Anticorrosion surface treatments based on saponified vegetable oils

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Carboxylic acids as corrosion inhibitors
Non-toxic compounds extracted from plant oils

linear saturated carboxylic acid

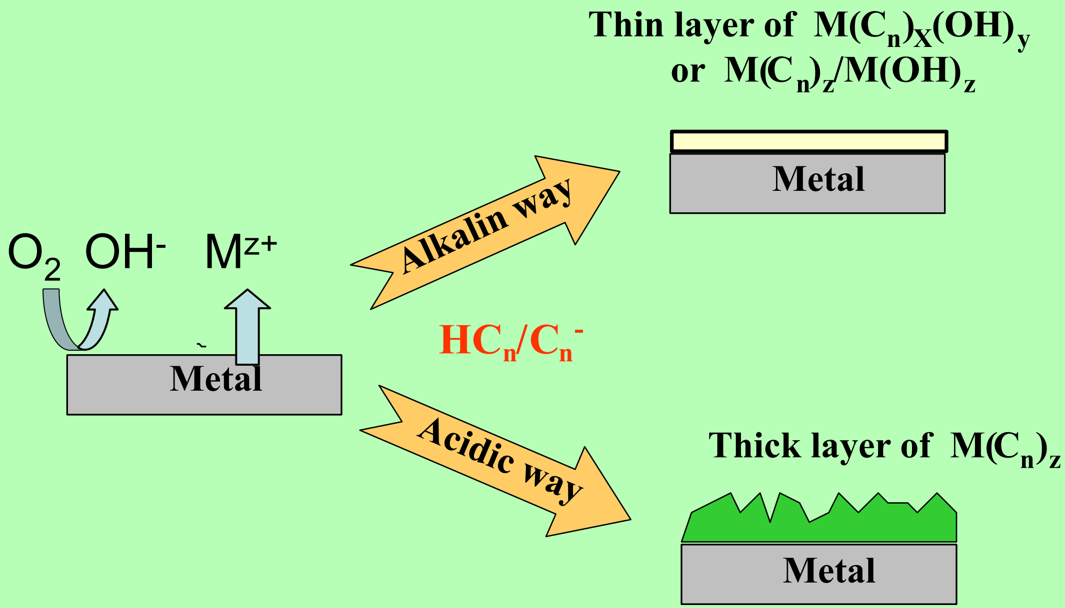
$CH_3\text{-}(CH_2)_{n\text{-}2}\text{-}COO^- Na^+$ noted NaC_n

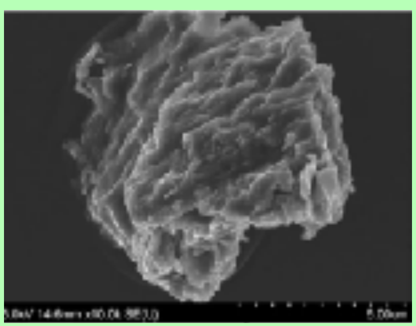
$CH_3\text{-}(CH_2)_{n\text{-}2}\text{-}COOH$ noted HC_n

Fatty acid	Formula	Origin
Heptanoic acid	$CH_3(CH_2)_5COOH$ HC_7	Ricin oil
Lauric acid	$CH_3(CH_2)_{10}COOH$ HC_{12}	Palm and coprah oils
Palmitic acid	$CH_3(CH_2)_{14}COOH$ HC_{16}	Palm oil
Stearic acid	$CH_3(CH_2)_{16}COOH$ HC_{18}	Colza, sunflower oils

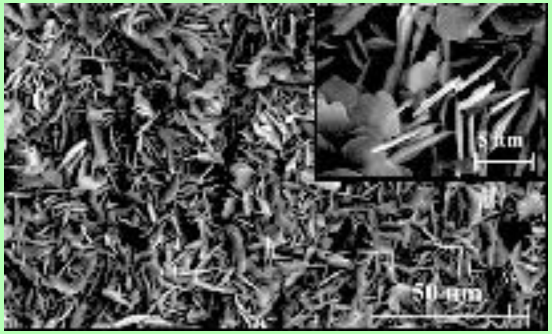
Carboxylic acids as corrosion inhibitors

