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Improving zinc-rich epoxy primer performance with lamellar zinc incorporation

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HIGHLIGHTS

- Introduction
- Objectives
- Methodology
- Results
- Summary

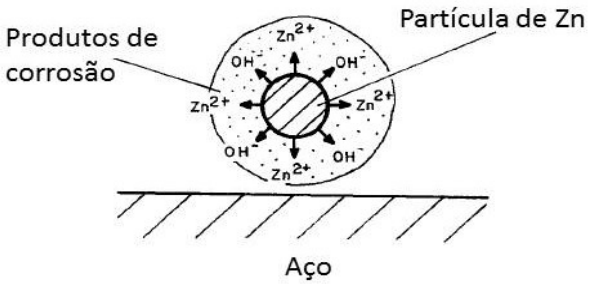
Zinc-rich paint – Contextualization

- Zinc-rich paint (ZRP)
  - ZRPs have as their main characteristic the high concentration zinc in their formulation (92% to 95%), in order to ensure that the percolation limit between the zinc particles in the film and the steel is reached;

  - Zinc rich paints are commonly used as a paint system primer for carbon steel protection exposed to highly corrosive environments;
  - the high concentration of solids on the film results in lower adhesion and flexibility properties

ZRPs protection mechanisms

- Cathodic protection
  - the presence of zinc particles (Zn) in ZRPs applied to steel, cathodic protection is initially promoted, with preferential corrosion of zinc (sacrificial anode, less noble metal than iron) and a consequent protection of the metallic substrate;



- Barrier protection
  - as a consequence of the formation of zinc corrosion products around the particles over time, barrier protection occurs.

Objectives

- This work aims at obtaining ZRPs with a reduced zinc concentration in relation to a conventional paint available in the market and that present better mechanical properties (flexibility and impact resistance) and better adhesion to the substrate without compromising its conductivity, thus being able to offer adequate anti-corrosion protection.

Methodology

- Formulation of the modified ZRP
  - The base formulation of the reference was mixed with the metallic spherical zinc particles and the metallic lamellar zinc particles;
  - The rotation used was equal to 800 rpm for 20 min;
  - for application, the same curing agent of the commercial ZRP was used.

Methodology

- Characterization of the modified and commercial ZRPs
  - The conductivity was measured using a conductometer with an electrode Cond probe InLab 741-ISM by Mettler Toledo;
  - solid content of the dry film - ISO 3251-2008;

- Mechanical tests
  - sample preparation and the coating process were based on Brazilian standard PETROBRAS N1277-2017;
  - Pull-off adhesion test, according to ASTM D4541- 2017;
  - Direct impact test, according to ISO 6272-1:2002;
  - Bend test (conical mandrill), according to ISO 6860:2006;
  - Erichsen *Cupping* test, according to ABNT NBR 5902-1980.

Results and Discussion

- Liquid-paint characterization

Table 1 - Characteristics of liquid paint and dry film of ZRPs commercial and modified

ZRP	Liquid paint		Dry film
	Conductivity (S/cm)	Resin fraction (%)	Solid's fraction (%)
Reference ZRP	1.64×10^{-7}	6.8	91.5
Modified ZRP with lamellar zinc	2.64×10^{-7}	8.6	89.4

