novel Approach for Temporary Oil and Gas Well Abandonment

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Abstract : Following the advent of the Industrial Revolution, there has been a significant increase in the extraction and utilization of hydrocarbon and fossil fuel resources. However, a new era has emerged, characterized by a shift towards sustainable practices, namely the reduction of carbon emissions and the promotion of renewable energy generation. Given the substantial number of mature oil and gas wells that have been developed inside the petroleum reservoir domain, it is imperative to establish an environmental strategy and adopt appropriate measures to effectively seal and decommission these wells. In general, the cement plug serves as a material for plugging purposes. Nevertheless, there exist some scenarios in which the durability of such a plug is compromised, leading to the potential escape of hydrocarbons via fissures and fractures within cement plugs. Furthermore, cement is often not considered a practical solution for temporary plugging, particularly in the case of well sites that have the potential for future gas storage or CO2 injection. The Danish oil and gas industry has promising potential as a prospective candidate for future carbon dioxide (CO2) injection, hence contributing to the implementation of carbon capture strategies within Europe. The primary reservoir component consists of chalk, a rock characterized by limited permeability. This work focuses on the development and characterization of a novel hydrogel variant. The hydrogel is designed to be injected via a low-permeability reservoir and afterward undergoes a transformation into a high-viscosity gel. The primary objective of this research is to explore the potential of this hydrogel as a new solution for effectively plugging well flow. Initially, the synthesis of polyacrylamide was carried out using radical polymerization inside the confines of the reaction flask. Subsequently, with the application of the Hoffman rearrangement, the polymer chain undergoes partial amination, facilitating its subsequent reaction with the crosslinker and enabling the formation of a hydrogel in the subsequent stage. The organic crosslinker, glutaraldehyde, was employed in the experiment to facilitate the formation of a gel. This gel formation occurred when the polymeric solution was subjected to heat within a specified range of reservoir temperatures. Additionally, a rheological survey and gel time measurements were conducted on several polymeric solutions to determine the optimal concentration. The findings indicate that the gel duration is contingent upon the starting concentration and exhibits a range of 4 to 20 hours, hence allowing for manipulation to accommodate diverse injection strategies. Moreover, the findings indicate that the gel may be generated in environments characterized by acidity and high salinity. This property ensures the suitability of this substance for application in challenging reservoir conditions. The rheological investigation indicates that the polymeric solution exhibits the characteristics of a Herschel-Bulkley fluid with somewhat elevated yield stress prior to solidification.

Keywords : polyacrylamide, hofmann rearrangement, rheology, gel time
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