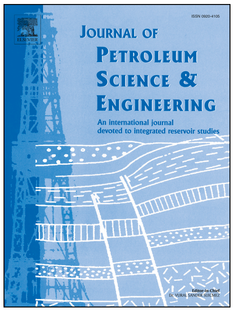

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Characterization of the wax precipitation in Iranian crude oil based on WAT: The influence of electromagnetic waves

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Abstract

This paper investigated the effects of microwaves (MW) on WAT, the shape and morphology of wax crystals, and the content of elements in crude oil. After Wax Appearance Temperature (WAT) was determined using cross-polarized microscopy (CPM), the intra-molecular bonds and the structure of the molecules were determined by subjecting crude oil and its wax content to Fourier-transform infrared (FTIR) spectroscopy analysis. Cracking and simultaneous evaporation of crude-oil combinations due to irradiation with MW caused peaks with different intensities in the oils' spectrums to appear. In addition, with irradiation, peaks reappeared that had been hidden in the range of virgin oil samples, and which were more closely related to aromatic compounds. The two processes of cracking and evaporation together resulted in a lighter oil sample with a lower WAT, which is evident in the samples' FTIR spectrum. Analysis of the images from the wax crystals under a polarization light microscope with image processing revealed a close connection between the shape and size of the wax particles and peak intensity of the FTIR spectrum and the crude-oil composition. Oil samples exposed to MW radiation had more rounded crystals and more similar proportions than virgin-oil samples. Radiation of MW waves caused asphaltene cracking to produce saturated, aromatic, and resin compounds. Since asphaltene is the heaviest oil-producing compound, this conversion lightened the oil and reduced the WAT. MW radiation also increased the amount of aromatic compounds derived from the resin in oil. The presence of asphaltene as one of the heavy-oil compounds and its interaction with wax molecules was investigated. It was observed that with respect to the naphthenic/polar of the wax sample, the decrease in the amount of asphaltene in the oil sample after irradiation reduced the interactions between the wax molecules and asphaltenes, and subsequently reduced the WAT. Scanning electron microscopy (SEM) images showed that the MW wax samples were composed of rounded and compacted particles, making it difficult to detect single grains. The size of the grains in the SEM images of MW samples was smaller than in the virgin sample. MW affected the dispersion and the mean size and shape of the wax particles under both the polarized light microscope and SEM; they also affected the bond/molecular structure as determined by FTIR and the amount of resin, asphaltene, saturation, and aromatics of the oil constituents, and decreased the average carbon number of the oil samples, which lowered the WAT.