Results and Discussion

- Mechanical tests

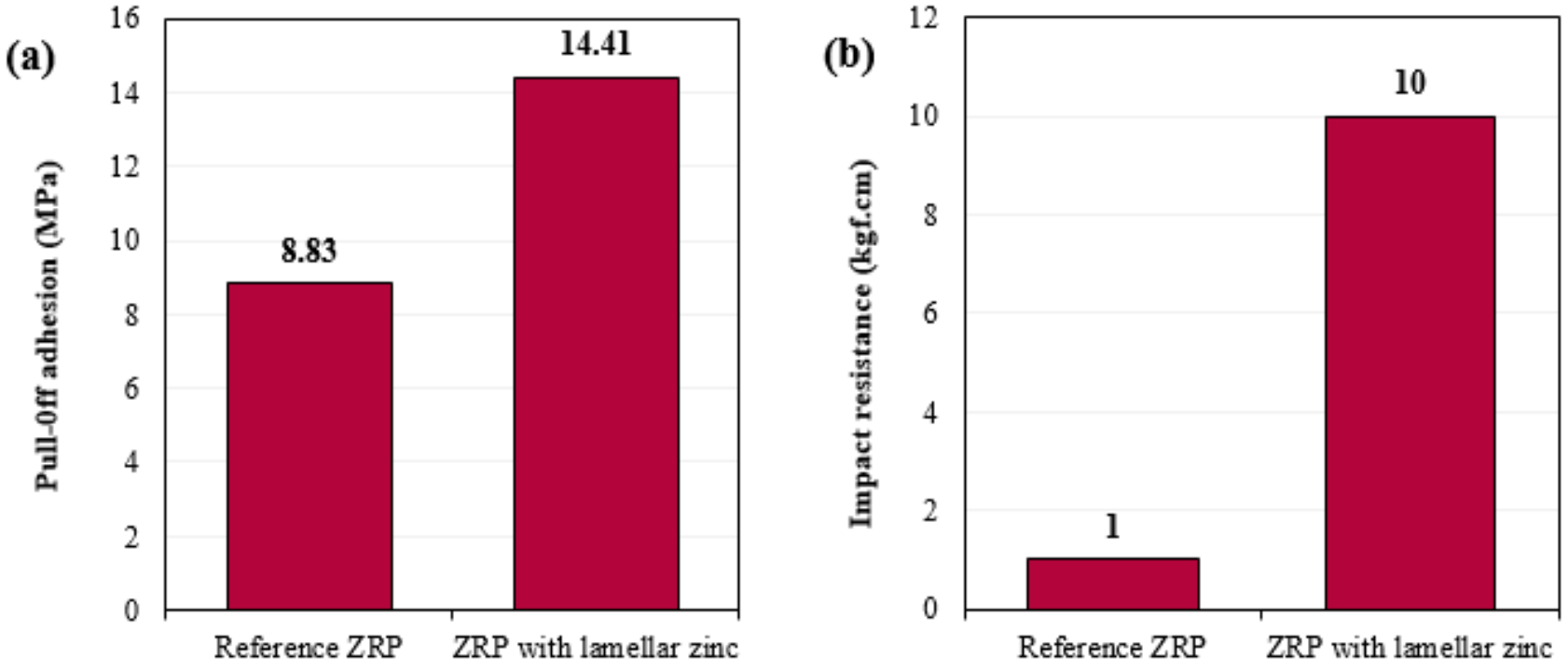


Figure 1 - Mechanical properties of reference and modified ZRP: (a) Pull-off adhesion test, (b) impact resistance, (c) conical mandrill bend test and (d) Erichsen cupping test

