

Scale Inhibiting Features of Solid Treatment Feed Products C20M-C and C20-C

A Report to APTechgroup, Inc.

Buckman Laboratories Incorporated

Introduction

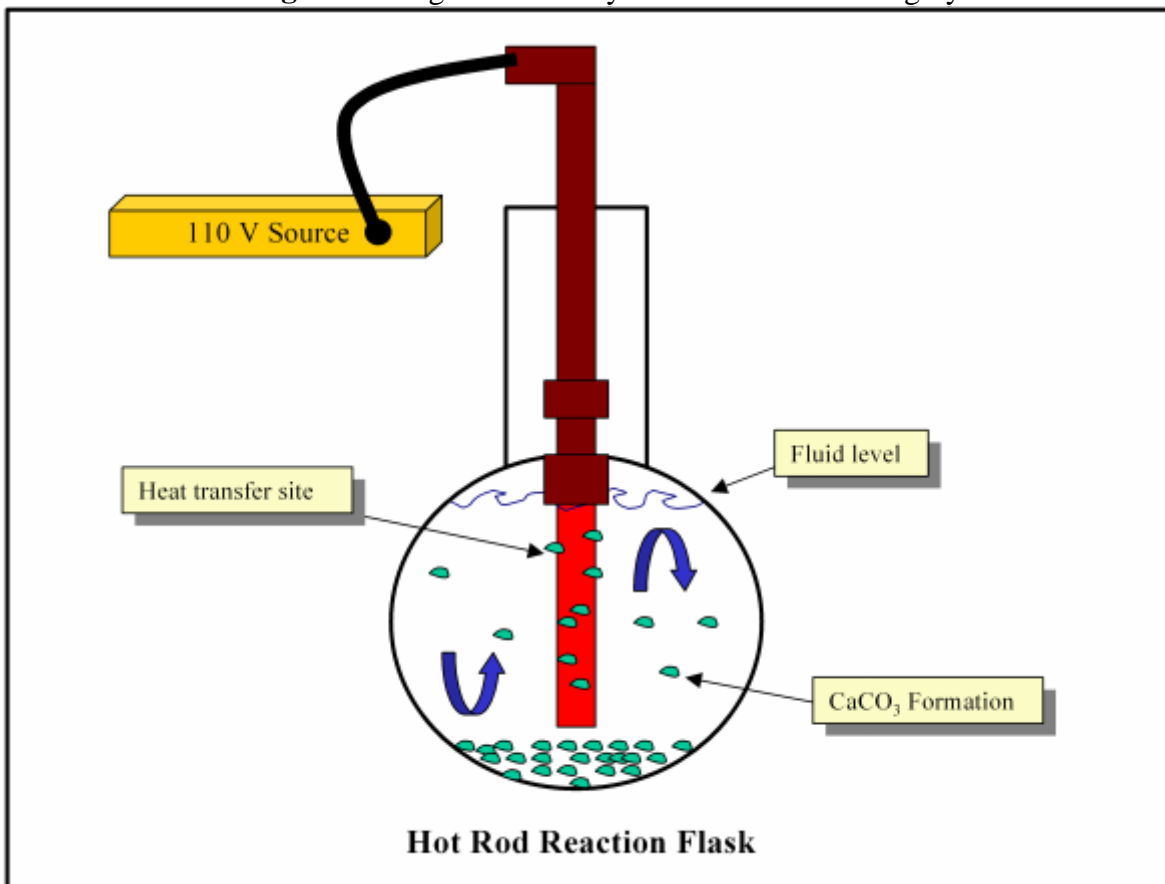
APTECHGROUP, INC., Incorporated employs a unique process-water chemical delivery system. Chemical treatments are deployed and installed as a solid. Dissolution into a system takes place as water passes over the condensed product. A satisfactory feed rate was initially established, but it is not known if a single feedrate is economical for all water conditions.

This study was designed to optimize treatment dosages inhibiting calcium carbonate scale. Two products C20M-C and C20-C, supplied by the customer in final solid form, were evaluated in three different stressed water chemistries.

