ANTI-BIOFOULANT CORROSION INHIBITORS

A Special Filming Inhibitor
Coupled with a Practical Methodology for Treating Corrosion
Due to Sulfate Reducing Bacteria

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Abstract

A new type of anti-biofoulant corrosion inhibitor (ABF) has been developed that lays down a unique, smooth film that resists the adhesion of sessile bacteria and iron sulfide, thereby reducing the formation of biomass that initiates under deposit corrosion cells. This inhibitor, formulated with special surfactancy, can help penetrate existing biomass and lay down an inhibitor film. The ABF corrosion inhibitors coupled with a practical methodology can control corrosion due to sulfate reducing bacteria.

Introduction

In the production and transportation of oil and gas, and the related water processing for injection, corrosion of the metal surfaces is a well-known problem. Closely related to corrosion are problems of scaling and fouling due to insoluble solids. For corrosion to occur, water containing dissolved solids and corrosive gases must be present. The most severe corrosion problems occur when deposits adhere to the metal surfaces and create a cover for concentration cells which form deep pitting attack. (See Figure 1) General corrosion is far less severe of a problem compared to this under deposit attack. Preventing the deposits is the first step to provide the success in corrosion control.

The ideal chemical treatment would keep the metal surfaces free of deposits and inhibit the metal from a corrosive environment. This approach would prevent corrosion by-products (oxides and sulfides) that form deposits and foul the system. Bacterial growth would be discouraged because it could not find a safe place to multiply. This would significantly reduce microbiologically induced corrosion. Water quality could be improved, drag effect would be reduced and the need for biocide treatments would be significantly reduced. All of these factors translate into lower operating costs.

A new family of *anti-biofoulant* corrosion inhibitors (hereafter referred to as ABF corrosion inhibitors) has been found to provide a tenacious, smooth film that resists adhesions of sessile bacteria and iron sulfide.

Composition Of Anaerobic Biofilms

Frequent problems occur when anaerobic bacteria find a home beneath deposits of iron sulfide or biomass. (Scale deposits and paraffin deposition can also provide sites for unmolested growth.) Sulfate-reducing bacteria even produce their own environment beneath a biofilm that is safe from turbulence and flow velocities. As the biofilm grows, it forms an exoskeleton, which provides for sessile bacteria growth. Hydrogen sulfide is produced by the bacteria's metabolic processes and is released to the protected environment where it reacts with dissolved iron from the corrosion process to form iron sulfide. This combines with polysaccharides and other related molecules to form the cell walls with dead bacteria to produce a semi-permeable matrix we know as biofilm. Within the pores of these layers, sulfate-reducing bacteria (SRB) grow and produce highly localized concentrations of H_2S, accelerating the corrosion process and causing severe pitting. As the biofilm increases in volume, the ability to reach the bacteria with normal biocide treatments is reduced. Larger doses of biocide and longer contact time then produce marginal performance, at best. This biofilm limits access to the metal by the filming corrosion inhibitor and the corrosion inhibition is further compromised.

Anti-Biofoulant Chemistries

A new family of products has been developed for use in gas and oil production and in transmission systems. These products offer unique corrosion inhibitor properties through an improved filming process. The anti-biofoulant portion of the inhibitor provides exceptional surface activity to penetrate biomass and deter deposits such as iron sulfide, bacteria, mineral scales and other suspended solids from adhering to the metal and breaking down the protective film. Of course, other chemical programs, such as dispersants, surfactants, inhibitors, solvents, acids, EPA registered biocides applied by batch or continuous means, play an important roll in the total scheme of well control. Historically, each of these treatments have been applied, with varying degrees of success, in conjunction with "standard" filming amine inhibitors.

The ABF type inhibitors have been developed to address the problem wells, flowlines and injection systems that typically do not respond to the routine treatment. The high degree of surfactancy cleans the metal surface and helps lay a unique protective film that resists adhesion of solids.

Field Applications

Successful field treatments with anti-biofoulant inhibitors, like most other chemical applications, begin with a good protocol. A thorough assessment of the system will reveal the type and extent of fouling. Depending on the degree of fouling, the system may need cleaning in order to start with reasonably clean surfaces. Heavy deposits of iron sulfide may require an acid wash with special penetrating surfactants. This should be followed by a biocide application to sterilize the system. With the system clean, the ABF type corrosion inhibitors can now be applied. The unique film that is developed provides a slick surface where bacteria do not adhere. Soluble iron from corrosion is reduced and iron sulfide deposits do not form the protected breeding sites for bacteria. Infrequent applications of biocide to treat planktonic bacteria are successful even with reduced frequency and contact time.

