An Effective and Economical Process of Calcium Sulfate Scale Dissolution at High Temperature

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ABSTRACT

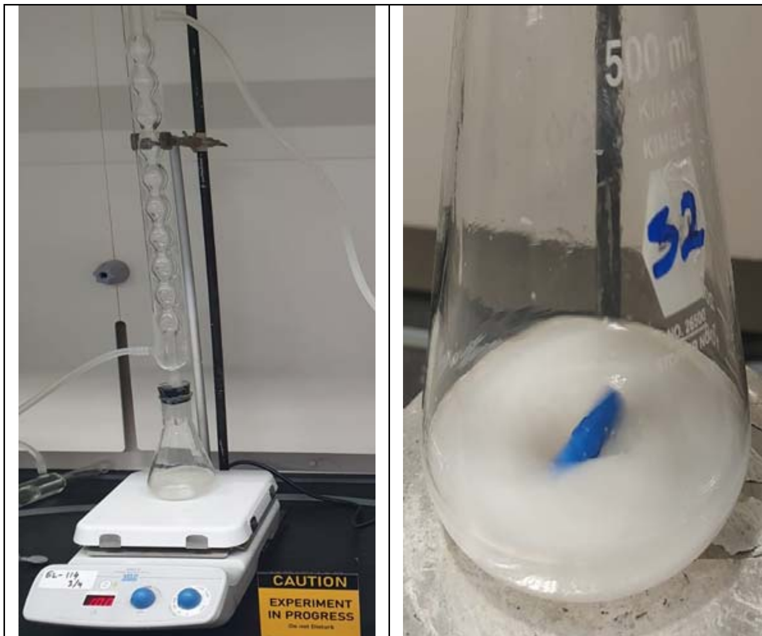
In oil and gas producing and injection wells, the calcium sulfate ($CaSO_4$) scale has been identified as a major scale causing various serious operational challenges. In the majority of instances, removing this scale is an economically viable technique, as it increases well productivity and prevents serious equipment damage. In this study, the $CaSO_4$ scale was removed in a single step using potassium carbonate (K_2CO_3) and tetra-potassium (K_4) EDTA at 200°F temperature. Under varying pH conditions, the $CaSO_4$ scale was converted to calcium carbonate and potassium sulfate utilizing potassium carbonate as a converting agent. The effect of dissolver pH, soaking time, the concentration of K4-EDTA, and the concentration of K_2CO_3 were investigated to determine the optimal dissolver composition for optimal dissolution efficiency. The dissolver solution was reported to be efficient at a pH of 7 and to produce a small quantity of reaction product for the dissolution of 3 wt% $CaSO_4$. The dissolver with a pH of 10.5 was effective in the majority of scenarios and had the highest dissolution efficiency. Both dissolvers, which varied in pH (7 and 10.5), exhibited great temperature stability and low corrosion rates. The single-step dissolving approach was shown to be effective and economically viable, and its use might greatly reduce pumping time.

Extended Abstract

Scale is a solid deposit that builds up over time and impedes fluid flow (Olajire, 2015). Scale formation is a significant operational issue because it obstructs pipelines, valves, and wellbore perforations, hence increasing equipment wear, corrosion, and flow restriction (Mitchell et al., 1980). The most prevalent scales in the oil and gas business sector are $CaCO_3$, $CaSO_4$, FeS, and $BaSO_4$ (Gasimli et al., 2022; Kamal et al., 2018; Mohammed et al., 2022). The $CaSO_4$ scale has been identified as the primary scale responsible for a variety of key operational issues. Hard, impermeable $CaSO_4$ scale deposits can diminish formation permeability, hence decreasing well injectivity and output. If $CaSO_4$ precipitates in down-hole equipment, well performance may deteriorate (Mahmoud, 2014). The formation of the $CaSO_4$ scale takes place due to interactions of two incompatible fluids. One of the most common cases is the mixing of injection brine with excess $SO4^{-2}$ ions and the formation of brine with excess calcium ions. Such interactions will result in the formation of scale.

$CaSO_4$ scale is problematic because they are resistant to acid dissolution. However, they do dissolve in very alkaline chelate solutions (Clemmit et al., 1985). Scale can be eliminated without the use of organic or inorganic acids by employing chelating agents for instance in ethylenediaminetetraacetic acid (EDTA) and diethylenetriaminepentaacetic acid (DTPA), N,N-Dicarboxymethyl Glutamic Acid (GLDA)(Alissa et al., 2022; Al-khaldi et al., 2011). In contrast, chelating chemicals are less harmful to the environment, biodegradable, and have a lower rate of corrosion than acids, which are toxic and damaging to tubing and downhole equipment.

