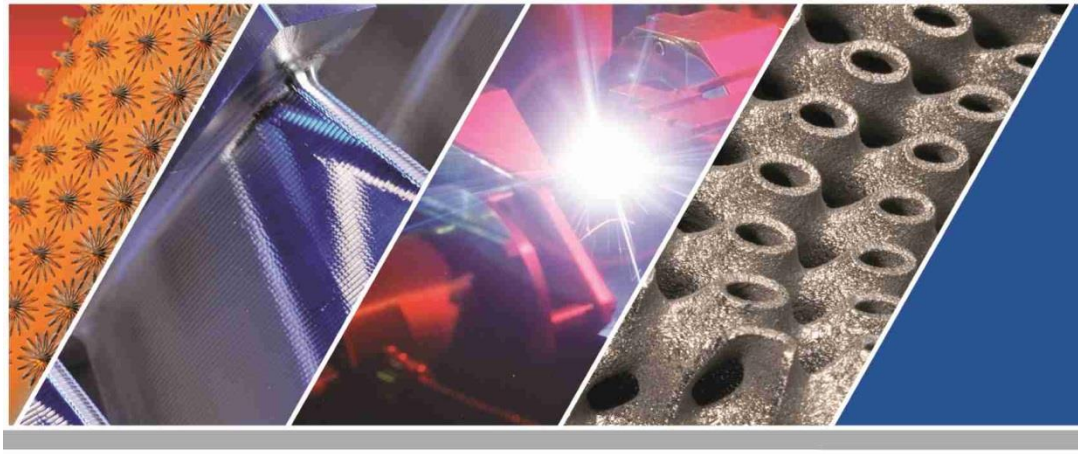
Combined Permeation of Pressurised CO2 with Impurities through Thermoplastics



JOINT INDUSTRY PROJECT OUTLINE

PR #311581

Summary

Overview

In applications for carbon capture and storage or enhanced oil recovery that include steel pipe remediation or liners for thermoplastic composite pipe, there is a need to assess the barrier performance of thermoplastic polymers. Specifically, this is to establish their effectiveness as barrier layers to impurities in carbon dioxide (CO_2) feedstock such as water vapour, ammonia, nitrous oxide, hydrogen and hydrogen sulfide. Generally, the liner reduces the rate of arrival of corrosive species at the load bearing steel support wires or base pipe.

The CO_2 fluid compositions may vary between locations and, potentially, there will be an enormous cost and environmental impact in needing to expose thermoplastic systems to each fluid composition on a case by case basis using autoclave-based ageing studies.

This study aims to establish whether some impurities are selectively blocked by the internal structure of the thermoplastic resin, allowing them to be excluded from screening studies for ageing in the future. This work will provide guidance as to which impurities within CO_2 compositions are most relevant when assessing the barrier properties and ageing of thermoplastics.

The chosen thermoplastics may be from the polyethylene, polyphenylene sulfide or polyvinylidiene families, and will be determined by the Sponsors. TWI Ltd will work with the Joint Industry Project (JIP) sponsors and third party suppliers to acquire the pre-prepared specimens as appropriate for the JIP.

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Combined Permeation of pressurised CO_2 with impurities through thermoplastics

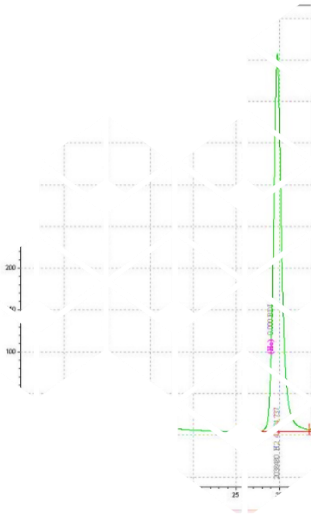
Project Concept

Establish selectivity for impurities in the presence of pressurised CO_2

The project will use the established TWI permeation facility, supported by gas chromatographs, to measure over several months the rate of transport through thermoplastics of CO_2 with water vapour and trace amounts of one of hydrogen sulphide, ammonia, nitrous oxide or hydrogen. It is expected that the concentrations of the impurities will be of the order of 500ppm. In any one permeation test, the pressures and temperatures of the CO_2 feed can start in the gaseous phase and be pressurised to liquid at 250barg with the temperature altered above 31°C to create a supercritical fluid.

Where transport is detected, then the flux and permeability coefficients will be calculated for each species at each pressure and temperature step. This may allow the activation energy for permeation to be determined. Assuming that initial breakthrough is captured, then diffusion coefficients will be calculated at various temperatures with the potential to estimate the solubility and enthalpy of adsorption of each component.

Using this data, it is hoped that the expected transport levels at other pressure and temperature conditions can be estimated. The analysis of the thermoplastic will be for swelling, alteration in crystallinity, glass transition temperature, storage and loss modulus.



Objectives

- To establish the barrier performance of thermoplastic materials to CO_2 with associated impurities.
- To establish if any transport of these impurity species causes ageing in the thermoplastic matrix.

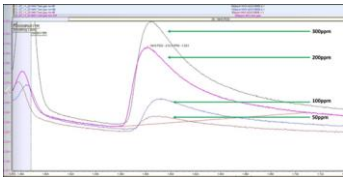
Benefits

This work will provide guidance as to which generic CO_2 composition with impurities are relevant to assess the barrier properties and ageing of thermoplastics.

Approach

Permeation and assessment studies on small disc specimens

The permeation of liquid and supercritical CO_2 through extruded thermoplastics from supercritical mixtures has been studied extensively over the last decade because of their use in liners for traditional flexible risers and flow lines.



As a result, TWI has a facility to carry out continuous sweep permeation testing using supercritical CO_2 pressurised to 626barg in the presence of H_2S.

Building on established methodologies with the addition of an impurity with water to the CO_2, this work will be extended to thermoplastics. The choice of the impurity will depend on the chemistry of the thermoplastics and the wishes of the sponsors. It will be important to include water.

Four multistep permeation tests can be performed with an overall duration of 3 months each. The condition of the thermoplastics after exposure will be assessed. The experimental methodologies used and data treatment will act as a guide irrespective of the functionality of the thermoplastic in the final product, be it a thermoplastic composite pipe or a polymer lined steel pipe or tubular.

Deliverables

This JIP will provide permeation data to confirm if the contaminants enter into the thermoplastic materials and so have the potential to contribute to ageing of the thermoplastic matrix.

Combined permeation of pressurised CO_2 and impurities through thermoplastics

Price and Duration

The overall estimated price for the work is £336,000 (excluding VAT), which requires £25,000 per company per annum for 3 years (£84,000 total) from each of the 4 Sponsors. It is anticipated that the project will commence with an agreed scope of work with a minimum of 4 Sponsors. If the number of sponsors increase then the ticket price can reduce or scope of work increase accordingly.

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

https://www.twi-global.com/what-we-do/research-and-technology/current-research-programmes/joint-industry-projects#/

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