DOWNHOLE MICROENCAPSULATED CHEMICAL TREATMENT IN ROD PUMP

Nelson Patton
Maverick Oil & Gas
Renzo Arias Ugarte, Shivani Vyas, Gustavo Gonzalez,
Odessa Separator Inc.

ABSTRACT

Chemical treatment from surface is required to prevent common issues associated with corrosion and scale formation, such as carbonates and sulfate.[1] Unfortunately, sulfate species associated with calcium, Barium, or strontium, commonly known by gypsum, barite and celestine respectively, if not controlled properly from the beginning, can cause serious issues to be removed; especially when no continuous chemical inhibition have been provided and have let it to a crystallization, creating insoluble solid and clogging the system.[2] At this point a mechanical removal or a 2-step process dissolution will be required, consuming time and money in the process.[3]

In that sense microencapsulated chemical inhibition technology represents a potential alternative, to provide a continuous inhibition downhole, near perforations or at any other strategic point. The mechanism associated to this technology are through a slow dispersion, from bottom to top or as soon as the produced fluid touch our homogenous microencapsulation matrix.

Our microencapsulation matrix technology, carrying out a combo combination of corrosion, THPS and scale inhibitor, have been successfully implemented to Maverick, increasing the runtimes on a 3-fold, and currently well in still in production, implying the success inhibition of the sulfate and carbonate scale issues, reported before to a 3-month average failure, even after chemical treatment was done from surface. In conclusion our microencapsulated chemical technology has demonstrated its ability to continuously deliver chemical inhibition and control in this particular case, scale as sulfate and carbonate formation, extending the runtime to a 3 fold and currently well still running.

INTRODUCTION

Gaines County, located in Central Basin – sits in the heart of the Permian is a shallow subsurface located in West Texas and portion of New Mexico (Fig.1); between the Delaware and Midland Basins (Fig. 2). About 45% of the total barrels produced in the Permian is sourced through the Central Basin Platform. This region is embodied with conventional wells which employ enhanced oil recovery techniques.

In production operations, the presence of inorganic and organic deposits is a common and critical problem that generates significant loss of production. At the downhole conditions, the balance of the fluids is fragile and easily could change and create corrosion, scale and organic precipitation on the production string. The downhole pump is the most important component of the production string and is responsible for the production of fluid, however, when is affected by chemical problems, depending of the type of problems, the amount of fluid start to decreases until the production stop completely due to a failure in the pump. Pump failures demand workover that summed the lost in production will result in a serious affectation to the incomes of the companies.

To control the chemical problems, the oil industry uses different remedial treatments that aim to balance the downhole conditions and/or inhibit the agent that triggers the reactions. Some of these methods are: Continuous injection, mechanical removal, squeeze, acid treatment, solvent treatment and magnetic inhibition. Despite the quantity of options available, it is a challenge for adequate concentration of chemical treatment to reach the pump intake. Some of the agents that affect this dilution are the column of fluid, the bottom hole temperature, the interface gas/liquid, and so on. Looking for an effective treatment that guarantees a long-term solution with an effective concentration at the pump intake, new investigations have focused their efforts to use the micro-encapsulation as a method to take the chemical treatment from

surface to downhole. However, for encapsulation the main components are not only the problems but to achieve a successful application of this concept it is required to incorporate more relevant concept such as release time, the dispersion area, the right placement at downhole, and the effect of the external agents (BHT, BHP, so on).
This paper summarizes the findings of the downhole conditions in the microencapsulation through application on conventional rod pump.

MICROENCAPSULATION

Over the years many industries such as pharmaceutic, food, cosmetic among others have developed many processes that allow to create a membrane that stop (stops) a substance to be released until is necessary for some specific function. These processes have varied and are based on scientific principles that deal with polymerization, surface energetic and reaction kinetics. The microencapsulation process (Table 1) contains physical and chemical considerations, for example, there are three forms of physical encapsulation, a slurry, a wet cake, and dry powder. The slurry form is a suspension of microcapsules in water containing preservatives. The wet cake is a slurry that has been filtered to approximately 50% to 70% capsule solids, with the remainder weight being water containing preservatives. The dry powder form of microcapsules contains less than 5 wt% moisture. This Form is typically provided only for capsules that are about 500 microns or less in size and is also dependent upon the type of capsule required membrane-type used to prepare the coating. Figure 2 shows the Microencapsulation Techniques, each technique depends on the nature of the fluid that would be encapsulated, the physicochemical properties, compatibility, and the application.