Extensive experimental work was undertaken to evaluate the efficacy of a chelating agent and catalyst-based conversion approach for $CaSO_4$ scale dissolution. The impact of various parameters such as temperature, pH, and concentration of reactive fluid on scale dissolution was investigated. A detailed study on $CaSO_4$ dissolution can be referred to in our recent article(Murtaza et al., 2022). By use of a conversion procedure, the $CaSO_4$ scale was dissolved easily as converting agent converted $CaSO_4$ into an acid and chelating agent dissolvable product. A series of experiments were conducted under various conditions to find out the best optimum concentrations of K_2CO_3 and K_4-EDTA for the solubility of $CaSO_4$. It was dissolved in a dissolver containing 5wt% K_2CO_3 and 20wt% EDTA. In some of the experiments, the reaction product in form of white solids was produced which was acid soluble. Figure 1 shows the experimental setup and reaction product obtained in some of the experiments.



A	B

Figure 1: A shows the scale dissolution experimental setup, and B shows the reaction product

As demonstrated in Figure 2, the temperature has a minimal effect on the $CaSO_4$ dissolution for the tested dissolver solutions. The test was conducted at two distinct temperatures (75°F and 200°F), and the temperature had no discernible effect on dissolution. For instance, the dissolution effectiveness of dissolver 1 marginally increased from 88.50% to 90.3% as the temperature rose from 75°F to 200°F. At 75°F and 200°F, the dissolving efficiency for dissolver 2 was 100 %.

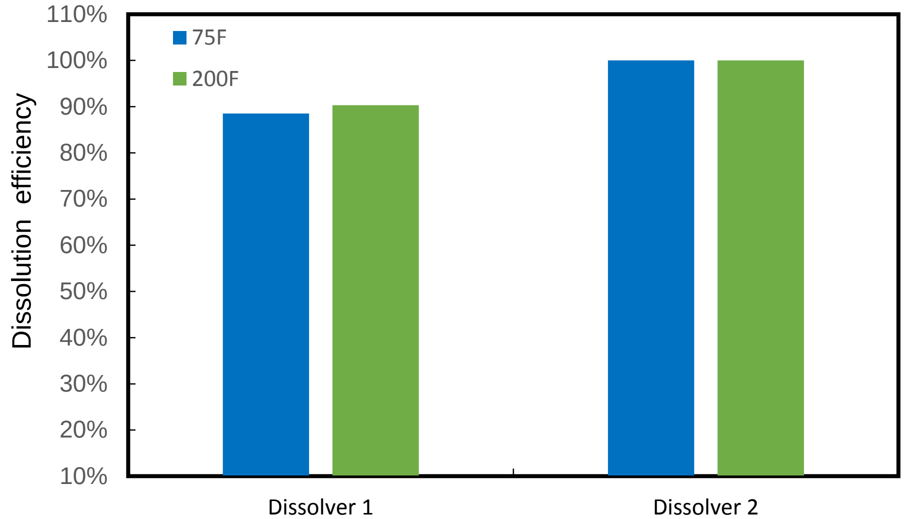


Figure 2: Effect of temperature on dissolution efficiency

The pH of the dissolver affected the dissolution of $CaSO_4$. $CaSO_4$ scale dissolves differently depending on the pH of the dissolver and the concentration of $CaSO_4$; thus, pH contributes to dissolution. Figure 3 depicts the dissolving efficiency as a function of pH variation. Despite having the same formulation, the pH of the evaluated dissolvers varied; dissolver 1, dissolver 2, and dissolver 3 have pH values of 7, 10.5, and 12.2, respectively. The dissolvers were composed of same 5% K_2CO_3 and 20% K_4-EDTA. The pH effect was performed on 3% $CaSO_4$ for six hours at 200°F. The $CaSO_4$ scale was found to be completely dissolved by all of the dissolvers during a high-temperature soaking period. After storing the solutions at room temperature, it was discovered that precipitates were present in the high pH dissolvers, which was an intriguing finding. The low pH dissolver-1, on the other hand, did not reveal any precipitates. Due to high concentrations of solids in dissolver 3, it was not further used for testing.