Chemical conversion

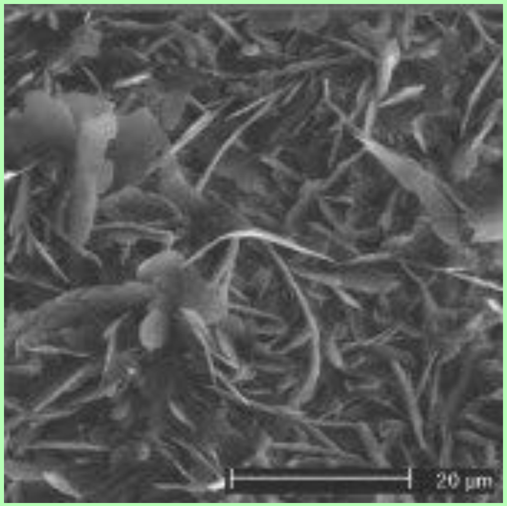




Fe



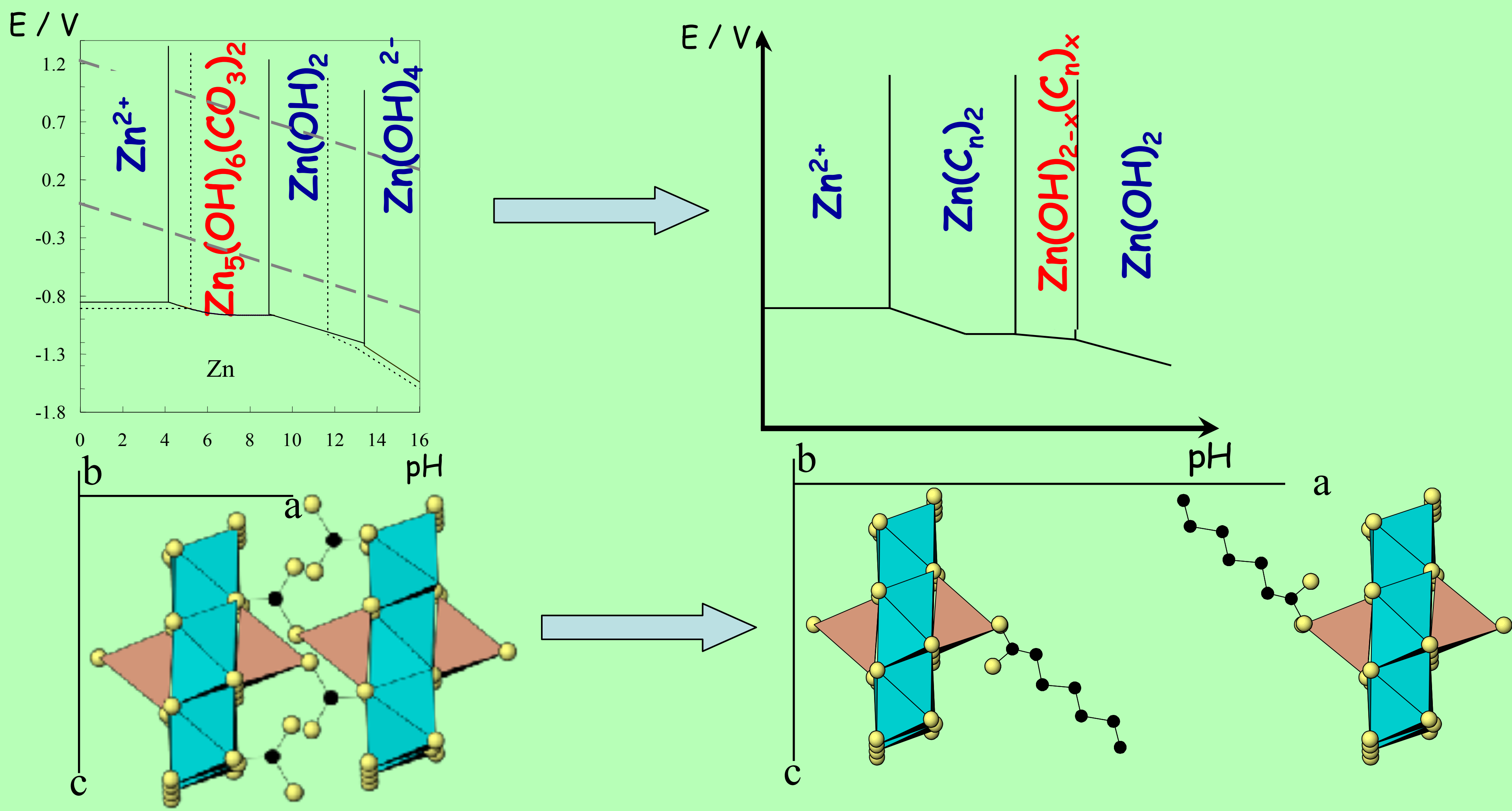
Pb



Zn

Carboxylic acids as corrosion inhibitors

