Future Proofing Corrosion Control

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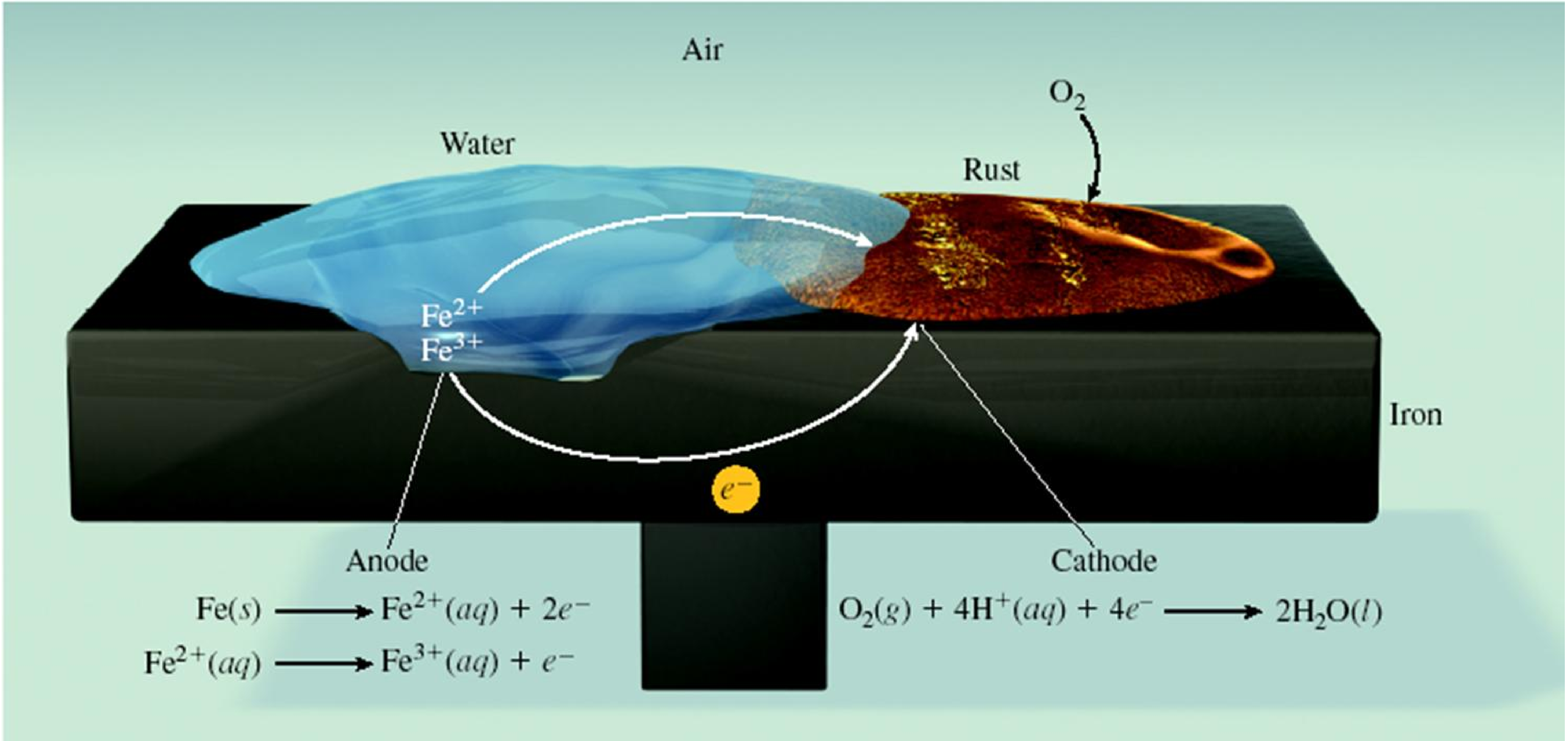
AGENDA

Future Proofing Corrosion Control

Corrosion Formation & Inhibition

Corrosion Cell Diagram



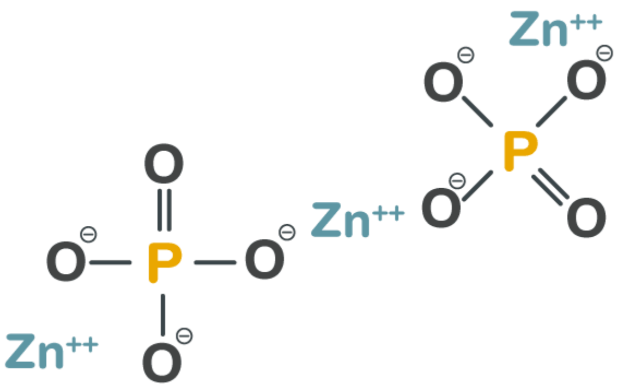
Traditional Corrosion Inhibition

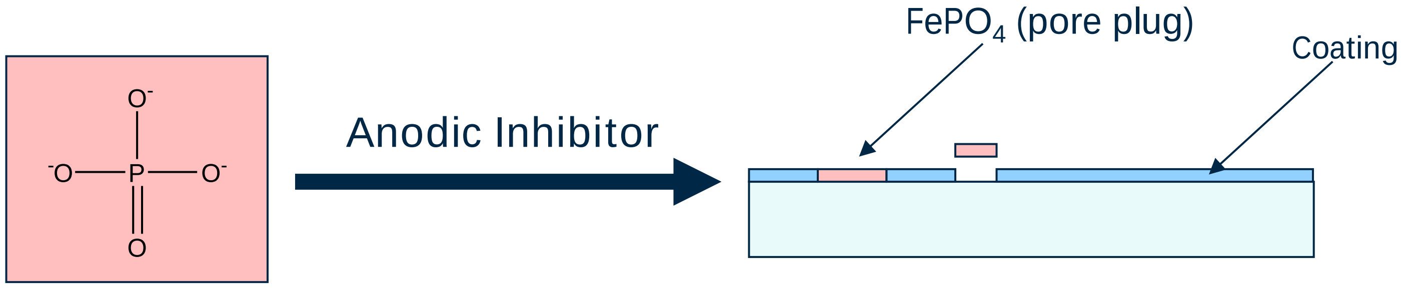
Inorganic Metallic Salts

Mechanisms:

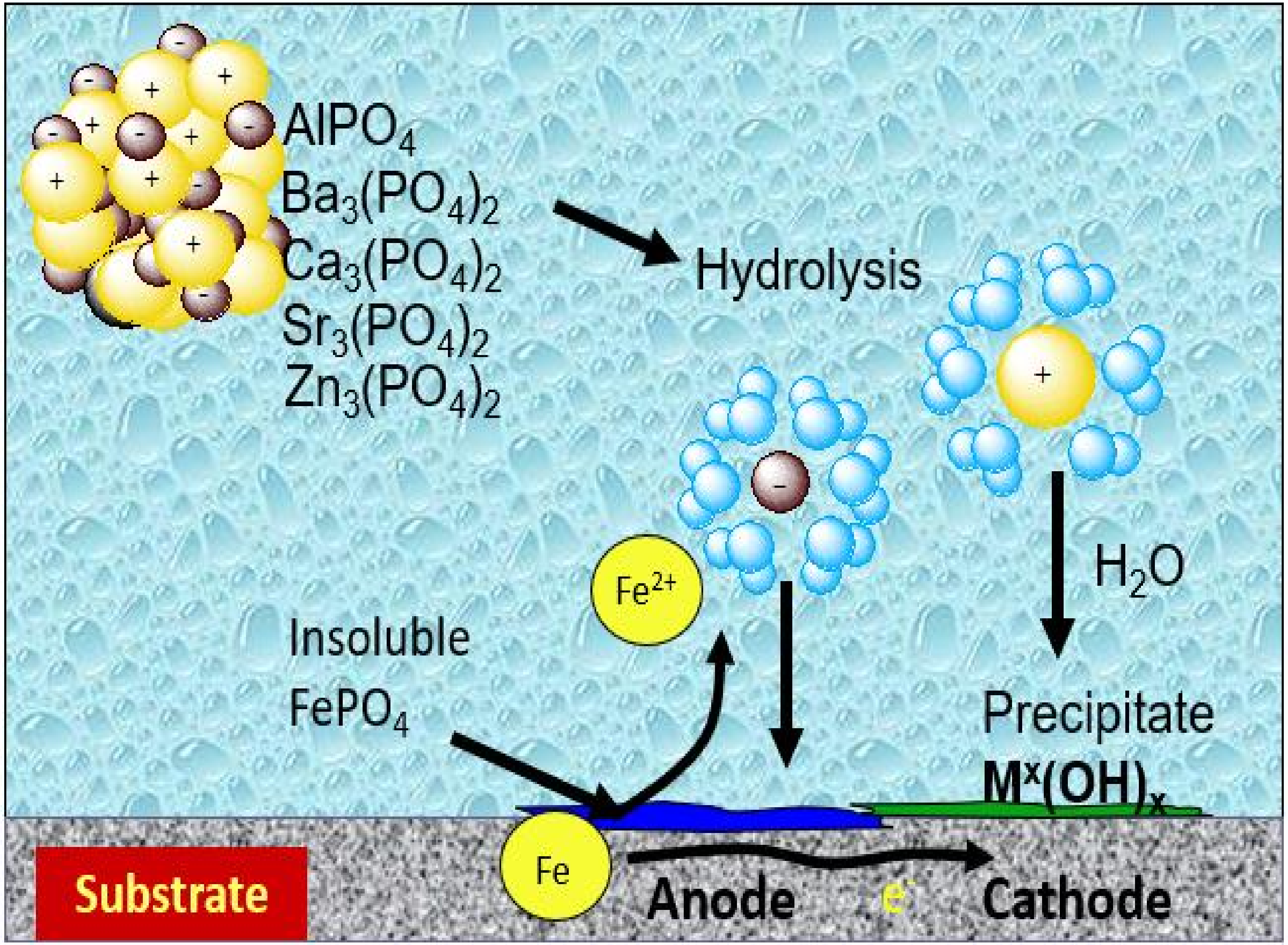
- Anodic Passivation
  - Migrate and react at the anode to form salts that act as a protective barrier.
  - Adsorb at anodic sites, preventing dissolution of metal in acidic media.

- Precipitation
  - Protective film-forming compounds.
  - Block anodic and cathodic reactions by precipitating onto surface of metal





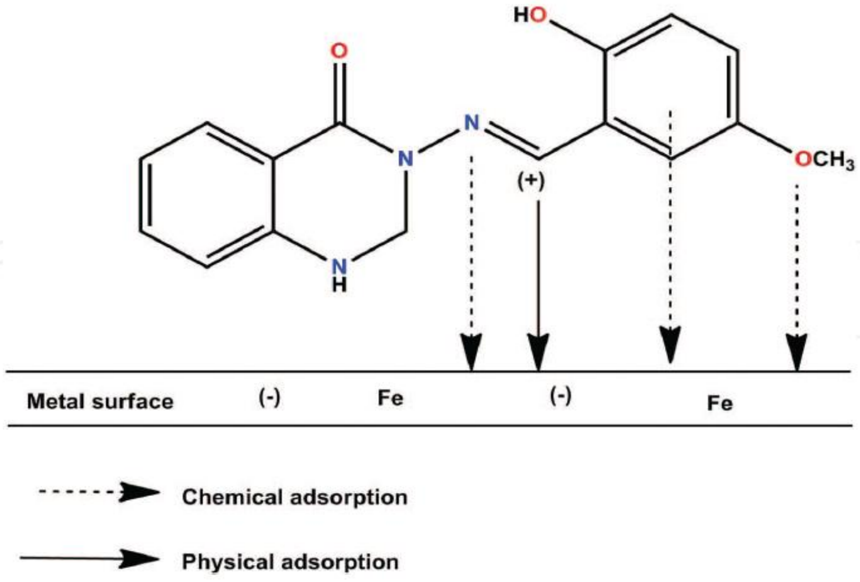
Mixed Metal Cation Phosphates – Passivation Mechanism



