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Motivation

Corrosion is a MAJOR risk to aviation safety

- **Coatings** prevent corrosion on aluminium-alloy based aircraft
- Hexavalent chromium coatings are effective, but **carcinogenic**
- There is a significant (\$4B) industrial and regulatory demand for high-performance coatings that are safe and sustainable
- **Controlled release** has been a desire of the industry due to its ability to **increase the lifespan** of materials up to 2x
- No current competitor achieves **controlled inhibitor release**

\$4B

Market for advanced ccoatings

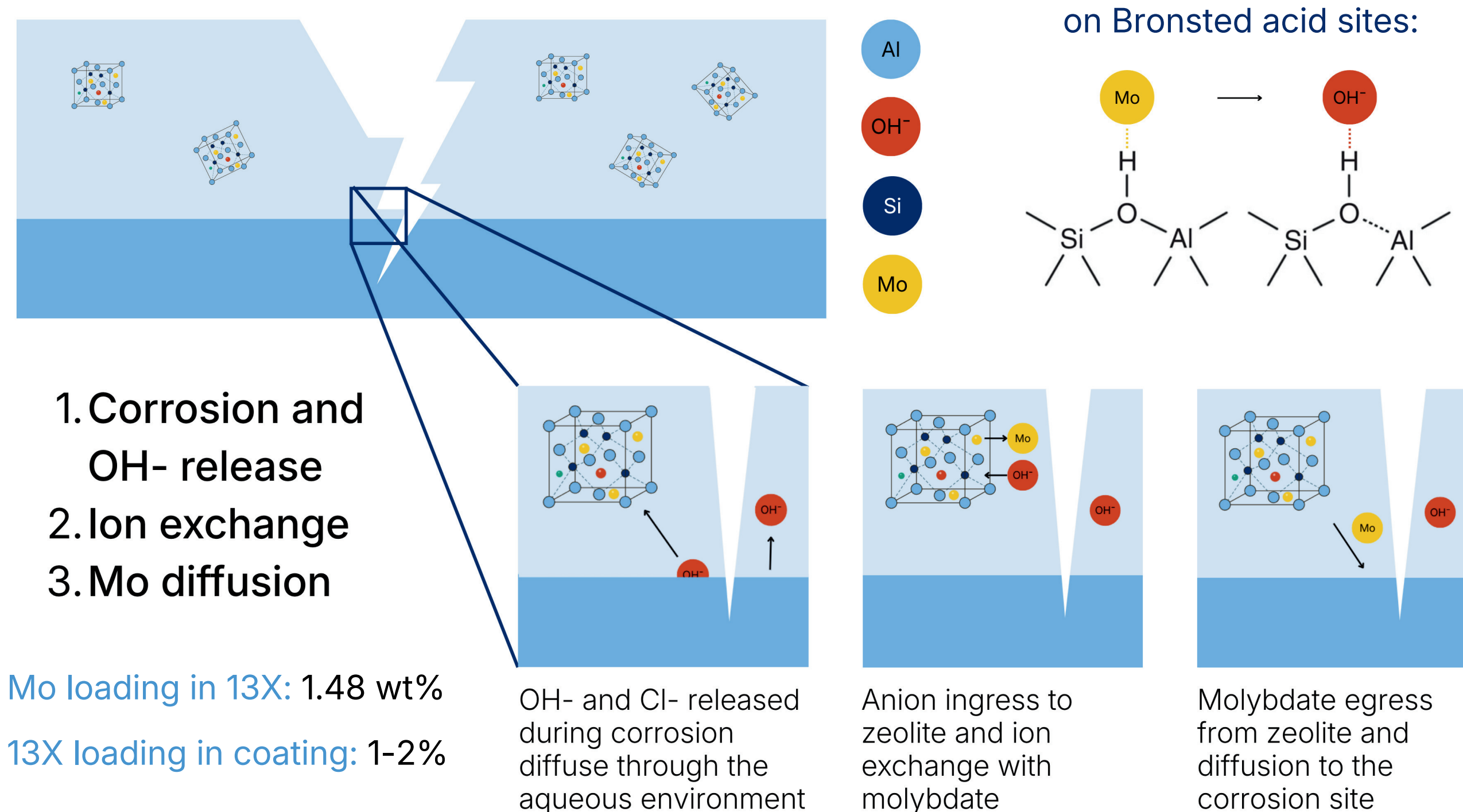


Epoxy or sol-gel coating + pre-treatment

Aluminum alloy substrate

Product Specs

Zeolite 13A enables controlled release of molybdate to active corrosion sites at the aluminum substrate. Release of inhibitor occurs proportional to corrosion.