A New Downhole Chemical Treatment has been developed for an optimal solution for chemical problems occurring downhole. This new technology includes chemical microencapsulation, a concept that has been around for many years, and that represents advantages such as control of the release rate of chemicals, easy installation, and protection of the encapsulated active agent against degradation.

MICROENCAPSULATION TECHNOLOGY APPLIED IN CHEMICAL TREATMENT

Our current microencapsulation technology can be classified as chemical microencapsulation by polymerization that creates a homogenous matrix. The polymer created can absorb x times its weight by the corresponding liquid chemical inhibitor in its highest concentrated form, creating a homogeneous matrix in the microscopic range. (Figure 3A).

The homogeneous matrix concept, refers to the ability of the matrix to be activated immediately after being exposed to the corresponding fluid, liberating microcapsules in the microscopic range of the chemical inhibitor and being able to inhibit the current chemical issue (see Figure 3B).

The matrix can be modified to be able to adjust to the different chemical compositions such as hydrocarbons base, acid or alkaline substances or any other substance. In that way after matrix have been regenerated and follow internal process is continued named curing process. The curing process involves subsequent internal reactions that will increase the polymerization sites and consequently their ability to hold the chemicals inside.
Important Note: The current microencapsulation chemicals are totally biodegradable, implying their total dissolution in either water or oil phase, depending on the matrix design.
Additionally, our microencapsulation technology can integrate different chemical combinations in the solid state, which otherwise will be difficult to do in the liquid phase, especially at higher concentrated values.

DELIVERY METHOD

For this specific application, there must be a control method to release the treatment. The New Chemical Treatment for Downhole Applications Tool is designed to control downhole corrosive and scale deposition environments and organic deposits (paraffin and asphaltene). Depending on the well conditions, a short-term treatment combined with a long-term treatment is the best option to extend the run life of problematic wells. However, if the chemical is released all at once, the long-term treatment would disappear that is why it is so important to simulate and estimate the quantity of internal phase that will go through the capsule shell. There are several factors that affect the release control such as solubility of the internal phase, type of polymer, Molecular Weight of the coating polymer, the capsuled particle size, and the environment temperature. All these factors are studied carefully to simulate the well conditions and make sure that the chemistry would be applied now and depth that was planned.

The encapsulated compound is encased in a screen-jacket metal tube. The tools are designed with 24 feet J-55 joint pipe base that contains 2 feet perforated pipe section along with 304 stainless steel v-wire screen that offers an optimal dispersion area for the chemical (Figure 4). This downhole assembly containing the chemical matrix, slowly delivers chemical treatment at the level of production perforations, releasing all the chemical compounds and offering a solution for chemical problems occurring downhole.

Mechanism of Dispersion

The contact between the production fluid and the Chem sticks triggers the release of the chemical treatment (Figure 5). The chemical released from the Chem stick is now flowing upwards with the production fluid which allows the inhibition of scale, paraffin, corrosion depending on well conditions. Fig. 7 shows the configuration of Chem screens on Rod pumps below the Tubing.

RETRIEVABLE CHEM SCREENS

This tool (Figure 8) is designed specifically for wells with high lifting cost associated with chemical issues downhole, such as corrosion, scale, paraffin, asphaltenes, etc. The tool provides an even distribution of well-specific chemicals while offering an easy installation. For cases where the tubing isn't pulled, retrievable chem screen is a variable option. In the case of Sucker Rod Pump with an insert pump, the tool can be installed on the bottom of the pump, replacing the nipple strainer.

CHEM SCREENS

Chem screens is a technology that challenges the traditional concept of downhole chemical treatment. Through micro-encapsulation technology, all the active components of the most effective liquid chemical treatments in the oil industry are processed in a solid stick that is then installed below the pump intake. The installation of this tool downhole allows the activation and dispersion of the chemical problems to be treated and inhibited faster and more effectively, thus preventing harmful effects on downhole equipment. Figure 7 shows chem screen installed on rod pump, in both cases – pulling the tubing and not pulling the tubing: ensuring a proper contact of the chemicals with the production fluid ensuring an effective dispersion of the treatment and as well as enough concentration.

