



# Encapsulated Cerium Salt for Enhancing Corrosion Protective Properties of Polyurethane (PU) Coating

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# Motivation and Objective

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- Different organic coatings are being used to protect the metal from corrosion
- Recently organic coatings are boosted by their self healing nature.
- Microcapsule addition advances a huge protection ability of coatings.
- However the advantage of the microencapsulation technique only work when the microcapsule release the active compound (inhibitor) timely. An uncontrollable leaching of inhibitor from microcapsule is also common.
  
- Main objective
  - Prolonged control leaching of inhibitor by using microcapsules in polyurethane (PU), this can improve the corrosion resistance of PU coating.

# Microencapsulation

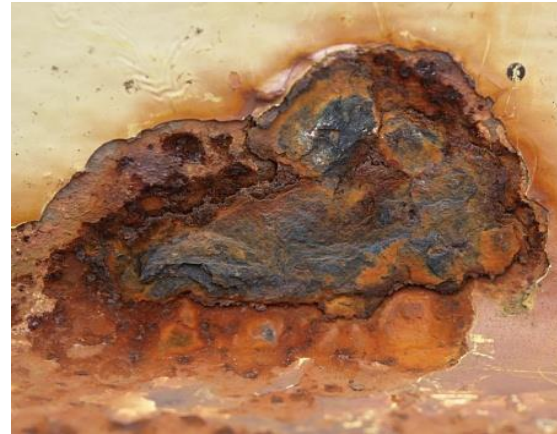
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- Microencapsulation is the process of surrounding or enveloping one substance (core) within another substance (shell) on a very small scale, yielding capsules
  
- It is mean of applying thin coating to small particle of solid or droplet of liquid or dispersion
  
- Two phases
  - Shell
  - Core
  
- Also known as microcapsule, microsphere,

# Corrosion

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- Corrosion is the gradual destruction of materials (usually metals).
- The electrochemical deterioration of a metal due to the reaction with its environment involving the oxidation and reduction of the metal.
- Factors influencing:
  - Presence of water
  - Presence of oxygen
  - Presence of ions
  - Temperature
  - Humidity
  - pH
- Corrosion Control
  - Using proper metal and their alloy (for internal and external corrosion)
  - Using chemical compound (for internal corrosion)
  - Using proper coatings (for external corrosion)



# Corrosion control by organic coatings

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## PASSIVE

- Protect through the barrier properties of resin or pigment having low water transmission

## ACTIVE

- Inorganic inhibitor and pigments
- Organic corrosion inhibitors
- Ion exchange
- Vapor pressure

## SACRIFICIAL

- Zinc rich primers protect through the preferential oxidation of metal
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# Coating

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## What is a coating?

- Coating is a covering that is applied to the surface of an object, usually referred to as the substrate.

## Examples of Organic Coatings

- **Chemically Resistant Epoxies** – line of high chemical resistant modified epoxies.
- **Coal-Tars** – excellent water resistance for immersion and below grade conditions.
- **Polyurethane** – Series of polyurethane coatings and clear coats characterized by their color and gloss retention. They have excellent protection properties.