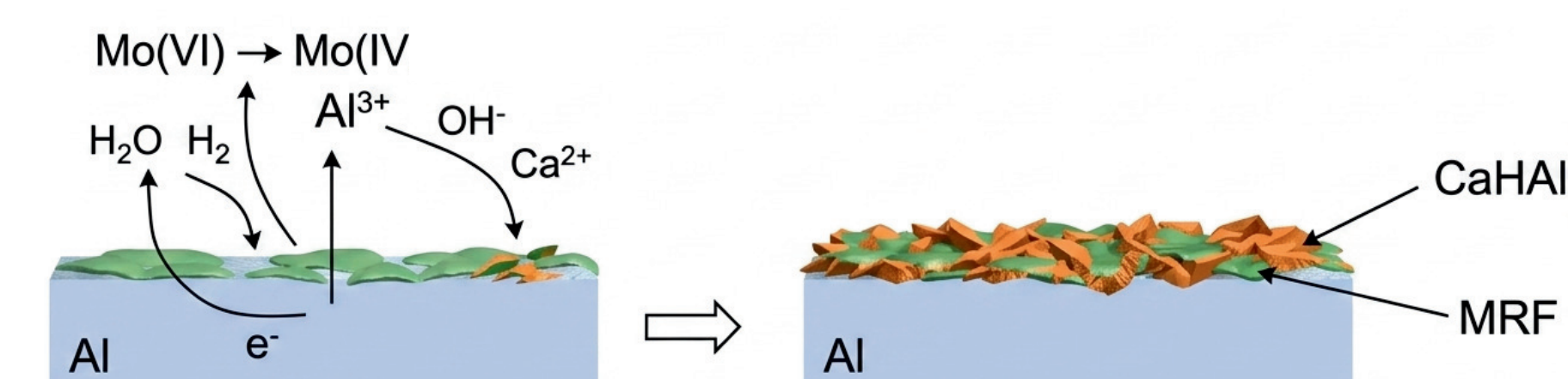


Mo loading in 13X: 1.48 wt%
13X loading in coating: 1-2%

OH- and Cl- released during corrosion diffuse through the aqueous environment

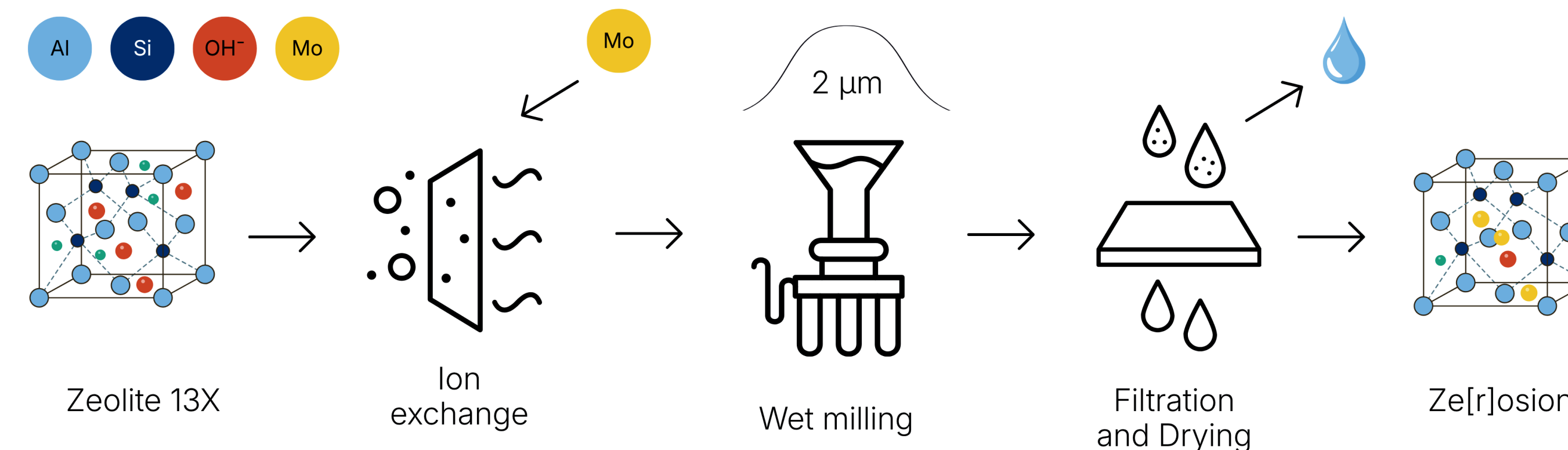
Anion ingress to zeolite and ion exchange with molybdate