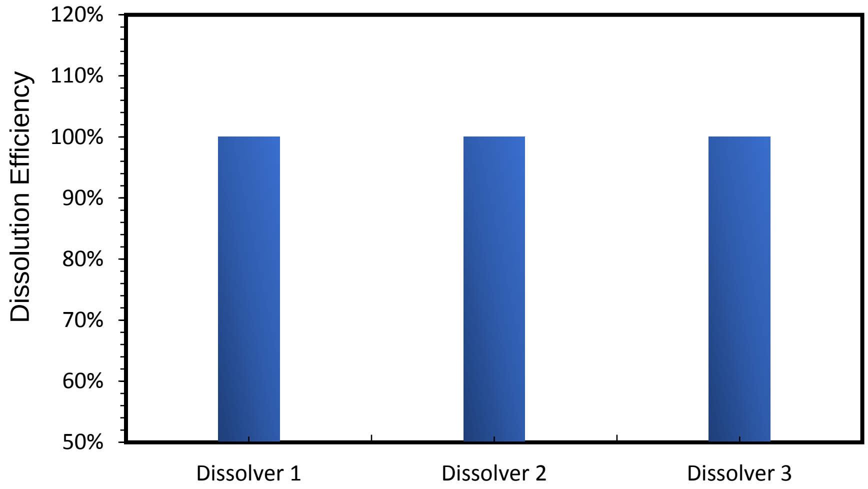


Figure 3: Dissolution efficiency vs pH change

Despite having the identical formulation across all evaluated dissolver, their pHs varied (7 and 10.5). The formulation contained 20% EDTA and 5% K2CO3. All formulations dissolved the CaSO4 scale in 3 hours, yet the efficiency differed with the concentration of scale as shown in Figure 4. It was shown that when the quantity of CaSO4 in formulation increased, the effectiveness dropped. For example, the efficacy was 100%, when the concentration of calcium sulfate was upto 3%. At higher concentration (5%), efficiency dropped to 90%. The decreases in the efficacy of the formulation by incrasing calcium sulfate concentration was also observed in case of high pH. For dissolver 2, it exhibited improved performance than dissolver 1. It dissolved completely CaSO4 up to 5wt%.

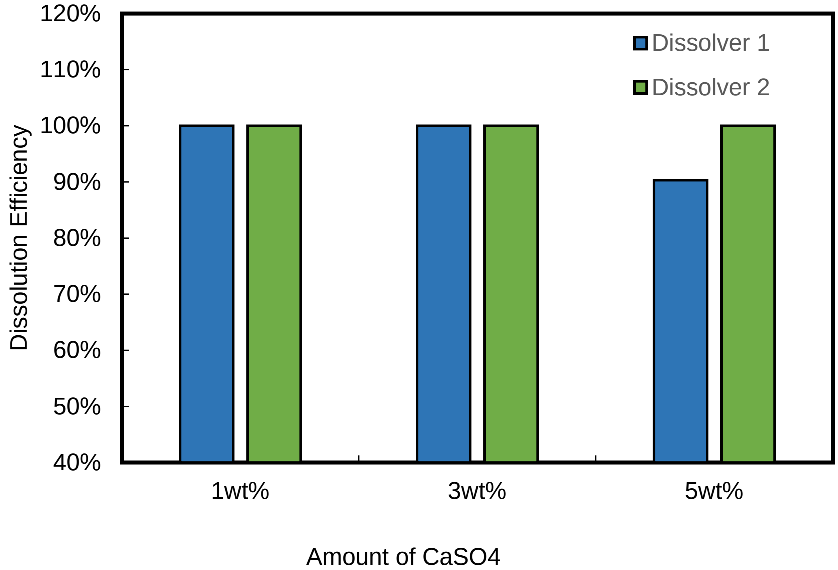


Figure 4: Effect of CaSO4 concentration on dissolution efficiency

Conclusions

This study investigated a single-step approach utilizing K_2CO_3 and K_4-EDTA for the dissolution of the $CaSO_4$ scale. Several factors were examined to find a dissolver composition with the best dissolution efficiency, including the effect of temperature, $CaSO_4$ concentration, and dissolver pH. The following conclusions were made from this study:

1. The single-step approach effectively dissolved the $CaSO_4$ scale at high temperatures (200°F).
2. The pH of the dissolver affects the $CaSO_4$ dissolvable concentration. At 200°F temperature, $CaSO_4$ up to 3 wt% (30g/L) was completely dissolved in a 7-pH dissolver, whereas 5 wt% (50g/L) was only dissolved in a 10.5-pH dissolver.
3. Both low and high pH dissolvers (7 and 10.5) were effective and showed high thermal stability and minimum corrosion.
4. The single-step approach is approved to be a more effective and economic technique that can save enough pumping time.

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