UNIVERSITY OF LEEDS

Assessing corrosion inhibition performance using advanced in-situ characterisation techniques.

Introduction and Background

One of the main challenges in oil and petrochemical industry is to control the corrosion, which accounts for 3.5% of the global GDP. Several strategies are used in order to limit the cost of corrosion, including materials selection, surface treatments, cathodic protection and corrosion inhibitors. Among these strategies, the use of corrosion inhibitors (CI) is usually the more economically advantageous one.

The main drawback of corrosion inhibitors is their toxicity and negative impact for the environment. In order to tackle this issue, there is active research on new "green" corrosion inhibitors, but limitations, especially in terms of applicability in extreme environments apply at the current stage. An alternative option is to optimise the use of CI, obtaining the maximum corrosion protection with minimal usage of these additives. In this scenario, a clear understanding of the formation and resilience of the protective layer developed by CI, the corrosion products, and the electrochemical behaviour of the system is the key achieve this optimisation.

In order to achieve this understanding, an integrated approach combining electrochemical techniques, mass loss measurements and direct surface observation using advanced microscopy analytical techniques would enable a time-resolved qualitative and quantitative corrosion evaluation that can be directly linked to the dosage of the inhibitors, establishing the perfect framework for the optimised use of corrosion inhibitors in industry.

Proposed methodology

The cornerstone of the present project is a flow corrosion cell with capabilities for in-situ advanced microscopy techniques. This corrosion cell will enable direct electrochemical measurements that can be combined by direct observation of the surface, tracking real-time the evolution of the protective layer and corrosion products formation and dissolution.

Among advanced characterisation techniques, Raman microscopy has already been proven useful in determining the formation and dissolution of corrosion products on carbon steel surface, both in a qualitative and quantitative way. Moreover it presents a huge potential to identify a large variety of chemical species.

Direct observation of corrosion and other surface chemical changes using Raman microscopy under flow conditions, will be combined with traditional immersion electrochemical tests and with post-mortem analysis using a diverse variety of techniques (EDX, X-diffraction, microscopy, etc.)

Outline

The project involves the following distinctive phases:

Phase 1: Ex-situ analysis:

- Ex-situ immersion electrochemical tests on different CI, in order to determine effectiveness under stagnant conditions, and establish the protective layer formation time.

- Characterisation of the tested coupons using analytical tools, assessing Raman detection capabilities of corrosion products and protective layer.
- Selection of the best CI candidates.

Phase 2: In-situ direct observation of corrosion evolution with CI application:

- In-situ flow-cell preparation and conditioning, enabling efficient CI dosage, and mirroring industry conditions and processes.
- In-situ time resolving Raman microscopy analysis, quantifying formation of species on the surface, in combination with real time electrochemical data.
- Post-mortem coupon analysis, validating the results obtained in-situ.

Phase 3: Data analysis and Transferrable protocols:

- Study of the data obtained, determining the kinetic equation(s) for the inhibition layer and corrosion products formed, predicting corrosion evolution based on a series of inputs.
- Develop an integrated methodology with applications in industry.