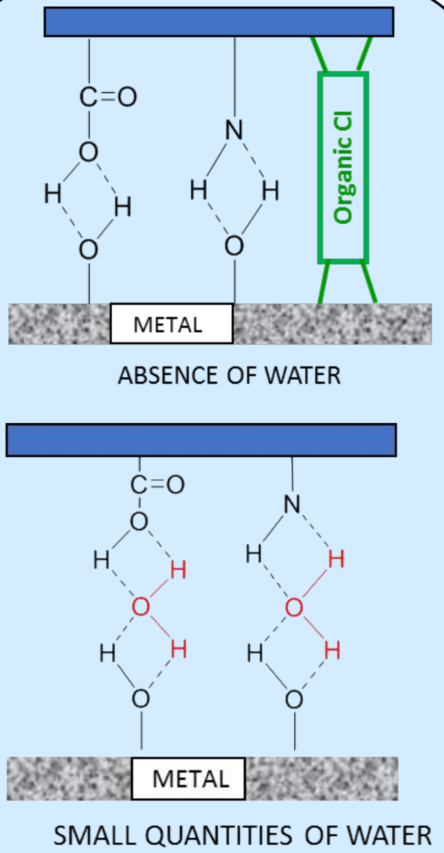
Phosphate	Ksp
Li3PO4	2.4×10^{-4}
CaHPO4	1.0×10^{-7}
MgNH4PO4	2.5×10^{-13}
AlPO4	1.3×10^{-20}
FePO4	1.3×10^{-22}
Mg3PO4	6.3×10^{-24}
Ba3(PO4)2	1.3×10^{-29}
Ca3(PO4)2	2.0×10^{-29}
Sr3(PO4)2	1.0×10^{-31}
Zn3(PO4)2	9.0×10^{-33}
CePO4	2.9×10^{-34}

Why Use Organic Corrosion Inhibitors?

- Provide multiple inhibitive mechanisms
- Good solubility
- Low particle size >> minimal gloss impact
- Liquid and powder options
- Low use levels >> maintain cost of use
- Adhesion promotion
- Adsorb on surfaces (physisorption or chemisorption)
  - Physisorption (electrostatic interaction b/n charged metal surface and charged inhibitor)
  - Chemisorption (transfer or share of unbounded electrons b/r molecule and metal surface)
- Act synergistically with inorganic corrosion inhibitors



Mechanisms of Organic Corrosion Inhibitors



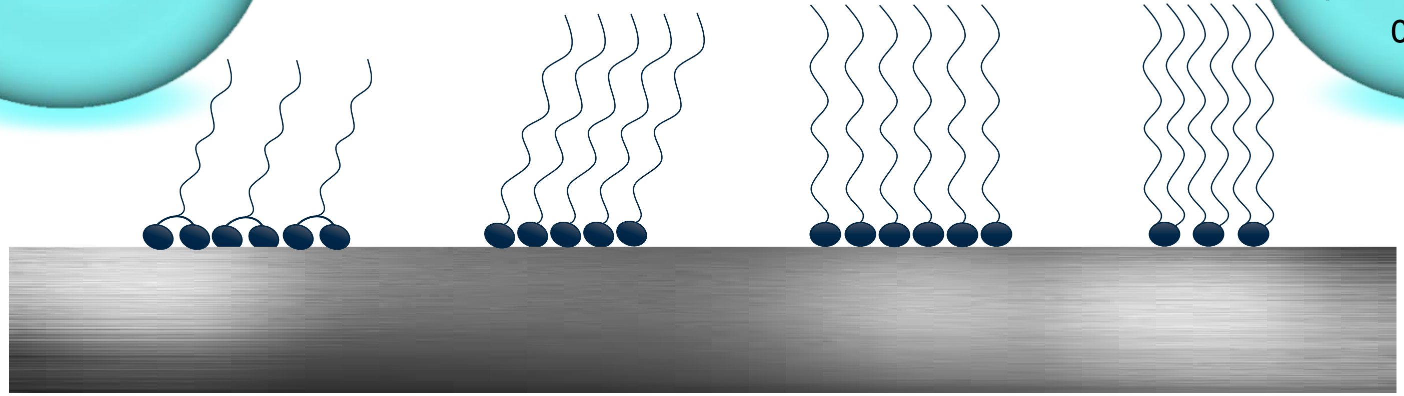
- Adhesion via mechanical and polar interactions (e.g. hydrogen bonding).
- Water displacement

<u>Interfacial Activity</u>

Improve coating wet adhesion

<u>Barrier Properties</u>

Reduce porosity & permeability in coating



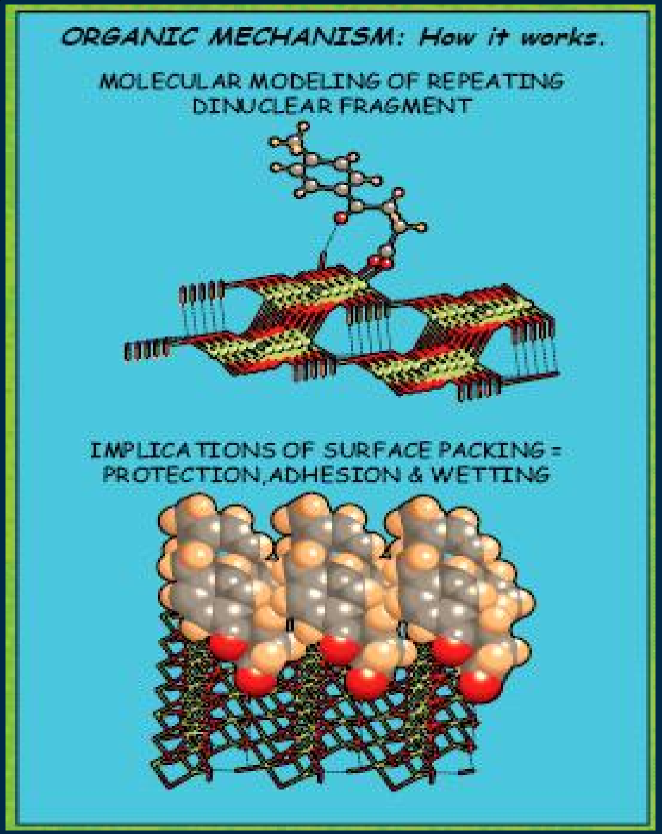
<u>Anodic Activity</u>

Formation of insoluble complex salts at anodic defect sites

<u>Adsorption Activity</u>

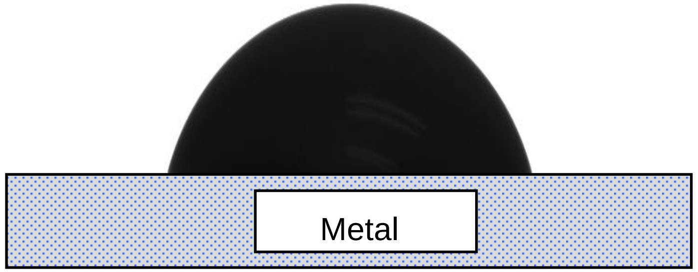
Protective layer formation

Mechanisms of Organic Corrosion Inhibitors



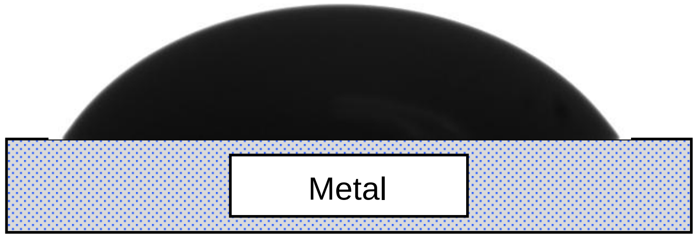
- Adhesion Promotion
- Pore Plugging
- Reduce Water Uptake
- Anodic Passivation
- Flash Rust Prevention

Improve Substrate Wetting



Higher contact angle = poorer wetting

Acrylic resin solution: 77°



Lower contact angle = better wetting

Acrylic resin solution + 3% organic Inhibitor: 57°

Organic Inhibitor Benefits

Best practices for utilizing organic chemistries

Performance enhancer

- Synergy with inorganic inhibitors.
- Provides unique mechanisms to enhance performance
- Provides adhesion + passivation.