California

The problems in a small oil-producing field in California had steadily grown worse. Treatments were aimed at symptoms and slowly the amount of various treating chemicals had grown significantly. In addition, failure rates had steadily increased. Because water injectivity was trending downward, additional separation and settling tanks had been added to improve water quality for disposal. Iron sulfide deposits in the disposal water were severe. Frequent biocide treatments were not controlling bacteria, and changes in product did not improve the performance.

The new ABF corrosion inhibitor treatment protocol started on a ten-well test. A continuous injection of a penetrating surfactant, was initiated, both downhole and through the water injection system. This was followed with a flush with a biocide. ABF corrosion inhibitor was applied downhole and through the water handling system. After monitoring for the next three months with iron counts at the wellhead, and monitoring the water quality, the application was expanded to all 60 wells. Figure 2 pictures the side stream filter used for monitoring water quality. Figure 3 shows the "before and after" water quality as measured with a side stream filter. Figure 4 shows the improved water quality as demonstrated by the improved injectivity.

As a result of the improved corrosion-treating program by the ABF inhibitor, the down hole filming practically eliminated iron sulfide. Bacteria were controlled with reduced biocide treatments, several surface treating units were taken out of service, and failure rates dropped precipitously. See Table 1 for a list of surface treating units taken from service:

TABLE 1
Surface Facilities Reduced

11	Produced water tanks
3	Solids disposal pits
2	Vapor recovery units
3	Heater Treaters
1	WEMCO Unit
1	Sand Filter
2	Cartridge filters

New Mexico

A fairly sizable field in Eastern New Mexico had 20 wells on one side of the field that were problem wells. Failure rates within the 20 wells were running 5 failures per month, even with high treating rates of corrosion inhibitors and frequent batching with biocide. A close study of the well failures revealed severe deep pitting by bacteria under deposits. The deposits were analyzed and found to be mostly biomass of polysaccharides and polymer fragments from an earlier polymer flood. Anaerobic bacteria (SRB's) had found safety under the biomass and were thriving. Deep pits caused failures in the down hole equipment.

The treatment began with an acid wash containing penetrating surfactants to remove iron sulfide and some biomass. All wells were treated with a concentrated batch of biocide. Then, ABF corrosion inhibitor was applied with batch treatments. Almost immediately there began a reduction in well failures.

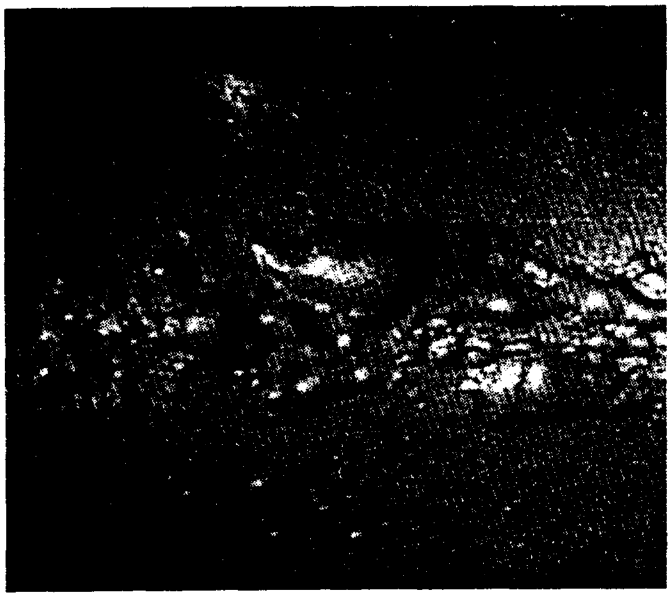
Figure 5 shows the failure rate before and after the application of the ABF Corrosion inhibitor. At approximately $4500 average cost per failure, $22500 per month has been saved. This does not consider down time or manpower requirements. Because of this performance, ABF corrosion inhibitors have been phased into the other wells in the field. Even though the other wells were not experiencing high failure rates, the injection water has seen a jump in quality.

The unique filming properties were obvious on the monitoring probes. Figure 6 shows probes used in the Field Film Persistence Test Unit while evaluating different types of inhibitors.

Conclusions

When the oil economy is low, it is difficult to spend extra money for down hole clean-up. However, by using a proper protocol, the reduced failures make up for the expenditure many times over. ABF type corrosion inhibitors lay down such a smooth film on the clean surfaces that sessile bacteria do not readily find a place to lodge. And with the corrosion mitigated, no iron is in solution to form iron sulfide. Therefore, no deposits form on the surfaces to make a safe haven for bacterial growth. Infrequent batching with biocide keeps the planktonic bacteria in control.