# Commercial Organic Coating Limitation

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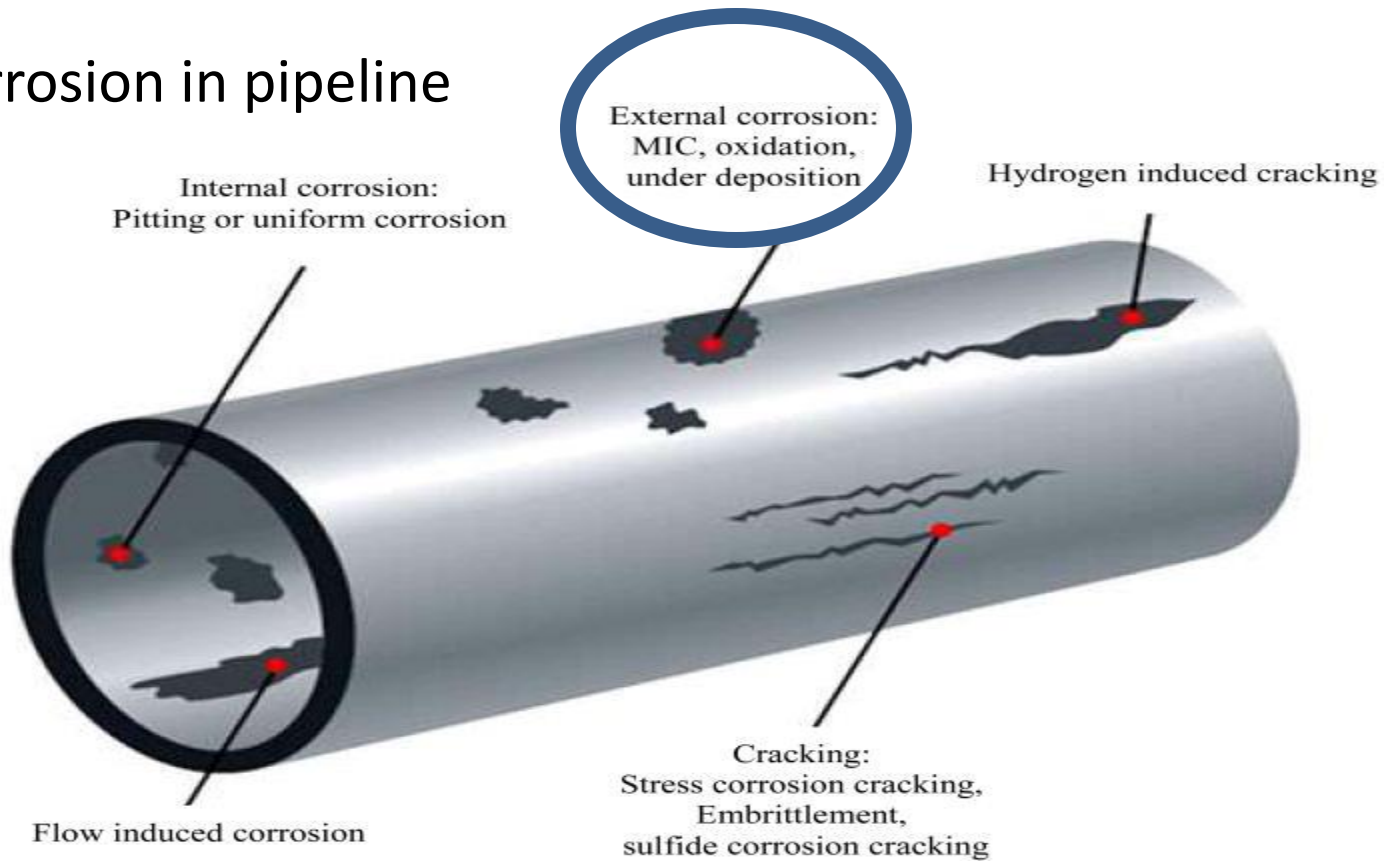
- Major limitation of commercial organic coatings:
  - Contain toxic compounds
  - Using toxic Volatile Organic Compound (VOC)
  - Burst release of inhibitor
  - Uncontrolled leaching of inhibitor
  - Expensive
  - Multi coating system
  - Lack of sufficient self healing ability

# Our Technique and Application

## ➤ By coatings:

PASSIVE • PU resin + ACTIVE • cerium salt → Smart coating

## ➤ Corrosion in pipeline



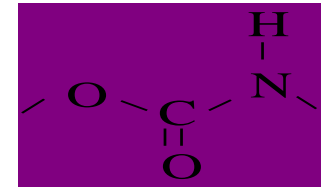


# Polyurethane Coating

- Any polymeric coating which contain urethane group is called polyurethane coating
- First introduced 1937 and commercially available 1952

