Corrosion in ethanol containing gasoline

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Triggered by the discussion on the change of world's climate the use of renewable biological products as fuel-substitutes of fossil oil has increased in recent years and will become even more important in future. Alcohols like methanol, butanol and mainly ethanol are already added to gasoline in contents varying from 5% (e.g. EU) up to 100% (Brazil). Figure 1 shows the world wide production of biofuel in 2007, figure 2 depicts the development of biofuel production in the U.S. until 2007.

The replacement of gasoline by ethanol leads to the question if the fuel becomes more aggressive. Critical factors in terms of corrosion are the increased solubility of water which may also lead to the presence of impurities, e.g. aggressive ions like chloride, in the fuel. Also biogenous fuels show a decreased long-term stability compared to fossil gasoline and are subject to ageing processes which e.g. produce acetic acid from ethanol [1, 2].

A variety of metallic materials like steels, stainless steels, copper and light alloys are used in modern vehicles fuel injection equipment (pumps, valves, sensors, etc.) and have direct contact to the fuel or its vapors. So the corrosion resistance of the metallic components is an important factor for the reliability of a vehicle over its lifetime.

In our present work corrosion effects of stainless steels in ethanol containing gasoline are investigated. Due to the uncertainty on the composition of "real" fuel obtained at a gas station surveys were performed and the composition of the fuel was analyzed. Subsequently the influence of the concentration of components in the fuel on the observed corrosion was investigated by electrochemical and surface analytical methods. However electrochemistry turned out to be problematic due to the low conductivity of the fuel and the lack of appropriate reference electrodes so some adjustments to the system were made. Additionally material samples were stored in fuel over several hundred hours to gather information about the corrosion's progression and time dependence.

As well the storage experiments as the electrochemical investigations revealed that corrosion in fuel is different from corrosion in aqueous solutions with an identical concentration of aggressive impurities (Figure 3). The most obvious results are that the addition of ethanol to the fuel leads to pitting corrosion on many stainless steels. Also the intensity and speed of the fuel-corrosion significantly exceeds the corrosion effects observed in aqueous solutions. Analysis of the stored samples showed an increase of pitting corrosion quantified by statistical factors like pit density (number of pits per surface increment), pit diameter and pit volume by – depending on the used fuel – several orders of magnitude. Obviously the gasoline, which is itself inert in behalf of corrosion, has a corrosion promotion effect if the ethanol part of the fuel is capable of initiating corrosion. As this capability is dependent on the concentration of impurities in the ethanol and the percentage of ethanol in the fuel we found a complex system whose actual behavior and aggressiveness depends on multiple factors. So besides the extend corrosion also different forms of corrosive attacks were found in relation to the ethanol content of the used fuel suggesting that different corrosion mechanisms can be triggered by fuel.

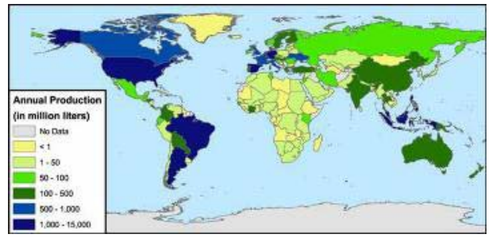

Fig. 1: Production of fuel from renewable biological sources in 2007

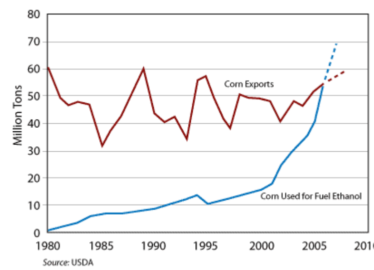

Fig. 2: Development of bioethanol production in the U.S.

a) b)

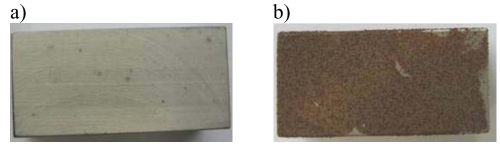

Fig. 3: Stainless steel after exposure to a) aqueous solution; b) ethanol containing fuel

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