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Study of the Iron Behavior in Acid Rain Water Solution by Application of Two Green Corrosion Inhibitors

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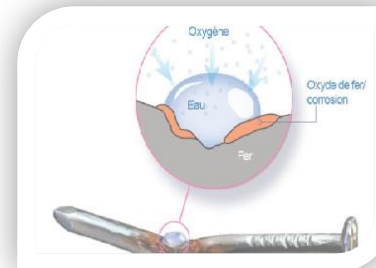
Introduction

Different techniques are applied to suppressing or at least mitigating the rate of corrosion of metals and their alloys, among which the use of corrosion inhibitor

Due to its low cost and availability, iron is considered one of the most important and widely used metals in many industrial applications



The iron structure is extremely susceptible to corrosion in many circumstances, including humidity, corrosive agents and polluted atmosphere

Resulting in enormous economic and environmental losses often difficult to eliminate completely

Negatively affects the physicochemical properties of the metal

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Purpose

The chemical compounds extracted from plants are the new alternative adapted as green corrosion inhibitors, this ecological alternative is environment-friendly, safe and biodegradable.

Team from the Materials, Electrochemistry and Environment Laboratory (LCOCE) of Kenitra (Morocco)

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Faculty of Sciences and Techniques of Maroni University (Comoros)

The valuation of oils extracted from ***Jatropha curcas*** and ***Aleurites moluccana*** seeds for their use as <u>**green corrosion inhibitors**</u>

