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TRACK OR CATEGORY

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ORGANO SILICATES AND SILANES AS CORROSION/STAIN INHIBITORS IN MWF

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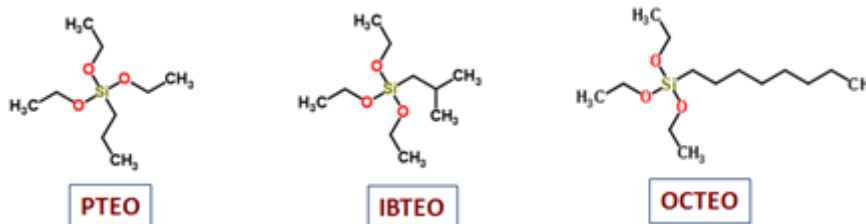
INTRODUCTION

The efficiency of corrosion inhibitors is dominated by the electron configuration in their molecular structure and their charge transfer capability to metal surface. Most of organic inhibitor systems possess hetero atoms such as phosphorus, sulfur, nitrogen or oxygen in their molecular structure although some also contain labile π bonds to further enhance charge transfer efficiency. Those hetero atoms naturally have non-bonded electron pairs which actually participate in chemical/physical interaction with metal surface. All other things being held constant, it is known that the inhibition efficiency decreases in the following sequence: P > S > N > O. Accordingly, organophosphorus or organosulfur compounds would be the best choice, but they are also good food sources for various bacteria and fungus causing serious microbial proliferation which is detrimental to metalworking fluids (MWFs) sump life. On the other hand, nitrogen or oxygen compounds such as amine carboxylates or esters require relatively large quantity in the formulation due to their low inhibition efficiency compared to phosphorus or sulfur compounds. Thus, there has been a great deal of research at Chemetall to develop phosphorus/sulfur-free high performance inhibitor technology focusing on organosilicate and organosilane chemistry. Along this line, in this paper we report the effect of silicate and different organosilane chemistries on anti-staining performance of MWFs on aluminum alloys.

EXPERIMENT & RESULTS

In last year's report, we introduced silicate chemistry as a potential microbial growth-free aluminum corrosion inhibitor and demonstrated its excellent anti-staining performance. However, low hydrocarbyl silicates such as tetra ethyl silicate are rather unstable with significant tendency to form insoluble three dimensional networks known as gelling especially in high water system. This gel formation occurs through facile hydrolysis reaction of the silicates, and the hydrolyzability is known to decrease in the following sequence: Methyl silicate > Ethyl silicate > Propyl silicate. This means higher hydrocarbyl group is favorable to minimize hydrolysis and ultimately the unnecessary gel formation.

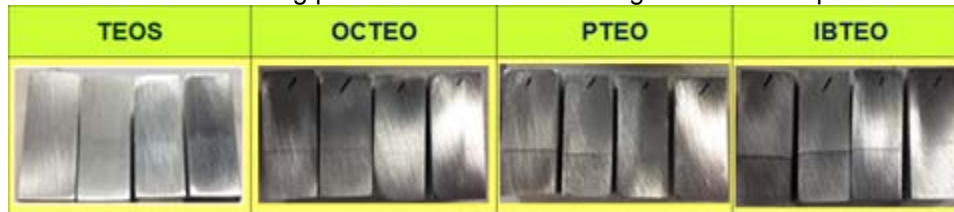
In an effort to minimize the gelling issue we have investigated applicability of less reactive organosilane compounds in MWFs as alternative corrosion inhibitors. In order to investigate the hydrocarbon structure effect of different organosilanes on inhibition efficiency, the anti-staining performances of isobutyl triethoxysilane (IBTEO), propyl triethoxysilane (PTEO) and octyl triethoxysilane (OCTEO) were assessed and compared with ethyl silicate.



For the performance evaluation their inhibition efficiency was assessed by aluminum alloy metal compatibility test and inductively coupled plasma atomic emission spectroscopy (ICP-AES).

For aluminum alloy compatibility test, first the semi-synthetic MWFs with 2.0% of different inhibitor systems were diluted at 10% in DI water. Four different aluminum alloy coupons (Al319, Al356, Al6061 and Al7075) were then immersed in the diluted solution over 24 hours.

Table 1. Anti-staining performance of different organosilane compounds



As indicated in Table 1, organosilicate (TEOS) exhibited superior performance to organosilanes with no stain on all alloys. OCTEO with longer alkyl chain revealed better performance than PTEO and IBTEO but still showed minor stains especially on Al319 & Al356. The overall inhibition performance trend displayed the following order:

TEOS > OCTEO >> PTEO > IBTEO

The post metal compatibility test solution was then retrieved and run on ICP to determine the dissolved aluminum level. ICP elemental analysis results also displayed a consistent trend with the metal compatibility test results confirming the same performance order (Figure1).

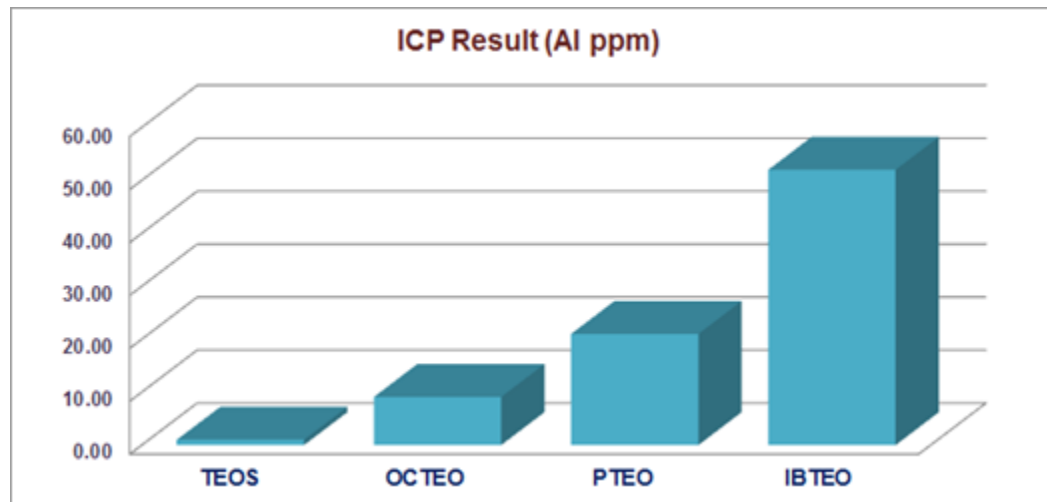


Figure 1. ICP result for different organosilane compounds (Al ppm)

OCTEO could be a good candidate as a phosphorus/sulfur-free inhibitor system with low potential gelling issue.

CONCLUSION

In summary, anti-staining performances of three organosilanes with different molecular structures in MWF were investigated, and compared to silicate-based inhibitor system (TEOS in this study). For the performance evaluation their inhibition efficiency was assessed by aluminum alloy metal compatibility test and inductively coupled plasma atomic emission spectroscopy. Based on both test results, TEOS exhibited superior inhibition efficiency to organosilanes. OCTEO revealed good performance very close to TEOS. Long hydrocarbon chain structure could be beneficial to enhance the inhibition efficiency of organosilane-based systems.

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KEYWORDS

Corrosion/staining inhibitors, Microbial growth-free inhibitors, Silicates, Silanes, Aluminum alloys