Results and Discussion

- Mechanical tests

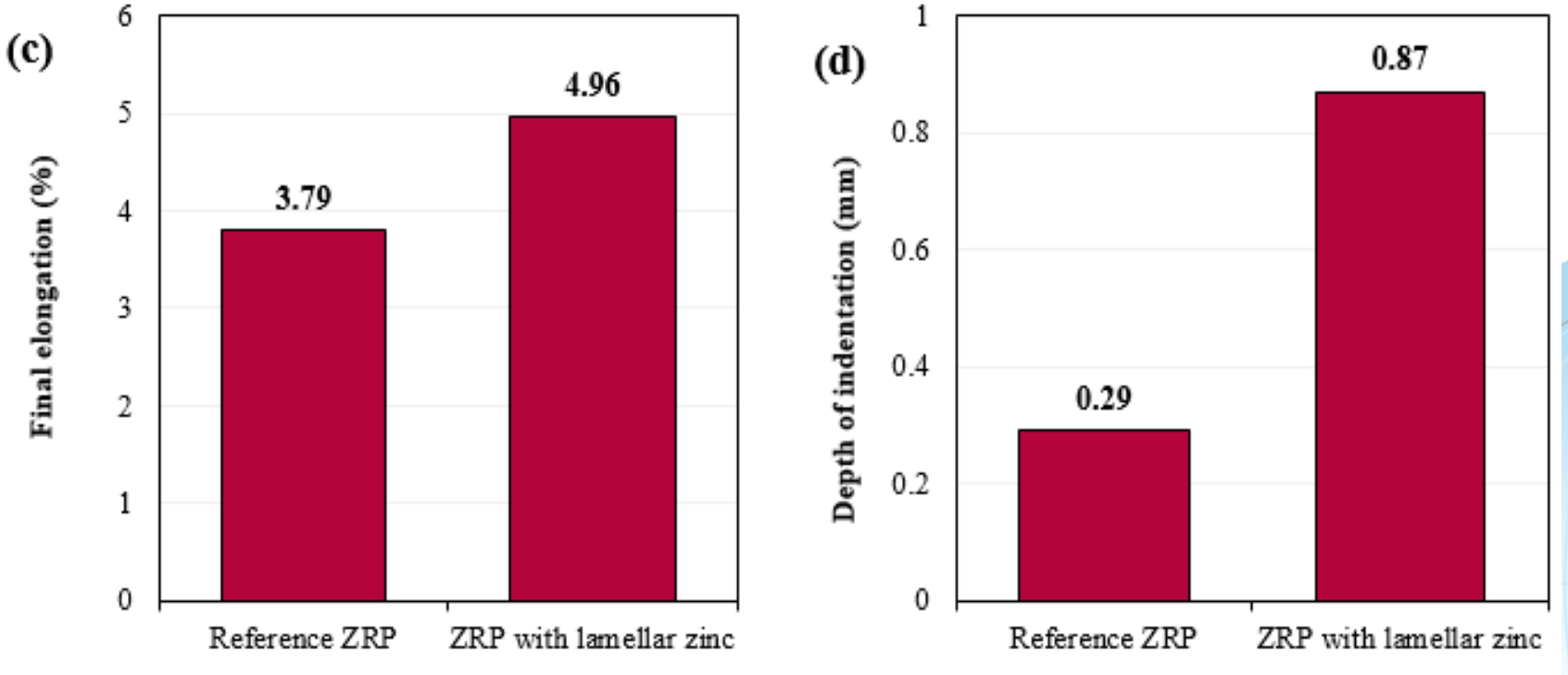


Figure 1 - Mechanical properties of reference and modified ZRP: (a) Pull-off adhesion test, (b) impact resistance, (c) conical mandrill bend test and (d) Erichsen cupping test

Summary

- A commercial zinc-rich paint was modified by partially replacing micrometric zinc particles with lamellar particles;
- increase in the adhesion, cohesion and flexibility properties of the modified paint with lamellar zinc;
- the electrical contact between the conductive particles (spheric micro-size zinc and lamellar zinc) in the film was not compromised by the new formulation.

Thank you!

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AMPP ANNUAL CONFERENCE + EXPO

Corrosion 2022

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Highlights

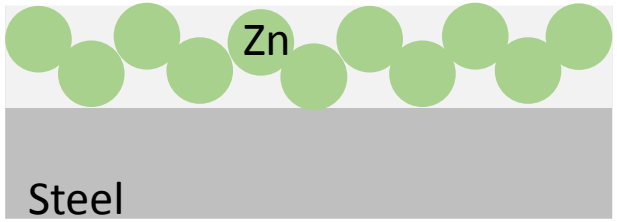
- Introduction
- Objectives
- Methodology
- Results
- Summary

