

APPLICATION OF CARBOXYLIC ACIDS AS INHIBITORS FOR CHLORIDE INDUCED REINFORCING STEEL CORROSION



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INTRODUCTION

- Reinforcing steel corrosion in chloride contaminated concrete is one of the major issues in prolongation of concrete structures durability.
- Presence of chloride ions can cause severe damage to the reinforcing steel functionality through the localized attack of the steel passive oxide film, where pitting corrosion can appear as major destruction pathway.
- The latest trends in reinforcing steel inhibitor research point towards the importance of application of organic molecules with less environmental hazards, like some carboxylic and amino acids.
- Compounds containing carboxylic functional group have been reported to be effective inhibitors of chloride induced passive film

breakdown at the surface of steel by means of their competitive adsorption through the surface complex formation.

MAIN GOAL

• Investigation of the inhibitory action of nine carboxylic acids (ascorbic, benzoic, 4-hydroxybenzoic, salicylic, glutaric, tartaric, sorbic, glycolic, maleic acid) in simulated pore solution contaminated with high concentration of chlorides.



 $v = 10 \text{ mV s}^{-1}$

- Electrode: non alloy special prestressing steel (EN 10020)
- Electrode pretreatment: abraded by grit 600 and 1200 emery paper, polished with 1.0, 0.3, 0.05 mm Al_2O_3 , degreased in ethanol
- Electrolyte: saturated $Ca(OH)_2 + 0.9 \text{ M NaCl} + 10^{-3} \text{ M inhibitor}$
- **Electrochemical setup:** PAR VMP2 potentiostat/galvanostat with VMP3/Z impedance option
- Techniques:

ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY POTENTIODYNAMIC POLARIZATION

f = 100 kHz - 10 mHz, ampl. 10 mV



CYCLIC VOLTAMMETRY 3rd cycle, $v = 10 \text{ mV s}^{-1}$



Nyquist plot of the EIS spectra of the

reinforcing steel in sat. $Ca(OH)_2 + 0.9 M NaCl$





Interfacial capacitance (C_{if}) and charge-transfer resistance (R_{ct}) determined from the EIS measurements and open circuit potential (E_{OC}), pitting initiation potential (E_{pit}) and width of the passive range determined from the anodic polarization curves

Inhibitor	C _{if} / μF cm ⁻²	<i>R</i> _{ct} / kΩ cm ²	E _{oc} / V	E _{pit} / V	$(E_{\rm OC} - E_{\rm pit}) / V$
no inihbitor	27.2	44.4	- 0.410	0.153	0.563
ascorbic acid	139.5	140.3	-0.545	0.186	0.731
benzoic acid	28.5	63.8	-0.409	0.426	0.835
sorbic acid	28.9	60.5	-0.397	0.364	0.761
maleic acid	31.2	54.3	-0.407	0.354	0.761
glutaric acid	30.7	50.6	-0.401	0.481	0.882
		47 7	0 4 4 5	0 0 0 0	0 770



0.05

0.00

no inhibitor



- Linear polarization measurements revealed that the presence of carboxylic acids shifted pitting potential by c.c.a. 300 mV towards more positive values, compared to the inhibitor-free system.
- EIS results revealed better properties, i.e. higher interfacial capacitance, C_{if} , and charge transfer resistance, R_{ct} , of the film formed in the presence of the inhibitors.
- Cyclic voltammetry measurements enabled useful insight into the mechanism of action of a particular
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- The highest inhibition activity was exerted by ascorbic acid that has diminished all the redox peaks in cyclic voltammogram and was
 also confirmed to be most effective by EIS.