Coatings



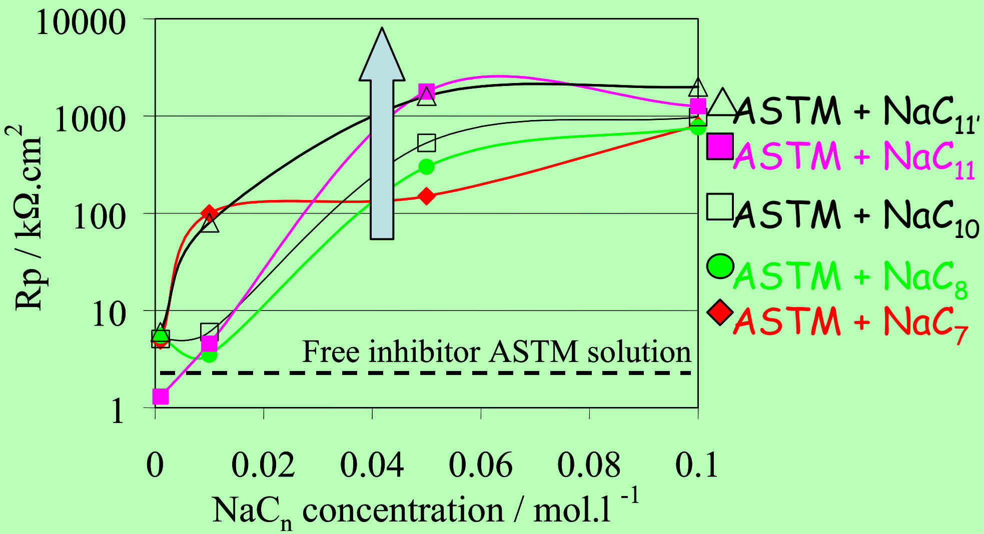
Reinforcement of the natural passive layer by intercalation of carboxylate anions

