Results of a Study of Biodiesel Compatibility with Steel

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Outline

- Objective
- Approach
- Test Coupons and Fuels/Blends
- Some Corrosion Rate Results
- Summary

Objective

- Measure the corrosion rate of steel in various biodiesels and petroleum/biodiesel blends

Approach

- Soy and yellow grease biodiesel
- With and without water
- Low sulfur and ultra-low sulfur diesel fuels
- Corrosion was measured by weight-loss, optical examination, and electrochemical characterization
- Simulated 12-month storage period (43°C storage temperature)

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Electrochemical Impedance Spectroscopy

Steel Coupons

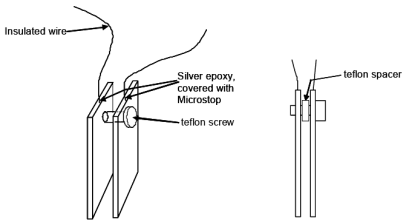
- Supplied by STI
- 1 square inch
- Low carbon steel comparable to ASTM 36
- Used as received, with the exception of one set which was polished to 600 grit to study the effect of polishing

Test Fuels and Blends

- Two petroleum diesel fuels (15 ppm and 4000 ppm total sulfur) –
- Two biodiesels, soy and yellow grease selected as representative of commercial biodiesel
- Blends from B0 to B100
- Half with 1% water bottom
- One aggressive biodiesel fuel blend of 95% soy biodiesel and 5% acid water (600 ppm acetic acid in water)

Electrochemical Impedance Spectroscopy

- Two electrode configuration
- PTFE cell
- No separate standard reference electrode



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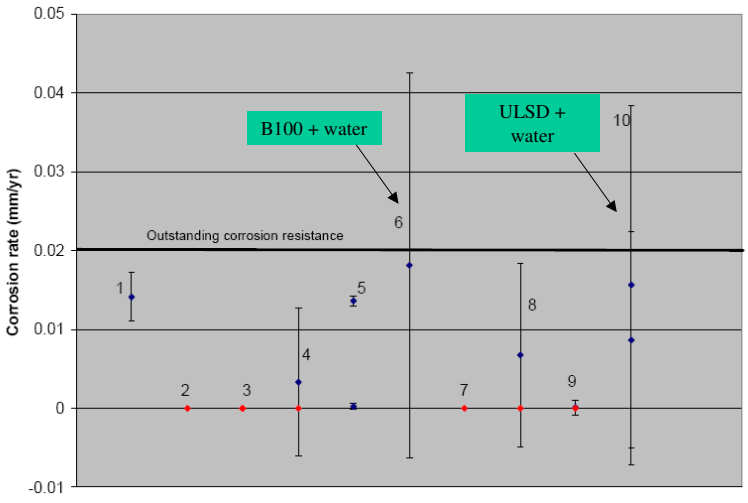
The electrochemical impedance spectroscopy (EIS) measurements were carried out in a two electrode setup, in which two electrodes made out of carbon steel were placed in a Teflon cell with very small separation distance. One electrode acted as the reference electrode, while the other one acted as the working electrode. The impedance signal was measured across the two electrodes. No separate standard reference electrode was used. A schematic of the experimental setup is shown here.

Corrosion Rates



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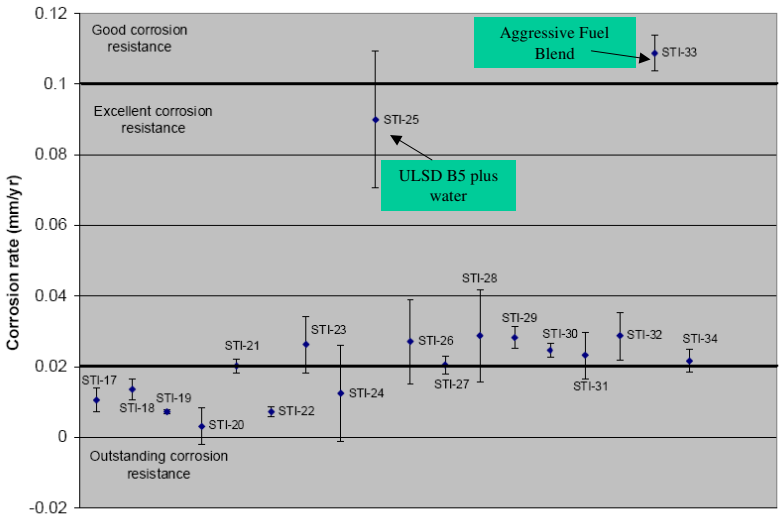
The corrosion rates were not significant in the case of the first set of exposures indicating the lack of corrosion in the system. The average corrosion rates were below 0.02 mm/yr, which corresponded to outstanding relative corrosion resistance for typical ferrous and nickel alloys.

No apparent correlation was found between the corrosion rate and solution chemistry

Corrosion Rates



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In the case of the second set of exposures, mass loss was observed in all cases; thus, corrosion rates were calculated for all fuel blends. Most of the average corrosion rate values were below 0.04 mm/yr, indicating outstanding or excellent corrosion resistance. The corrosion rates were slightly higher in a blend containing 5% animal-based biodiesel, 95% ULSD fuel blend with the presence of 1 vol% water. No trends were found between the corrosion rates and solution chemistry, similarly to set 1. Surface polishing was found to have no effect on the corrosion rate of steel (STI-30 and STI-34). The corrosion rate observed in the aggressive fuel blend was the highest of all tested solutions, as expected; although even this corrosion rate was small (< 0.12 mm/yr) and it corresponded to good corrosion resistance on the relative corrosion resistance scale.

Summary

- In most cases, surface rust was higher in ULSD than in B100 or in blends
- Surface rusting was slightly higher with yellow grease than in soy biodiesel
- No difference in surface rusting with and without water and between ULSD and LSD

Summary

- Surface rust was caused by a reaction between surface oxide/tarnish layer of the metal and the fuel blend
- Surface rust formed even on polished specimens although to a lesser extent
- With the exception of the aggressive fuel blend, all corrosion rates indicated outstanding or excellent corrosion resistance

Summary

- Corrosion rate with aggressive fuel blend indicated good corrosion resistance
- No trends were found between corrosion rates and solution chemistry
- Surface polishing was found to have no effect on the corrosion rate of steel
- Ratings are based on the relative corrosion resistance scale (M.G. Fontana, Corrosion Engineering, McGraw-Hill, 3rd ed., p.172, 1986.)

Acknowledgement

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