Lamellar double hydroxides based on Zn and Al and their application as a corrosion inhibitor: polarization curves study

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Abstract

The inhibition tests of the two HDls against the corrosion of iron and XC38 steel in a 3% NaCl solution were determined by the method of polarization curves.Two lamellar double hydroxides (HDL) were used in this work as corrosion inhibitors. ZnAl-HDL and ZnAl-HDL intercalated by methyl orange (ZnAl-MO-HDL) were synthesized by the co-precipitation method. The results obtained show higher inhibition performance of ZnAl-MO-HDL (96%) compared to ZnAl-HDL (52%). This can be explained by the presence of methyl orange (MO) in HDls molecules and its influence on the inter-sheet distance.

Introduction

Metallic materials have been extensively used in marine environments. However, the high concentration of aggressive Cl^- ion in seawater cause the degradation of these metals which reduces their workability, corrosion resistance, fatigue resistance and weldability behaviors.
The addition of inhibitor in the solution is the most common and cost effective method for corrosion protection.
Several research works have shown that LDHs (Layered double hydroxides) are effective corrosion inhibitors in NaCl medium. On the other hand, their intercaltion with other compounds make them very effective.
The objective of the present work is to prepare and characterize ZnAl-LDH by co-prepitation and its inercalation with methyl orange (MO) by anion exchange.
The performance parameters in protecting of iron and XC38 steel from corrosion in 3% NaCl solution are tested by polarization curves method.

Methods

Electrochemical characterization

A three-electrode cell was used with a gold electrode as the auxiliary electrode, Ag / AgCl / KCl (sat) as the reference electrode and iron metal with a purity of 99% or XC 38 steel as the working electrode. The exposed area of this electrode was 2 cm^2. Cyclic voltammetry and polarization curves were measured at 5 mVs^{-1} with an Autolab 30 potentiostat. The electrochemical measurements were conducted in an aggressive medium (3.5% NaCl in distilled water) and a non-aggressive medium (Britton-Robinson buffer sollution, adjusted to pH 7 with NaOH).
The metal species were inmersed in solutions with LDH and in solution with LDH-MO. To investigate the anticorrosive properties, the cathodic and anodic polarizations have been performed with independent samples, and the electrochemical behaviours in the aggressive versus non-aggressive media were compared. The corrosion current density (i_{corr}) and the corrosion potential (E_{corr}) were calculated by extrapolating the Tafel slopes (anodic and cathodic) determine from the polarization curves.

Conclusions

The polarization curves obtained on carbon steel show that ZnAl-MO-LDH is an anodic inhibitors and their efficiency was 90% and 96% for iron and carbon steel respectively, at the concentration of 1 $g.l^{-1}$.
This study has shown the feasibility of developing nanocontainers of corrosion inhibitor based on double layer hydroxide for protective organic coatings.

References

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Results

Anticorrosion tests of LDHs

II.1. Tests of Iron : The polarization curve were used to evaluate the properties of the ZnAl-LDH and ZnAl-MO-LDH on protecting **iron** from corrosion in 3% NaCl solution, the results of which are shown in Fig. 1.