- **Industrial Application:**

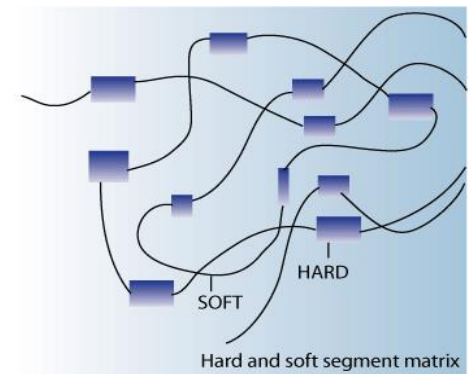
- Moderate performance on machinery, tanks, pipelines
- Low VOC using waterborne PU
- Fast drying
- Good adhesion to steel, plastic and aluminum



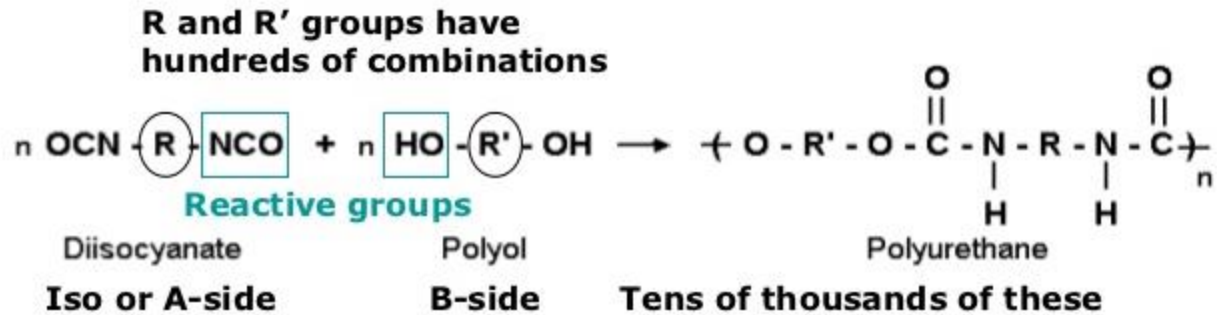
Urethane group

- **Properties:**

- Elongation/flexibility
- Excellent chemical/solvent resistance
- Not sensitive to moisture during application
- Can be applied in low temperatures (below freezing)
- Good thermal stability



# PU Preparation



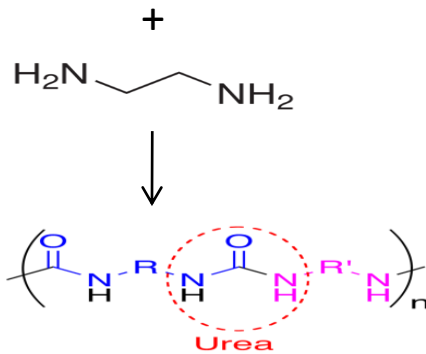
**Tens of thousands of these repeating units make up the polymer 'backbone' which defines most performance properties**