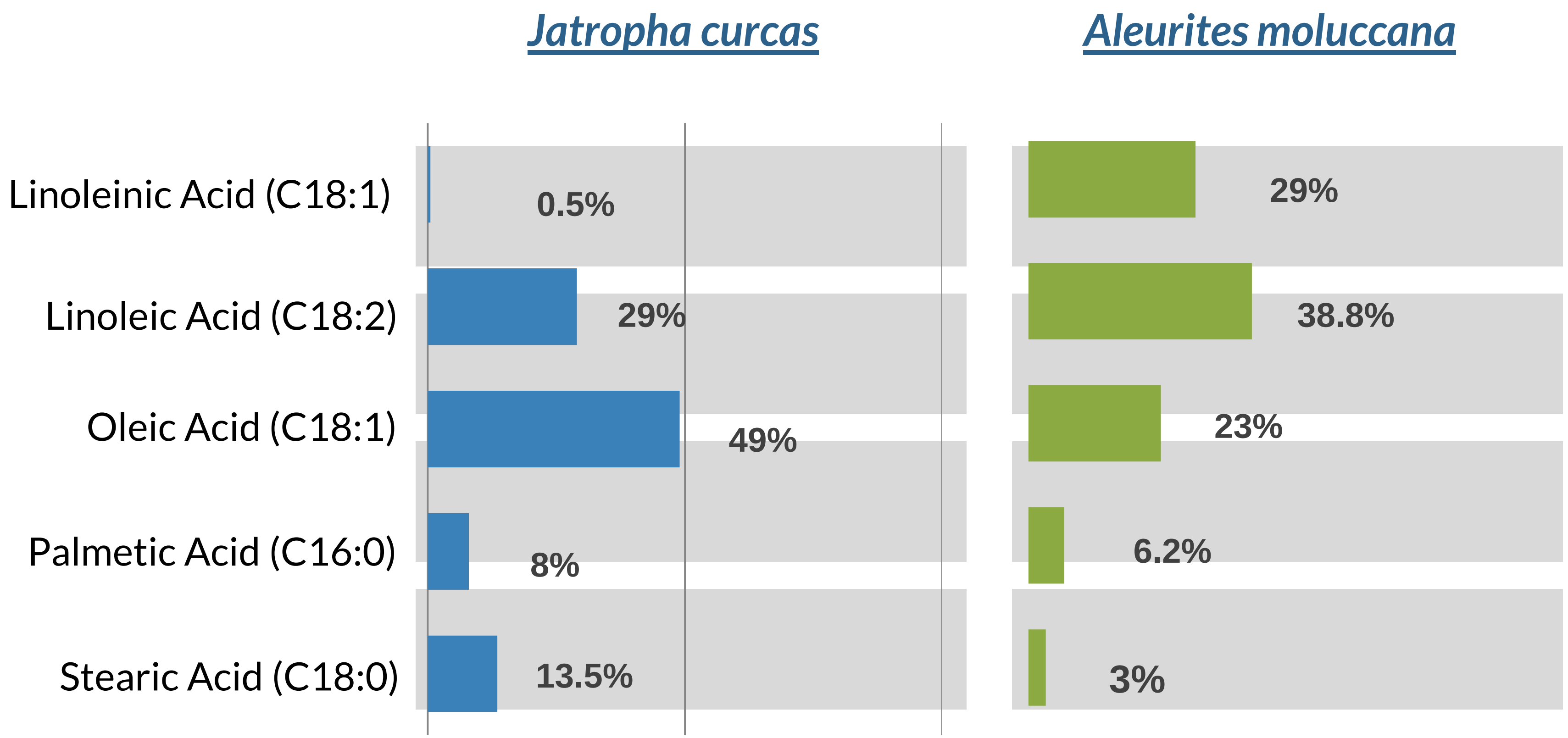
Plants Presentation

Aleurites moluccana

Jatropha curcas

▷ *Jatropha curcas and Aleurites moluccana are two species belonging to the Euphorbiaceae family. Their seeds are rich in oil which has a renowned potential, exploited for the biodiesel production.*

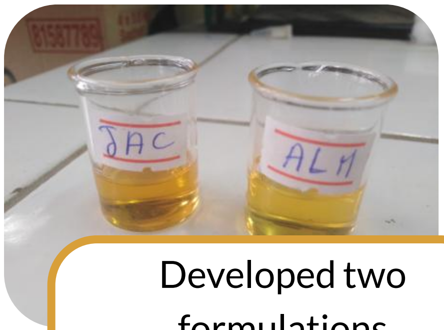
Fatty Acids composition of *Jatropha curcas* and *Aleurites moluccana* seeds oils



Unsaturated fatty acids: 78.5% 90.8%

Experimental study

After extracting and characterizing of the seed oils



Developed two formulations (**JAC** and **ALM**)(*) based on the extracted oils

Evaluate as a green inhibitors of iron corrosion in acidic medium

We aimed to evaluate and compared the inhibiting effect of the two green formulations containing oils extracted from the seeds of *Jatropha curcas* (labeled JAC) and *Aleurites moluccana* (labeled ALM), toward the iron corrosion in the aggressive acid rain atmosphere.

(*)N. Hajjaji, N. Bettach, H. Hammouch, A. Srhiri, A. Dermaj, D. Chebabe. OMPIC Casablanca, Morocco. Patent N3069/10.2011.

Iron composition :

Elements	Si	Mn	C	P	S	Fe
%Weight	0 ,201	0,514	0,157	0,007	0,009	≥ 99%

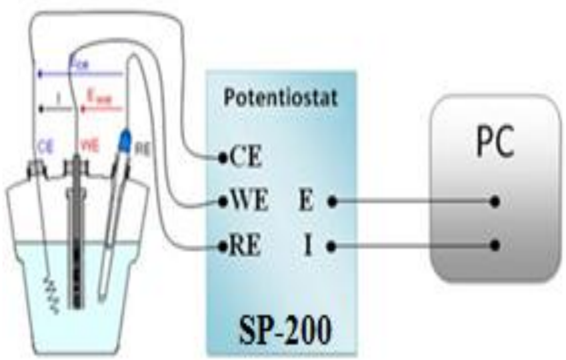
Solution corrosive :

- Simulated solution to acid rain water (noted AR) at a pH = 3.6.
- Composition: 0,2g/l NaCl ; 0,2g/l $NaHCO_3$ and 0.2g/l Na_2SO_4 .

