Passive materials selection (CRAs) versus corrosion inhibitor development for CO_2 transport and injection

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Ettore di Sabato

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Background *and* Research Questions

CCS infrastructure requires reliable CO_2 **transport and injection** in harsh environments.

- *What are the most effective* ***corrosion mitigation strategies*** *in* ***acidic, wet, and high-pressure environments****?* → ***Passive materials (CRAs) and corrosion inhibitors***
- *How do* ***CO_2 stream impurities*** *interact with pipeline materials and influence corrosion?*
- *How do* ***corrosion inhibitors and CRAs*** *work under such conditions?*

Secondments

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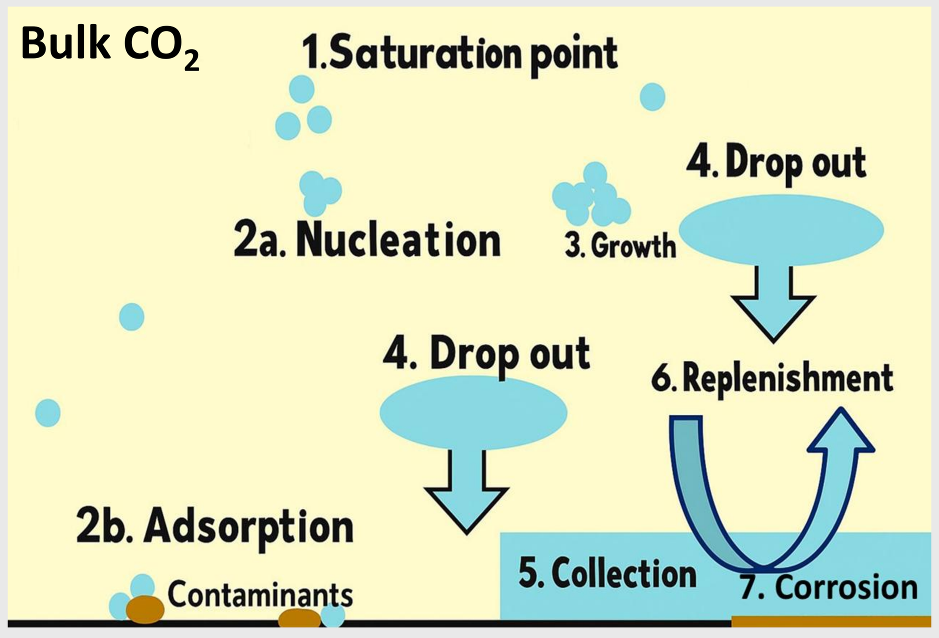
Transport pipelines (X65)

- Analysis of different levels of **water content and impurities** in the form of **NO_x, SO_x, and O_2;**
- **Acid drop-out,** [1].



Representation of the different steps of corrosion due to formation and drop-out of liquids in a bulk CO_2 phase, [1].

Injection pipeline (CRAs) Alleima

- High-**salinity brine** flowback from a saline aquifer;

→
- Super 13Cr;
- SAF 2507, super-duplex stainless steel;
- SANICRO 28, high-alloy multi-purpose austenitic stainless steel;
- SANICRO 35, alloy combining the best features of a super austenitic stainless steel and a nickel alloy.

*Materials provided by Alleima.