## Aromatic isocyanate

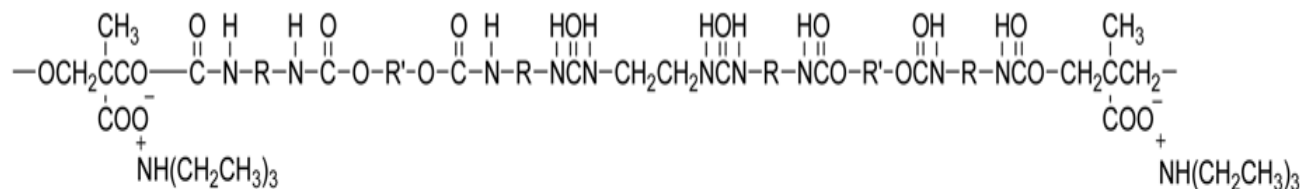
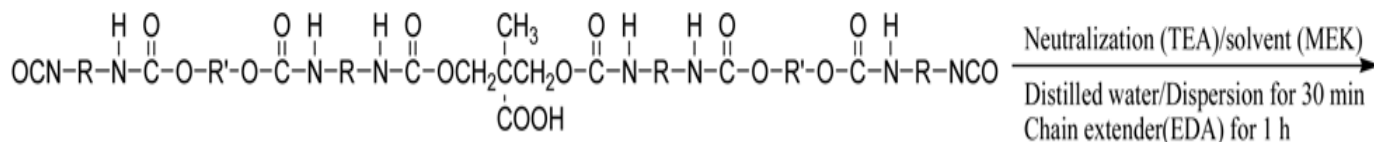
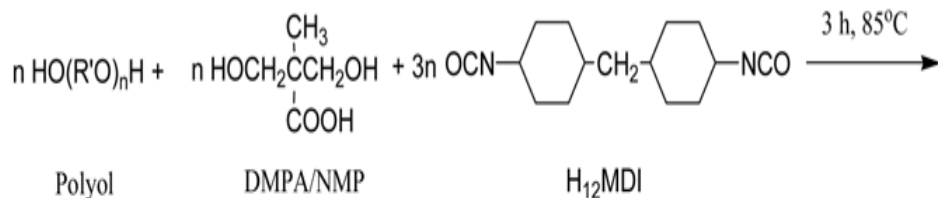
- MDI (methylene bisphenyl di-isocyanate)
- most common
- excellent corrosion performance, economical
- not color stable

## Aliphatic isocyanate

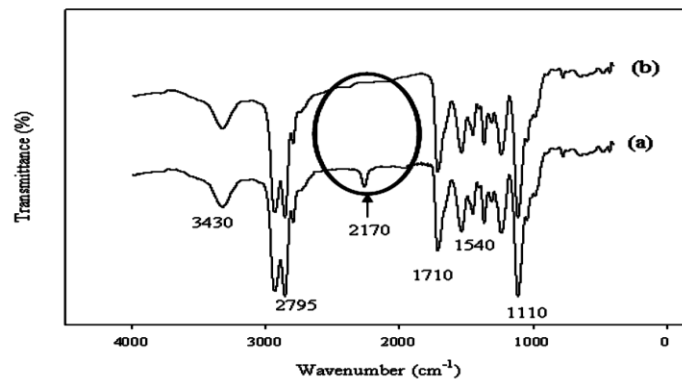
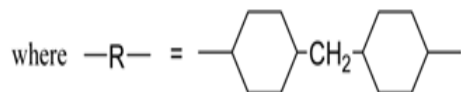
- exterior, aboveground topcoat
- very UV resistant and color stable
- not as effective in corrosion resistance
- 3-4 times more expensive than aromatic