Carboxylic acids as corrosion inhibitors

Corrosion inhibition

Electrochemical characterization in standard corrosive water ASTM D1384-87

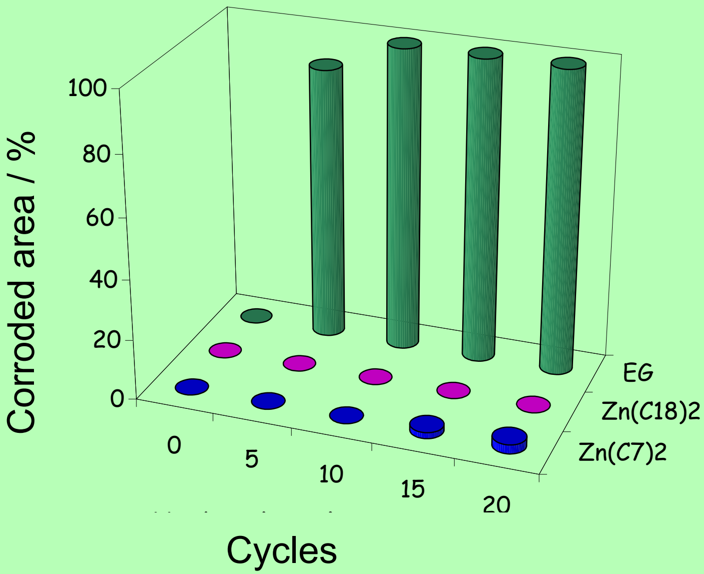
(148 mg L^{-1} Na_2SO_4, 138 mg L^{-1} $NaHCO_3$, 165 mg L^{-1} NaCl)



Long carbonated chains induce better corrosion resistance but require the use of hydroorganic media or tensio-active species.

Atmospheric corrosion in climatic chamber

(8h humidity – 16h drying)

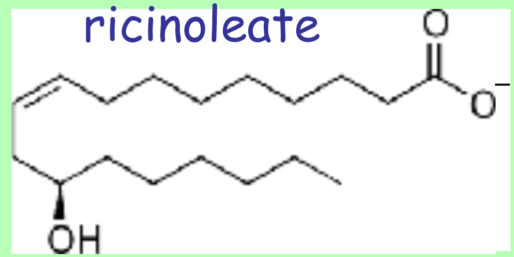


Saponified vegetable oil

Saponification process

$$\begin{array}{l} CH_2 - OOC - R \\ CH - OOC - R \\ CH_2 - OOC - R \end{array} \quad + \quad 3\ OH^- \longrightarrow 3\ R - COO^- \quad + \quad \begin{array}{l} CH_2 - OH \\ CH - OH \\ CH_2 - OH \end{array}$$

Triester — Carboxylate anion — Glycerol



Without separation/ purification

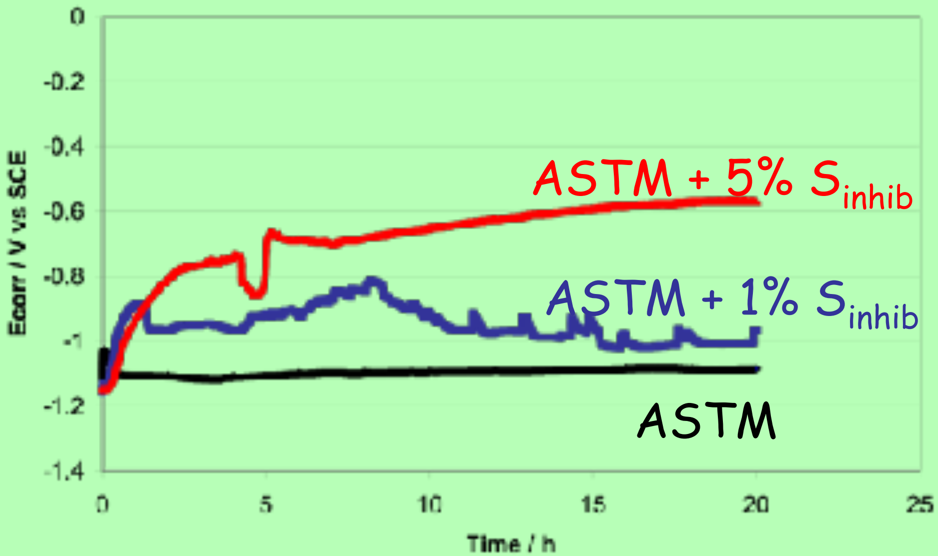
Stable liquid aqueous formulation (noted S_{inhib}):