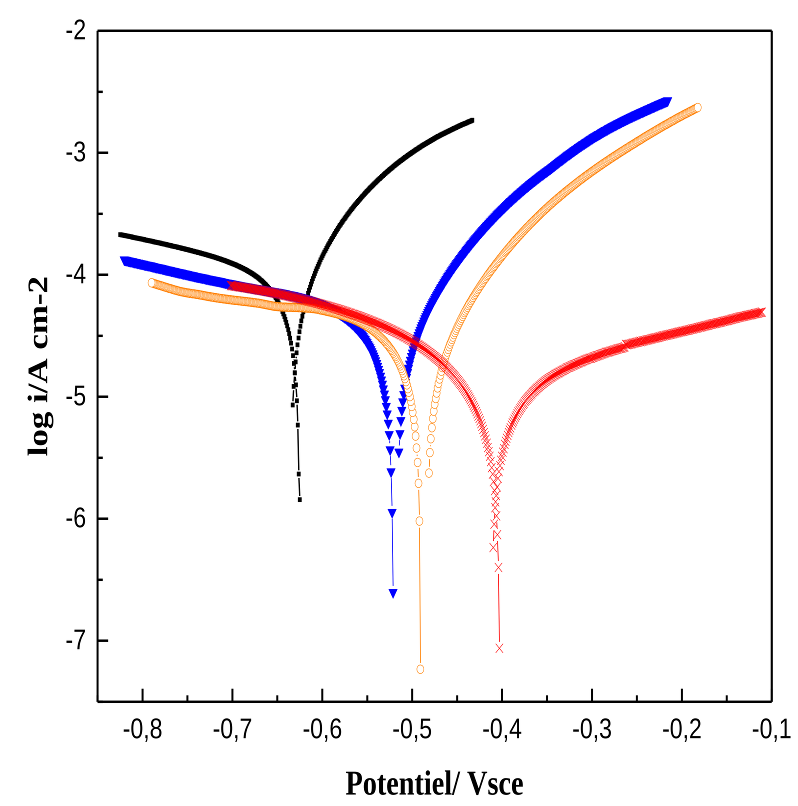

Fig. 1. polarization curves o.btained for the iron electrode after 2h of immersion in the 3% NaCl (■) solution without inhibitor (▼)with ZnAl-LDHs (1 gL^{-1}) (○) with MO concentration of 10^{-4}M with (×) ZnAl-MO-LDHs (1 gL^{-1}).

The corrosion-inhibiting efficiency calculated from polarization curve (ηpc) can be calculated as follows:

$$E.I = \frac{icorr - i'corr}{icorr} \times 100$$

where icorr and i'corr are the corrosion current densities in the absence and presence of the inhibitors , respectively

Sample	E_{corr} (mV/CSE)	I_{corr}(µA cm^{-2})	E.I (%)
Blank	-630	21.3	-----
ZnAl-LDH	-520	4.16	80
ZnAl-MO-LDH	-407	2.13	90

II.1. Tests of XC38 steel : The polarization curve were used to evaluate the properties of the ZnAl-LDH and ZnAl-MO-LDH on protecting **XC38 steel** from corrosion in 3% NaCl solution.

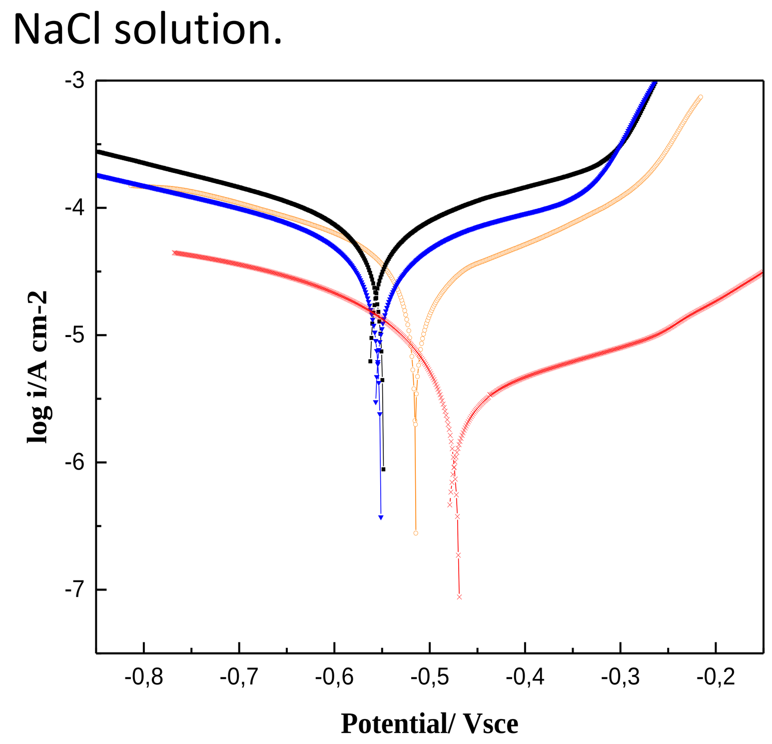

Fig. 2. polarization curves obtained for the XC38 steel electrode after 2h of immersion in the 3% NaCl : (■) solution without inhibitor (▼) with ZnAl-LDHs (1 gL^{-1}) (○) with MO concentration of 10^{-4}M with (×) ZnAl-MO-LDHs (1 gL^{-1}).

Sample	E_{corr} (mV/CSE)	I_{corr} (µA cm^{-2})	I.E (%)
Blank	-550	27.5	----
ZnAl-LDH	-554	13.1	52
ZnAl-MO-LDH	-473	1.07	96