11th International Conference on Advanced Materials

ICAM 2009

Rio de Janeiro Brazil
September 20 - 25

Effects of the Chemical Composition of Ethanol Fuel on Carbon Steel Pipelines

L. Goodman(1)*, P. M. Singh(2)*

* Department of Materials Science and Engineering, Georgia Institute of Technology, 771 Ferst Dr. Atlanta, GA 30327, USA.
(1) Email: Lindsey.goodman@gatech.edu
(2) Email: Preet.singh@ipst.gatech.edu

Abstract – There has been much evidence of the phenomenon of stress corrosion cracking (SCC) in steel equipment in the ethanol fuel industry. Studies on SCC susceptibility of carbon steels in different commercially produced fuel grade ethanol (FGE) shows large variations in their corrosivities, possibly arising from compositional differences due to the FGE source, production process, or other transportation related parameters. Slow strain rate testing (SSRT) was performed on carbon steel samples in 5 FGE environments. SCC susceptibility was evaluated using scanning electron microscopy (SEM), load/elongation curves, and fracture analysis. Composition of the used FGE environments was characterized and correlated to the SCC susceptibility of the carbon steel.

Recent studies done by the American Petroleum Institute (API) have found severe stress corrosion cracking (SCC) in carbon steel tanks and equipment used in the ethanol fuel industry[1]. Due to very large increases in the quantity of ethanol used as fuel and fuel additive in the past decade, SCC has become a very pertinent issue.

Studies on carbon steel in simulated fuel grade ethanol (SFGE) have shown that water, chloride ions, and dissolved oxygen content play a large role in SCC severity[2]. Some fuel grade ethanol (FGE) has also been shown to cause SCC in carbon steel during slow strain rate testing (SSRT), and it is hypothesized that variations in chemical composition of FGE bears an impact on SCC behavior in the FGE environments. Research on carbon steels in fuel grade ethanol (FGE) will be displayed in this poster.

SSRTs were performed on X60 carbon steel samples in five different batches of FGE, sources unknown. Chemical compositional analysis of the FGE samples was performed by gas chromatography-mass spectroscopy (GC-MS), inductively coupled plasma spectroscopy (ICP), and electrophoresis. Water content of the FGE samples was analyzed by Karl Fischer titration method before and after slow strain rate testing. The fracture surfaces of the notched carbon steel samples were evaluated by scanning electron microscopy (SEM) for SCC behavior. Load vs. elongation curves were plotted for all samples, further implicating corrosion behavior of the samples.

SCC was found in two of the as-received FGE environments, and in FGE environments to which NaCl was added. GC-MS analysis showed numerous hydrocarbons, organic fatty acids and fatty acid esters, and varying chemical composition among all the FGE samples. Cyclic polarization tests showed differences in the electrochemical behavior of carbon steel in each of the five environments. Further analysis will be done in order to explore possible chemical degradation during polarization, and to evaluate effects of specific impurities and compositional variations on SCC of carbon steel.

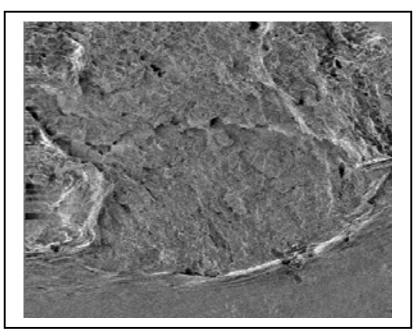

Figure 1: Fracture surface of notched carbon steel sample exhibiting SCC

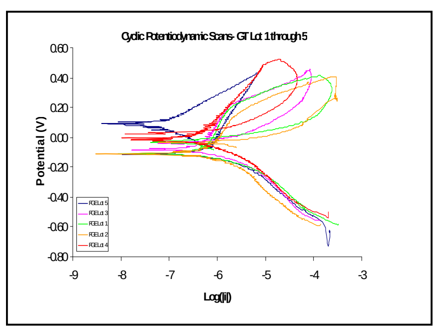

Figure 2: Cyclic polarization performed in 5 batches of FGE

References

[1] API TR 939-D, ``Stress Corrosion Cracking of Carbon Steel in Fuel-Grade Ethanol: Review, Experience Survey, Field Monitoring, and Laboratory Testing," American Petroleum Institute, May 1, 2007.
[2] Sridhar, N.; Price, K.; Buckingham, J.; Dante, J., Stress Corrosion Cracking of Carbon Steel in Ethanol. *Corrosion* 2006, *62* (8), 687-702.