# PU Preparation

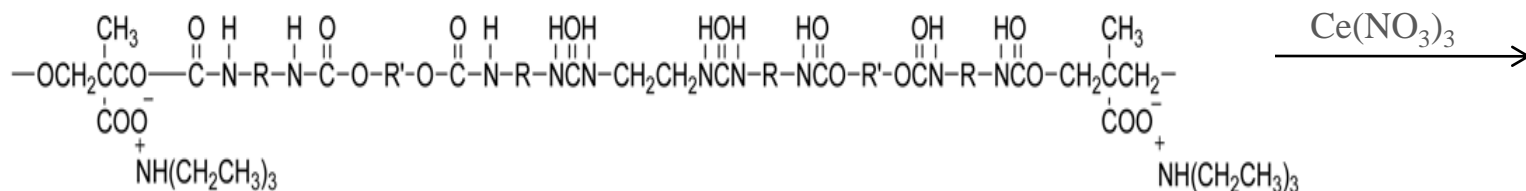
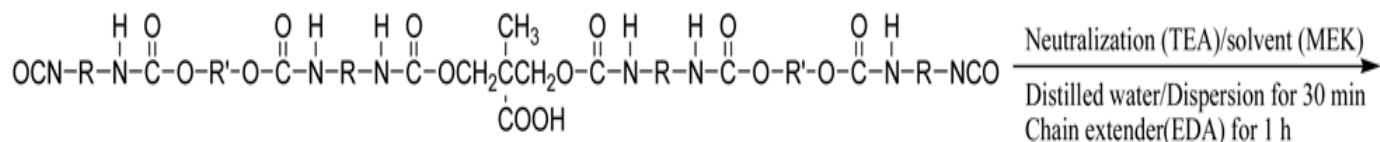
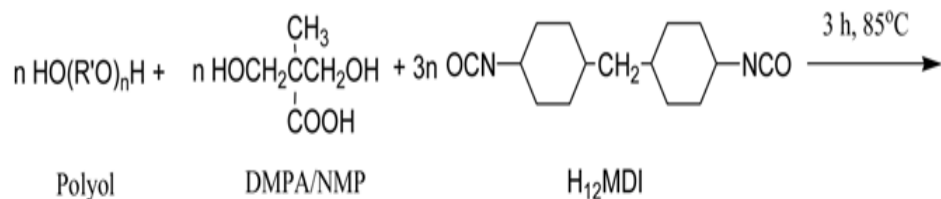


MEK removal → Waterborne polyurethane dispersed in water

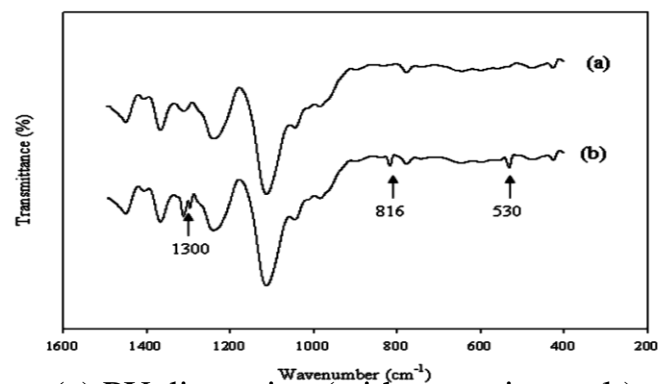
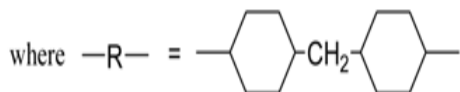


(a) NCO-terminated PU  
(b) PU dispersion

# PU Preparation with Cerium Salt



MEK removal → Waterborne polyurethane dispersed in water



(a) PU dispersion (without cerium salt)

(b) PU dispersion (with cerium salt)

# Factors

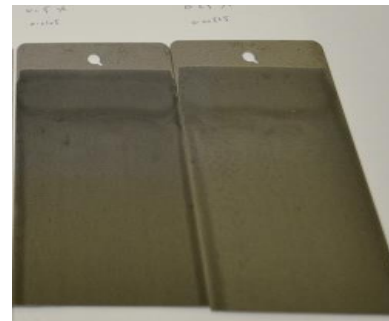
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➤ Factors affecting PU coating properties:

- Composition (monomers and their ratio) (Polyether polyol and aliphatic/aromatic mixture 1:1 of isocyanates)
- Coating thickness (100  $\mu\text{m}$ )
- Crosslinking (5 wt% aromatic polyisocyanate)
- Curing (RT)



