Colloidal and Interfacial Effects of Impurities in Supercritical CO2: Implications for Corrosion in CO2 Dense Phase Pipelines (Carbon Capture and Storage)

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Carbon Capture and Storage (CCS) is being implemented at a large scale to mitigate the impact of CO_2 emissions on the climate. Currently, capital-intensive projects are being developed to capture CO_2 from major industrial emitters, transport it in dense-phase state, and store it in geological formations. However, impurities such as SO_x, NO_x, O_2, H_2O, and H_2S tend to react chemically [1] and produce small acidic droplets, potentially leading to severe corrosion issues in transport infrastructure.

To understand the colloidal aspects of the corrosion process, as a first step, we replaced CO_2 with surrogate solvents—benzene and tert-butylbenzene—possessing similar dielectric properties to CO_2 while conducting experiments at atmospheric pressure. Concentrated aqueous acid solutions at different concentrations were studied. The adsorption behaviour of ions and oxidation products at the water/oil interface was followed in time using profile analysis tensiometry. It was concluded that H^+ behaviour at this interface is different from any other adsorbing ion [2]: it is the only sticky ion to adsorb less on water/oil than on water/air, and shows peculiar temperature dependence. The difference in the anion results in HNO_3 adsorbing on water/benzene interface, HCl has zero adsorption, whereas H_2SO_4 desorbs.

The coalescence stability of droplets was evaluated using the thin liquid film technique with the Scheludko-Exerowa cell, while their attachment to the pipeline walls was assessed by contact angle measurements and a modified cell for wetting films (water/oil/metal). Main outcomes from this study can be summarized as follows: (1) sulfuric acid–water droplets coalesce rapidly upon encounter in benzene and tert-butylbenzene, without an energy barrier; (2) the droplet interfaces are not sufficiently immobilized by Marangoni effects to slow down film drainage. Hence, the charging of the surface by ions such as H^+, HSO_4^-, and NO_3^- are not sufficient to stabilize the emulsion. As a next step, we plan to study the effects of organic impurities, either naturally present in CO_2 stream or introduced as additives, on emulsion stabilization and corrosion mitigation.

Keywords:
Carbon Capture and Storage (CCS), thin liquid films, adsorption, coalescence, corrosion.

References:

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