Sulfide Stress Corrosion Study of a Super Martensitic Stainless Steel in H_2s Sour Environments: Metallic Sulfides Formation and Hydrogen Embrittlement

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Thanks to their high corrosion resistance, super martensitic stainless steels are commonly used in the oil and gas industry, particularly in sour environments. Some grades are however susceptible to undergo hydrogen and mechanically-assisted corrosion processes in the presence of H_2S, depending on the pH. The EN 1.4418 grade exhibits a clear protective passive behavior with no signs of sulfide stress corrosion cracking when exposed to sour environments of pH $\geq$ 4, but undergoes a steep decrease in its corrosion resistance at lower pH conditions. The present study investigated this abrupt loss of corrosion resistance with electrochemical measurements as well as different physicochemical characterization techniques. Results indicated that below pH 4.0 the metal surface is covered by a thick (ca 40 μm) porous and defect-full sulfide-rich corrosion products layer shown to be straightforwardly related to the onset of hydrogen and sulfide mechanically-assisted corrosion phenomena. Indeed, H_2S diffuses across the film or percolates along the porous structure and form metallic sulfides as it reacts at the film metal interface, thus liberating hydrogen previously bonded with sulfur that can be absorbed by the alloy. The thick film hence plays the role of a permanent and rich reservoir of hydrogen close to the metallic surface that can trigger and sustain hydrogen absorption.