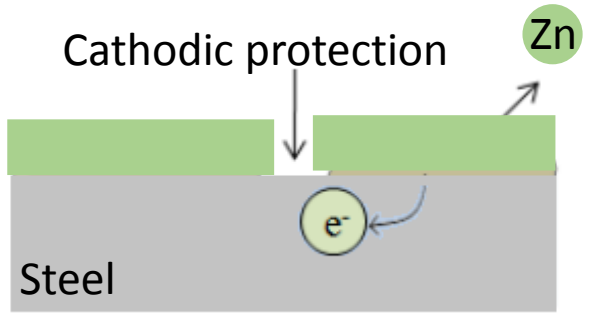
Zinc-rich paints - context

Zinc-rich paints (ZRPs) are characterized by having high metallic zinc content (92 % to 95 %) in the dry film to guarantee the electrical contact between pigments, an important condition for good corrosion protection.

- ZRPs are commonly used as a paint- system primer for carbon steel protection exposed to highly corrosive environments.
- The high concentration of solids in the film results in lower adhesion and flexibility.

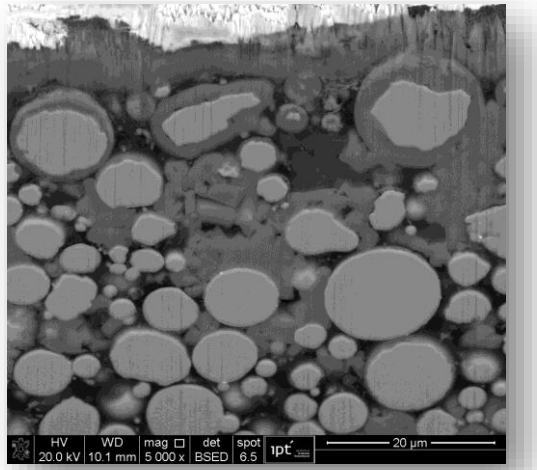
ZRPs' protection mechanisms





Cathodic protection

- The presence of interconnected zinc particles in ZRPs applied on steel, cathodic protection is initially promoted, with preferential corrosion of zinc (sacrificial anode, less noble metal than iron) and a consequent protection of the metallic substrate;



Barrier protection

- Because of the formation of zinc corrosion products around the zinc particles over time, barrier protection occurs.

Goal

This work aims at obtaining ZRPs with a reduced zinc concentration than a conventional paint available in the market but with better adhesion and flexibility of the paint layer and similar corrosion protection.

Methodology

- **Preparation of the modified ZRP using as a reference a commercial formulation**
  - The base formulation of the reference was mixed with the metallic spherical zinc particles and the metallic lamellar zinc particles (the exact ratio of spherical/lamellar is an industrial secret).
  - The rotation used was equal to 800 rpm for 20 min.
  - for application, the same curing agent of the commercial ZRP was used.

- **Characterization of the modified and commercial of the liquid ZRPs**
  - The conductivity of the liquid paint was measured using a conductometer with an electrode Cond probe InLab 741-ISM by Mettler Toledo. The goal was to obtain a liquid paint with the same conductivity of the reference (same amount of solvents)
  - Solid content of the dry film - ISO 3251-2008.

- **Characterization of the modified and commercial of dry ZRP films**
  - Sample preparation and the coating process were based on Brazilian standard PETROBRAS N1277-2017.
  - Pull-off adhesion test, according to ASTM D4541- 2017.
  - Direct impact test, according to ISO 6272-1:2002.
  - Bend test (conical mandrill), according to ISO 6860:2006.
  - Erichsen *Cupping* test, according to ABNT NBR 5902-1980.

Methodology

- **Salt spray and humidity chamber**
  - According to Brazilian standard PETROBRAS N1277-2017.