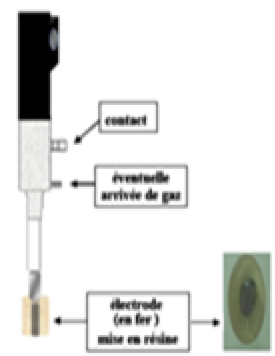
Potentiostat SP 200:

Electrochemical measurements stationary and transient analysis :

- **Counter electrode**
- **Working electrode**
- **Reference electrode**

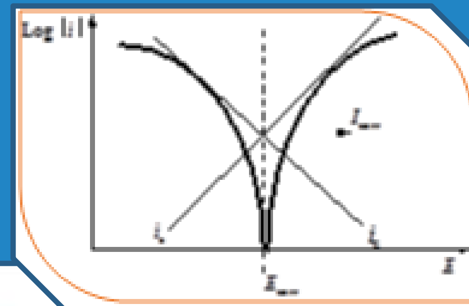


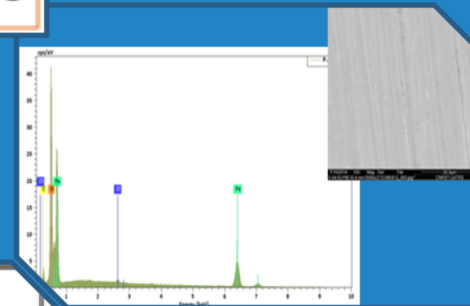
Schema for the electrochemical assembly

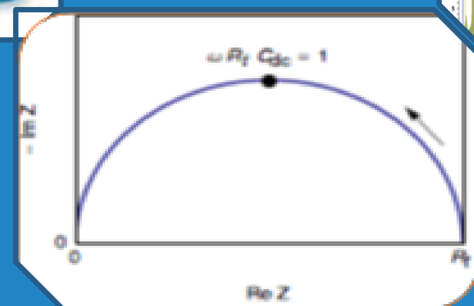


The rotating disk electrode (CTV 101)

Surface Analysis : (MEB/EDX)