Experimental Procedures

Calcium carbonate inhibitor treatments were evaluated in twelve separate Dynamic Hot Rod Scaling Reactors (Figure 1) using synthetic make-up water. Each rod, or heat transfer site, is a 250W 120V stainless steel immersion heater placed at a specific depth in a 1L reaction flask. The rods draw full current from a common 110V outlet. Water in each flask quickly boils at the center and cools near the flask wall providing convection circulation.

Figure 1. Diagram of the Dynamic Hot Rod Scaling System



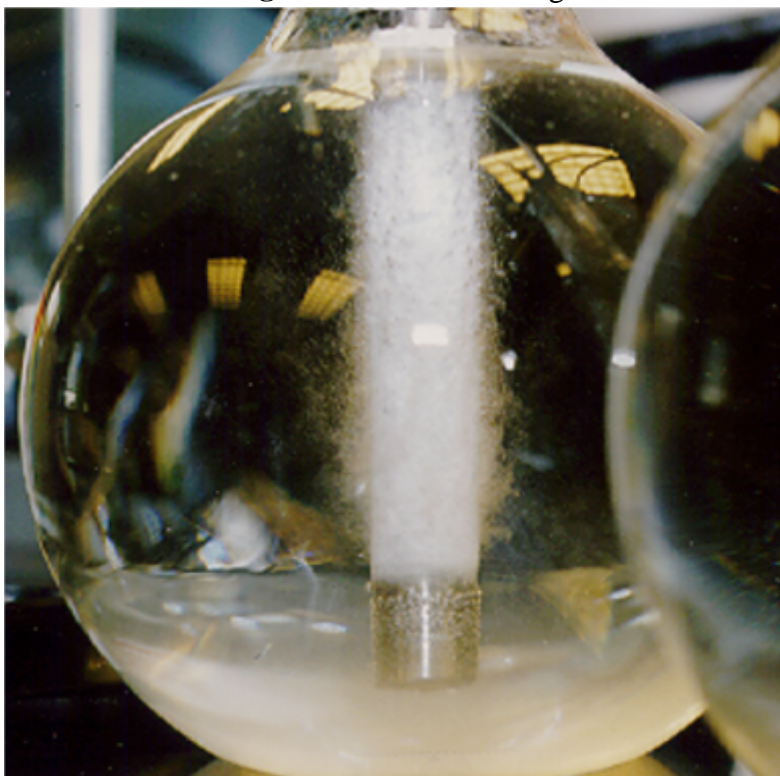
Calcium carbonate crystals form and adhere to the rod and flask walls. Other CaCO₃ crystals can free float and settle at the bottom of the flask. Depending on a treatment's crystal modifying ability, more or less scale accumulates to the bottom as conditioned "sludge". Calcium can also remain soluble in the system water.

Scale Distribution was determined by quantifying the Ca^{2+} residing on the rod itself and on the flask walls. Rod and bottle-bound CaCO_3 were dissolved off in 5% (v/v) nitric acid, collected, and analyzed for Ca^{2+} using Inductively Coupled Plasma (ICP) mineral detection.

Figures 1 and 2 show the actual 12-chamber rig and the rod heat-transfer site as it accumulates scale.

Figure 1 – 12 Hot Rod Reaction Flasks

Figure 2 – A Rod Scaling



Data

Twenty liters of synthetic water was made up to specified hardness and alkalinity (Table 1) in DI water using ACS grade calcium chloride dihydrate and sodium bicarbonate.

Table 1 –Synthetic Water Targets

| Condition | Units | Water A | Water B | Water C |
|------------------|------------------------|---------|---------|---------|
| Calcium Hardness | ppm as CaCO_3 | 500 | 1200 | 1000 |
| Total Alkalinity | ppm as CaCO_3 | 200 | 400 | 1000 |

C20M-C and C20-C were dosed as product into each reaction chamber at 10, 25, and 50ppm. Each dose was run in triplicate and averaged to insure statistical validity. Results for relative scale are recorded as milligrams of Ca^{2+} in tables 2-4.

