# 새로운 히드라존에 의한 염화물 오염 합성 콘크리트 공극 솔루션에서 철근의 부식 억제에 대한 통찰력

## Insights into the corrosion inhibition of steel rebar in chloride-contaminated synthetic concrete pore solutions by a new hydrazone

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Abstract

A new hydrazone derivatives namely (E)-N'-(4-(dimethylamino)benzylidene)-2-(5-methoxy-2-methyl-1H-indol-3-yl)aceto-hydrazide (HIND) has been confirmed for mitigating the corrosion of the steel rebar exposed to chloride contaminated synthetic concrete pore solution (ClSCPS). The mitigation of corrosion properties has been characterized by weight loss and electrochemical methods (Electrochemical impedance, Potentiodynamic polarization studies) as well as surface observations. The presence of HIND in the ClSCPS decreased the corrosion of steel rebar by adsorption of HIND molecules on the surface of the steel rebar. The optimal HIND concentration was 0.5 mmol/L, corresponding to an inhibition efficiency of 88.4%. The use of HIND enables the corrosion process to have a higher energy barrier. X-ray photo electron spectroscopy (XPS), atomic force microscopy (AFM), scanning electron microscopy-energy-dispersive spectroscopy (SEM-EDS), and X-ray diffraction (XRD) spectroscopy interpretations confirmed that HIND mitigates the corrosion attack on the surface steel rebar.

키 워 드 : 탄소강, 콘크리트,EIS, XPS, 알칼리 부식
Keywords : carbon steel, concrete, EIS; XPS, alkaline corrosion

## 1. Introduction

Corrosion of steel rebar is one of the main causes for the failure of reinforced concrete structures. The steel rebar surface, in general, forms a passive film in a high alkaline concrete environment, which works as a barrier against corrosion. However, when chloride ions penetration exceeds a certain amount, the passive film may be broken, resulting in severe corrosion of the steel bar[1].

The use of corrosion inhibitors is one of the most common methods due to its low cost, ease of operation, and available effective corrosion inhibitors. Green corrosion inhibitors are considered an emerging alternative to conventional toxic corrosion inhibitors such as nitrites[2].

We report herein the synthesis and application of a new hydrazone derivative namely (E)-N'-(4-(dimethylamino) benzylidene)-2-(5-methoxy-2-methyl-1H-indol-3-yl)acetohydrazide (noted HIND) based on 5-methoxy-2-methyl -3-indoleacetic acid (MMIAA), which is one of the well-defined impurities found in the NSAID Indomethacin (IND) for steel rebar protection in concrete environments.

## 2. Materials and methods

The steel rebar employed in the present work had the following chemical compositions (wt.%): 0.240% C, 0.040% Cr, 0.030% Ni, 0.950% Mn, 0.020% Cu, 0.010% Mo, 0.001% Sn, 0.016% P, 0.08% S and 98.613% Fe. The used corrosion inhibitor is (E)-N'-(4-(dimethylamino)benzylidene) -2-(5-methoxy-2-methyl-1H-indol-3-yl) acetohydrazide which was synthesized in our laboratory. The SCPS solutions consist of 3.36 g/L of KOH, 8.33 g/L

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NaOH prepared per liter of saturated Ca(OH)2 solutions, with 35 g NaCl/L for contaminated solutions. Experiments have been carried out using electrochemical techniques while the surface state of the steel rebar was investigated by different characterization techniques such as XPS, AFM, XRD, and SEM/EDS.

## 3. Results and discussion

EIS tests were carried out at various immersion times ranging from 1h to 720 hrs. Figure 1 shows Nyquist and Bode representation of EIS results for steel rebar immersed in ClSCPS and in presence of different concentrations of HIND inhibitor at 1h and 720 hrs.

An overall observation indicates that the radius of all capacitive loops decreases with the increase in immersion time, signifying an increased corrosion rate with time. Also, increasing the inhibitor dose considerably increases the arc radius of the capacitive loops. This concentration-dependent behavior of the capacitive loops' diameter results mostly from the formation and growth of an inhibitor film on the steel rebar surface. As shown in Figure 1, Bode phase angle plots show a characteristic behavior of multilayer, which is noticed by the presence of more than one peak maximum.

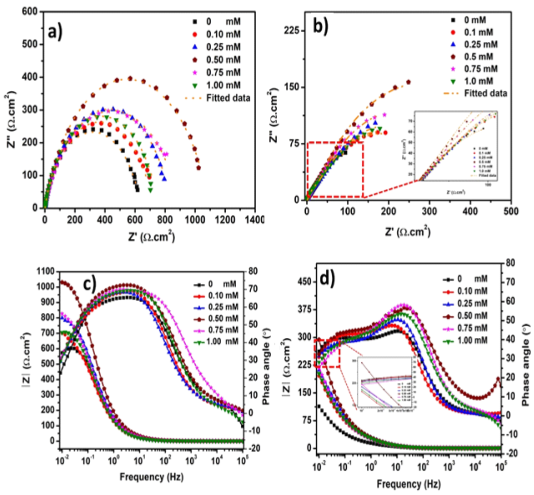


Figure 1. EIS results for steel rebar immersed in ClSCPS with different concentrations of tested inhibitor.

Potentiodynamic polarization results show that in presence of inhibitor's concentration, both cathodic and anodic current densities are shifted towards values significantly lower than that of the blank test. It signifies that the inhibitor molecules mostly inhibit both anodic and cathodic corrosion reactions, by exerting a mixed-type inhibition effect.

The XPS results showed that in the blank system, an oxide layer formed on the surface of steel rebar, whereas in inhibited solutions, results showed strong evidence of inhibitor adsorption on the steel rebar.

The inhibitor reaches maximum efficiency at an optimal concentration of 0.5 mmol/L, corresponding to an inhibition efficiency of 88.4%.

## 감사의 글

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