Corrosion Inhibitor Chemical
DESIGN, SELECTION AND EVALUATION

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CLARIANT OIL SERVICES
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Corrosion Inhibitor Chemicals
Classification of Corrosion Inhibitors

- Scavengers
  - remove $\text{H}_2\text{S}$ and $\text{O}_2$

- Biocides
  - remove microbes

- Adsorption/Organic Film Forming
  - forms barrier to corrosive reactants

- Anodic
  - reduce corrosion rate by retarding anodic reactions

- Cathodic
  - reduce corrosion rate by retarding cathodic reactions

- Vapour Phase
  - volatile inhibitors
Corrosion Inhibitor Molecules

- Generally surfactants
- Water soluble polar head group
- Oil soluble tail
- Hydrophilic head group interacts with metal surface
- Changes the wettability of the metal surface
Surfactants
Partitioning

- In most cases we want the inhibitor to partition preferentially into the water phase.

- The partitioning co-efficient of the inhibitor can be derived experimentally.

- Helps determine the suggested dose rate.

<table>
<thead>
<tr>
<th>Water Cut (%)</th>
<th>90</th>
<th>20</th>
<th>10</th>
<th>5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fluids Dose Rate to Give 30 ppm in Water Phase (ppm)</td>
<td>31.0</td>
<td>11.2</td>
<td>7.5</td>
<td>5.7</td>
<td>4.6</td>
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</table>
Corrosion Inhibitor Formulations

• Corrosion Inhibitor Bases
  – Can be a combination of several different molecules to achieve synergistic effects or mitigate corrosion occurring through different mechanisms

• Solvents
  – Improve viscosity and stability, alter dose rate to match pump spec

• Synergists
  – Generally sulphur-containing molecules to improve performance

• Secondary surfactants
  – Small quantities to affect partitioning behaviour, formulation stability, wetting

• Other Bases
  – Anti-foams, demulsifiers, scale inhibitors
Inhibitor Evaluation
Evaluation Process

1. Health Review
2. Risk Assessment and Modelling
3. Laboratory Testing – Performance
4. Laboratory Testing – Other Requirements
5. Third-Party Confirmation/ Specialist Specific Testing
6. Field Trial
7. Deployment
8. Monitoring
Process Overview

• What are conditions like in the field?

• How do we best replicate this in the laboratory?

• Which chemicals mitigate corrosion in these conditions?

• Which other properties does the chemical need to have?

• Which chemical is the best candidate when everything is considered?
System Review

• A full system review should be performed and risks understood

• Relevant system conditions include
  – Water chemistry, bicarb, organic acids
  – Temperature and Pressure
  – Partial pressure of H₂S and CO₂
  – Production rates, pipeline diameters, flow regimes
  – Materials used
  – Sand production
  – Solid deposits
  – Microbes
  – Other specific corrosion risks...
Specific Corrosion Risks

- General CO2 corrosion
- Pitting
- Sour
- High temperature
- High pressure
- Under deposit
- Weld
- High shear
Other Information

- Other information required:
  - Environmental restrictions
  - Dose rate restriction
  - Cost
  - Physical property requirements
  - Compatibility requirements
  - Storage/handling requirements
  - Residual analysis methods
  - Field fluids available for testing
Laboratory Testing
Bubble Cells

- Up to 90°C, ambient pressure
- Linear Polarisation Resistance
- Electrochemical Impedance Spectroscopy
LPR Data
High Temperature Bubble Cells

- Up to 150°C, > ambient pressure
- Linear Polarisation Resistance
- Electrochemical Impedance Spectroscopy
Rotating Cylinder Electrode

- Similar to Bubble Cells but with the ability to add shear stress
Weld Test

• LPR measured, along with Galvanic Current between different sections of the electrode
• Can be manufactured different metals to be project specific
LPR Weld Data
Galvanic Current Weld Data

![Graph showing current in mA/cm² over time (hours) for different categories: WELD, HAZ 1, HAZ 2, P 1, P 2. The graph illustrates the changes in current as time progresses.]
Under Deposit Corrosion

- LPR measured, along with Galvanic Current between different sections of the electrode
- Different solids can be used
Auto clave Testing

- Can use coupons and/or LPR probes
- High pressures and Temperatures
- Shear
HPRCA

• Uses one or two weld electrodes
• Higher Pressures and Temperatures
• High Shear stress
Jet Impingement

- Very High Shear
- Higher Pressures and Temperatures
- Sand can be added to look at erosion
Testing Additional to Performance

- Includes:
  - Emulsion tendency
  - Foaming tendency
  - Brine compatibility
  - Chemical compatibility
  - Thermal stability
  - Elastomer compatibility
  - Viscosity
  - Flash point
  - Residual analysis...
## Screening Matrix

<table>
<thead>
<tr>
<th>Product</th>
<th>Stability (Ambient)</th>
<th>Performance &lt; 0.1 mm/yr</th>
<th>Compatible with incumbent</th>
<th>Foaming</th>
<th>Stability (low temp)</th>
<th>Viscosity</th>
<th>Elastomer Compatibility</th>
<th>Cost</th>
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<td>N/A</td>
<td>N/A</td>
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<tr>
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</table>
Summary

- Corrosion inhibitors are surfactants and partition between oil and water phases to different degrees.
- Increased dose rate does not always equal increased corrosion inhibition.
- They can inhibit corrosion by:
  - Removing factors that cause corrosion (O2, H2S, microbes, acidity).
  - Forming films on the metal surface.
- Complex formulating can be required to make a suitable product.
- Products need to be tailored to suit specific applications.
Summary continued

- A full system review is essential to understand the corrosion risk and system requirements
- A number of routine and specialised techniques are available
- The correct choice of tests are essential and these are based on the system conditions and requirements
- Performance is not the only factor taken into consideration when selecting a corrosion inhibitor
Thank You