Table 2 - Water A

| Treatment | Dose (ppm) | Rod Scale (mg Ca ²⁺) | Bottle Scale (mg Ca ²⁺) | Total Ca ²⁺ (mg) |
|-----------|------------|----------------------------------|-------------------------------------|-----------------------------|
| Control | -- | 15.64 | 1.78 | 17.42 |
| | | | | |
| C20M-C | 10 | 5.79 | 1.12 | 6.91 |
| | 25 | 4.45 | 0.25 | 4.70 |
| | 50 | 2.32 | 0.93 | 3.25 |
| | | | | |
| C20-C | 10 | 6.00 | 2.26 | 8.26 |
| | 25 | 3.00 | 0.22 | 3.22 |
| | 50 | 2.09 | 0.20 | 2.29 |

Table 3 - Water B

| Treatment | Dose (ppm) | Rod Scale (mg Ca ²⁺) | Bottle Scale (mg Ca ²⁺) | Total Ca ²⁺ (mg) |
|-----------|------------|----------------------------------|-------------------------------------|-----------------------------|
| Control | -- | 31.67 | 16.98 | 48.65 |
| | | | | |
| C20M-C | 10 | 36.33 | 3.19 | 39.52 |
| | 25 | 26.33 | 7.00 | 33.33 |
| | 50 | 21.04 | 5.40 | 26.44 |
| | | | | |
| C20-C | 10 | 39.73 | 3.00 | 42.73 |
| | 25 | 26.53 | 9.32 | 35.85 |
| | 50 | 19.71 | 6.3 | 26.01 |

Table 4 - Water C

| Treatment | Dose (ppm) | Rod Scale (mg Ca ²⁺) | Bottle Scale (mg Ca ²⁺) | Total Ca ²⁺ (mg) |
|-----------|------------|----------------------------------|-------------------------------------|-----------------------------|
| Control | -- | 186.5 | 9.23 | 195.73 |
| | | | | |
| C20M-C | 10 | 96.4 | 5.13 | 101.53 |
| | 25 | 78.87 | 10.02 | 88.89 |
| | 50 | 67.6 | 11.04 | 78.64 |
| | | | | |
| C20-C | 10 | 84.33 | 3.13 | 87.46 |
| | 25 | 71.87 | 10.72 | 82.59 |
| | 50 | 60.07 | 16.00 | 76.07 |