Improve product labeling

- Reduce dependency on heavy metals. (chromium, zinc, lead, barium)
- Replace VOC containing CI's.
- Lower use level than inorganics.

Stand Alone Inhibitor

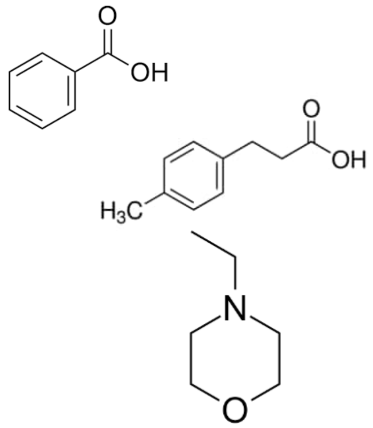
- Effective at low use levels in WB and SB formulations.
- Minimal impact on gloss.
- Can provide flash rust protection.

Organic Compounds as Corrosion Inhibitors

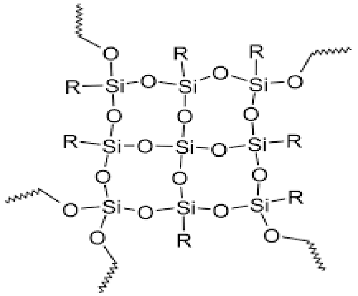
Structure and Compatibility

Compatibility

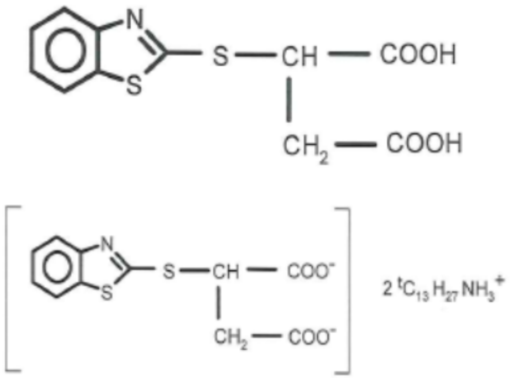
Amine-Acid Salts



Silane-Siloxane derivatives

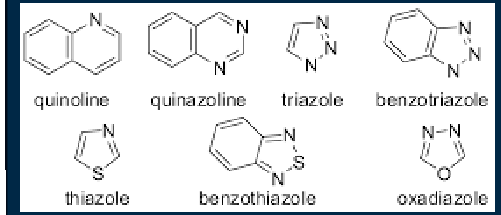


Di-Acids, Acid-Amines



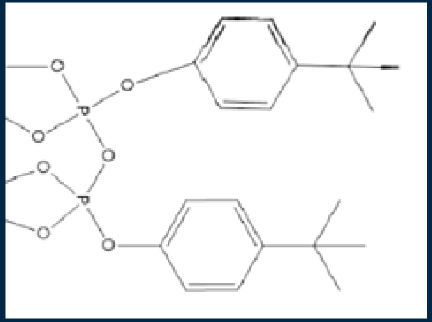
NEW

Heterocyclic Ion Exchange (HIE)



NEW

Bio-based Organophosphate (BOP)



Organic Corrosion Inhibitor Case Studies

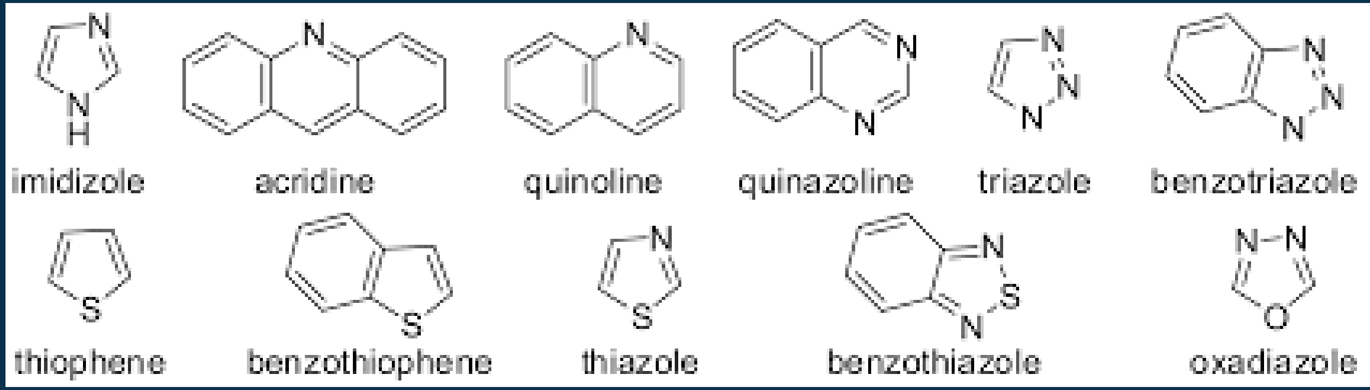
HIE - Heterocyclic Ion Exchange

BOP – Biobased Organophosphate

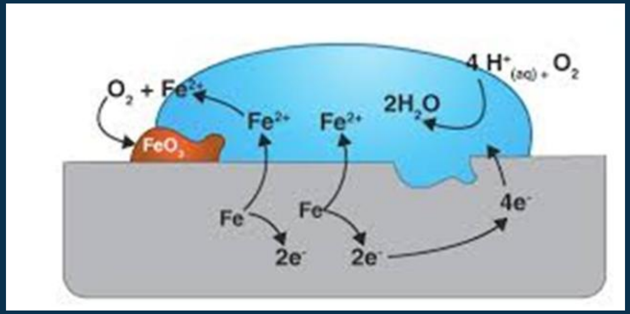
HIE: Heterocyclic Ion Exchange

- Smart anti-corrosive pigment
- Releases a heterocyclic organic corrosion inhibitor from a micro-reservoir
- Release occurs via ion-exchange
- Released organic combats corrosion

Key **Features**



- Fast reaction
- Long lasting within coating
- Multiple protective mechanisms
  - Forms a protective layer blocking anodic activity.
  - Neutralizes pH of corrosion front by donating electrons or receiving H^+ protons.
  - Bind with substrate slowing down cathodic delamination.

