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Evaluation of Benzotriazole as Corrosion Inhibitor for Carbon Steel as Reinforcement of Concrete

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Chlorides are very often the cause of localised corrosion in concretes due to their penetration from environment, mainly in marine atmospheres. Corrosion inhibitors is usually used as a corrosion prevention method against this form of corrosion in reinforced concretes. Nitrite is the main inhibitor for this purpose and it has been widely used for many years. However there are some limitations to its use such as environmental constraints due to the its toxic effect, mechanism of inhibition (anodic type), and also the relatively high costs of this type of additive. Research has been carried out in order to find other non toxic inhibiting additives for this application. In this investigation, benzotrizole (BTA), that is a well known corrosion inhibitor for stainless steel and carbon steels in acid media, has been evaluated as a possible corrosion inhibitor in the chloride containing alkaline environment typical of concretes in marine atmospheres.

The corrosion inhibiting efficiency of BTA in the concentrations corresponding to 0.5%, 1% and 1.5% im massa, was investigated. These concentrations were added to a reference solution composed of 0.01N NaOH plus 0.05N KOH with 3.5% NaCl and the efficiency was estimated based on the corrosion rates obtained in this last solution. The effect of BTA was compared to the nitrite using solutions with similar concentration of the inhibiting additive. All reagents used for solutions preparation were of analytical grade. The test solutions were maintained at 20 ^{o}C under naturally aerated conditions. The surface of the carbon steel samples were prepared by ground with silicon carbide paper up to #600. After surface preparation the electrodes were immersed in the various test solutions used and the open circuit potential was measured as a function of time. The evolution of the corrosion resistance was evaluated by electrochemical impedance spectroscopy (EIS) from 1 until 6 days of immersion in the various test solutions. After this period, potentiodynamic polarization tests were carried out.

A three-electrode cell arrangement was used for the electrochemical measurements, with Ag/AgCl and a platinum wire as reference and auxiliary electrodes, respectively. All potentials referred to in this work are with respect to Ag/AgCl.

Polarization measurements were carried out using a Solartron SI 1287 potentiostat in the potential range from –0.25 V to 0.25 V versus the open circuit potential (E_{ocp}) at a scan rate of 0.5 mV/s.

The EIS tests were accomplished by means of a Solartron Model SI 1255 Frequency Response Analyzer coupled to a Princeton Applied Research (PAR) Model 273A Potentiostat/Galvanostat. The diagrams were obtained in potentiostatic mode at the corrosion potential, E_{corr}, with an ac perturbation amplitude of 10 mV in the frequency range from 100 kHz to 10 mHz, with 8 points per decade.

The EIS results for the solutions with various BTA contents after 6 days of immersion are shown in Figure 1 as Nyquist and Bode diagrams.

The polarization curves of the reference solution, without and with various BTA concentrations are shown in Figure 2.

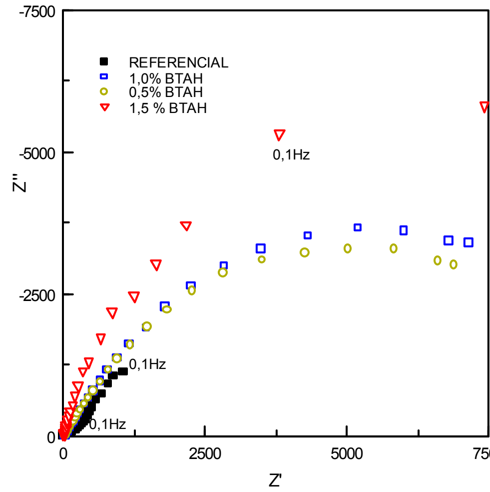

Figure 1. Nyquist diagrams of reinforcement steel in 0.01N NaOH plus 0.05N KOH with 3.5% NaCl solution (reference) without and with various BTA concentrations.

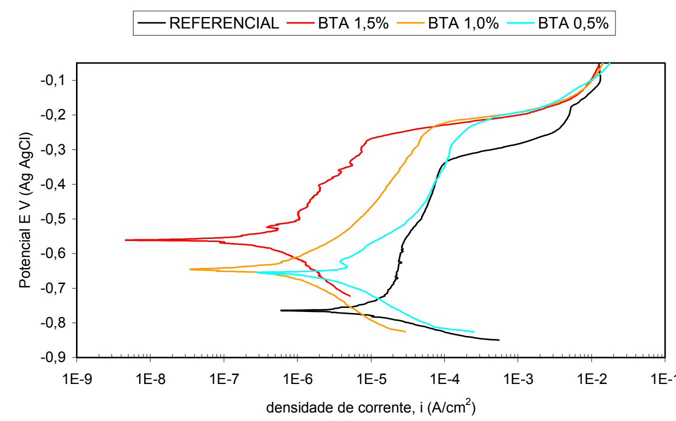

Figure 2. Potentiodynamic polarization curves of reinforcement steel in the resference solution without and with various contents of BTA showing an increasing inhibiting effect with the BTA concentrations.

The EIS and polarization curves results show clearly a significant corrosion inhibiting effect of BTA that increases with the BTA content. The corrosion inhibition efficiency using both techniques were estimated and compared to the nitrite ones. The results are shown in Table 1.

Table 1. Corrosion potential and efficiencies estimated from EIS and polarization curves for BTA and nitrite at various concentrations in the reference solution.

SOLUTION	E_{CORR} (V)	*EIS*	*Polarization*
Reference(Cl)	-0.76	------	------
NIT (0.5%)	-0.75	49.78%	57.5%
NIT (1.0%)	-0.66	81.41%	60%
NIT (1.5%)	-0.60	83.68%	65%
BTA (0.5%)	-0.65	82.80%	70%
BTA (1.0%)	-0.63	91.86%	91%
BTA (1.5%)	-0.55	98.46%	97%

The results in Table 1 clearly show that BTA was a more effective inhibitor than nitrite for carbon reinforcement steel in alkaline environments typical of those found in the pores of concretes.The efficiencies increased with the BTA content up to 1.5% in mass, and similar values were obtained by both techniques.