Viscosity ≈ 100 cPo

$[R\text{-}COO^-] \approx 1\ mol\ L^{-1}$

Saponified vegetable oil

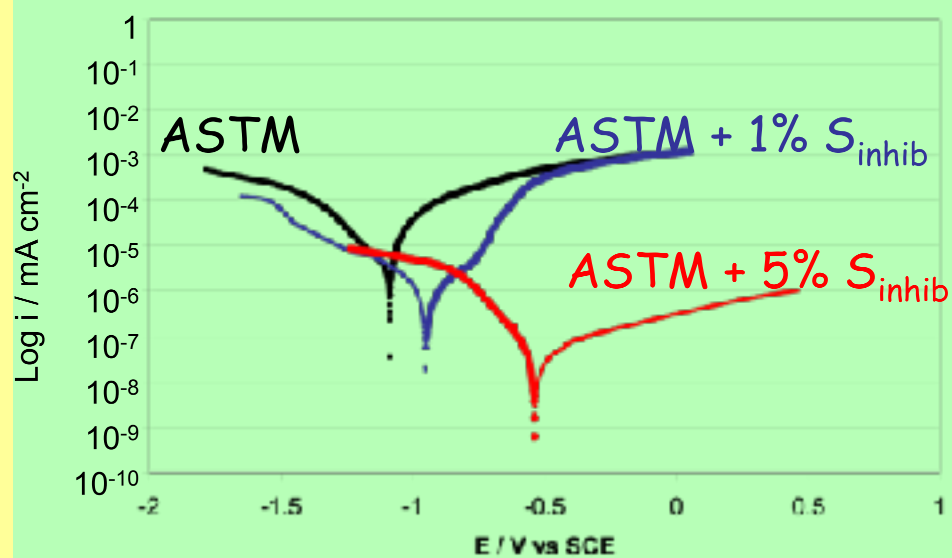
Corrosion inhibition



Standard corrosive water:
ASTM D1384-87
(148 mg L^{-1} Na_2SO_4,
138 mg L^{-1} $NaHCO_3$,
165 mg L^{-1} NaCl)

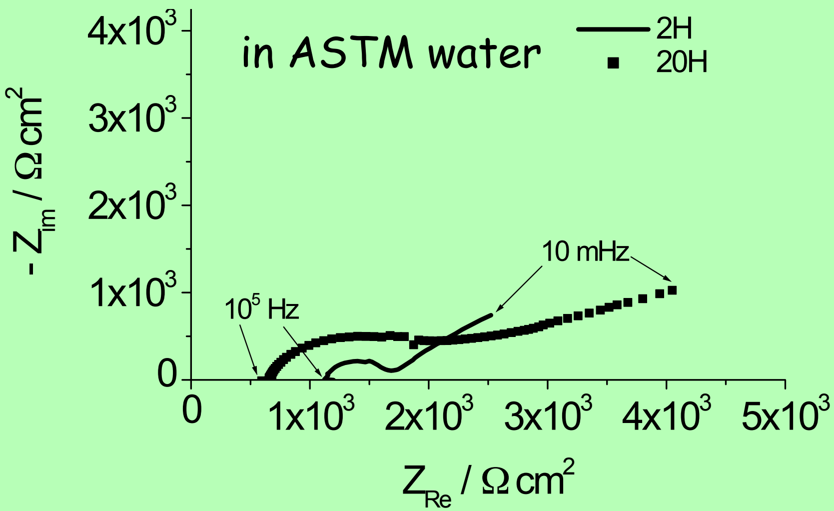
With 5% S_{inhib} diluted in a standard corrosive water ([R-COO^-] ≈ 5.10^{-2} mol L^{-1}) :