- **OCP measurements x time in NaCl solution**
  - According to Brazilian standard PETROBRAS N1277-2017

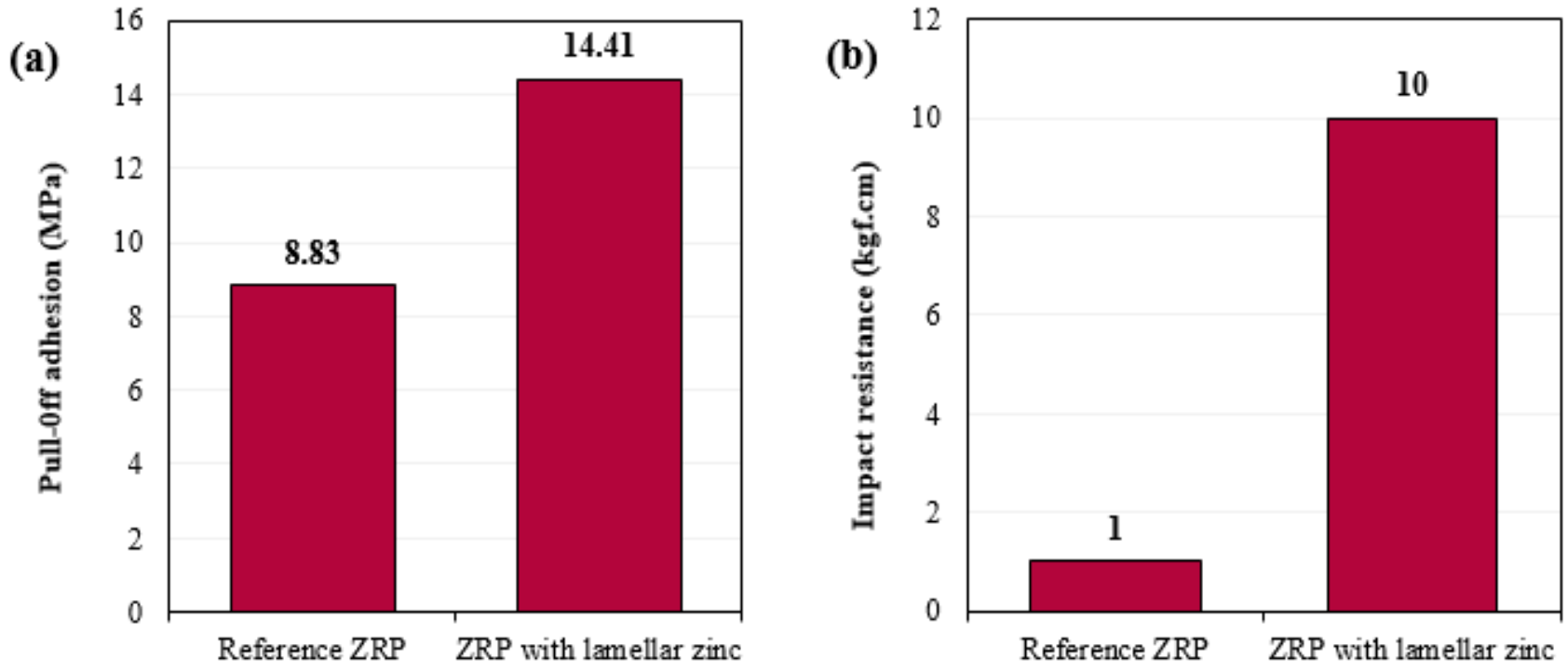
Results and discussion

Characteristics of the liquid paint and solid content of the dry film of ZRPs commercial and modified

ZRP	Liquid paint		Dry film
	Resin content (%)	Conductivity (S/cm)	Solid content (%)
Reference ZRP	6.8	1.64×10^{-7}	91.5
Modified ZRP with lamellar zinc	8.6	2.64×10^{-7}	89.4

Results and discussion

- Mechanical tests: pull off and Impact resistance



Mechanical properties of reference and modified ZRP: (a) Pull-off adhesion test, (b) impact resistance, (c) conical mandrill bend test and (d) Erichsen cupping test