Molybdate egress from zeolite and diffusion to the corrosion site

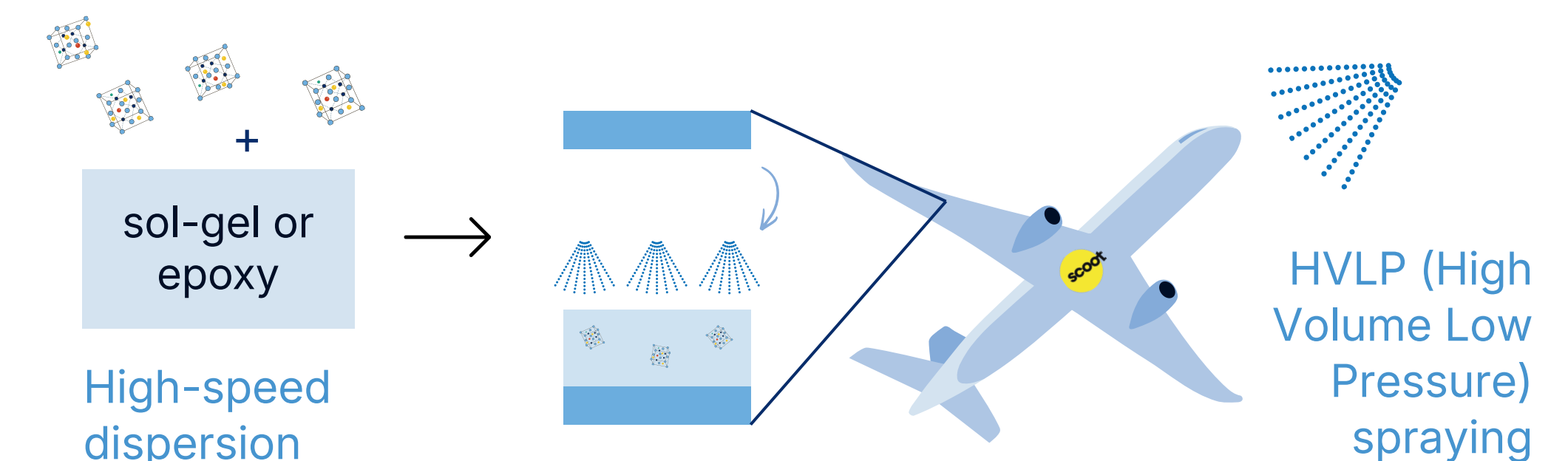


Reduced Mo ions form a protective Molybdc Reaction Film (MRF), preventing further corrosion of the Al alloy

Manufacturing Process



Designed for facile integration into existing workflows for chromate:



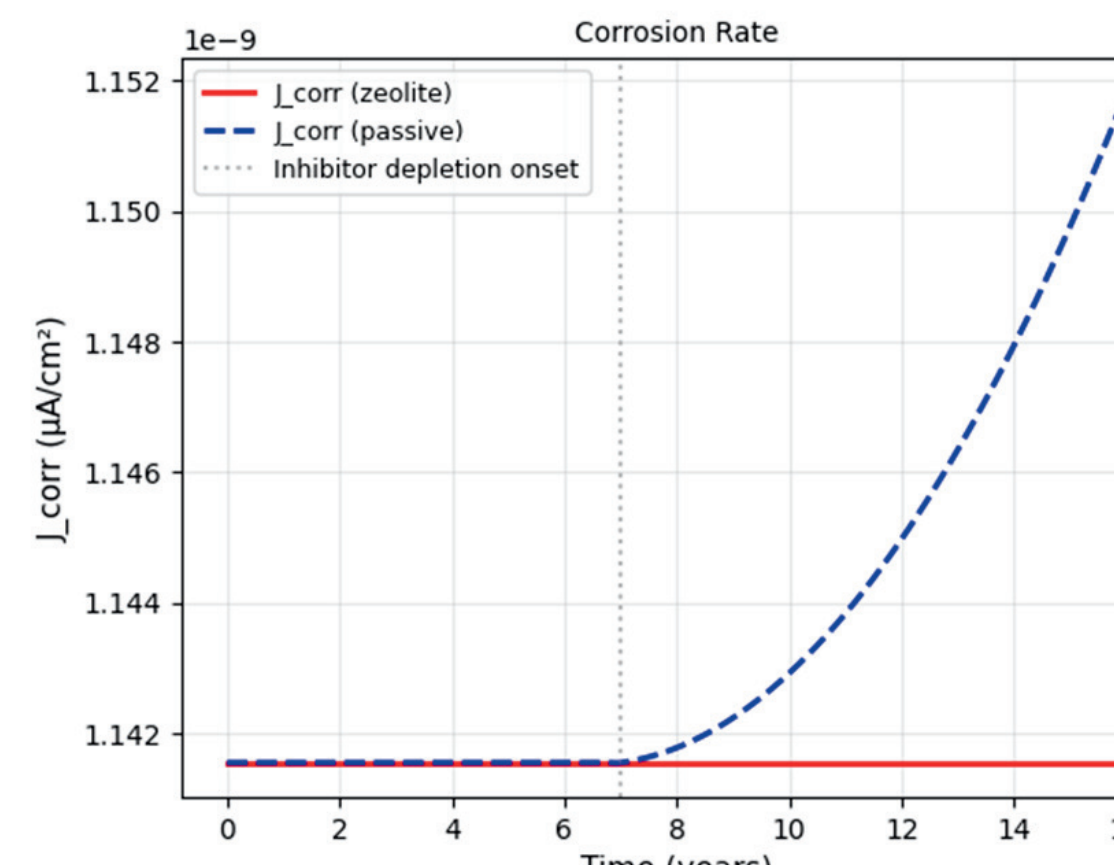