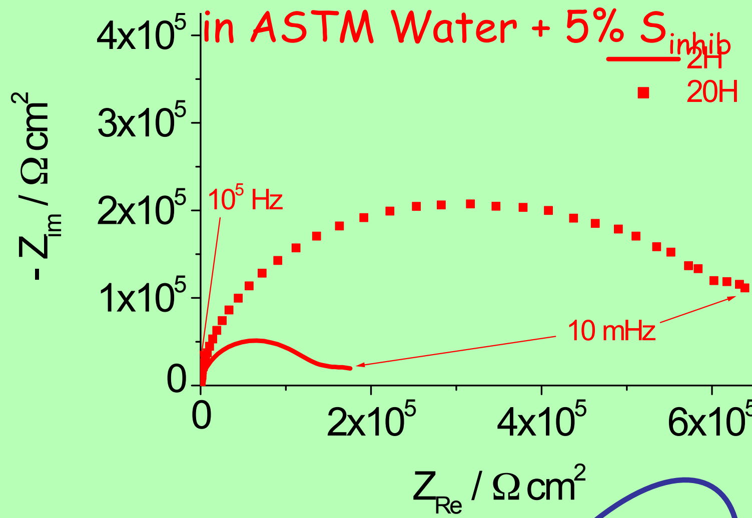
- **The corrosion rate is divided by 100**
- **A passivation of the surface is observed**



Saponified vegetable oil

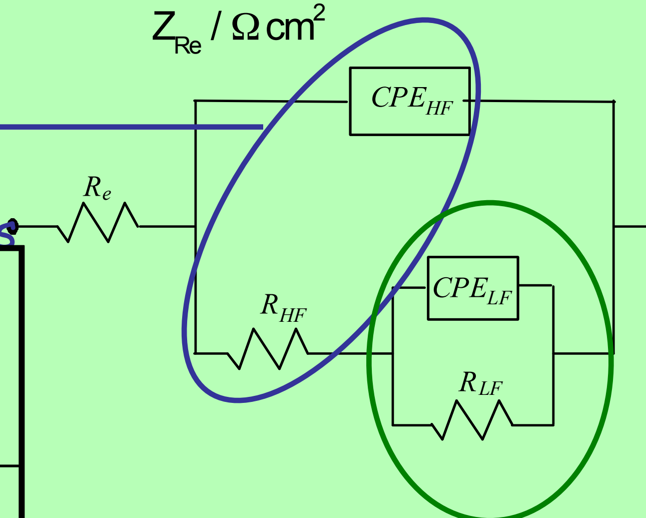
Electrochemical impedance spectroscopy





R_{HF} : charge transfer resistance

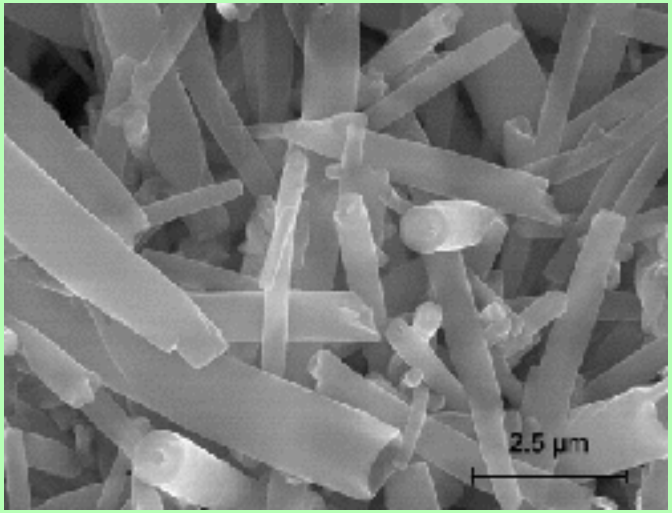
CPE_{HF} : double layer + protective coating capacitances



