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Research interests:

- Adhesion / adhesives
- Corrosion
- Coatings
- Interfacial bonding and degradation mechanism
- Surface treatment and analysis

Durable steel-to-composite bonds: physicochemical bonding and degradation at the adhesive-adherend interface

Recent Research activities:

The increasing implementation of steel-to-steel and hybrid material adhesive joints in highly loaded structures in maritime environment creates a high industrial interest in reliable durable adhesive bonding of steel. Within our project we focus on the physicochemical mechanisms of (de)adhesion across the polymers-to-steel interface. The fundamental understanding of these mechanisms can lead to superior long-term stability of the system through knowledge-based design of the steel/oxide/polymer interface.

Our earlier work showed that the bond between an epoxy adhesive and steel substrate resists load by a combination of both physicochemical bonds and mechanical interlocking. It was found that the long-term strength and durability of the adhesive bond is highly dependent on the chemical stability of the oxide/adhesive interface. Diffusion of water and corrosive species through the bulk polymer and transport along the metal-adhesive interface play a significant role in degrading the mechanical properties of the adhesive as well as its interfacial bonding to the adherends.

In our experimental setup, a thin 25-nm iron film is deposited on an IR-transparent Ge-crystal. The iron film is coated with a 60- μm thick layer of adhesive and an electrochemical cell with electrolyte is placed on top. This setup allows for combined *in situ* electrochemical measurements and IR spectroscopy of the adhesive-iron interface to monitor water and ion transport.

As a result, we were able to examine the diffusion behaviour and diffusion coefficient of water and ions through the bulk adhesive. We discovered that the diffusion coefficient of water is dependent on the supporting electrolyte and

that transport of water and ions is not simultaneously.

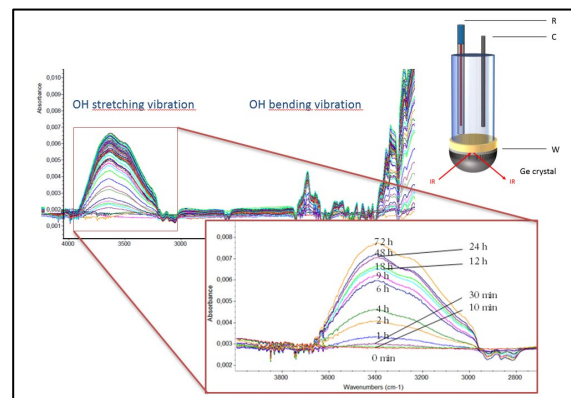


Figure 1: Kretschmann-setup allowing for *in situ* IR spectroscopy to monitor water and ion transport. Gradual increase of the OH-stretching band shows diffusion controlled transport of water through the adhesive towards the interface.

Water fully penetrates the bulk adhesive within hours, whereas ions are significantly slower. The buried iron-adhesive interface is highly stable, even upon the arrival of ions, when exposed through the adhesive. When the interface is directly exposed from the side through an artificial defect, rapid interfacial transport and the corresponding loss of interfacial adhesion was detected. The industrial aim is to assist the consortium in the development of a knowledge-based iron-adhesive interface based on an improved understanding of the physicochemical surface properties. This leads to the development of superior long-term lightweight constructions. Results in our work have shown that samples with enhanced surface chemistry demonstrate comparable initial adhesion strengths and superior interfacial stability compared to the current industrial standard.