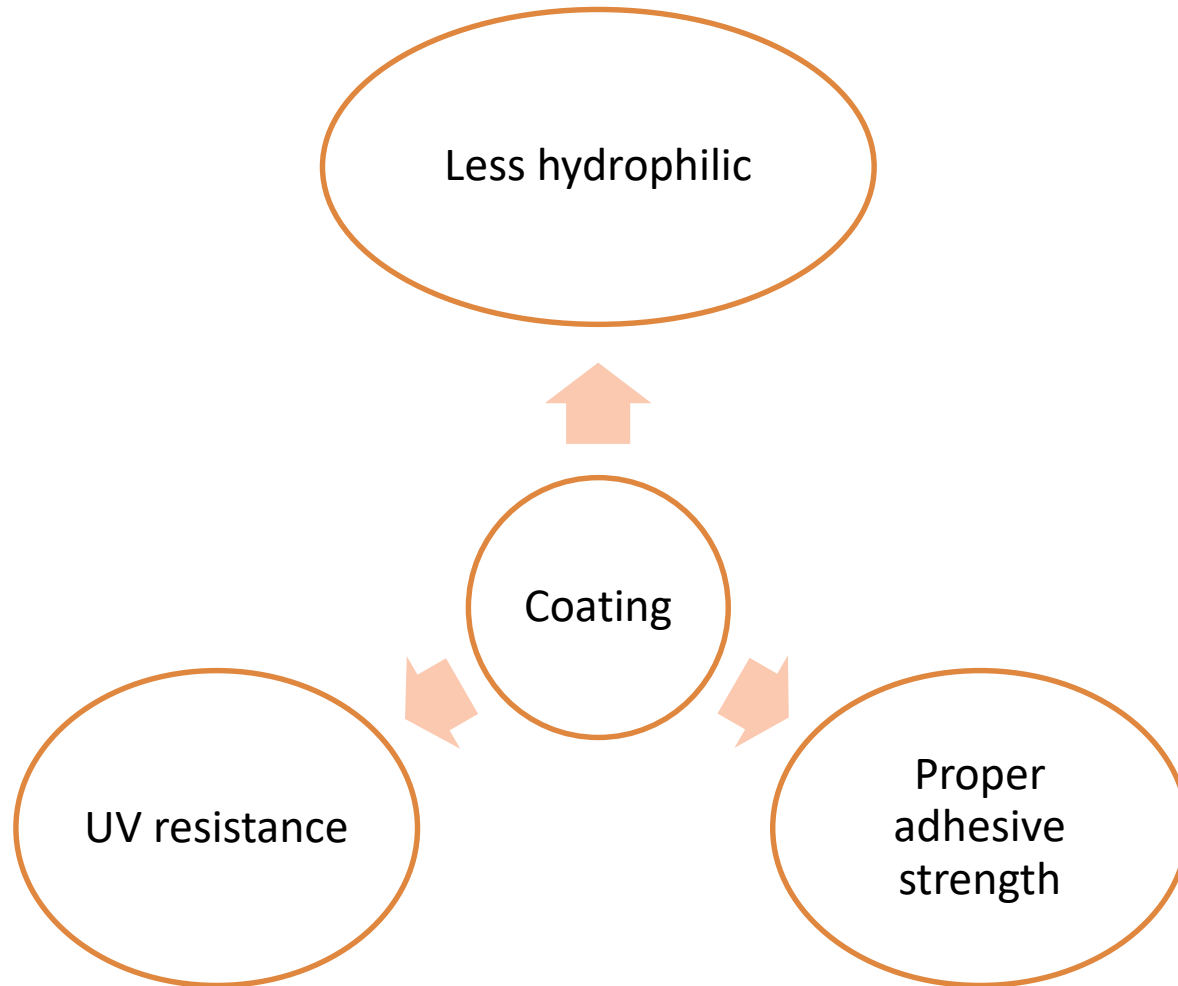
Dispersion



Coated mild steel

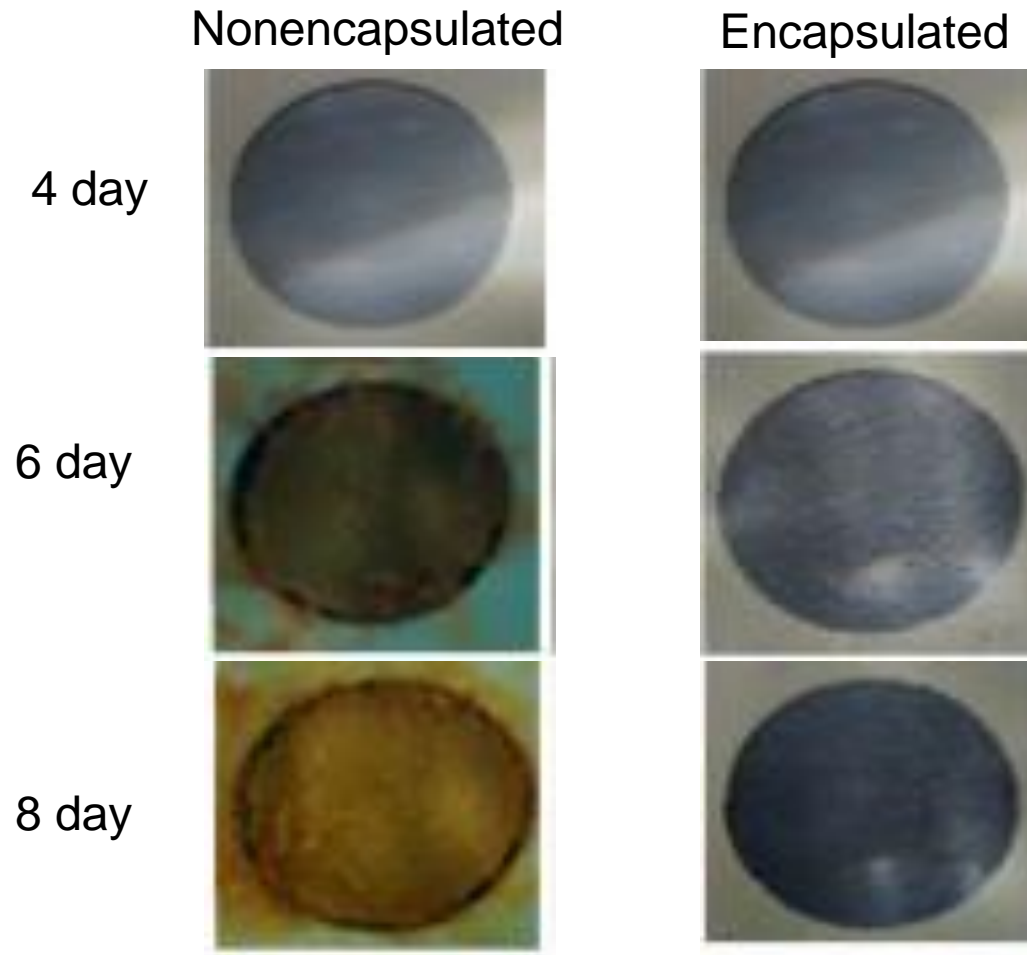
# Coating Properties

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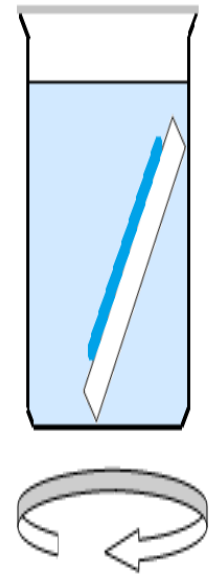
