Study of asphaltenes adsorption onto different minerals and clays
Part 2. Particle characterization and suspension stability

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In gas and oil production, produced water usually contains dispersed solids along with dissolved and dispersed oil. Solids are of reservoir origin as well as corrosion products (e.g. Fe3O4 from pipelines) and waste products of bacterial metabolic activities (e.g. FeS) under anaerobic conditions. These particles are coated with surface active components upon contact with oil. In the present paper we studied eight model particles coated with asphaltenes from different oils in order to mimic the wettability changes and behavior in water after contact with oil. The effect of different variables (concentration, temperature and coating) on the suspension stability has been studied with Turbiscan LabExpert. Various analysis methods for Turbiscan data have been evaluated, and based on this our data have been analyzed in two modes. Transmission profiles from the middle of the samples have been considered at 75 (overall water quality) and 15.5 min (suspension behavior during a representative time in the separator) time scales. Furthermore, the clarification rate and time has been evaluated. Principal component analysis (PCA) has been used to visualize trends in the data sets as well as identifying the most important variables affecting the systems. At longer time scales temperature generally has the largest effect on suspension behavior, while asphaltene coating and particle concentration are important at the shorter time scale.

1. Introduction

Currently, water accounts for about 60% of the produced volume in offshore oil and gas production. A high percentage of this brine is polluted and the water to oil ratio (water cut) increases as the oil fields mature, making water an even more significant byproduct of oil and gas production. American Petroleum Institute’s produced water surveys in 1985 [1] and 1995 [2] calculated a water-to-oil ratio of approximately 7.5 barrels of water for each barrel of produced oil. In 2006, 173 million m³ of produced water were discharged on the Norwegian Continental Shelf, which was a decrease by 4 million m³ compared to 2005. Current regulations (since 2007) for installations on the Norwegian Continental Shelf have set an upper limit of 30 mg/l of oil in water for water discharged to the sea [3]. The amount of dispersed oil in produced water decreased from 19.5 mg/l (2005) to 16.9 mg/l (2006) [4]. However, the goal for the Norwegian authorities is to ensure that this produced water is completely free of pollutants when discharged [5]. This goal has not been reached yet, and polluted produced water is currently either discharged into sea or re-injected into the reservoirs. Water injection is typically done for two reasons:

1. Disposal of water recovered from the crude oil–water separation process.
2. It facilitates production by maintaining formation pressure and displacing the crude oil in the reservoir [6].

Produced water has no direct commercial value but it has an indirect value when it is re-injected. The composition of produced water depends on the type and maturity of the reservoir. It contains dissolved organic compounds (including hydrocarbons), dispersed oil droplets, heavy metals, dissolved inorganic salts, dispersed solids (sand and silt) and a variety of treatment and workover chemicals. The produced water also contains dissolved gases (particularly hydrogen sulfide and carbon dioxide), bacteria and other living organisms, as well as radioactive isotopes. However, the particular concentrations of these components vary over an extremely wide range.

The solid particles occurring in produced water are mainly of reservoir rock origin. In sandstone reservoirs, the main contribution is from sand (silica) accompanied by smaller amounts of different minerals and silt. In addition, iron-based salts, either as a product of corrosion or as a product of anaerobic bacteria in the reservoir,