Solving ethanol's corrosion problem may help speed the biofuel to market

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To meet a goal set by the US Environmental Protection Agency's Renewable Fuels Standard to use 36 billion gallons of biofuels each year—mostly ethanol—the nation must expand its infrastructure for transporting and storing ethanol. Ethanol, however, is known for triggering stress corrosion cracking of steel. Researchers investigated the mechanism of how ethanol triggers stress corrosion cracking, reported in *Corrosion* journal, along with ways to circumvent this issue to prevent ethanol-related corrosion issues.

If we're to meet a goal set by the U.S. Environmental Protection Agency's Renewable Fuels Standard to use 36 billion gallons per year of biofuels—mostly ethanol—the nation must expand its infrastructure for transporting and storing ethanol. Currently, ethanol is transported via trucks, trains, and barges. For the large volumes required in the future, transportation by pipeline is considered to be the most efficient method to get it to customers.

The integrity and safety of pipelines and storage tanks is crucial, because ethanol is both flammable and, at certain concentrations, can cause adverse environmental impacts.

"One of the most important concerns with regard to the integrity of pipelines and tanks is the propensity of ethanol at concentrations above 20 volume percent in gasoline to cause cracking of steel," explains Narasi Sridhar, vice president, director of the materials program at Det Norske Veritas. "This phenomenon is called stress corrosion cracking."

The Pipeline Research Council International, a consortium of pipeline companies, and the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration funded intense research to find the cause of cracking of steel in ethanol from 2005 through 2012.

"We found that dissolved oxygen in ethanol causes cracking and if oxygen can be removed, cracking can be prevented. This and other engineering measures can form the basis for safe transport of ethanol," says Sridhar.

The fundamental mechanism of how oxygen causes cracking of steel is described in a paper by Liu et al., published in *CORROSION* journal. This paper is significant because it was extremely difficult to tease apart the fundamental processes occurring in ethanol due to its low electrical conductivity.

By developing novel techniques, the researchers found that oxygen has two effects that conspire to cause the cracking of steel.

"The first effect is that oxygen protects most of the steel surface. It may seem counterintuitive that protection can lead to cracking of steel, but by protecting most of the steel surface oxygen channels all the degradation to occur on isolated areas of steel that is highly stressed. Such focused degradation results in rapid penetration of steel," says Sridhar. "The other effect of oxygen is that it pushes the corrosion processes to occur faster in the unprotected portion of the steel. Corrosion is an electrochemical process in which two electrons are emitted into the steel for every atom of iron corroding. Oxygen absorbs the electrons emitted by steel corrosion and propels the steel to corrode faster."

The practical implication of this paper is that it's now possible to prevent stress corrosion cracking without resorting to completely removing oxygen from ethanol, which is expensive to do. Sacrificial metals, for

example, can be used to prevent cracking. Inhibitors can also be used to prevent cracking by reforming the protective film on steel faster.

More information: The paper, "Effect of Oxygen on Ethanol SCC Susceptibility, Part 2: Dissolution-Based Cracking Mechanism," written by Liu Cao, G.S. Frankel, and N. Sridhar, appears in NACE International's journal, *Corrosion*, Sep. 2013, Vol. 69, No. 9, pp. 851-862. See: dx.doi.org/10.5006/0895

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