CASE STUDY

The well was converted from ESP to Rod pump in July of 2019 with a severe issue of sulfate scale. Surface chemical injections were conducted to combat the issue. The well started facing severe issues within short span of time right after:

- 8/19/'19 – ESP to Rod
- 10/21/'19 – Rod part
- 11/15/'19 – 7/8" rod parted – POH w/ TBG: Scale samples found in pump: Sulfate + Carbonate Scale
- 11/30/'20 – Well not pumping. Starved for fluid entry. Pump stuck in SN w/ Sulfate Scale. Drill out Sulfate Scale through perfs (Fig 8). Pumped dissolver + acid
- 2/22/'21 – Parted on shear tool. Pump stuck in SN w/Scale. POH w/ TBG. Sulfate + Carbonate treatment on chemical
- 4/7/'21 – POH w/ TBG. Scale on OD on bottom joints & Perfs.
- 4/8/'21 – Installed downhole chemical screens after performing CWA & Solid analysis (Fig 9). Recommendation was given with combination of Scale, Acid surfactant and THPS for Top, Center and Bottom Chem Screen.
- 2/8/'22 – POH w/ Pump. Scale on the pump
- 5/22/'23 – POH w/ Rod & Pump. POH w/ Tubing. Installed new chemical screens.

PROBLEM DEFINITION

Mineral scale formations, particularly calcareous formations, are a very common persistent and extensive problem in several industries, going from oil and gas to desalination. In that sense calcium carbonate is the most common and stable in oilfield operations. Calcium carbonate crystals are large, but when the scale is found together with impurities in the form of finely divided crystals, the scale appears uniform. Deposition of $CaCO_3$ scale results from precipitation of calcium carbonate as show below:

$$Ca^{++} + CO_3^{--} \_\_ CaCO_3 \quad (a)$$

Calcium carbonate deposition scale on surface and subsurface production will create problems. In analogy formation water in which the carbonate scale-forming components are initially dissolved can becomes supersaturated with calcium carbonate due to pressure drop during production. On the other side a continuous flow of a supersaturated solution through the production equipment can result in the growth of a dense layer of calcium carbonate crystals. Most of the time carbonate scales will appear in the wellbore, especially near the well head, due to pressure drop, allowing dissolved CO_2 escapes from the produced water and causing an increase in the pH of water as well as an increase in the saturation index of carbonate minerals.

Contrary to the current description, calcium carbonate can also be formed by a combination of calcium and bicarbonate (HCO_3), being this one, the major cause of calcium carbonate deposition in oilfield operations. Normally a small percentage of the bicarbonate happens at the pH conditions on the wells, creating two mayor elements, equation (b), allowing more carbonate species that can easily react with calcium species, as we have suggested on equation a.

$$HCO_3 \text{ -------- } H^+ + CO_3^{-2} \quad (b)$$

From the economic point of view, it is more helpful to control the scale formation before it happens, and the best suggested way is to use scale inhibitors. Scale inhibitors are a type of metal quelator or molecules that has a great affinity to bind to metallic species such as Ca++, Mg++, Fe++, etc. In that way scale inhibitors delay the binding between calcium and carbonates, sulfates, etc, species in solution, preventing the formation of scale. The mayor problem sometimes relies on the lack of continuity on adding scale inhibitors from surface, that create a time where the scale can reach to a saturation point and crystallize, becoming

insoluble in water conditions. When that happens, the only solution is to run an acid job, which contains an strong acid such as hydrochloric acid in combination with a corrosion inhibitor and surfactant as a wetting agent.
On the other side Calcium sulfate can exist in 3 different phases: Gypsum (CaSo4.1/2H2O, Low temperature, Anhydrite (CaSO4) 100C and semi hydrate between 100-121ºC. Calcium sulfate precipitation happen by pressure drops or increase on the relative concentration of calcium or sulfate, due to incompatibility of brines for example, fluid dynamics, etc., see below:

$$Ca^{2+} + SO_4^{-2} \text{ ----- } CaSO_4 \text{ (c)}$$

Unfortunately, the solubility of calcium sulfate compared to calcium carbonate is very low, and typical acidic solution won't be able to solve the problem.
Alternatively, the use of scale inhibitor is needed as well, to prevent crystallization or saturation point of these species before it gets worse. Normally, if there is not enough control or lack of continuity of chemical inhibitor addition, the problem won't be controlled, and deposition will happen. At this point there are only 2 solutions: mechanical removal or the use of converters.
Converters: Inorganic converters are usually carbonates or hydroxides that react with calcium sulfate and convert it to acid-soluble calcium carbonate or calcium hydroxide. The conversion treatment is then followed by a hydrochloric acid treatment to dissolve the resulting scale:

$$CaSO_4 + (NH_4)_2CO_3 \text{ ---- } (NH_4)_2SO_4 + CaCo_3 \text{ (d)}$$

$$CaCO_3 + 2\,HCl \text{ ----- } H_2O + CO_2 + CaCl_2 \quad \text{(e)}$$

The first stage on the conversion process efficiency will depend of the well conditions, but in general it will need to stop production and leave on stationary system for 24 hours to increase conversion efficiency.

