Effect of corrosion product scale on gaseous hydrogen permeation of pipeline steel

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Abstract Hydrogen energy plays a key role in the energy revolution. An effective and practical method for delivering hydrogen energy at a reasonable cost is to blend hydrogen into the existing natural gas pipelines. Internal corrosion is inevitable for the in-service natural gas pipelines, which typically results in the formation of corrosion product scale on the steel surface. Significant effects on hydrogen permeability and compatibility can result from the corrosion product scale after hydrogen has been blended. However, the impact of the corrosion product scale on gaseous hydrogen adsorption and diffusion remains unclear. This study provides an experimental method for corrosion product scale preparation and gaseous hydrogen permeation[1] in the hydrogen blended natural gas environments. The hydrogen permeation kinetics of pipeline steel in the presence of corrosion product scale was studied. Additionally, density functional theory (DFT) and molecular dynamics (MD) techniques were used to study the hydrogen adsorption mechanism on Fe and iron carbonate ($FeCO_3$) surfaces. It was suggested that the presence of $FeCO_3$ scales considerably reduced the stable hydrogen permeation flux, effective hydrogen diffusion coefficient, and effective subsurface hydrogen concentration. The suppression of hydrogen permeation into the steel substrate is caused by the surface adsorption effect and structure blocking impact of the $FeCO_3$ scales. This suggests that the corrosion product scale can be used as hydrogen barriers in gaseous hydrogen environments.

Keywords Hydrogen blended natural gas; pipeline steel; corrosion product; hydrogen permeation

Reference

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