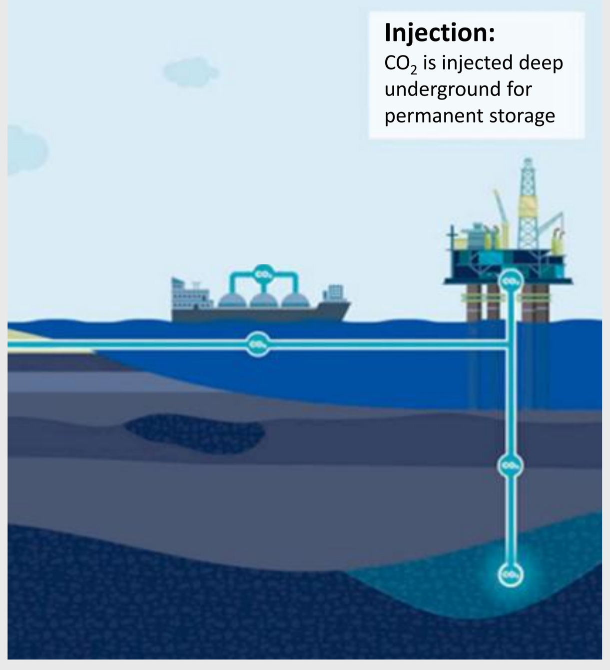
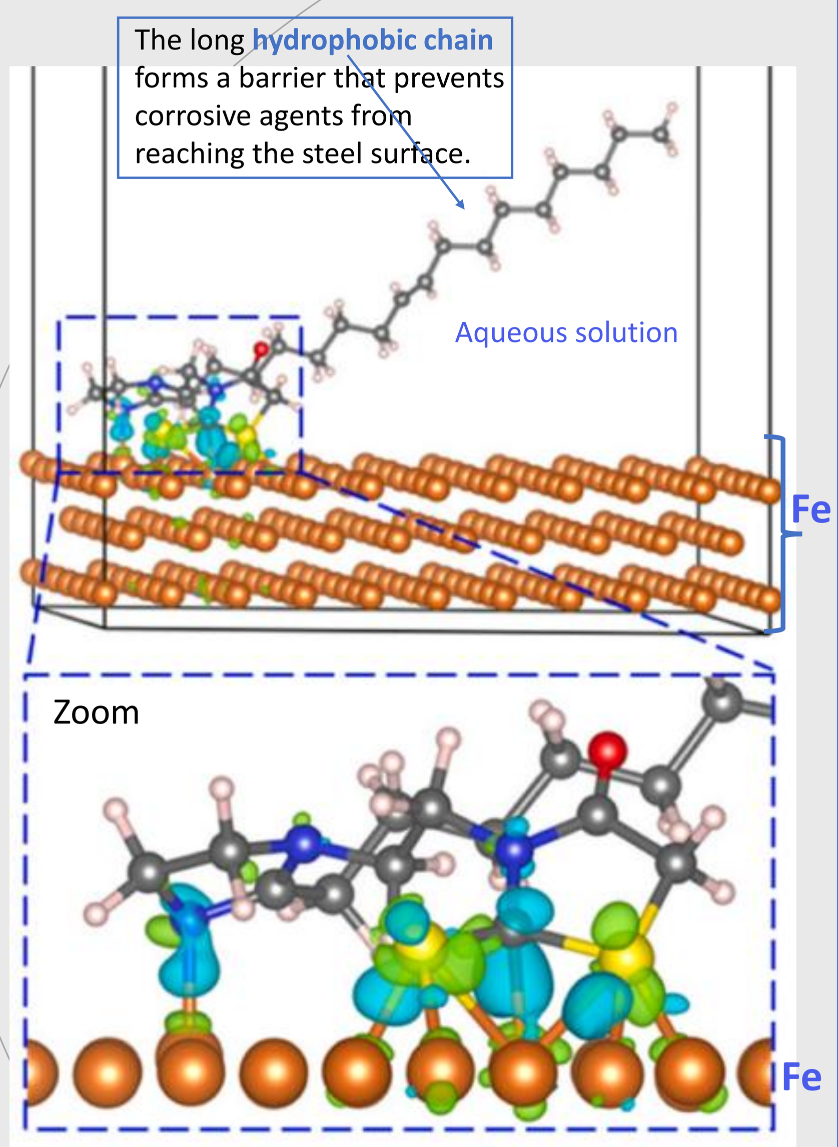


Image from S.K. Kairy, S. Zhou, A. Turnbull, G. Hinds, Corrosion of pipeline steel in dense phase CO2 containing impurities: A critical review of test methodologies, Corrosion Science (2023) 214 110986.

Inhibitors selection Baker Hughes

- **Chemical structure** → Role of heteroatoms in the imidazole ring;
- **Solubility** → Sapphire cell; DTU
- Interaction with impurities → H_2O, O_2, SO_x, NO_x
- Degradation products;
- Adsorption mechanism → Efficiency;
  (Optimal concentration)
- **Film's stability** → Inhibitors blend.

*Some inhibitors provided by Baker Hughes, others from literature reviews.



Adsorption of imidazoline derivative corrosion inhibitors on Fe surface through N and S atoms, [2] .