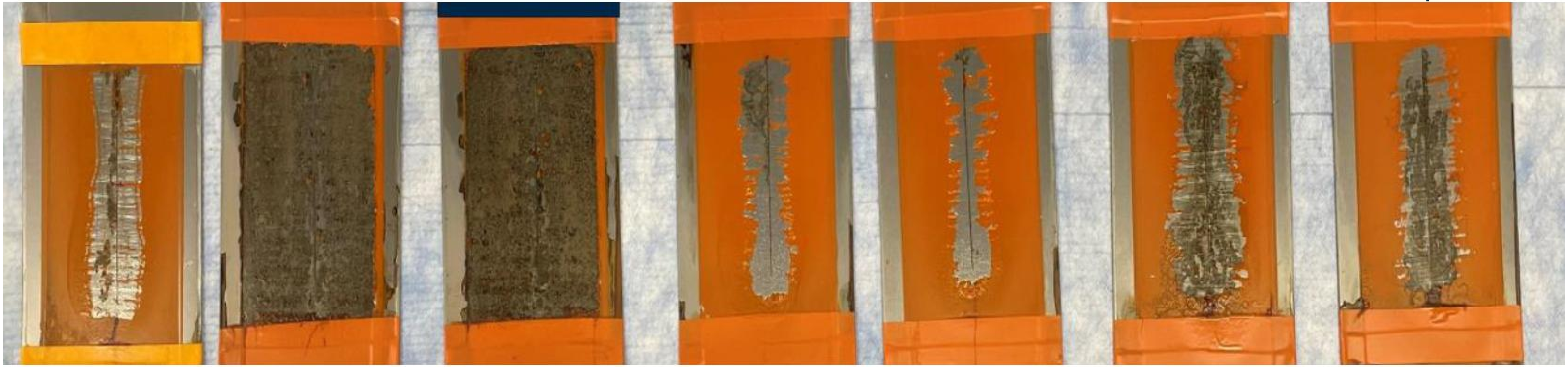


Solvent-based Medium Oil Alkyd Primer

HIE as stand alone corrosion inhibitor

CRS ~ ASTM B-117 ~ 336 hours ~ DFT 75µm

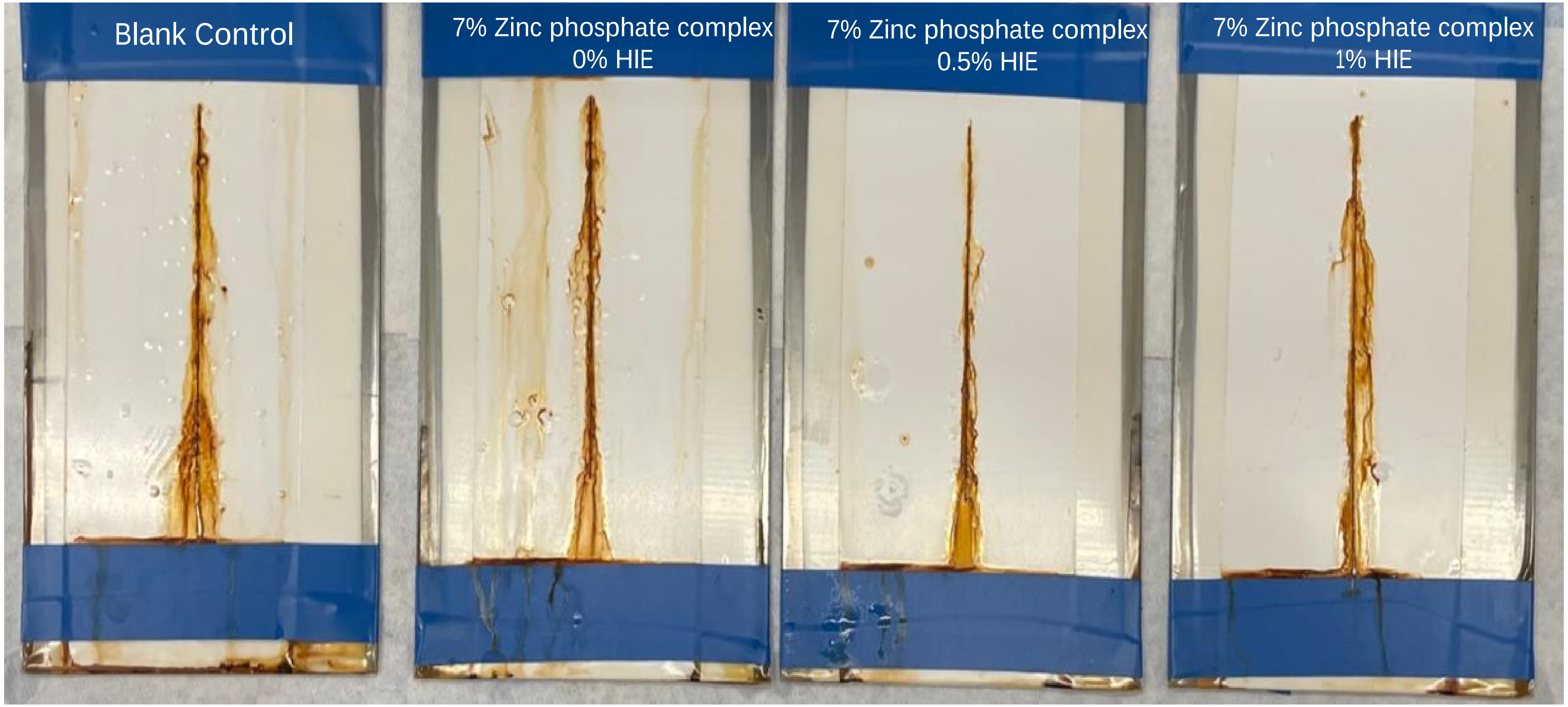
Control	1% Organic Comp A	2% Organic Comp A	1% HIE	2% HIE	1% Organic Comp B	2% Org Comp B



