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SUBJECT: The Removal of Corrosion Scale From Heat Exchanger by Chemical Treatments

TO: See Distribution

FROM: Oscar Menis OM-35

ABSTRACT

A study was made to select a suitable solvent for disintegrating a corrosion scale from stainless steel systems without attacking the stainless steel. In this investigation a particular sample of stainless steel corrosion scale appeared to be disintegrated most effectively in a solution of the trisodium-salt of N-hydroxyethylethylenediaminetriacetic acid (Versenol) and ammonium acetate. In a subsequent test with this solution in a REED dynamic loop a considerable disintegration of scale from the loop was observed. In this test after a period of approximately 60 hours, the iron content in the solution was found to be 10 g per liter; thus indicating that the mixture of Versenol and ammonium acetate can be used to disintegrate partially the corrosion scale from a stainless steel system.

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DISCLAIMER

THE REMOVAL OF CORROSION SCALE FROM HEAT EXCHANGER BY CHEMICAL TREATMENTS

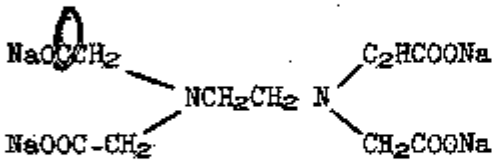
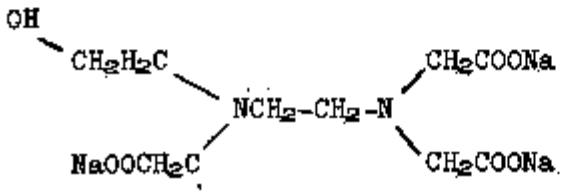
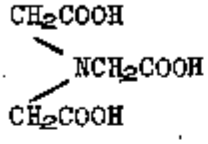
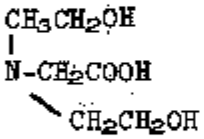
O. Menis

Purpose

To test solutions which would aid in disintegrating a corrosion scale without attacking a stainless steel system.

Introduction

A problem arose in which it was necessary to find means for removing a corrosion scale product which was believed to be plugging the HRT heat-exchanger system. A method was needed for dissolving corrosion scale in the form of metallic oxides or hydrated oxide without attacking the stainless steel system. This latter requirement ruled out the use of hot acid solutions. For this reason complexing agents capable of dissolving iron oxide and chromium oxide were investigated. The series of compounds containing polyaminopolycarboxylic acid, such as ethylenediaminetetraacetic acid (ethylenedinitrilotetraacetic acid, EDTA or Versene) and related compounds, was considered, among others, as the most promising ones. Hot 5 per cent Versene solutions have been used in cleaning and descaling heat exchangers.(1) The following characteristics of a series of compounds sold under the trade mark Versene are tabulated:

Type	pH Range	Application
Versene		
Tetra sodium salt of ethylene-dinitrilotetraacetic acid 	2 to 7	Complexing agent for iron in acid solution.
Versenol		
Trisodium salt of N-hydroxy-ethylethylenediamine triacetic acid 	3.0 to 12.5	For large amounts of polyvalent metals especially ferric iron in the pH range 7 to 12.
Versene Fe-3		
Nitrilotriacetic acid 	2.0 to 12.5	Complexes small amount of iron as well as large amounts of other metal ions.
Versene Fe-3 Specific		
N,N-dihydroxyethylglycine 	7.0 to 12.5	Suitable for complexing large quantities of iron.
Versene T		
Structure not revealed	> 12	Dissolves a precipitate of iron in strong caustic solutions.

Of these compounds Versene, Versenol and Versene Fe-3 were the only ones available in the laboratory. Actually, the latter two compounds are more suitable for this application because they can be used effectively in a neutral or alkaline pH range. These were tested alone and in combinations with other compounds to determine their effectiveness in the disintegration of a typical corrosion scale sample.

Experimental

Into a 100-ml beaker approximately 10 to 20 g of reagent were added, dissolved in approximately 50 ml of water, and then a piece of corrosion scale was added. These solutions or slurries were then boiled for several hours. The condition of the scale and of the solution was then observed.

The following compounds and combinations were tested:

Versene
Versene Fe-3
Versenol
Glacial Acetic Acid
Calgon
Tartaric Acid
Versene + Glacial Acetic Acid
Versene + Tartaric Acid
Versene + Sodium Acetate
Versene + Ammonium Acetate
Versene + Sodium Oxalate
Versene + Ammonium Tartrate
Versene Fe-3 + Glacial Acetic Acid
Versene Fe-3 + Tartaric Acid
Versene Fe-3 + Sodium Acetate
Versene Fe-3 + Ammonium Acetate
Versene Fe-3 + Sodium Oxalate
Versene Fe-3 + Ammonium Tartrate
Versenol + Glacial Acetic Acid
Versenol + Tartaric Acid
Versenol + Sodium Acetate
Versenol + Ammonium Acetate
Versenol + Sodium Oxalate
Versenol + Ammonium Tartrate
Ammonium Acetate
Sodium Acetate

Observations

Of all these tests only the test with Versenol plus ammonium acetate showed a change which could be readily recognized by visual observation. In this solution a turbidity was noted which was colored violet to blue. This mixture was then tested in a dynamic circulating system in one of the REED experimental loops.

Discussion

The apparent successful attack of the scale by a mixture of Versenol and ammonium acetate may be attributed to several factors. Versenol can be used to chelate ferric ion even in an alkaline medium. In a boiling solution, chromic oxide in the scale could also be expected to react. Přibil and Klubalova[2] report that Cr(III) forms a complex with Versene on heating. This complex has a purple color which changes to blue in alkaline solutions. The authors also report that, on boiling with Versene, the chromate ion is reduced to Cr(III). This reaction is catalyzed by traces of manganese. The observed coloration in the solution from this test evidently is due to the formation of a Cr(III)-Versenol chelate. In

addition, the ammonium acetate solution which was added to buffer the solution at pH 9.7 also served to form the basic acetate complexes and ammonium complexes with the metallic elements in the scale. Thus, the conditions were favorable for achieving a partial dissolution of the components of the scale, such as iron, chromium and other oxides. Once this process occurs it may be easier to dislodge the more fragile scale by hydrodynamic forces of the circulating fluid.

The analysis of solutions circulated in a loop test carried out by the REED showed a progressive increase of iron in the solution. The iron content of this solution rose from 0.4 g per liter after the first hour to 10 g per liter after 65 hours, thus indicating that the mixture of Versenol and ammonium acetate can be used to dissolve, at least partially, a corrosion scale from a stainless steel system.

Conclusion

It was demonstrated that by the use of a solution of the trisodium salt of N-hydroxyethylethylenediaminetriacetic acid (Versenol) in conjunction with ammonium acetate a partial disintegration of a corrosion scale from a stainless steel system can be attained.

References

1. The Versenes, Technical Bulletin No. 2, Bersworth Chemical Co., Framingham, Mass., Feb, 1954, Sect. II, p. 38.

2. R. Přibil and J. Klubalova, "Use of Complexones in Chemical Analysis, VI. Colorimetric Determination of Chromium," Collection Czechoslov. Chem. Communs. 15, 42, 1950.

3. O. Menis, Notebook A-954, p. 130-134. 3-2-59

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