Simplifying corrosion inhibitor selection for oilfield pipelines

Selecting and qualifying corrosion inhibitors to protect oilfield pipelines from internal corrosion is a notoriously challenging task, but work by a team of Ohio University researchers can help simplify the process.

The equation “steel + water = corrosion” is often used by corrosion engineers to express what occurs in oil and gas upstream operations.

Carbon steel is a material widely used by the oil and gas industry for pipelines. But it comes with a serious downside: carbon steel freely corrodes when it comes into contact with water, which is produced with crude oil or natural gas from underground reservoirs.

In upstream production environments, by contrast, crude oil isn’t corrosive to pipelines. This inspired a team of researchers at Ohio University’s Institute for Corrosion and Multiphase Technology to explore the concept of “steel + oil = no corrosion,” as part of their Water Wetting Joint Industry Project with major oil companies.

Earlier corrosion inhibitor research has focused almost exclusively on the water phase—essentially neglecting the effects of the crude oil phase. But now, in a paper published in the September 2014 issue of CORROSION, the Ohio University team describes their work studying the effects of the crude oil phase on the performance of corrosion inhibitors.

“The current practice to mitigate pipeline internal corrosion is to inject corrosion inhibitors,” explains Chong Li, formerly a Ph.D. student at Ohio University. “This makes understanding corrosion inhibition of carbon steel critical to ensuring asset integrity and supporting new field developments.”

To explore the effects of the crude oil phase on the performance of corrosion inhibitors, the researchers relied on common techniques, but also created a “doughnut cell” device designed specifically to provide measurements of steel wettability.

For starters, corrosion testing within a glass cell was accomplished by using electrochemical measurements. “The corrosion testing cell generates data about the corrosion rate of carbon steel with different testing fluids—including water without
an added corrosion inhibitor, water with an added corrosion inhibitor, or water with a layer of crude oil and an added corrosion inhibitor,” notes Li.

The team also obtained contact angle measurements with a custom-built goniometer to determine the wettability of steel—how much oil or water will spread on its surface. To do this, they created a “doughnut cell” to simulate oil-water pipe flow on a small scale. This device is capable of providing measurements of the wettability of the steel surface under dynamic (flow) conditions, whereas a goniometer provides only details about static (no-flow) conditions.

Using these combined techniques, Li and colleagues found that beyond lowering the corrosion rate, corrosion inhibitors can increase the oil wettability of steel—making it more difficult for water to come into direct contact with the steel, while also making it easier for water to be dispersed and flow as droplets within the oil rather than flowing as a separate phase at the surface of the pipe.

“We hope that our work will simplify the process of selecting, qualifying, and optimizing corrosion inhibitors to protect oilfield pipelines from internal corrosion,” Li says. “Our small-scale ‘doughnut cell’ device reduces the time and costs associated with inhibitor qualification.”

What’s next for the team? While their work has centered on studying oil-water two-phase flow, the researchers are now exploring corrosion inhibition in gas-oil-water three-phase flow. “We’ve built a high-temperature, high-pressure version of the ‘doughnut cell’ for testing conditions similar to oilfield operation conditions,” says Sonja Richter, formerly the Water Wetting project leader at the Institute for Corrosion and Multiphase Technology. “Our team integrated the effects of the crude oil and corrosion inhibitor into a computer-based corrosion prediction model to work on further improvements and to validate this model.”

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**Image Caption:** Assembled doughnut cell, and schematic cross-section view of the doughnut cell.

**More Information:** The paper, “How Do Inhibitors Mitigate Corrosion in Oil-Water Two-Phase Flow Beyond Lowering the Corrosion Rate?” written by Chong Li, Sonja Richter, and Srdjan Nešić appears in NACE International’s journal, *CORROSION*, September 2014, Vol. 70, No. 9, pp. 958-966. See: [http://dx.doi.org/10.5006/1057](http://dx.doi.org/10.5006/1057)

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