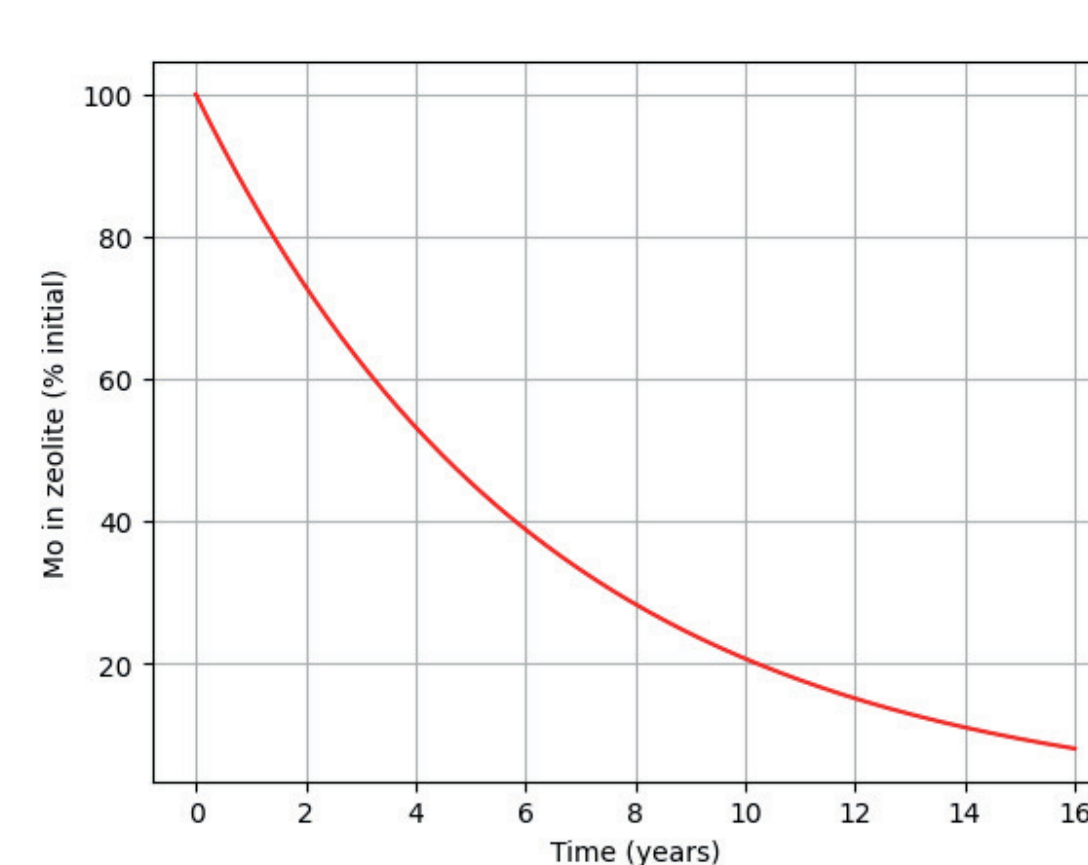
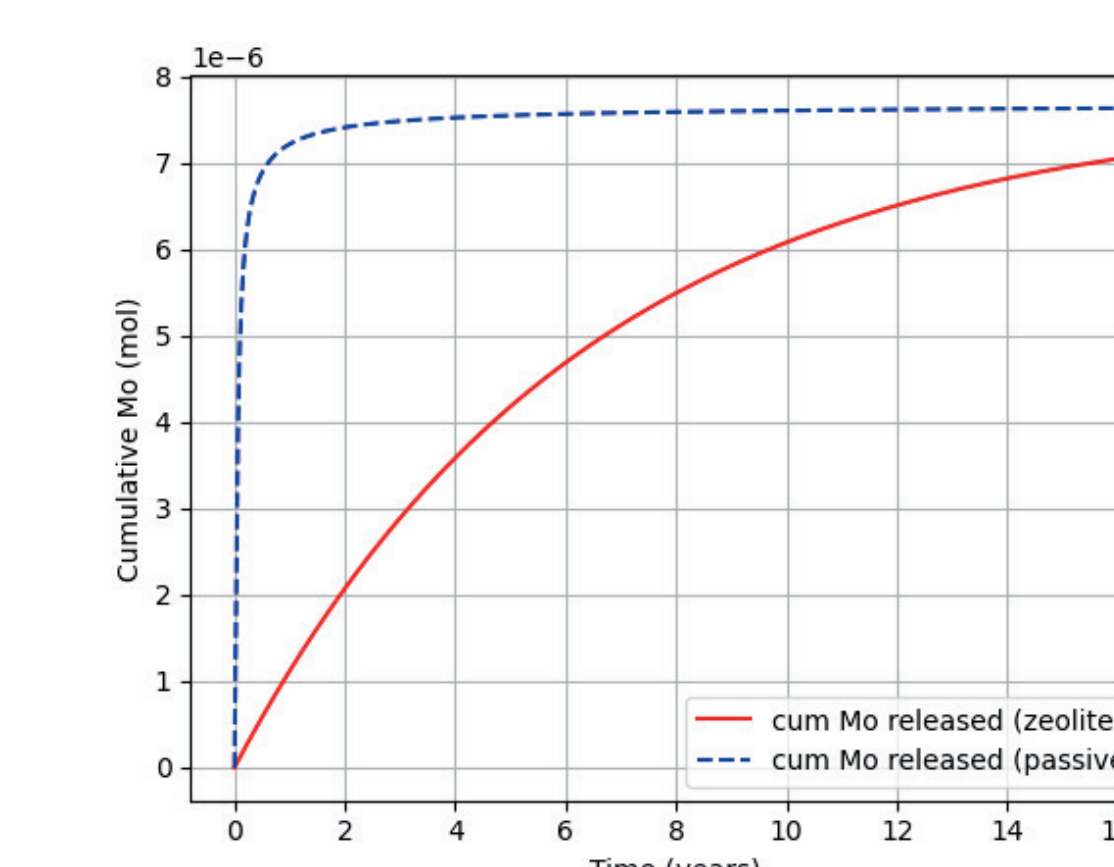
