

Investigation of sodium molybdate as corrosion inhibitor for protection against chloride ingress and carbonation in simulated concrete pore water

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The aim of this research was to characterize the effectiveness of sodium molybdate as a corrosion inhibitor for the two main causes (chloride ingress and carbonation resulting in pH drop) of corrosion of carbon steel rebars in reinforced concrete.

New results:

A series of experiments were conducted to determine the effectiveness of Na₂MoO₄ at protecting AISI 1020 carbon steel in simulated concrete pore water (saturated calcium hydroxide solution with a pH of 12.5) in the presence of Cl (1000 ppm Cl and 6000 ppm Cl). Carbonation was simulated by reducing the pH of the simulated concrete pore water by the addition of NaHCO₃. The corrosion behavior of the rebars was investigated by electrochemical impedance spectroscopy, potentiodynamic polarization, linear polarization resistance (LPR) and potentiostatic transients. SEM and EDX were performed on samples to characterize the surface before and after corrosion.

It was found that Na₂MoO₄ was effective at increasing both the polarization resistance and the pitting potential of the carbon steel, especially at lower Cl levels (1000 ppm Cl). At pH 12.5 in the presence of 1000 ppm Cl, Na₂MoO₄ at 0.2 wt% was sufficient to suppress pit initiation until after the oxygen evolution potential was reached. At pH 12.5 in the presence of 6000 ppm Cl, 0.4 wt% Na₂MoO₄ was able to increase the pitting potential by 400 mV. 1 wt% Na₂MoO₄ was also effective at a lower pH (pH 9, 1000 ppm Cl), reducing the current density in the passive region significantly. Based on the experiments conducted, Na₂MoO₄ extended the potential range of the passive region, with some metastable pitting occurring before the onset of stable pitting. This suggests competitive adsorption of molybdate with chloride. EDX carried out on pits detected the presence of Mo, which is an indication of support for the hypothesis of pore-plugging mechanism in which molybdate precipitates out in the anodic sites and helps to repair the damaged passive film.

It was shown that NaHCO₃ also acted as a very weak inhibitor. This slightly complicates analysis of the effectiveness of a chosen corrosion inhibitor. However, it was found that simulating pore waters of carbonated concrete by adding sodium bicarbonate yielded more stable solutions than simply diluting the calcium hydroxide to obtain a lower pH. This is because of the better buffering capacity of the former method compared to the latter. For the latter solution, it was found that there was a significant pH increase (> 2 pH units) at the end of

a potentiodynamic scan due to the reduction of oxygen in the corrosion process, which might cast doubt on the validity of experiments conducted at a chosen pH.

Significance of work:

Sodium molybdate is a potential candidate for use as a corrosion inhibitor in reinforced concrete, based on accelerated laboratory tests. Calcium hydroxide solution modified with sodium bicarbonate is preferable to diluted calcium hydroxide solution in simulating pH drop of concrete pore water.