When both scales are present, which happen very often, it is important to design and select a high efficiency scale inhibitor that can selectively attack sulfate formation and carbonate formation efficiently and sometime that will require the use of a metal quelator in their formulation, especially when high iron concentrations are present, that can poison the scale inhibition and reducing efficiency.[4]

SOLUTION

In that sense Odessa separator microencapsulation technology for chemical downhole delivery, will be a great contribution to the current case study, where currently scale associated with carbonate and sulfate are creating mayor problems and the current surface addition have not been very successful. With our current technology will are looking to create a continuous treatment downhole to largely prevent the formation of these chemical issues and demonstrate their applicability for rod pump applications.
Our chemical combination designed for this case was based on scale inhibitor, specially formulated for carbonate and sulfate scale inhibition in combination with an acid surfactant, which is the analogues to a strong acid but with less corrosive properties, which have been designed to dissolve immediately any accumulated or already crystallized form of carbonates, which will enhance the scale inhibition by reducing the MEC to a minimum.

CONCLUSIONS

- Microencapsulation matrix technology, carrying out a combo combination of corrosion, THPS and scale inhibitor, has been successfully implemented to Maverick Resources to treat severe scale as carbonates and sulfate formation.

- The runtime time before applying technology on an average of 3 moth was successfully increase by a 3-fold, implying the success inhibition of the sulfate and carbonate scale issues, and confirming the ability of our microencapsulated chemical inhibition to provide a continuous dispersion and consequently a constant protection to the well in question.

- The well is currently under operation and the runtime could be extended potentially a little bit longer.

