**Abstract**

During oil recovery, flow channels are created due to reservoir heterogeneities and fluids distributions. To improve sweep efficiency or temporary block undesirables productive zones, polymeric gels have been proposed. Partially Hydrolyzed Polyacrylamide (HPAM) crosslinked with metal ions or with organic compounds produce a gel used in water shut-off and conformance control. Water expulsion from the 3-D network causes the gel to shrink in a process known as syneresis, due to reservoir harsh conditions. To inhibit this phenomena, the inclusion of SiO₂, Al₂O₃, and MgO nanoparticles to the gel system was evaluated. An HPAM/resorcinol/formaldehyde gel was developed varying resorcinol and formaldehyde concentrations. Different nanoparticles dosages from 25 to 100 ppm were tested. The gel was set to 70°C. Results showed that 100 ppm of Al₂O₃ and MgO nanoparticles reduced syneresis progress in 71.3 and 40.4% at day 40, respectively. Also, both enhanced storage modulus G’, describing better gel strength. Repulsive interactions between SiO₂ and HPAM could explain syneresis increasing when using these nanoparticles.

**Materials Characterization**

<table>
<thead>
<tr>
<th>Size (nm)</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>MgO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Area (mg/m²)</td>
<td>389</td>
<td>43.4</td>
<td>21</td>
</tr>
<tr>
<td>Point of Cero Charge (pHₚC)</td>
<td>3</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

**Results**

**Gelation** at 25 °C

**Nanoparticles Effect**

- The presence of (-OH) stretching in the HPAM was confirmed by FTIR analysis in the 3325 cm⁻¹ wavelength and a 29.3% of hydrolysis, i.e. the amount of carboxylic group in the polymer estimated through back titration test, indicates good capacity to create bonds with the crosslinker.
- Rheological studies show an increase in the storage modulus G’ with the increase of formaldehyde and resorcinol concentration. Alumina nanoparticles also improve gel strength with the increment of dosages, which means a stronger 3-dimensional microstructure.
- Alumina and magnesium oxide nanoparticles inhibit syneresis developments in 71.3 and 40.5% at day 40 when the concentration is 100 ppm, while silica nanoparticles increased syneresis in 45% at the same conditions. This results could be explained due to the values of alumina and magnesium oxide nanoparticles points of zero charge being above the original gel pH and silica nanoparticles being below, fomenting a repulsion with the polymer.
- For further investigation it is recommended to test different size and superficial area alumina nanoparticles to analyze surface adsorption phenomena.

**Conclusions**

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