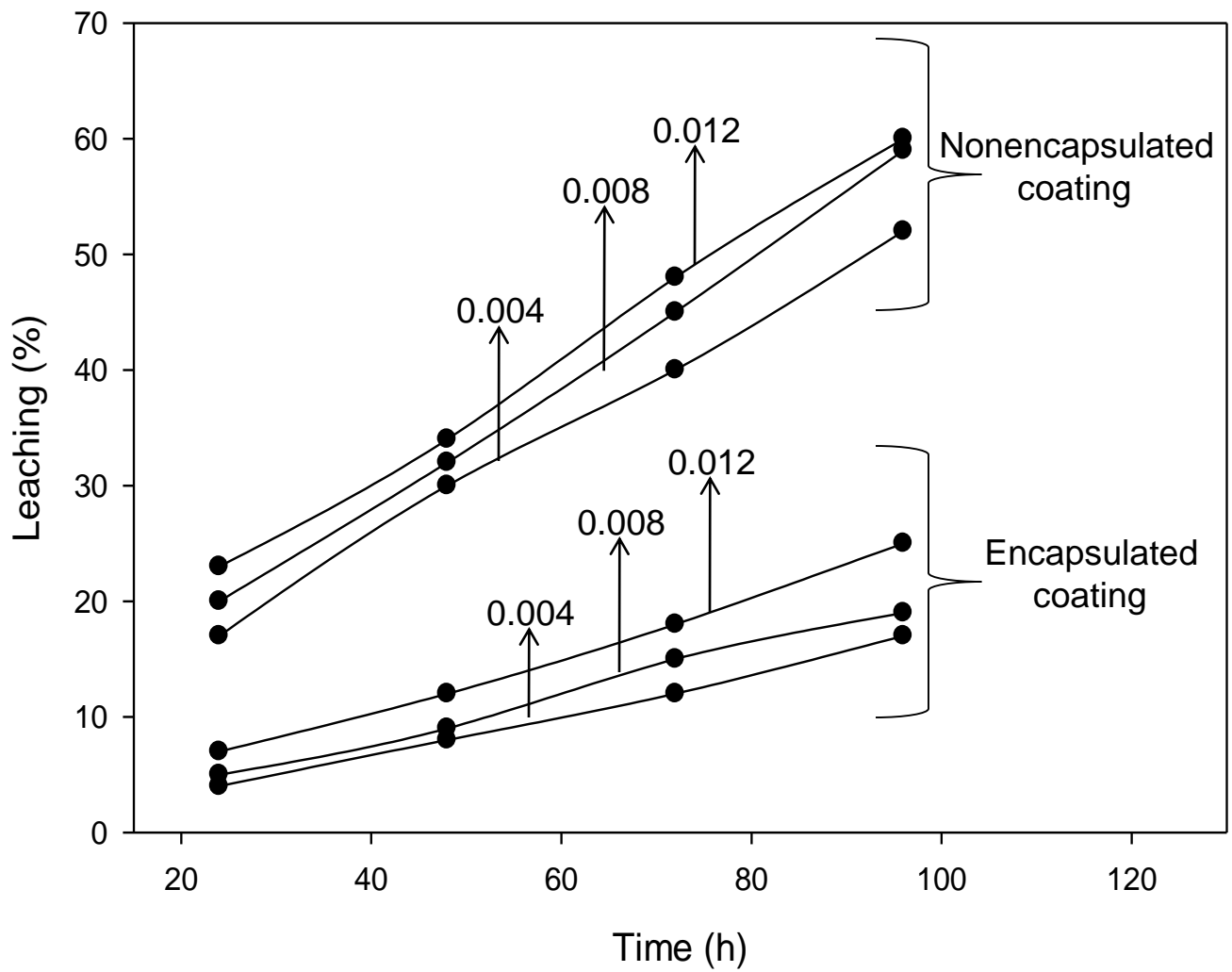


# Corrosion Test

- Mild steel
- 3.50 wt% NaCl
- 0.008 mole cerium salt



# Leaching Test



- Paint coating
- Release medium
- Paraffin





# Summary

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- Microencapsulated coating has better corrosion resistance.
- Microencapsulated coating showed slow leaching
- The technology is environmentally friendly.
- Not expensive.



Thank you