Summary

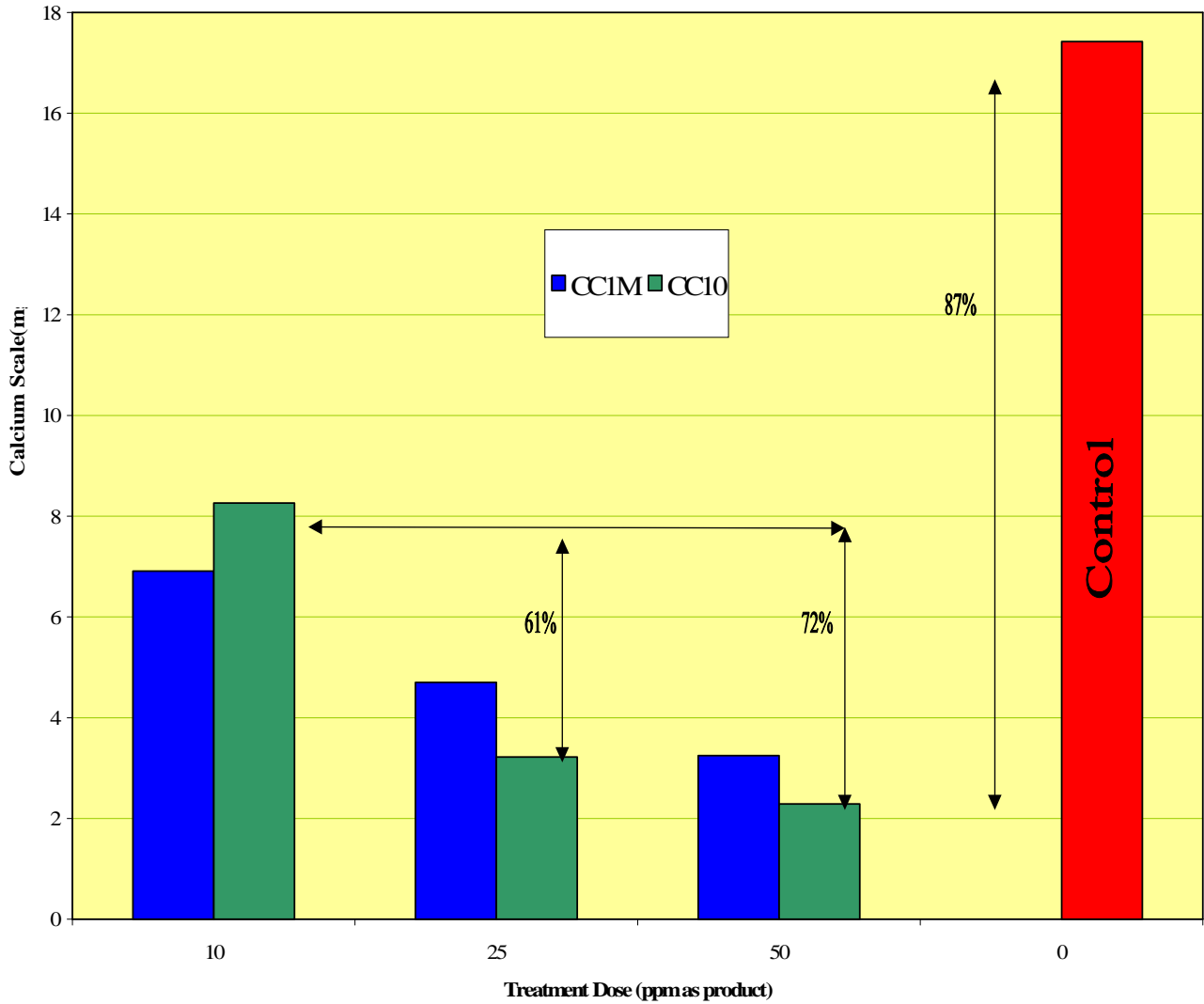
In all tests, regardless of water conditions, increasing the chemical dose from 10ppm to 50ppm decreases the amount of calcium on the rod and flask. Meaning that calcium carbonate scale is decreased. Also, the data here does not support one product consistently working better than the other under these specific conditions.

It is important to note that in each water condition experiment, the amount of calcium scaled is relative to the initial calcium in the synthetic water.

Water A

There is an 87% decrease in calcium scale from the control to the 50ppm dose of C20-C. Compared to the 10ppm dose, 25ppm and 50ppm have approximately a 61% and 72% improvement respectively (Graph 1).