Water-based Acrylic DTM

HIE as performance enhancer

CRS ~ ASTM B-117 ~ 144 hours ~ DFT 70-80µm



Co-blend for Synergy

HIE optimization of corrosion inhibitor synergy

Powder Performance - 1500 hours SST

5% Zn PHOSPHATE

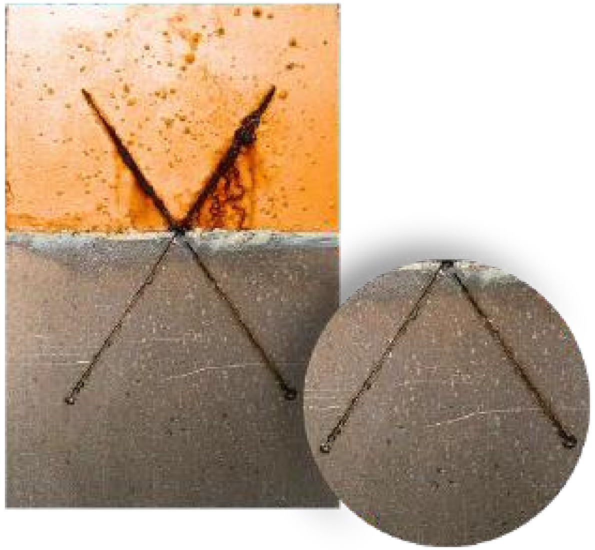
5% Zn PHOSPHATE &
1% HIE

Epoxy-polyester powder performance

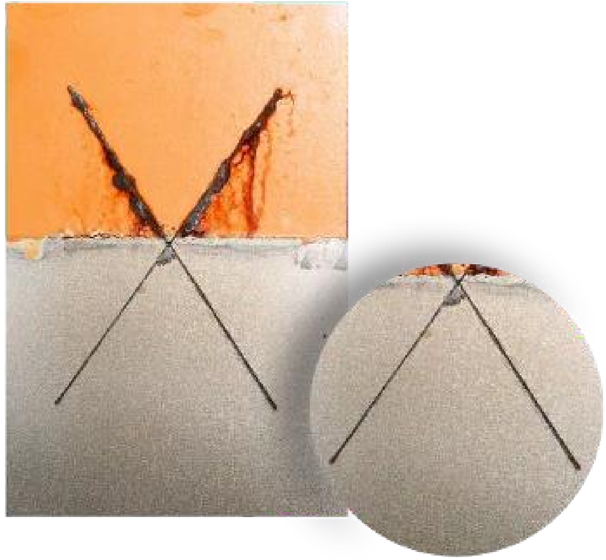
- Reduced corrosion at scribe according to ISO 12944
- Decreased coating delamination
- Substrate shot blasted steel Sa 2.5
- ISO 9227-Neutral Salt Spray DFT: 60-90 µm

WB Primer & Topcoat - 1000 hours SST

4% Zn PHOSPHATE



2% Zn PHOSPHATE &
2% HIE



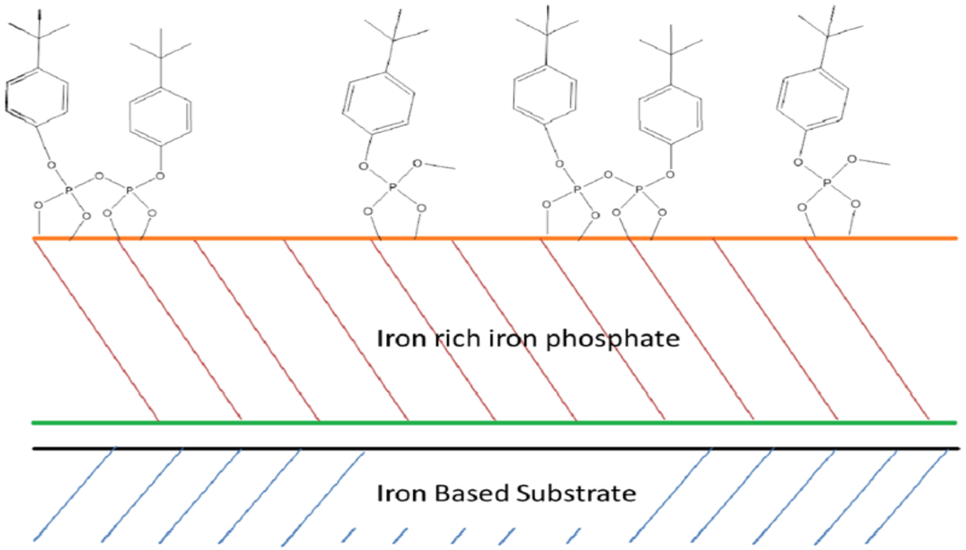
WB Acrylic with SB PU topcoat

- Reduced corrosion at scribe
- Improved surface corrosion protection
- Substrate Steel
- DFT: 40-50 µm (Primer) / 70-80 µm (Topcoat)

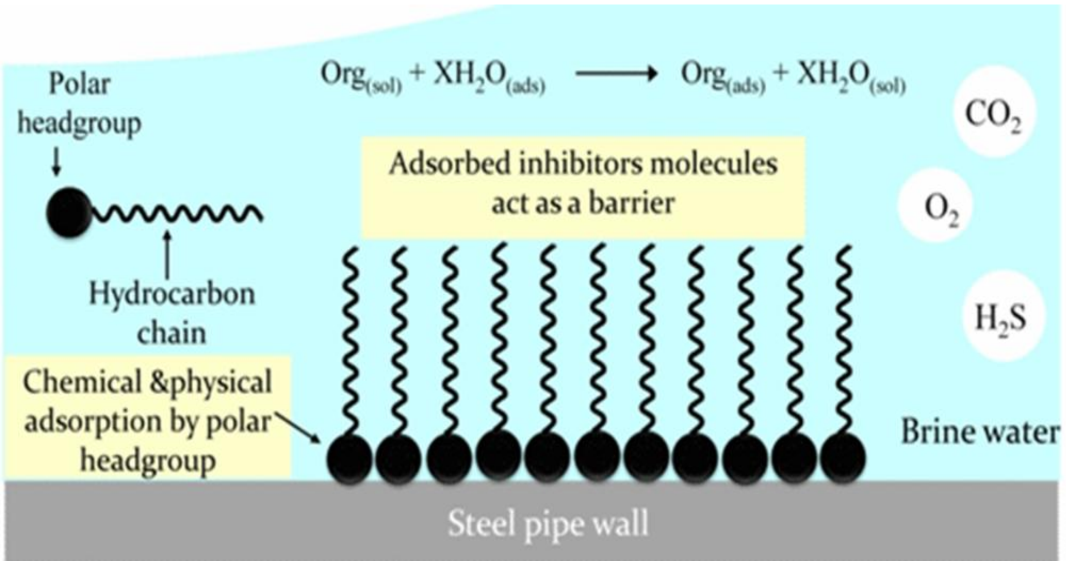
BOP: Bio-based Organophosphate

- ✓ Unique **liquid** CI with **clean MSDS** (50% biobased)
- ✓ Suitable for both **solvent- & water-based coatings**
- ✓ Long term corrosion protection up to **C4**
- ✓ **Good adhesion** on difficult substrates
- ✓ **Good stability** – easy to use
- ✓ **Ecolabel** compliant: <0.5% VOC