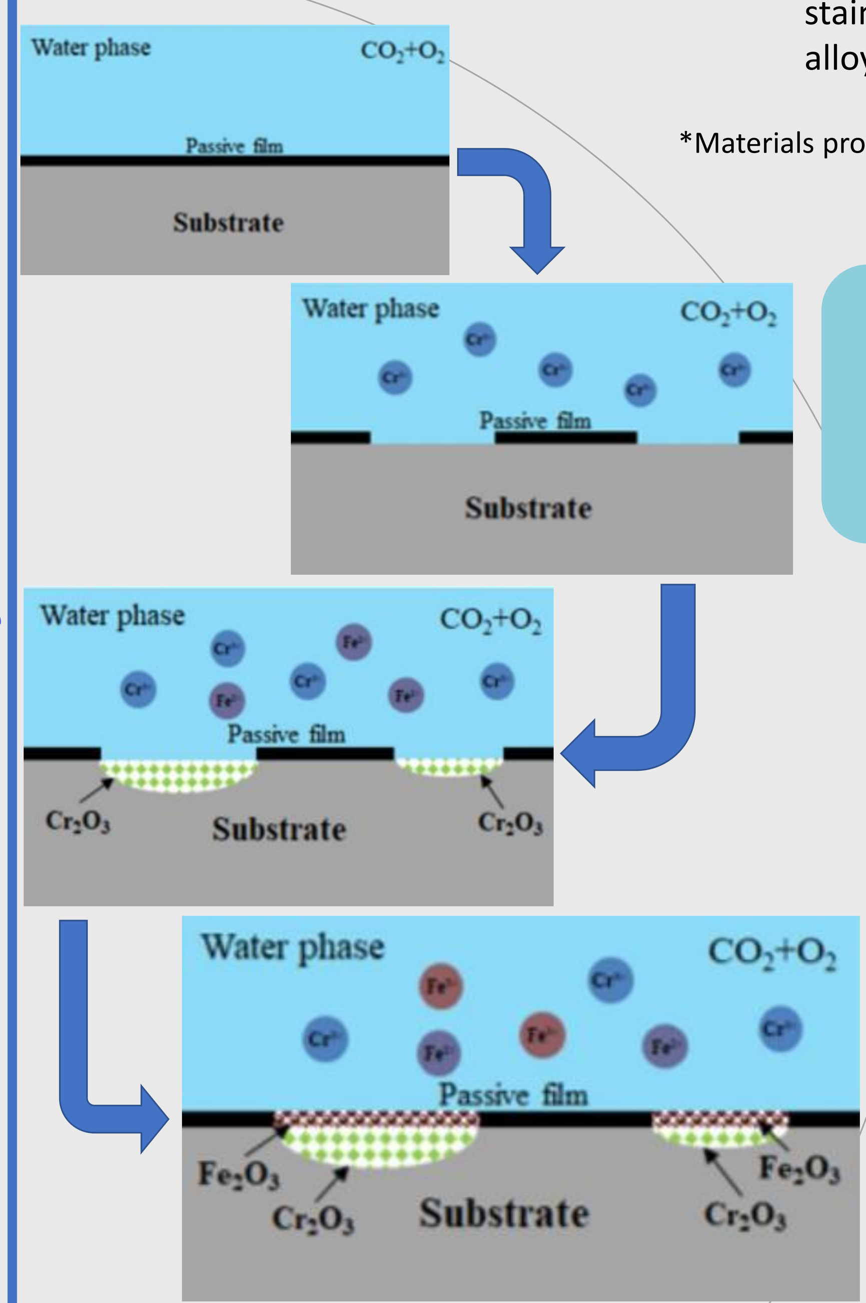


Diagram of the depassivation mechanism of Super 13Cr at high temperature, high CO_2 content, [5].

CRA passive film stability

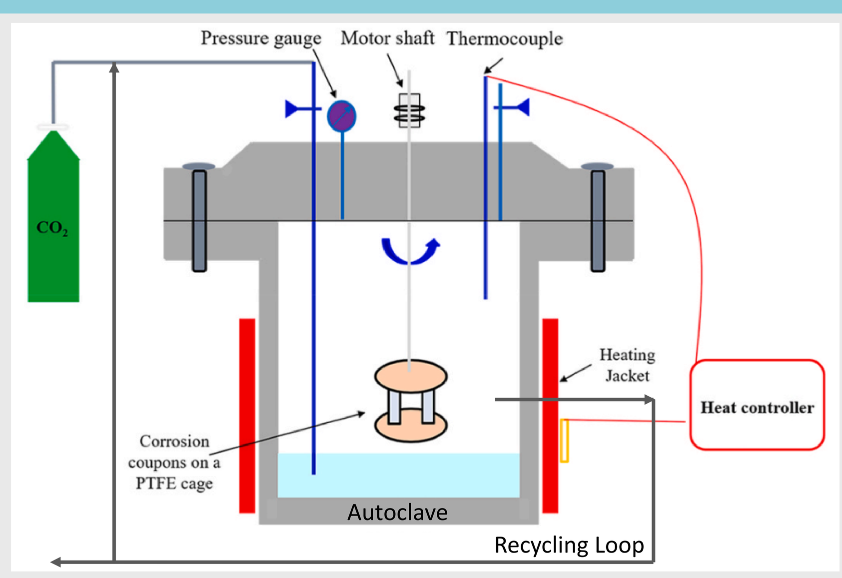
- Influence of impurities on the **passive plateau,** [3];
- Properties of **passive film;**
- **Chloride content** → Breakdown of passivity;
- **pH** → Depassivation;
- Ability to passivate → Repassivation mechanism;
- **Pitting** resistance → **PREN;**
- **Crevice corrosion** → Design.

Experimental Methodology: **Autoclave** Conditions *and* **Aqueous Solutions**

- **P > 80 bar**;
- **pH measurement** with a **ZrO_2-based** high temperature high pressure pH **electrode**.

First Step → **Static** autoclave;

Second Step → **Dynamic** Conditions: *Rotation Mechanism and Recycling Loop.*



Supercritical CO2 corrosion experimental device diagram.

- **P atm**;
- Use of **Aqueous Solutions** to investigate corrosion mechanism using **classical electrochemical techniques.** → **Birbilis' Protocol,** [4].

Standard three-electrodes set-up → The **working electrode is a rotating disk electrode** (RDE) with an exposed disk surface area of ~1 cm², made of the testing material (steel or CRAs).

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