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Mechanical Degradation of EOR Polymers and Its Effect on Droplet Size of Diluted Oil-in-Water Emulsion Produced Using Marmul Fluids

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Abstract

Polymer back-produced from Marmul EOR has posed a new challenge to surface operations and waste water treatment facilities. It stabilized the oil-in-water emulsions by increasing the viscosity of the continuous water phase. The research work presented in this thesis is concerned with the effect of mechanically degrading the polymer by injection through capillaries. The effect of this injection on droplet size was also investigated. The test liquids used were Marmul oil (density 0.934 g/cm_3 at 23 $_oC$) and synthetic Marmul brine (salinity 4905 mg/L). The experiments were carried out through the determination of droplet size and droplet size distribution using different capillary diameters, lengths and flow rates. Three molecular weights of the partially hydrolyzed polyacrylamide were used with different concentrations.

Using emulsions without polymer addition, the capillary study showed that smaller capillary diameters give smaller droplet sizes for the same flow rates. This might be attributed to the higher shearing stress in the smaller diameters reflected by the higher pressure droplet values. Moreover, the higher contraction ratios for the smaller capillary diameters exert elongational straining stresses at higher flow velocities at the capillary entrance. This decrease in droplet sizes of the oil resulted in higher turbidity of the emulsions. It was found that the median droplet size (D50) decreases with increasing the pipe length, which is an indication of the significance of shear inside the capillary on decreasing droplet size. The effect of the elongational flow at the entrance was found by extrapolation and was found to be remarkable only at the highest flow rates conducted in this study.

When the polymers were added during the emulsification stage, oil droplet sizes increase with the increase of polymer concentration and the decrease in polymer molecular weight. This might be due that the fact that high concentrations of polyacrylamides have flocculation activity, which enhances the small droplet diameters to aggregate and ultimately coalesce to form bigger ones. Moreover, the interfacial tension measurements indicated that oil droplets created at the initials stage of emulsification can decrease the interfacial tension and hence allowing smaller droplets to be formed. This action is
enhanced by the better diffusivity of these droplets at the lower polymer molecular weight and concentration.

The effect of polymer mechanical degradation by capillary shearing was found to decrease the viscosity of the continuous water phase. However, this positive factor in emulsion destabilization was counteracted by the associated decrease in the size of oil droplets. The overall effect of this approach is the increase in emulsion stability as indicated by the calculation of droplet rising velocity using Stoke's law. For the same polymer concentration, the mechanical degradation is higher for the lower molecular weight polymer. This is attributed to the viscosity difference between the polymer solutions investigated. Overall, the results of this

study emphasis that the mechanical degradation is not supporting the breakage of the oil in water emulsion produced from fields in which polymer EOR is applied.