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Synthesis of Temperature Sensitive Nano/Microgels by Soap-Free Emulsion Polymerization and Their Application in Hydrate Sediments Drilling Operations

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Abstract : Natural gas hydrates (NGHs) as promising alternative energy sources have gained increasing attention. Hydrate-bearing formation in marine areas is highly unconsolidated formation and is fragile, which is composed of weakly cemented sand-clay and silty sediments. During the drilling process, the invasion of drilling fluid can easily lead to excessive water content in the formation. It will change the soil liquid plastic limit index, which significantly affects the formation quality, leading to wellbore instability due to the metastable character of hydrate-bearing sediments. Therefore, controlling the filtrate loss into the formation in the drilling process has to be highly regarded for protecting the stability of the wellbore. In this study, the temperature-sensitive nanogel of P(NIPAM-co-AMPS-co-tBA) was prepared by soap-free emulsion polymerization, and the temperature-sensitive behavior was employed to achieve self-adaptive plugging in hydrate sediments. First, the effects of additional amounts of AMPS, tBA, and cross-linker MBA on the microgel synthesis process and temperature-sensitive behaviors were investigated. Results showed that, as a reactive emulsifier, AMPS can not only participate in the polymerization reaction but also act as an emulsifier to stabilize micelles and enhance the stability of nanoparticles. The volume phase transition temperature (VPTT) of nanogels gradually decreased with the increase of the contents of hydrophobic monomer tBA. An increase in the content of the cross-linking agent MBA can lead to a rise in the coagulum content and instability of the emulsion. The plugging performance of nanogel was evaluated in a core sample with a pore size distribution range of 100-1000nm. The temperature-sensitive nanogel can effectively improve the microfiltration performance of drilling fluid. Since a combination of a series of nanogels could have a wide particle size distribution at any temperature, around 200nm to 800nm, the self-adaptive plugging capacity of nanogels for the hydrate sediments was revealed. Thermosensitive nanogel is a potential intelligent plugging material for drilling operations in natural gas hydrate-bearing sediments.

Keywords : temperature-sensitive nanogel, NIPAM, self-adaptive plugging performance, drilling operations, hydrate-bearing sediments
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