NIST finds that ethanol-loving bacteria accelerate cracking of pipeline steels

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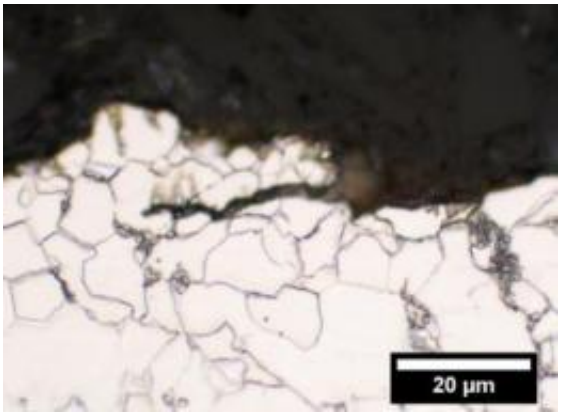

Micrograph of crack in X52 steel after the sample was subjected to mechanical forces for several days in an ethanol solution containing acid-producing bacteria, Acetobacter aceti. Researchers at NIST's biofuels testing facility found that the bacteria increased fatigue crack growth rates at least 25-fold compared to what would occur in air. Credit: Sowards/NIST

U.S. production of ethanol for fuel has been rising quickly, topping 13 billion gallons in 2010. With the usual rail, truck and barge transport methods under potential strain, existing gas pipelines might be an efficient alternative for moving this renewable fuel around the country. But researchers at the National Institute of Standards and Technology (NIST) caution that ethanol, and especially the bacteria sometimes found in it, can dramatically degrade pipelines.

At a conference this week,* NIST researchers presented new experimental evidence that bacteria that feed on ethanol and produce acid boosted fatigue crack growth rates by at least 25 times the levels occuring in air alone.

The NIST team used a new biofuels test facility to evaluate fatigue-related cracking in two common pipeline steels immersed in ethanol mixtures, including simulated fuel-grade ethanol and an ethanol-water solution containing common bacteria, Acetobacter aceti. Ethanol and bacteria are known to cause corrosion, but this is the first study of their effects on fatigue cracking of pipeline steels.

"We have shown that ethanol fuel can increase the rate of fatigue crack growth in pipelines," NIST postdoctoral researcher Jeffrey Sowards says. "Substantial increases in crack growth rates were caused by the microbes. These are important data for pipeline engineers who want to safely and reliably transport ethanol fuel in repurposed oil and gas pipelines."

Ethanol, an alcohol that can be made from corn, is widely used as a gasoline additive due to its oxygen content and octane rating. Ethanol also can be used as fuel by itself in modified engines. The NIST tests focused on fuel-grade ethanol.

The tests were performed on X52 and X70 pipeline steels, which are alloys of more than a dozen metals. Simulated fuel-grade ethanol significantly increased crack growth at stress intensity levels found in typical pipeline operating conditions, but not at low stress levels. The cracking is related to corrosion. The X70 steel, which is finer-grained than X52, had lower rates of crack growth at all stress levels. This was expected because larger grain size generally reduces resistance to fatigue. In the bacteria-laden solutions, acid promoted crack growth at stress intensity levels found in typical pipeline operating conditions.

Preliminary tests also suggested that glutaraldehyde, a biocide used in oil and gas operations, may help control bacterial growth during ethanol transport.

The findings are the first from NIST's biofuels test facility, where material samples are installed in hydraulic test frames and subjected to load cycles while immersed in fuel inside a transparent polymer tank. Fatigue crack growth and other properties are observed over a period of up to 10 days. NIST staff expect to continue and possibly expand the research to other potential biofuels such as butanol or biodiesel.

Collaborators at the Colorado School of Mines provided the bacteria, which were isolated from industrial ethanol storage tanks. The research was supported by the U.S. Department of Transportation.

Provided by National Institute of Standards and Technology (NIST)