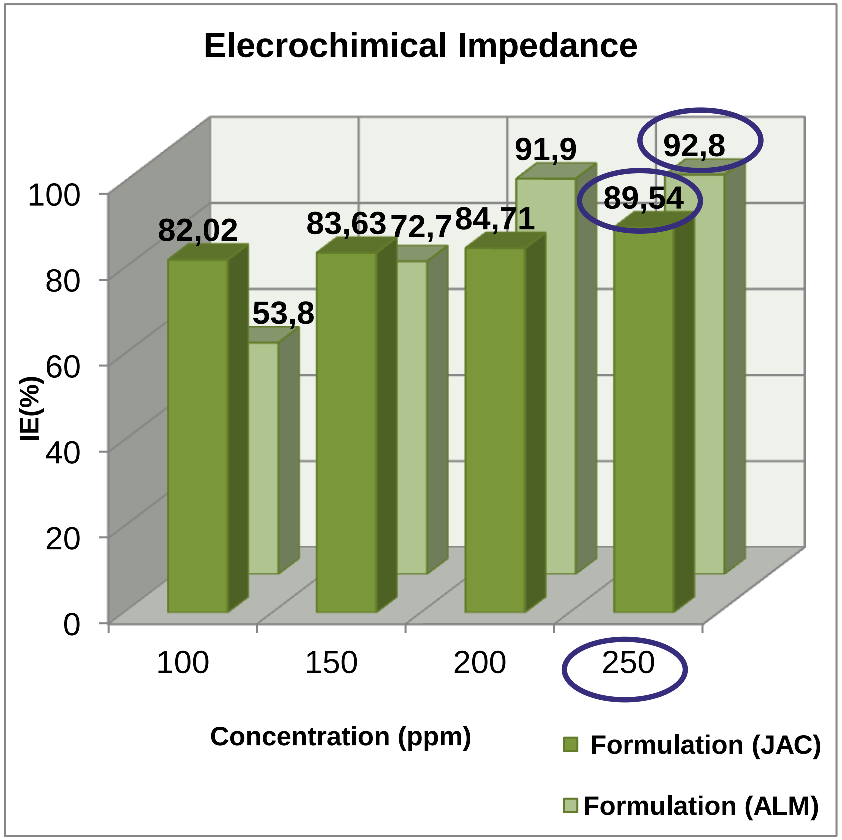


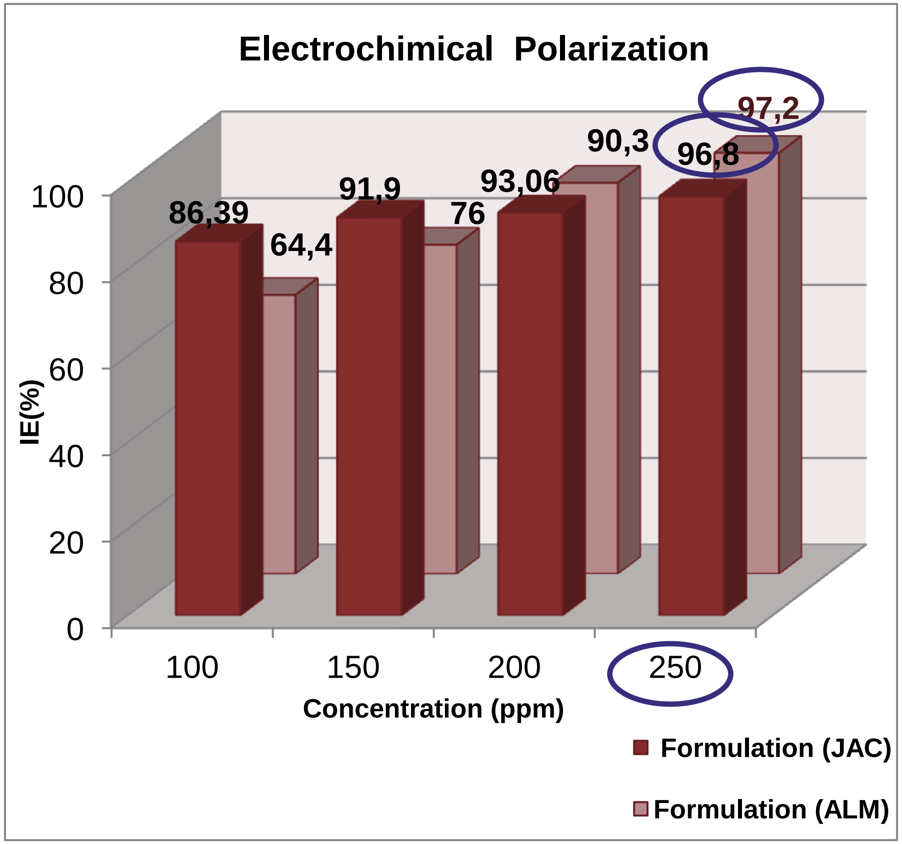




Results And Discussion

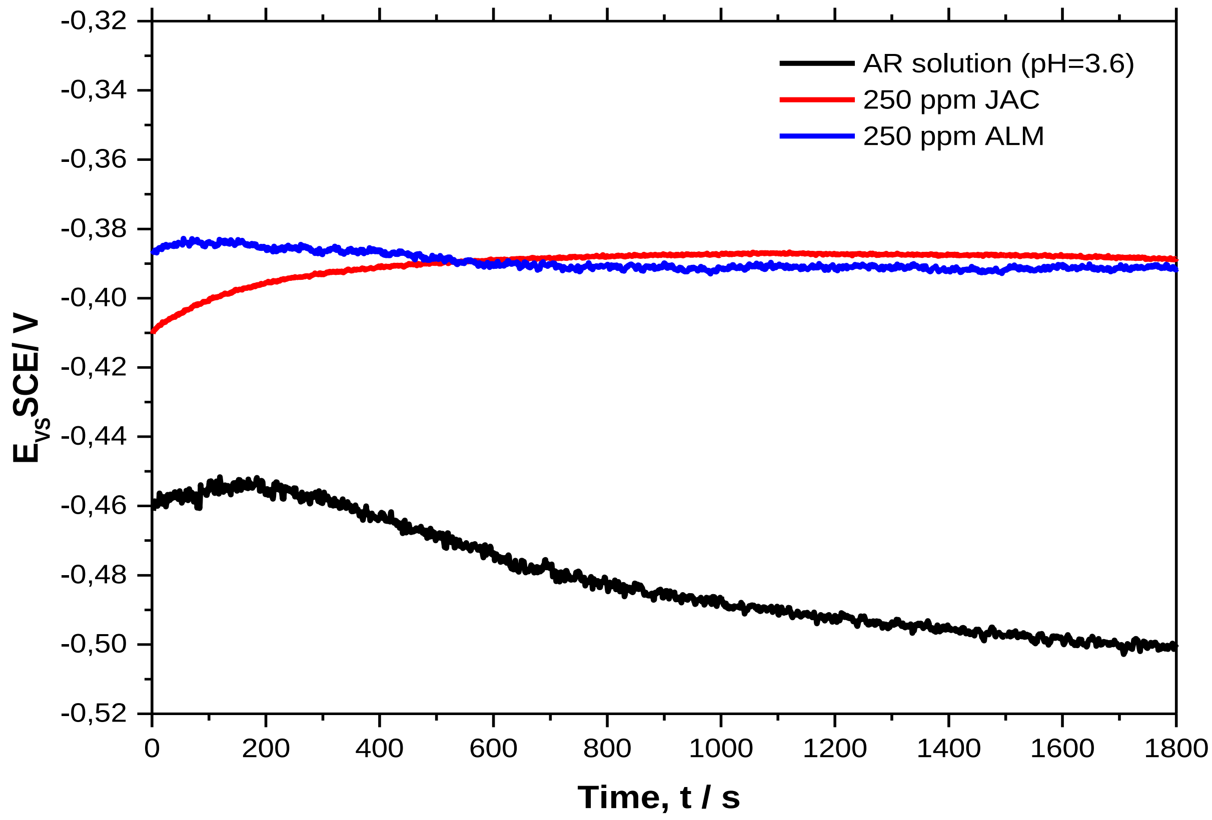
Concentration effect of JAC and ALM formulations





