Plugging wellbore formations with environment-friendly silicate gels

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In the framework of the MiReCOL three-year European project, a method for treating the surrounding of a well using a reactive suspension was studied. Amongst many possible choices, a silicate based product was selected due to the following key qualities: high performance, long term chemical stability (w.r.t. acid), good injectivity (low viscosity and no particles) and no or little environmental impact.

An experimental investigation of the precipitation of commercial low cost potassium silicate solutions was then conducted, using a weak acid to lower the pH. Below a pH of approximately 9, the gel formed is stable and no back-dissolution is possible unless the pH is increased again. Thus, induced in porous media, this process has the potential to plug the formation around a well, preventing gas or liquid flow. In order to estimate the bulk gelation times before the mixture became too viscous for injection, various environment-friendly concentrations of a socially acceptable and non-hazardous acidic compound were added to the silica-based solution. The impact of temperature was determined by performing experiments at 20, 40 and 60°C, with gelation times estimated between a few minutes up to 4 days. The run products were characterized using high resolution physico-chemical techniques, such as rheological visco-elastic properties to observe the gel onset, NMR relaxation time measurements to follow the gradual increase of water interactions within the gel, or infrared spectroscopy to observe the gradual formation of Si-O-Si bonds within the fluid. In addition, the syneresis process (expulsion of water from the gel) was also studied as a function of time and temperature.

The ability of the precipitates to plug a porous media was then tested by injecting an optimum mixture though analog sandstone samples, representative of some CO_2 storage formations. Subsequent breakthrough coreflood experiments were performed, and so far indicate a very large strength of the order of 600 bar/m. SEM imaging of the plug was then performed to verify the obstruction of the pore network by the solidified gel. A field-test injection was finally conducted by injecting several m^3 of the solution in a sandstone formation located within a CO_2 emission field. Limitations and potential improvements will be discussed in light of the obtained results.