Enhanced Performance of Biopolymer Treated Salt Contaminated Hydraulic Fracturing Fluid

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Abstract: In this study, the effect of 3% salt contamination on the rheological properties and fluid loss of fracturing fluid at two different temperature conditions were investigated. In this study three different mixes were used. Mix 1 had 90% water, 9% fine sand and 1% guar gum and Mix 2 had 87% water, 9% sand, 3% salt with 1% biopolymer and Mix 3 had 90% water, 5% sand, 3% salt with 2% biopolymer. Additional of 3% salt at temperature of 25°C decreased the viscosity of the fracture fluid at shear strain rate of 170 s^{-1} from 478 cP to 108 cP, a 77% increase. With adding 3% salt the fluid loss of the fracture fluid (mL/30 min) at room temperature reduced by 122%. The electrical resistivity of the fracturing fluid using Mix1, Mix 2 and Mix 3 at T=25°C were 3.75 Ω-m, 0.065 Ω-m and 1.36 Ω-m respectively.

1. Introduction: The composition of a fracturing fluid varies with the nature of the formation, but typically contains 99% of water and proppant sand to keep the fractures open and a small percentage of chemical additives (Murrill and Vann 2012). The quality of fracturing fluid can be effectively maintained by continuously measuring fluid characteristics in the field and controlling its viscous properties by modifying fluid additives and injection rate. Minimizing formation damage and fracture damage is regarded as a unique goal in hydraulic fracture design. A typical hydraulic fracturing treatment can consume, on average, 3 to 5 million gal of water (usually fresh water). This is particularly problematic for offshore jobs, where fresh water must be transported to the well site; whereas, seawater is readily available. Very few conventional polymers perform well in brine; however, even fewer perform well in hard brines, such as seawater, which typically includes high concentrations of divalent metal ions, such as magnesium and calcium. The presence of divalent metal ions in seawater inhibit the full hydration of the polymer, which results in a lower base gel viscosity and ultimately affects the final properties of the cross linked fluid system. Several sea water tolerant fracturing fluids are currently available, but none of these fluids meet the current requirements to reduce formation damage caused by a relatively high percentage (≥3%) of insoluble residues in the polymer system (Loan et al. 2014).

2. Objectives: The overall objective was to evaluate the effect of biopolymer treated salt contamination hydraulic fracturing fluid on the rheological properties and fluid loss at two different temperature conditions.

3. Methods and Materials: The rheological properties such as shear stress - shear strain rate, and viscosity (μ) for fracturing fluids were measured using a viscometer. Three different mixes (Mix 1: Conventional Mix; Mix 2: 3% salt contaminated Mix 1; Mix 3: 1% additional biopolymer added to Mix 2) with and without salt were used. The fracturing fluids were tested in the temperature range from 25°C to 85°C using a viscometer with the speed range of 0.3 to 600 rpm. Also the fluid loss for fracture fluid was tested using HPHT system. Shear stress-shear strain rate of the fracturing fluids where modeled using Eqn. 1.

$$\tau = \tau_o + \frac{\dot{\gamma}}{A+\dot{\gamma}B} \tag{1}$$

Where τ_{02} is the yield stress at zero shear strain rate (Pa), $\dot{\gamma}$ is the shear strain rate (s^{-1}) and A and B are the hyperbolic model parameters.

4. Results and Analysis: Additional of 3% salt to the fracturing fluid decreased the viscosity at shear strain rate of 170 s^{-1} by 77% at temperature of 25°C as summarized in Table 1. The viscosity at shear strain rate of 170 s^{-1} of the fracturing fluid using Mix 1, Mix 2 and Mix 3 decreased by 60%, 59% and 38% respectively when the temperature increased from 25°C to 85°C. Additional of 3% salt to the fracturing fluid decreased the yield stress by 49% at temperature of 25°C as summarized in Table 1. The yield stress of the fracturing fluid using Mix 1, Mix 2 and Mix3 decreased by 45%, 62% and 34% respectively when the temperature increased from 25°C to 85°C. The electrical resistivity of the fracturing fluid using Mix1, Mix 2 and Mix 3 decreased by 26%, 43% and 27% when the temperature increased from 25°C to 85°C as summarized in Table 1.

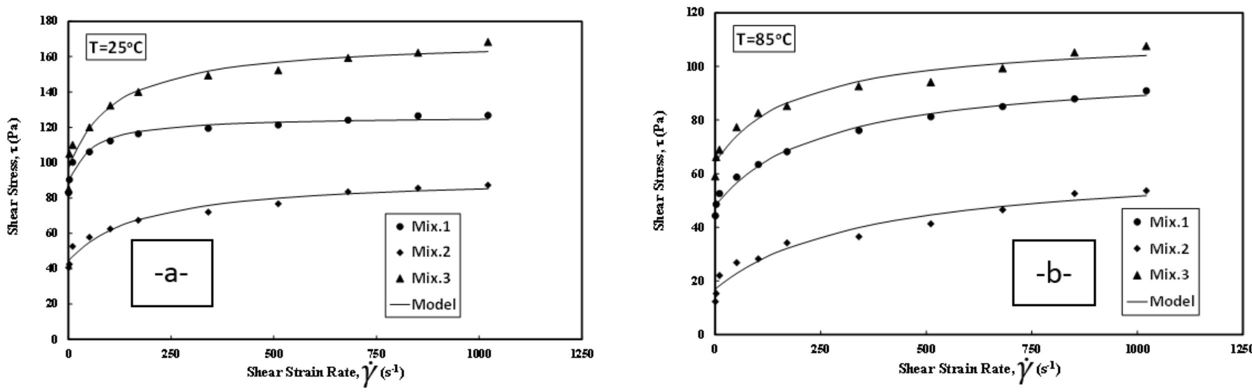

Figure 1. Relationship between Shear Stress- Shear Strain Rate of Fracturing Fluid (a) T=25°C (b) T=85°C

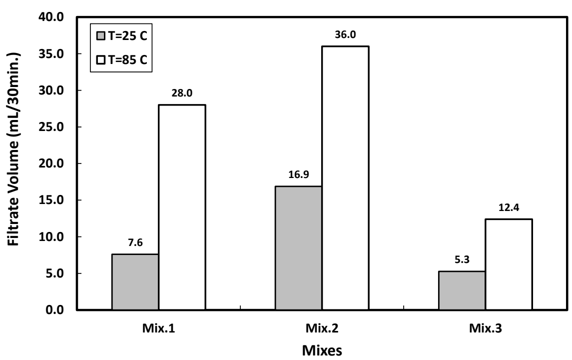

Figure 3. Variation of Fluid Loss and the Temperature for Fracturing Fluids

Table 1. Rheological Properties of Fracturing Fluid Mixes

	Temperature=25°C		
Mix #	**Resistivity (Ω.m)**	**Yield Stress, τ_o (Pa) Eqn. 1**	**Viscosity (cP at 170 s^{-1})**
1	3.75	87.3	478
2	0.07	44.4	108
3	1.36	96.9	333
	Temperature=85°C		
1	2.78	48.0	192
2	0.04	17	44
3	0.99	64.3	206

5. Conclusions: Based on this study, the rheological properties and the fluid loss of the fracturing fluid increased with increase in temperature of the fracturing fluid and biopolymer increased the viscosity and reduced the fluid loss of the fracturing fluid.

6. Acknowledgements: This study was supported by the Center for Innovative Grouting Materials and Technology (CIGMAT) with funding from Texas Hazardous Waste Research Center (THWRC).

7. References

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