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Study of $CaCO_3$ Scale Formation on DLC coated steel

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Abstract – Scale deposits formations were studied on DLC coated steel surfaces. Gravimetric and SEM analysis showed that coated surface present lower amount of scale compared with uncoated surfaces. Deposits in DLC coated surfaces showed $CaCO_3$ crystals with reduced size and cubic morphology unlike the deposits formed in solution with the presence of inhibitors, that do not present a cubic morphology It was also observed, in a qualitative way, that $CaCO_3$ deposit has low adhesion to DLC coated surfaces when compared with uncoated surfaces which is a good result form technological application point of view

Inorganic scale formation is a problem in the oilfield industry. Among many inorganic compounds, $CaCO_3$ is one of the most common and can be responsible for blockage of tubing and flowlines [1]. Traditionally, studies of scale formation have been done focused the precipitation in the bulk of the solution, using laboratory beaker or bulk jar test [2]. In recent years researchers are studying scale problem from a surface point of view.[3] and considering coating as a method to fight scale problems. Diamond like carbon (DLC) coating is a material widely studied because their interesting properties like: high hardness, low friction coefficient, high surface energy, chemical inert. This paper presents a study of the possibility of use of a protective DLC coating as method to mitigate $CaCO_3$ scale formation in a stainless steel surface and compare the results with another protective method, the use of inhibitors.

The deposits were produced from a 200ml supersaturated solution obtained from a mixture of 2 brines: $CaCl_2.2H_2O$ (100ml) and Na_2CO_3(100ml). Experiments were carried out in a 250 ml jacketed glass vessel containing circulating water in a constant temperature ensured by a water bath. The scale inhibitor used was diethylenetriaminepenta (methylenephosphonic acid), known as DTPMPA. In this study two concentrations were used: 1 ppm and 5 ppm. $CaCO_3$ was deposited on stainless steel cylinders (diameter of 12 mm). A balance, with accuracy of 0,0001 g, was used to measure the weight of the samples before and after the deposition The difference of weigh before and after de deposition was considered to be amount of $CaCO_3$. Deposition experiments were carried out in three different temperatures: 5ºC, 20ºC and 60ºC.

It was observed that the scale crystal grow depends on the surface properties. Coated surface showed smaller $CaCO_3$ crystal sizes and less amount of material when compared with unprotected steel surface. The use of DLC coat didn't affect the cubic shape of crystals. Inhibitors also reduced the amount of scale and affected the crystals morphology. With 5% pp of inhibitor was possible to reduce the majority of the scale deposits. It was also observed that the roughness and temperature affects the amount of deposited material. In a qualitative way, was possible to observe, that $CaCO_3$ deposit has low adhesive properties on DLC coated surfaces when compared with uncoated surfaces which is a good result form technological application point of view.

References

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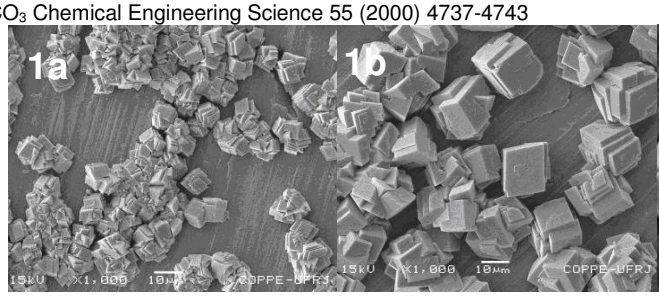

Figure 1: SEM image of a $CaCO_3$ crystals deposited in **a)** steel DLC coated surface and **b)** steel uncoated surface

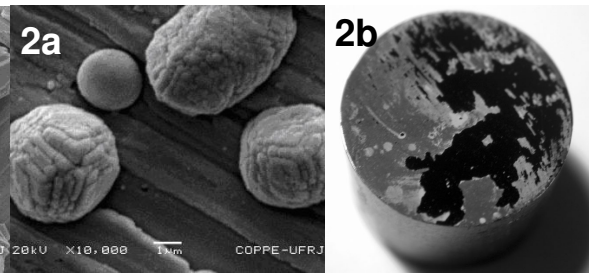

Figure 2: a) SEM image of $CaCO_3$ crystals in presence of inhibitor **b)** Image taken of a sample steel cylinder with scale after receive a compressed air jet.