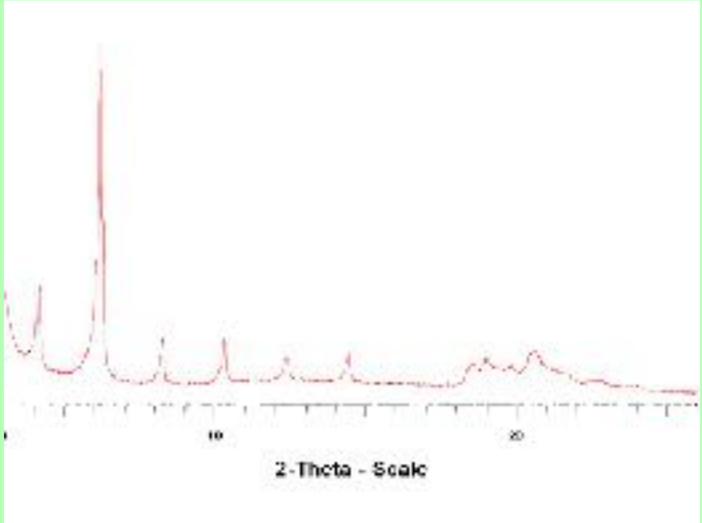
Diffusion processes

	in ASTM water		in ASTM water + 5% Sinhib	
	2H	20H	2H	20H
R_{HF} / Ω cm²	534	926	101579	142525
CPE_{HF} / S s^n cm^{-2}	2.0 10^{-5}	6.4 10^{-6}	8.3 10^{-7}	6.1 10^{-7}

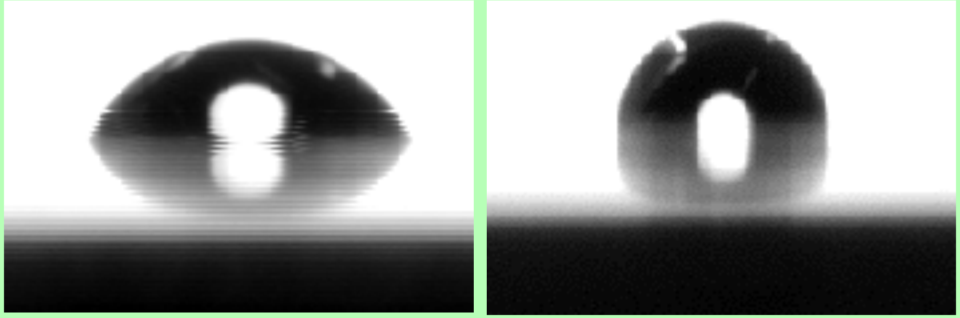
Saponified vegetable oil
Coating characterization



Surface morphology



X-Ray Diffraction



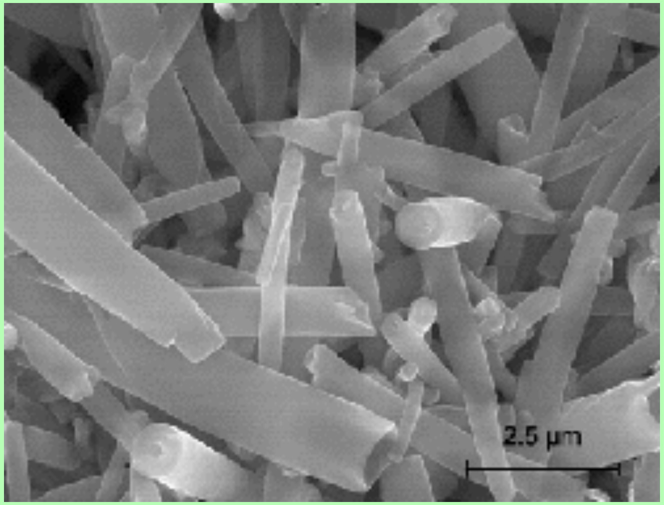
Zn Coated Zn

Contact angle

Nanotubular structure of the protective metallic soap

Saponified vegetable oil

Biomimetism



Surface morphology of a protective « dry film » formed on zinc

Surface morphology of leaf of Gommier cidre (Eucalyptus gunni)

K. Koch, B. Bhushanb, W. Barthlotta, *Diversity of structure, morphology and wetting of plant surfaces*, Soft Matter, 2008, 4, 1943–1963

Thank you for your attention

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