Graph 1

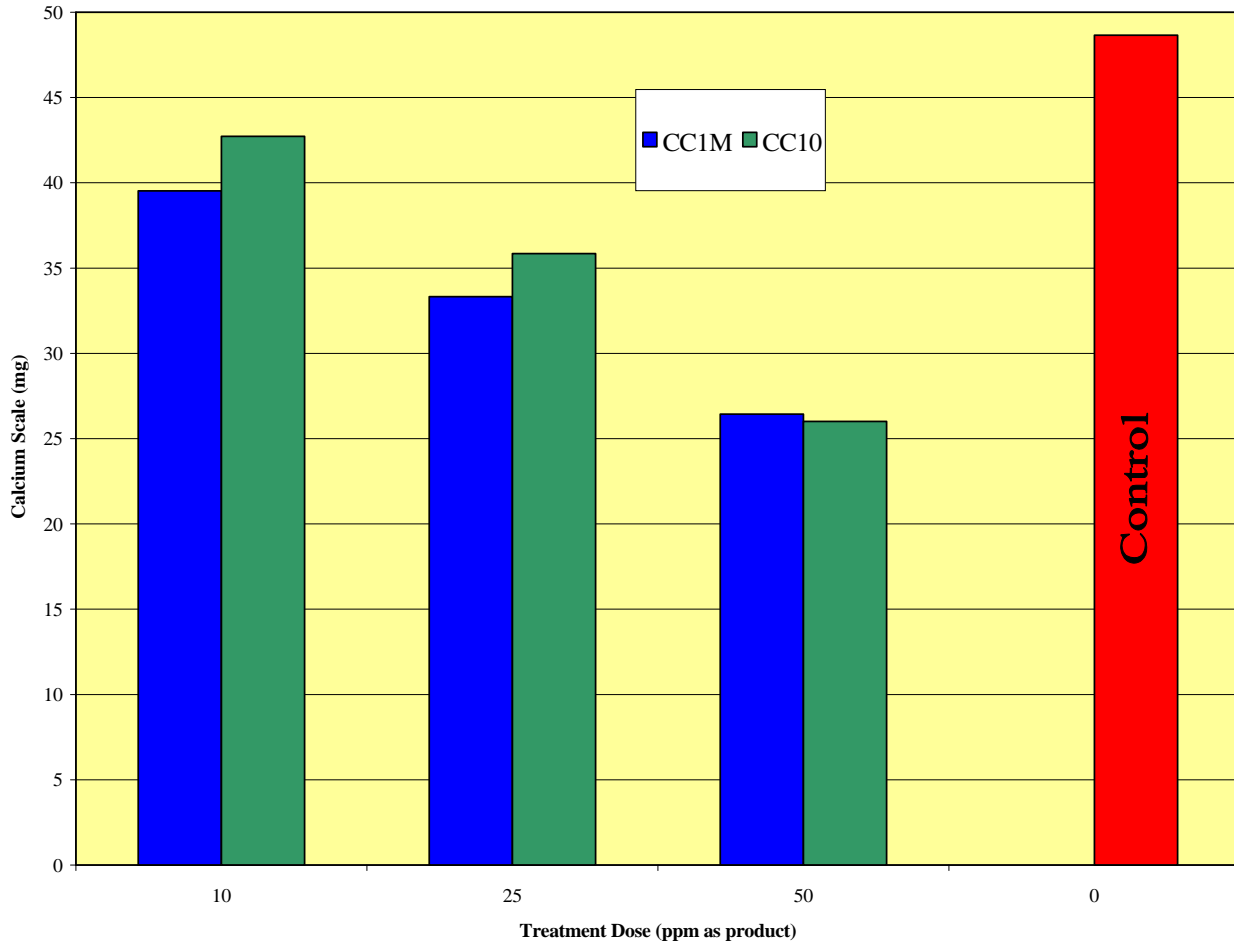


Treatments at 10ppm have the highest calcium scale, but are a 50% improvement over the non-treated control. 25 and 50ppm treatments have similar performance effects on scale inhibition.

Water B

Higher hardness/mid-range alkalinity water conditions alter the effectiveness of the treatments. Changes in product dosage from 10 to 50ppm are less dramatic than in graph 1 (Graph 2).

Graph 2



There is only minimal scale control over the control at 10ppm. Stepping up in dose to 25ppm improves scale inhibition; however, the improvement does not compare to the lower hardness waters found in Water A @ 25ppm. Treatment @ 50ppm provides the most desirable scale control under these water conditions.