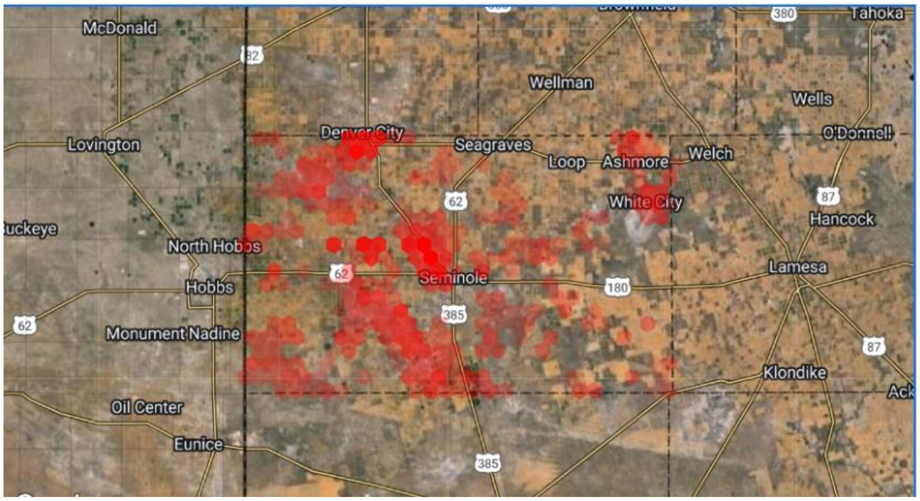


Figure 1 Wells Location

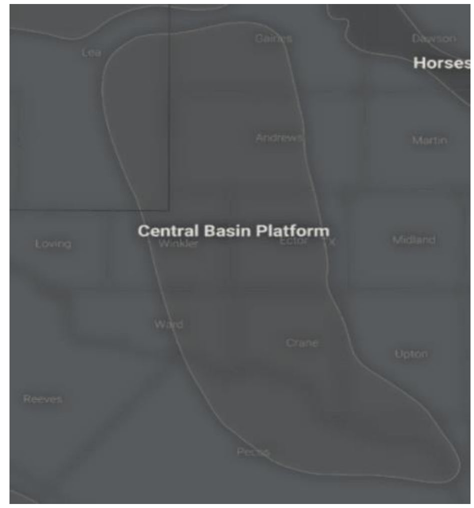


Figure 2 Central Basin location

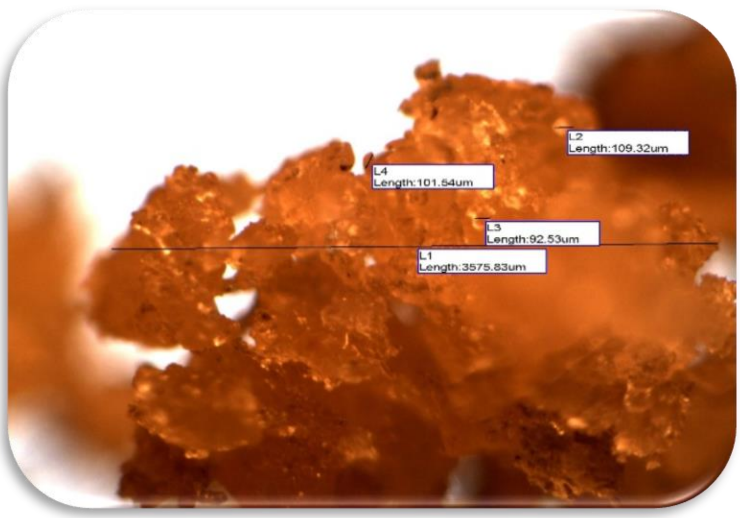


Figure 2A Inhibitor microencapsulated.

Figure 3B: Homogeneous microencapsulated matrix concept: from left to right: (a) calcium carbonate scale formation under heating, with no microencapsulated scale inhibitor (b) calcium carbonate scale inhibition, with Microencapsulated scale inhibitor.