Results and discussion

- Mechanical tests

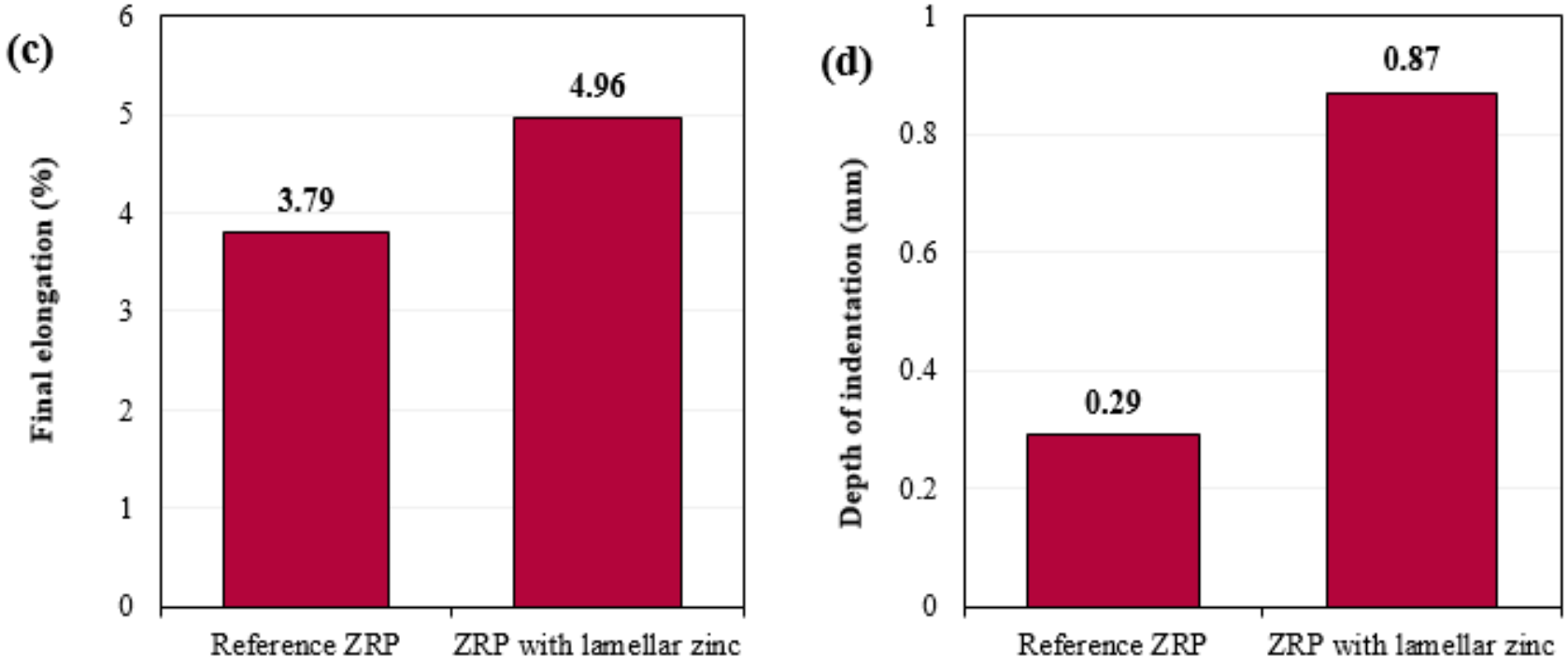
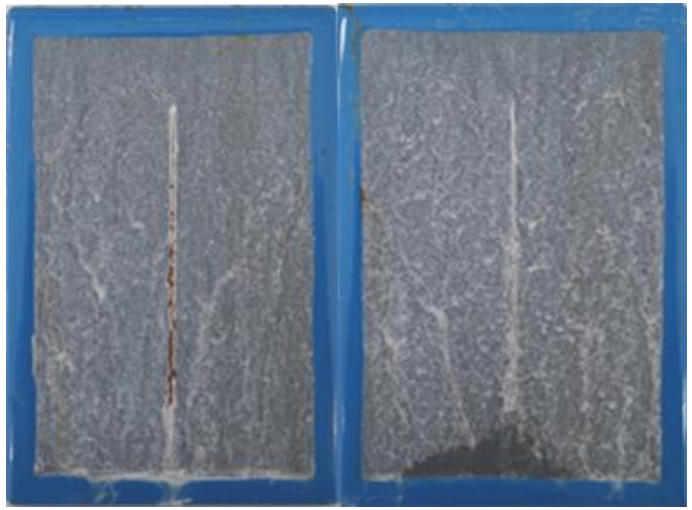


