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# $CuO/TiO_2$/PAM as a Novel Introduced Hybrid Agent for Water—Oil Interfacial Tension and Wettability Optimization in Chemical Enhanced Oil Recovery

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## Abstract

The main target of this research is the development of a novel nanocomposite consisting of copper(II) and titanium oxide nanoparticles and polyacrylamide (PAM) polymer for use as a hybrid agent beside other chemical factors in enhanced oil recovery (EOR) processes. The optimization of interfacial tension (IFT) and wettability alteration, the most important issues in improving oil recovery, orient both the selection of the aforementioned materials and the presentation of a hybrid agent in chemical enhanced oil recovery (CEOR). This work focuses on the development of a simple, economical, and ecofriendly method for green synthesis of the $CuO/TiO_2$/PAM nanocomposite to create a nanofluid that alters the oil-wetting state of carbonate and sandstone reservoirs into a water-wetting state, as well as reduces the water–oil IFT simultaneously. A green *Cassytha filiformis L.* fruit extract was used to synthesize the nanocomposite. The product underwent characterization tests, including the use of field-emission scanning electron microscope (FESEM), energy dispersive X-ray spectroscopy (EDS) and EDS Map, X-ray diffraction (XRD), and thermogravimetric analysis, to achieve better analytical characterization. Nanofluids at various concentrations ranging from 100–1500 ppm were formulated, and their stabilities were studied through zeta potential measurements. The results of zeta potential tests confirmed the stability of the developed nanocomposite in water-based solutions. The IFTs of the developed nanofluids and the crude oil of the Sarvestan oil field (a carbonate reservoir located in the south of Iran) were then measured. In addition, wettability alteration tests were conducted for both carbonate and sandstone rocks in order to observe all rock type dependency of mechanisms. The results showed that the novel synthesized nanocomposite reduced water–oil IFT by about 46% at the low concentration of 200 ppm. Optimization of wettability alteration is the main reason to use nanosized materials in a CEOR approach. Our investigation showed that, at the optimum nanofluid concentration of 200 ppm, a 90% wettability alteration (from 151° to 14.7°) in the water-