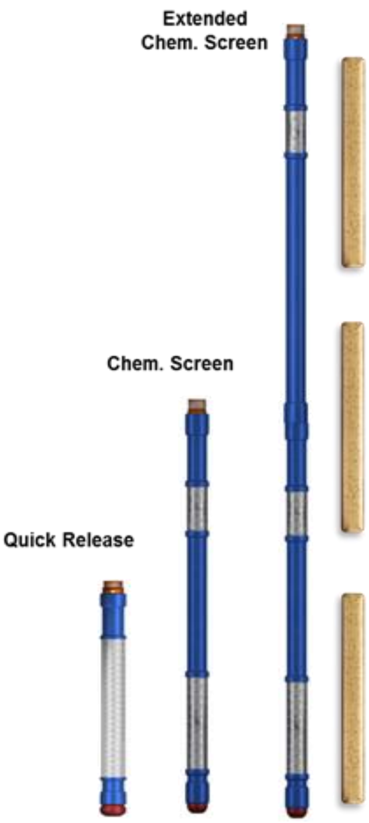


Figure 4 Chemical Screens

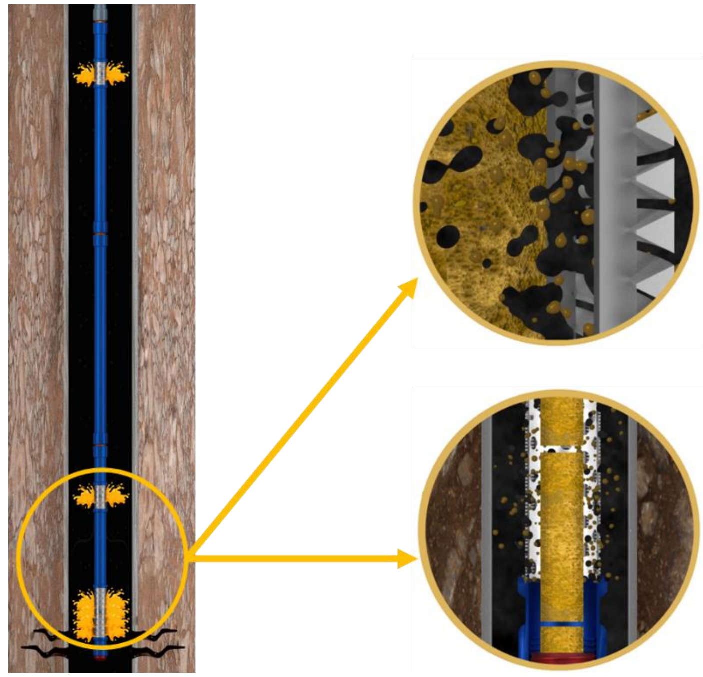


Figure 5 Mechanism of dispersion

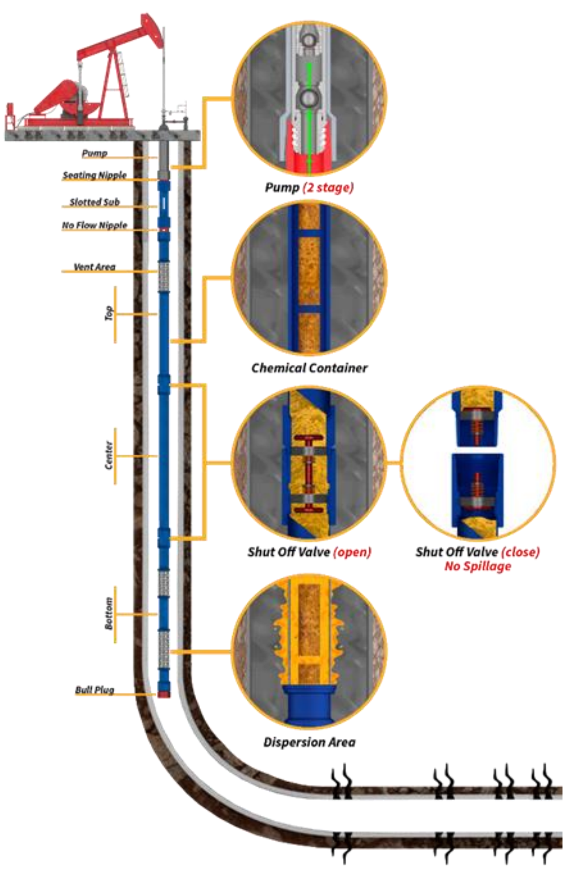


Figure 6. Configuration of Chem Screens on Rod Pump

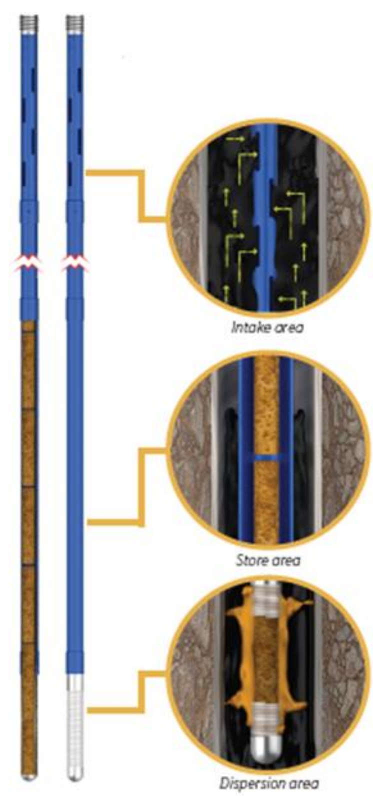
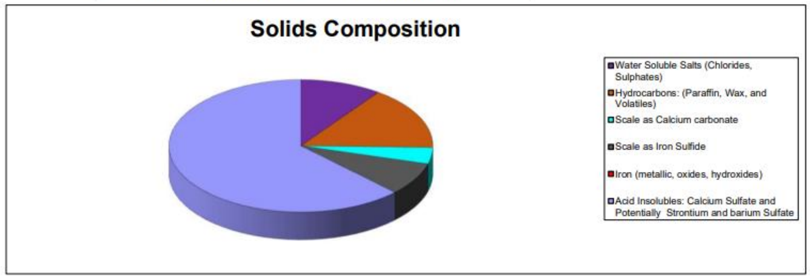


Figure 6. Retrievable Chem Screen

Figure 8. Calcium Sulfate drilled out

Company:	Maverick Resources	Sample Date:	4/8/2021
Lease & Well		Lab Date:	4/8/2021
Location			
Appearance:	Black Solid Plates		

Water Soluble Salts (Chlorides, Sulphates)	10.0%
Hydrocarbons: (Paraffin, Wax, and Volatiles)	15.4%
Scale as Calcium carbonate	4.0%
Scale as Iron Sulfide	8.0%
Iron (metallic, oxides, hydroxides)	0.0%
Acid Insolubles: Calcium Sulfate and Potentially Strontium and	62.6%



Initial Sample

Isolated Paraffin

Notes:

High amount of acid insolubles associated with calcium sulfate. Potentially strontium and barium sulfate may be present as well. Also iron sulfide detected and some water soluble salts . It is recomendable to treat these water solubles salts as well with salt removals to prevent corrosion problems or they can reduce the coating or filming protection as well through an osmotic process.