PART I:
Organophosphate: adhesion benefits



PART II:
Biobased solvent: hydrophobicity



Water-based 2K Epoxy

BOP as performance enhancer

ASTM B117
DFT: 65 microns
Substrate: Cold Roll Steel

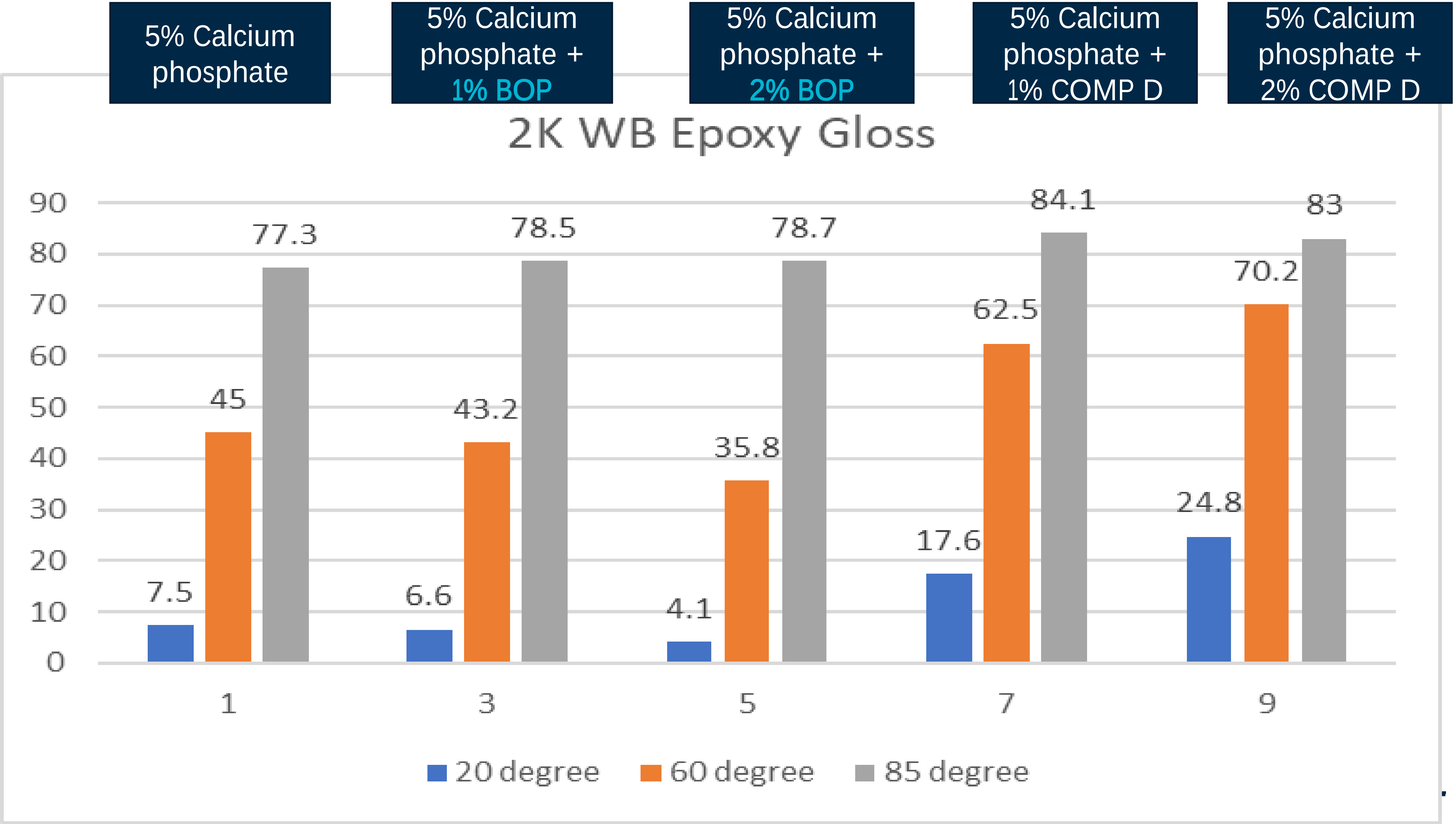
5% Ca phosphate

5% Ca phosphate
+ 1% COMP

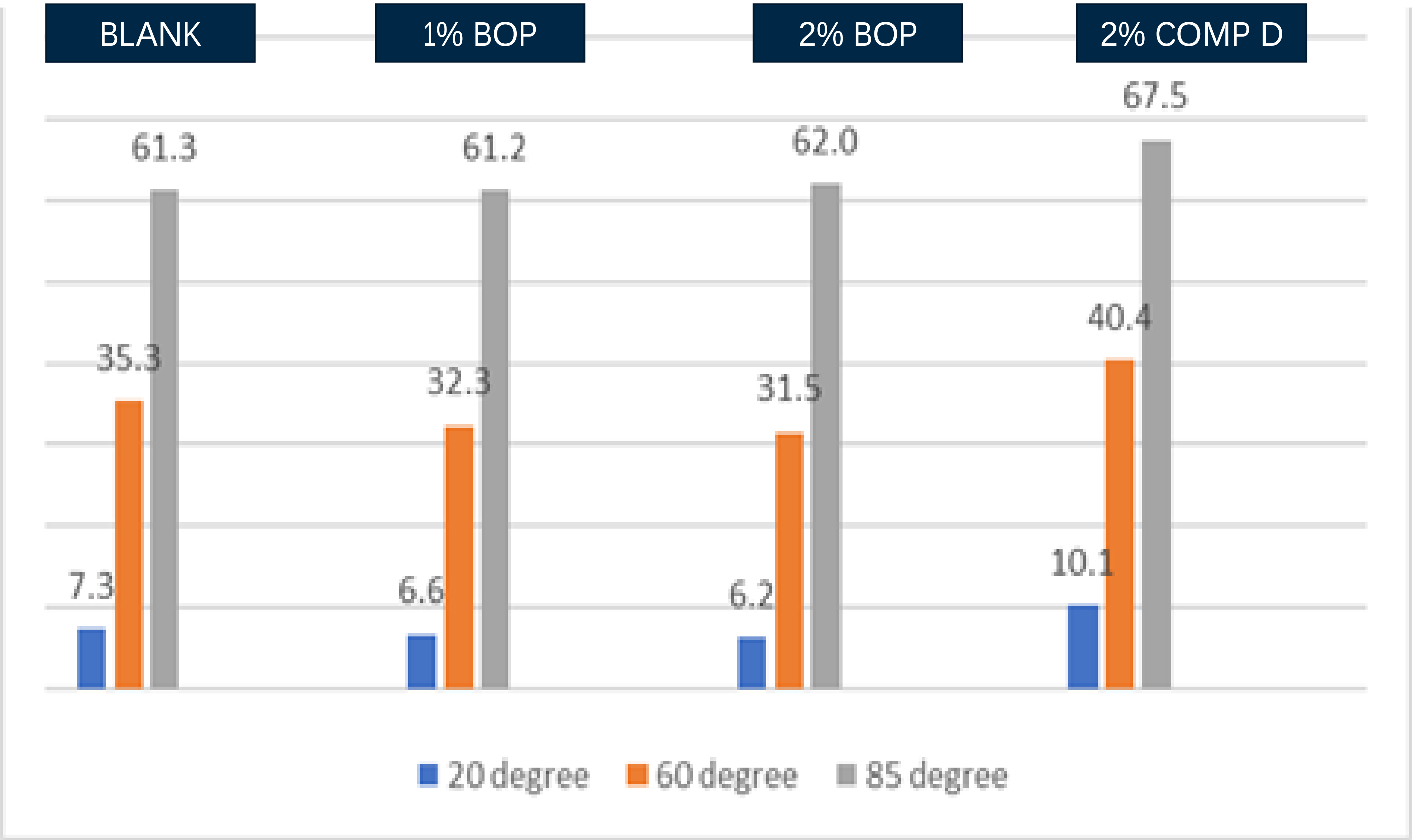
5% Ca phosphate
+ 1% BOP

5% Ca phosphate
+ 2% COMP

5% Ca phosphate
+ 2% BOP


5% Calcium phosphate
5% Calcium phosphate + 1% BOP
5% Calcium phosphate + 2% BOP
5% Calcium phosphate + 1% COMP D
5% Calcium phosphate + 2% COMP D
2K WB Epoxy Gloss
90
80
70
60
50
40
30
20
10
0
7.5
45
77.3
6.6
43.2
78.5
4.1
35.8
78.7
17.6
62.5
84.1
24.8
70.2
83
1
3
5
7
9
20 degree
60 degree
85 degree

WB Self-Crosslinking Acyrlic



WB Self-Crosslinking Acyrlic

BOP as stand-alone corrosion inhibitor

ISO 9227: 120 hour NSS
70-75µm
Single coat via drawdown
Cold Rolled Steel
Before Spatula Scrape Test

CONTROL

2% COMP D

2% BOP

WB Self-Crosslinking Acyrlic

BOP as stand-alone corrosion inhibitor

