Novel Enhanced Oil Recovery Method using Co$_{2+x}$Fe$_{2+1-x}$Fe$_{2O_4}$ as Magnetic Nanoparticles Activated by Electromagnetic Waves
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Deep water oil reservoirs buried more than 500m possess high temperature and high pressure conditions, which caused failure to most of the oil recovery methods involving fluid injection. A non-invasive electromagnetic (EM) wave transmission system coupled with nanofluid injection has been proposed to improve recovery factor of an oil reservoir. Interactions of the magnetic nanoparticles at low frequency radio wave range are mainly ionic, which could be manipulated to disturb the compatibility at oil-water interfaces. An attempt to measure oil recovery due to interaction of EM waves with magnetic nanoparticles has been performed. In this work, Co$_{2+x}$Fe$_{2+1-x}$Fe$_{2O_4}$ nanoparticles was synthesized via co-precipitation route. As deduced from the XRD line broadening, the average crystallite size of the samples was found to be in the range of 13.0-15.0 nm and contain fcc structure with smaller lattice constant as the Co/Fe ratios increases. nanofluid was prepared by dispersing Co$_{2+x}$Fe$_{2+1-x}$Fe$_{2O_4}$ nanoparticles in deionized water and ultrasonicated for 2 hours, which then injected into a packed glass bead column of 24 cm length and having permeability 380 mD, to replicate the reservoir material. Prior to this injection, the column was saturated with Arabian Heavy crude oil of viscosity 16.31 cp at 25°C, followed by water flooding to recover 73% of the original oil in place (OOIP). After 30 minutes exposure to electromagnetic wave radiation and nanofluid injection simultaneously, it has successfully recovered 27% of the remaining oil. It is expected that interaction between EM waves and Co$_{2+x}$Fe$_{2+1-x}$Fe$_{2O_4}$ nanoparticles in the column will induce atomic vibration on the pore surfaces and as a consequence, released the trapped oil.