OSI Lab

Figure 9. Solid analysis

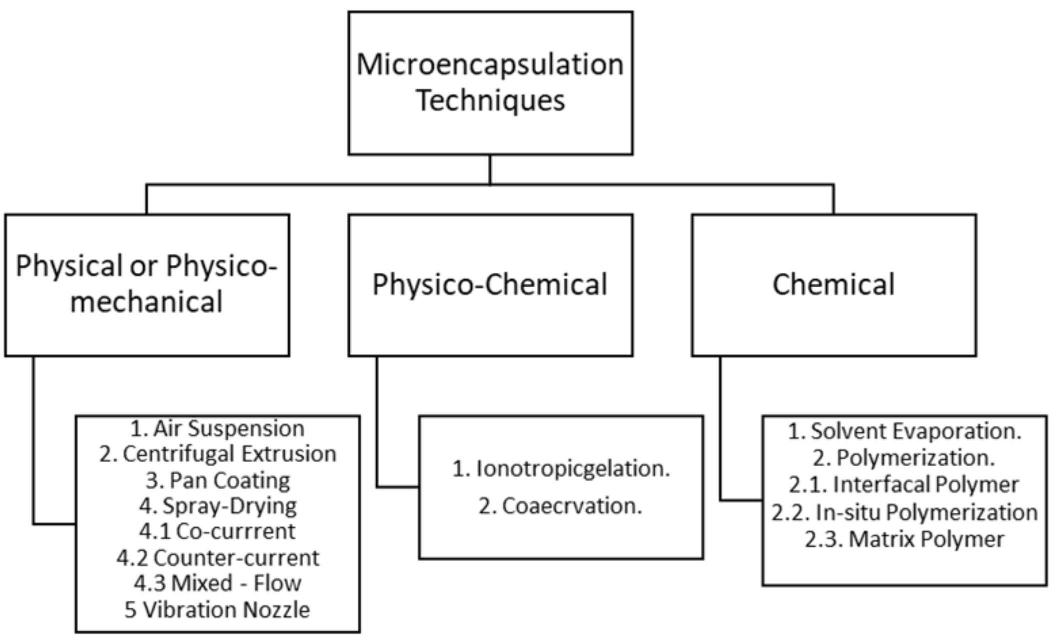


Table 1: Microencapsulation Techniques

REFERENCES

- (1)Eugenio Garribba, Giovanni Micera, Angelo Panzanelli, Liliana Strinna- Erre, and Giovanna Stara, J. Chem. Educ. **2001**, 78, 8, 1090
- (2)Hadi Poernomo, Tjuwati Makmur, Hadi Poernomo, Tjuwati Makmur, Scientific Contributions Oil $ Gas 2004 Vol 27 N1 29-34
- (3)Binmerdhah, Amer. (2010). Inhibition of Calcium Sulfate and Strontium Sulfate Scale in Waterflood. SPE Production & Operations - SPE PROD OPER. 25. 545-552. 10.2118/141168-PA.
- (4)M. AMIRI AND J. MOGHADASI, Petroleum Science and Technology, 30:223–236, 2012.
- (5)S. Hawkins, M. Wolf Microcapsules as a Delivery System. `William Adrew Inc.
- (6)N. Venkata Naga Jyothi, P. Muthu Prasanna , Suhas Narayan Sakarkar , K. Surya Prabha , P. Seetha Ramaiahand G. Y Srawan “Microencapsulation techniques, factors influencing encapsulation efficiency” Journal of Microencapsulation, 2010.
- (7)Odessa Separator Inc (www.odessaseparator.com).
- (8)L.R. Collins, SPE, BP Exploration Operating Co. M.M Jordan, SPE, Ondeo Nalco Enegy Services. “The Development and Application of a Novel Scale Inhibitor Deployment System” SPE 80286-PA.
- (9)Miaomiao Hu, Jintang Guo, Yongjin Yu, Lei Cao and Yang Xu. “Research Advances of Microencapsulation and Its Prospects in the Petroleum Industry”.
- Central Basin Platform | Permian | Enverus
- Gaines County, TX Oil and Gas Data Summary (shalexp.com)