Water C

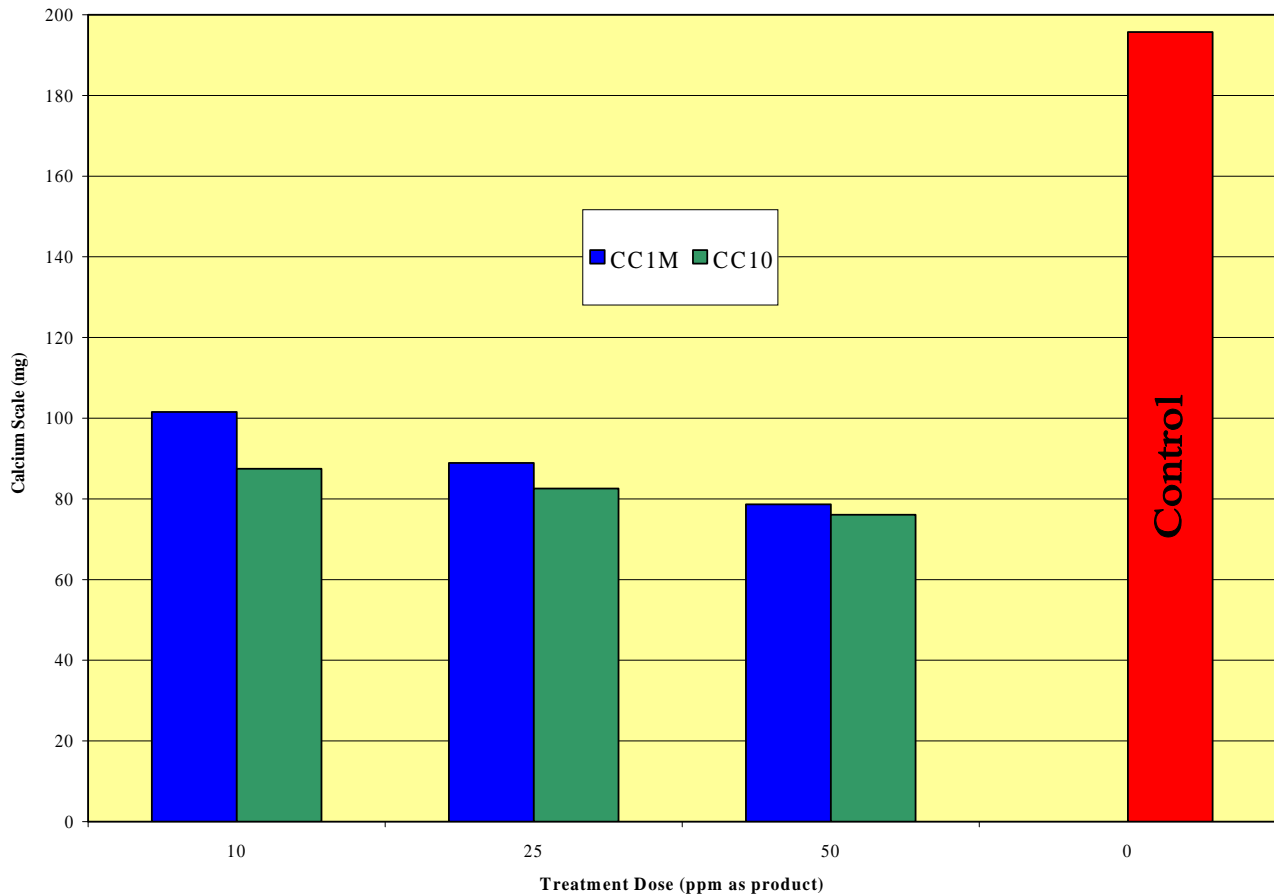
These water conditions are of the highest stress at 1000ppm calcium and 1000ppm alkalinity. Graph 3 indicates similar performance between the three treatment levels. Each with approximately 50% or greater reduction in calcium carbonate scale.

The product formulations for C20M-C and C20-C were not provided, but based on the amount of sludge accumulated at the bottom of the Water C reaction flasks, one could predict that crystal modifying agents are present.

Sludge accumulation without scaling is a typical response in high-stress water when sludge-conditioning agents are being fed. With combinations of the correct polymers, it does not require high doses to modify crystal structure. Similar results have been demonstrated using various Buckman polymers.

In high hardness and alkalinity situations such as this, total calcium-based precipitation inhibition is not realistic or economical. The goal is to condition and disperse scale so it will not stick to heat transfer surfaces and be removed during blow-down.

Graph 3



Conclusions

Water A – 500ppm calcium, 200ppm alkalinity

- 25ppm of either C20M-C or C20-C product is sufficient to maintain scale control.
- 10ppm of C20M-C or C20-C provides less desirable control, but still effective.

Water B – 1200ppm calcium, 400ppm alkalinity

- 50ppm treatment level should be the **minimum** dose for scale control under these conditions.

Water C – 1000ppm calcium, 1000ppm alkalinity

- 10 and 25ppm doses are sufficient to control scale under these conditions.