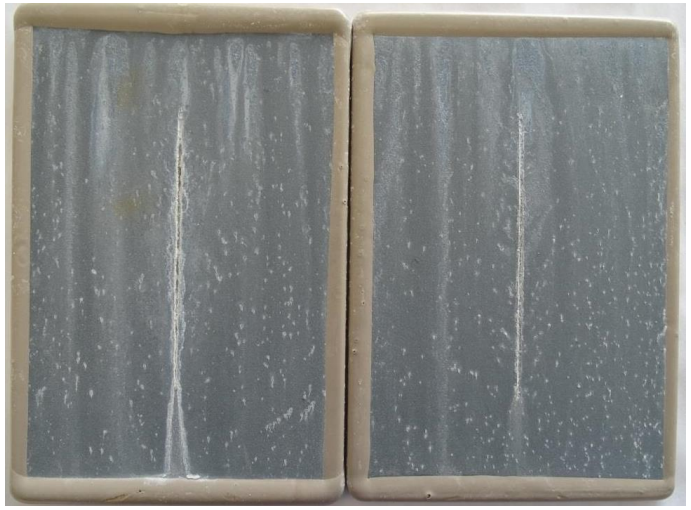
Figure 1 - Mechanical properties of reference and modified ZRP: (a) Pull-off adhesion test, (b) impact resistance, (c) conical mandrill bend test and (d) Erichsen cupping test

Results and discussion

Salt spray
1000 h

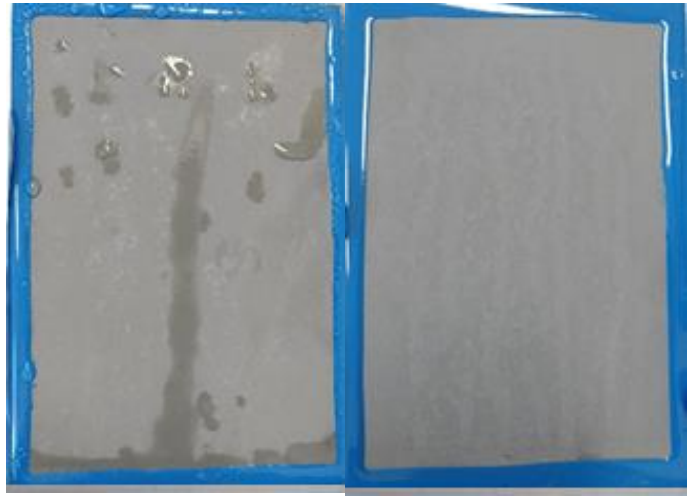


Reference ZRP



ZRP with lamellar Zn

Humidity chamber
1000 h



Results and discussion

Reference ZRP

ZRP with lamellar Zn

Summary

- A commercial zinc-rich paint was modified by partially replacing micro- size zinc particles with lamellar particles.
- An increase in the pull-off adhesion and flexibility test results was obtained for the modified ZRP with lamellar particles.
- Comparable corrosion resistance in accelerated corrosion test.

Thank you!

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