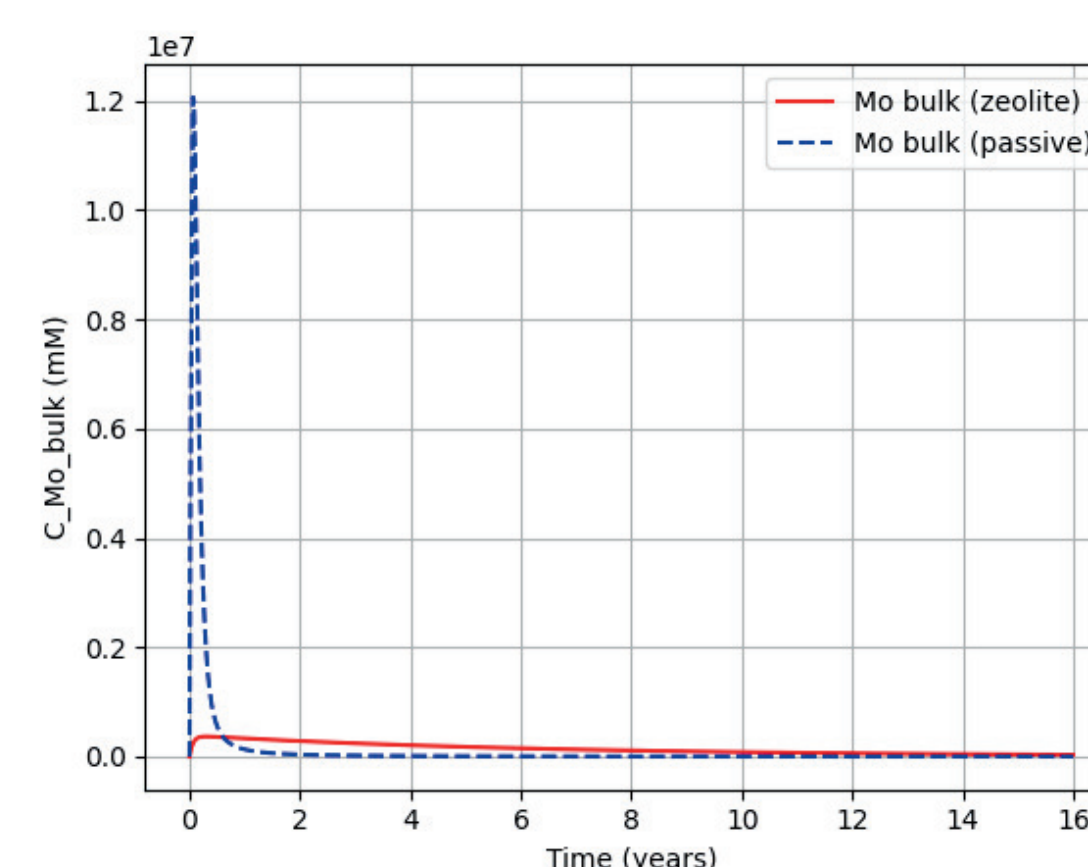
Product Model

