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Measurements of methanol permeation rates across thermoset organic coatings

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Abstract

Corrosion protection of steel structures, such as ships, wind turbine towers, and storage tanks, is almost exclusively done by the use of multilayer anticorrosive coating systems. However, the lifetime of a coating system is often limited by the permeation rate of aggressive species (e.g. acids, alkalis, and solvents) through the system. Methanol, in particular, is a conductive polar solvent, which, upon penetration of the coating system, can result in galvanic corrosion of metal substrates, thereby leading to potential failures of carbon steel tanks[1].

Phenolic epoxies and vinyl esters are widely applied as tank linings to form an electrically non-conductive barrier between the liquid methanol and the tank material. In the present study, the permeation of methanol through organic coating films was investigated.

A custom-made, one-chamber permeation cell was designed and used to monitor the permeation rate and the break-through time of methanol across organic coating films as a function of time. For novolac epoxy (NE) and polyurethane (PU) films, a decreasing permeation rate of methanol was observed. The break-through time of methanol at room temperature was 8 hours across 500 μm NE films and 2.5 hours across 170 μm PU films. It was found that the weight and the coating thickness of the NE films were both reduced after the methanol permeation experiment, suggesting some molecular leakage from the films. Presently, the compositions of the leaching substances are unknown.

Permeation experiments of methanol across poly(methyl methacrylate) (PMMA) and low-density polyethylene (LDPE) films were performed for comparison. A decreasing permeation rate, similar to that of NE and PU films, was observed when methanol permeated across PMMA. However, the permeation rate of methanol across LDPE was constant. This may be attributed to the fact that PMMA and the coating films considered contain polar domains, such as ester and ether groups, which can form hydrogen bonding with the hydroxyl groups of the methanol. This strong interaction of coating films with methanol can contribute to the rearrangement of the polymer or network system. For 1000 μm PMMA and 200 μm LDPE films, the methanol break-through time at room temperature was 25 hours and 3 hours, respectively.

The underlying mechanisms of methanol permeation across organic coatings will be discussed in the presentation.

References

[1] The Methanol Institute, Singapore, Atmospheric above ground tank storage of methanol (2018). www.methanol.org. Accessed: 2019-04-05.