ISO 9227: 120 hour NSS
70-75µm
Single coat via drawdown
Cold Rolled Steel
After Spatula Scrape Test

CONTROL

2% COMP D

2% BOP

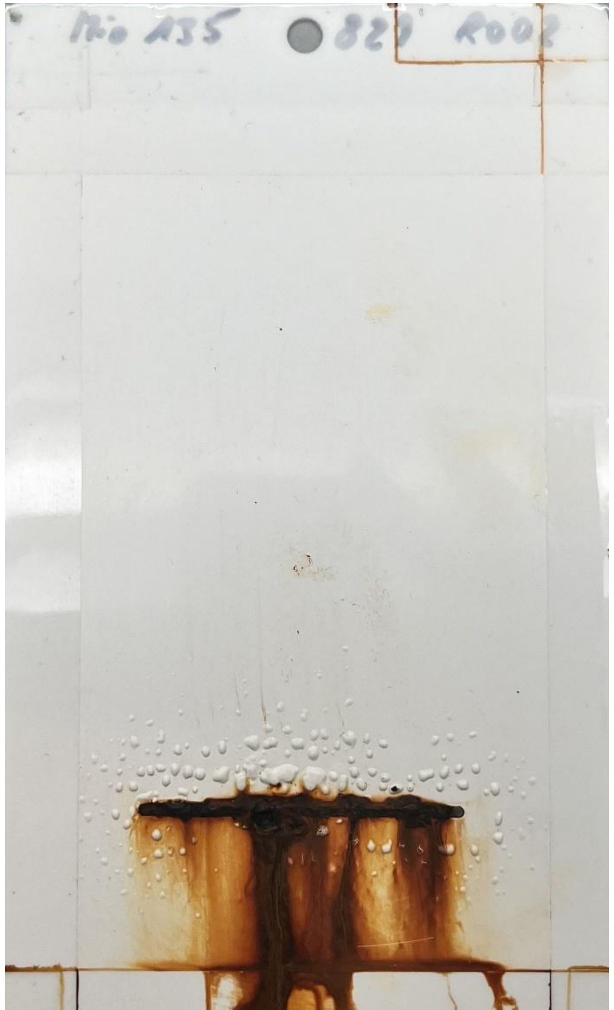
WB Self-Crosslinking Acyrlic

BOP as stand-alone corrosion inhibitor, heavy metal replacement

ISO 9227: 1080 hour NSS
120 µm DFT; 2 coat application
Cold Rolled Steel
Scribed according to ISO 12944-6

CONTROL

2% COMP D



2% BOP

2% COMP C

Summary

Best practices for utilizing organic chemistries

Performance enhancer

- Combining inorganic and organic corrosion inhibitors will take you to your next level of performance.

Improve product labeling

- Organic inhibitors can be used to reduce or eliminate heavy-metal usage.
- VOC-free and bio-based products are economical and effective.

Stand Alone Inhibitor

- Organic inhibitors can stand alone to…

"BUST THE RUST"

Thank You

Future Proofing Corrosion Control

Visit us at Table 4!

<u>Valuable contributions from the ICL P&C team:</u>

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