3 compartment model with **concentration driven transport and zeolytic speciation** for **worst-case corrosion chemistry** inside an aluminum pit over **multi-year timescales**.

Two inhibitor strategies are compared:

1. **Zeolite particles** that release Mo responsively
2. **Passive coatings** that leach Mo continuously

Zeolite (red) vs Passive (blue) — Long-term Mo Release and Corrosion



Corrosion Governing Equations:

$$i_a = i_{0,a} \cdot m_{act} \cdot (1 - \eta_{max} \cdot \eta)$$

$$m_{act} = \max \left(0.1, 1 + \gamma \log_{10} \left(\frac{[H^+]}{[H^+]_{ref}} \right) \right) \quad \eta(C_{Mo,surf}) = \frac{C_{Mo,surf}}{C_{Mo,surf} + K_{inh}}$$

Financial Projections

For a small-plant style operation:

Land: Charlotte, NC is ideally positioned for customer proximity and labor/land cost
Suitable manufacturing facility → **\$5MM**

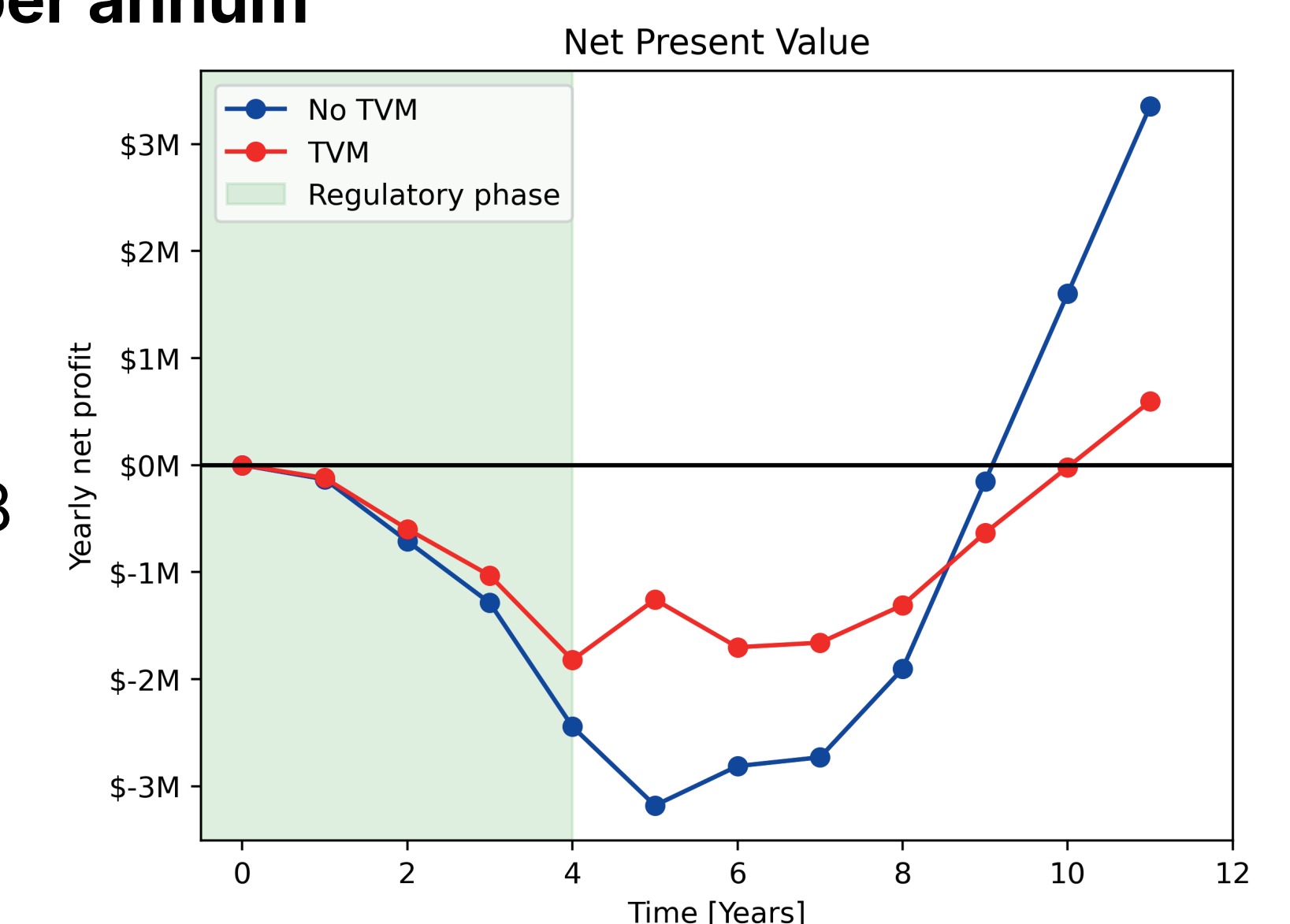
Capital cost: tank, miller, filter, drying cabinet → \$40,000

Timeline: 4 years regulatory approval phase, then ramping up to **1500 sales per annum**

Salaries: \$1.75MM

Sales: \$60/kg
(\$52 profit/kg)
Competitive with chromates (\$0.028 → \$0.031/m²)

Profitability by 10-11 years



Cost/m² = thickness * density * weight fraction * cost

Zeolite 13X: \$475

Molybdate Solution: \$324

Customers:

Aircraft manufacturers:



Maintenance companies:



References

[1] Milosev, Ingrid "Corrosion inhibition of aluminium alloys by molybdate ions..."

[2] Dias, S.E.S "...Protection against Corrosion of AA2024-T3 by Sol-Gel..."

We would also like to thank Dr. Tyler Josephson, Dr. Marc Donohue, and Gerald Poon Ho for their help in development and implementation of our design.