The unique film formed by the ABF corrosion inhibitors brings a new tool for control of corrosion caused by sulfate reducing bacteria.



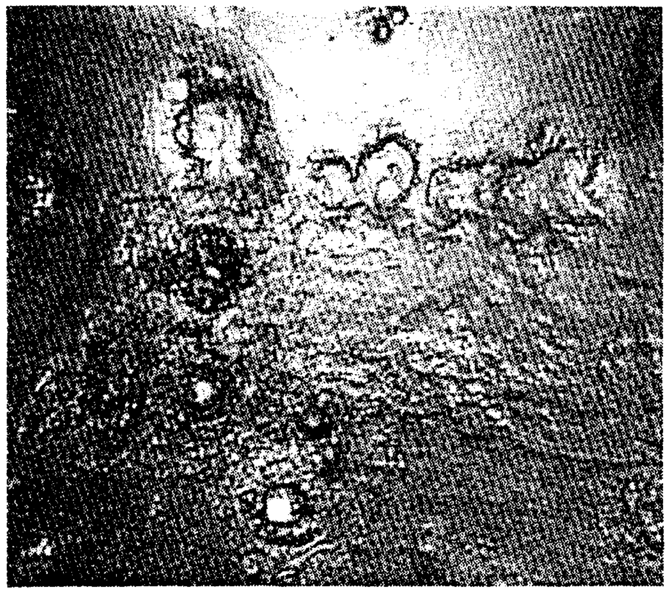


Figure 1 - Flow Line Section Showing Under Deposit Corrosion
Before Cleaning After Cleaning

