Effects of Surface Coatings on Crystallization of Calcium Sulfate

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Background

•Calcium sulfate is a particularly troublesome deposit from hard water. This is because it has inverse solubility. Compounds with inverse solubility become less soluble as temperature increases. If hard water is used in a cooling tower or boiler, the high temperatures will cause calcium sulfate scaling to occur. This scaling can reduce thermal efficiency.

•It would be advantageous to coat surfaces with materials that could prevent fouling.

•Polyhedral Oligomeric Silsequioxanes (POSS) are silicon oxide compounds that have “cages” in their molecular structures. Because of their structure, they have very low surface energy, which theoretically inhibits crystal nucleation.

•POSS compounds have been considered as possible coatings for the interiors of boilers and cooling towers.

Methods

•Microwave vials (10 ml) had their interior surfaces dip coated with various silicates, including fluorodecylPOSS. These compounds are listed in the table.

•The vials were filled with $CaSO_4(aq)$, then sealed and placed inside of an oven at 95˚C for several days

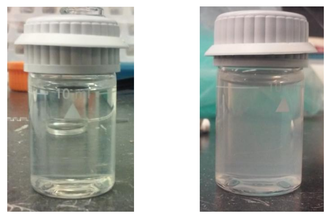
•Turbidity tests were done using a Lovibond Photometer MD 600 to determine the amount of $CaSO_4$ in solution, which was compared between vials with different surface coating agents.

•The more $CaSO_4$ in solution, the less nucleation that occurred.

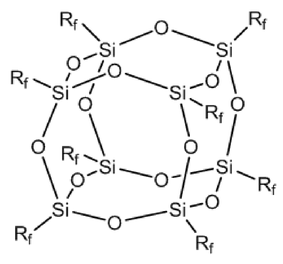
$$BaCl_{2(aq)} + CaSO_{4(aq)} => BaSO_{4(s)} + CaCl_{2(aq)}$$

The reaction between the dissolved barium chloride pellet and the calcium sulfate in the solution. This forms a cloudy solution, where the turbidity is directly dependent on the amount of barium sulfate formed.

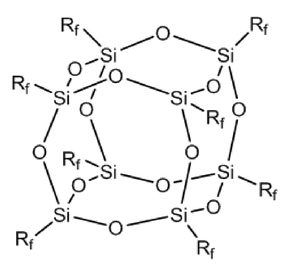
A vial internally coated with fluorodecylPOSS.



Calcium sulfate solution before and after addition of barium chloride pellet



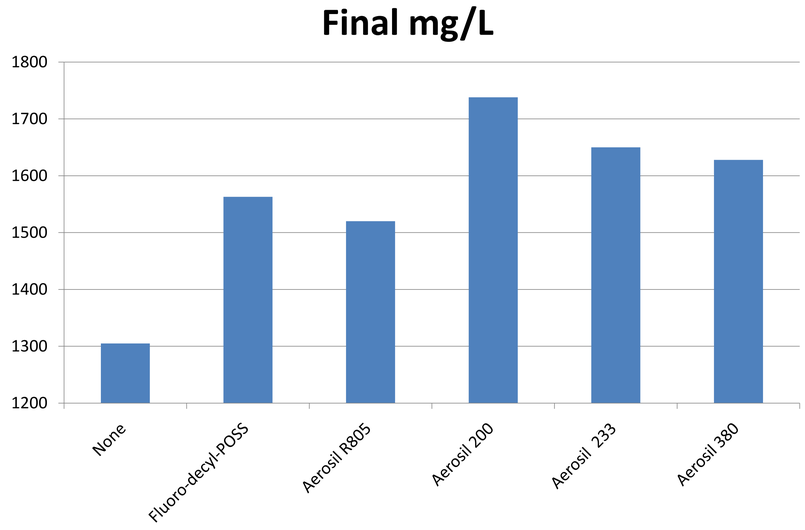
$Rf = (CH_2)_2(CF_2)_5CF_3$



$Rf = (CH_2)_2(CF_2)_7CF_3$

Two examples of fluoroPOSS compounds, fluorooctylPOSS and fluorodecylPOSS.

Results



Surface Coating	Final mg/L $CaSO_4$
None	1305
FluorodecylPOSS	1563
Aerosil R805	1520
Aerosil 200	1738
Aerosil 233	1650
Aerosil 380	1628

Conclusion: FluorodecylPOSS appears to inhibit nucleation, although several Aerosil compounds do as well. Further testing will reveal more about their effectiveness as anti-fouling coatings.

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This project has been made possible with support from Chevron (www.chevron.com) and the California State University STEM Teacher Researcher Program in addition to contributions from the Air Force Office of Scientific Research and the Air Force Research Laboratory, Aerospace Systems Directorate

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Locomotive and all others by Shawn Kirby