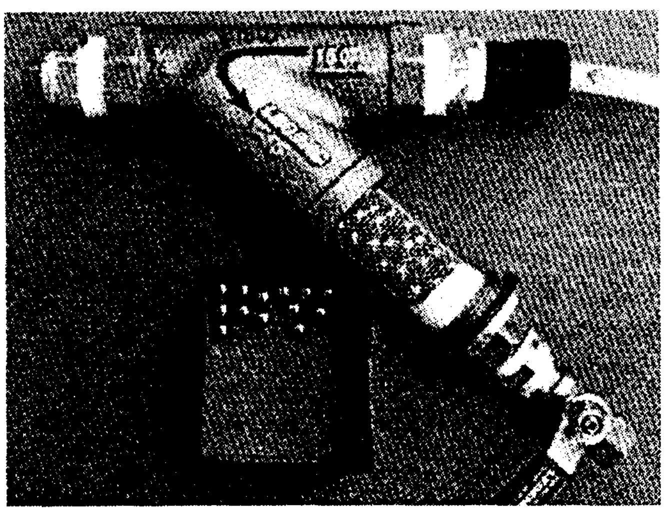


Figure 2 - Side Stream Filter for Monitoring Water Quality

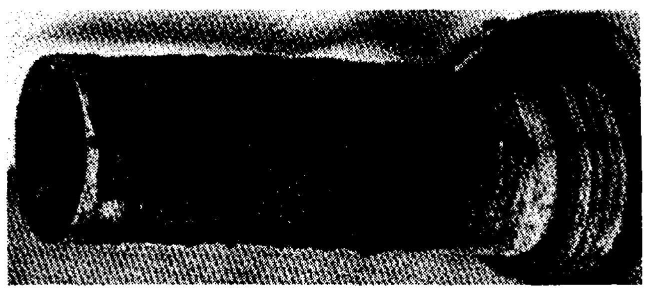


Figure 3 - 28 Days Before Starting Treatment

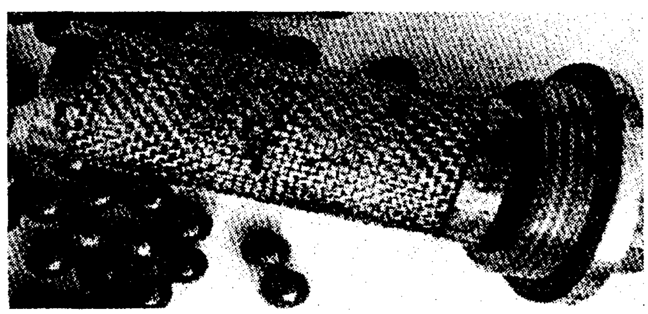


Figure 3 - 30 Days After Starting Treatment

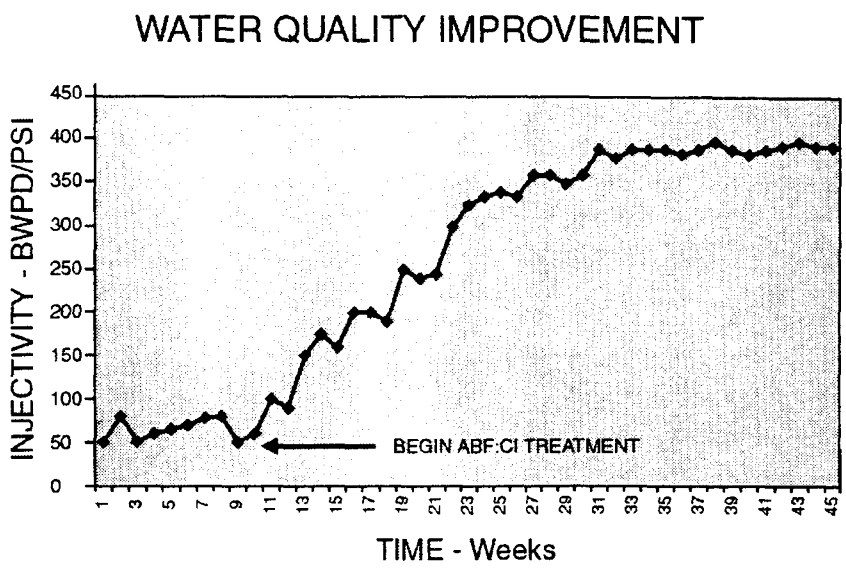


Figure 4 - Water Quality Improvement as Measured by Improved Water Injectivity

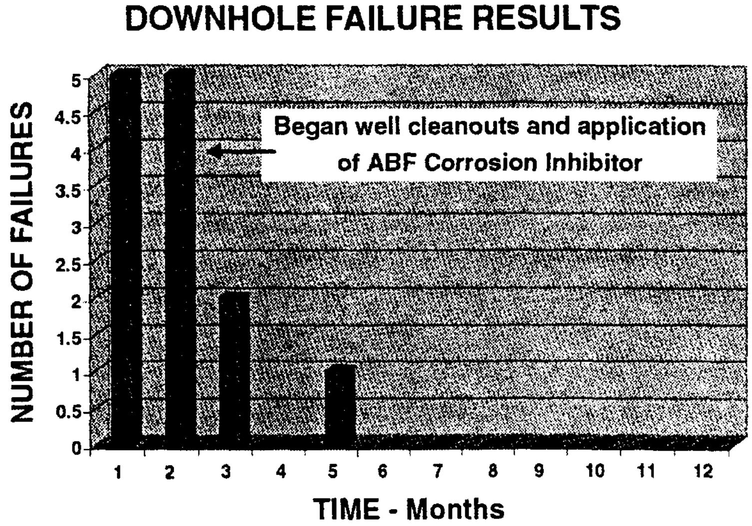
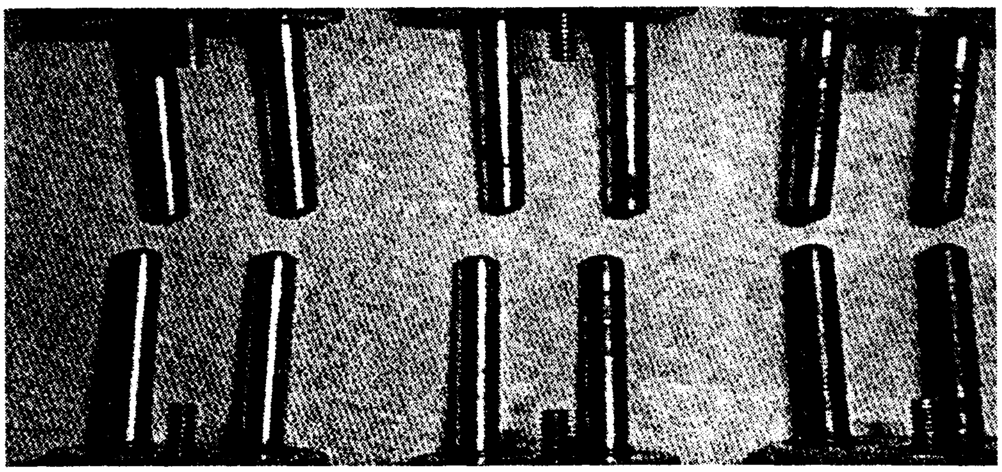


Figure 5 - Failure Rates Before and After Application of ABF Corrosion Inhibitor



Anti-Biofoulant Oil Soluble Water Soluble

Figure 6 - Corrosion Probes Showing Resistance to Adhesion of Deposits