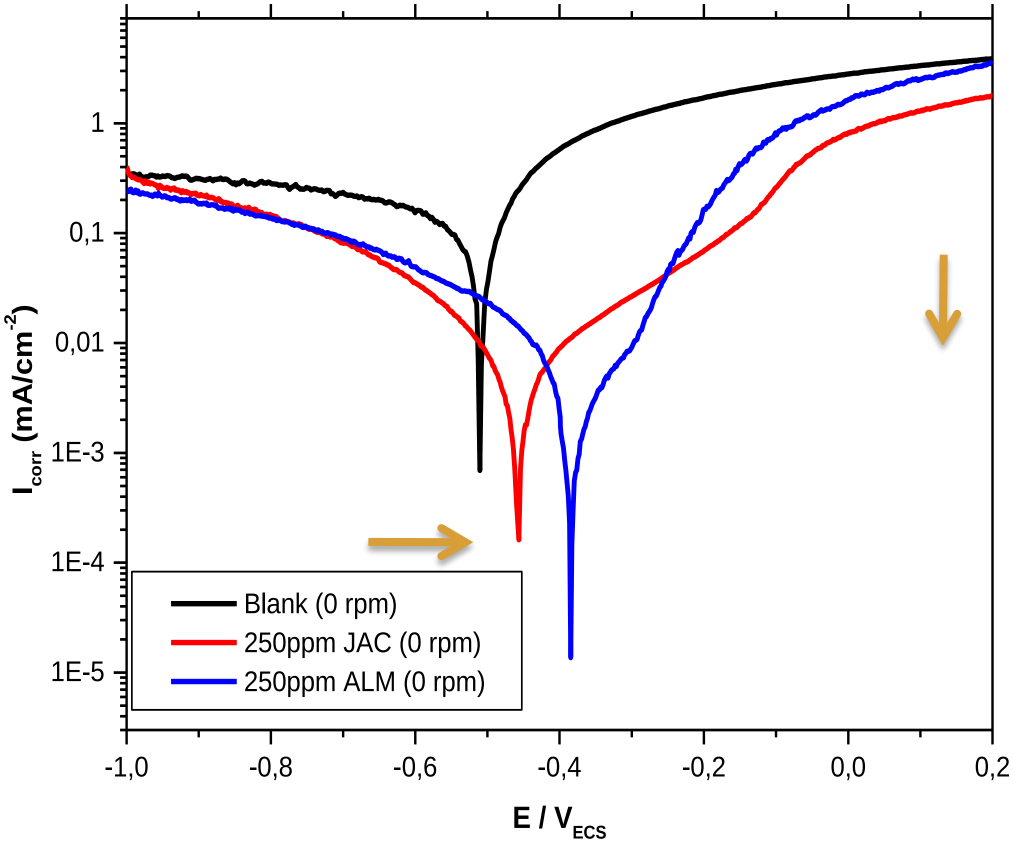
Histograms of the evolution of the inhibitory efficacy of JAC and ALM formulations as a function of the concentration

Open circuit potential (OCP)

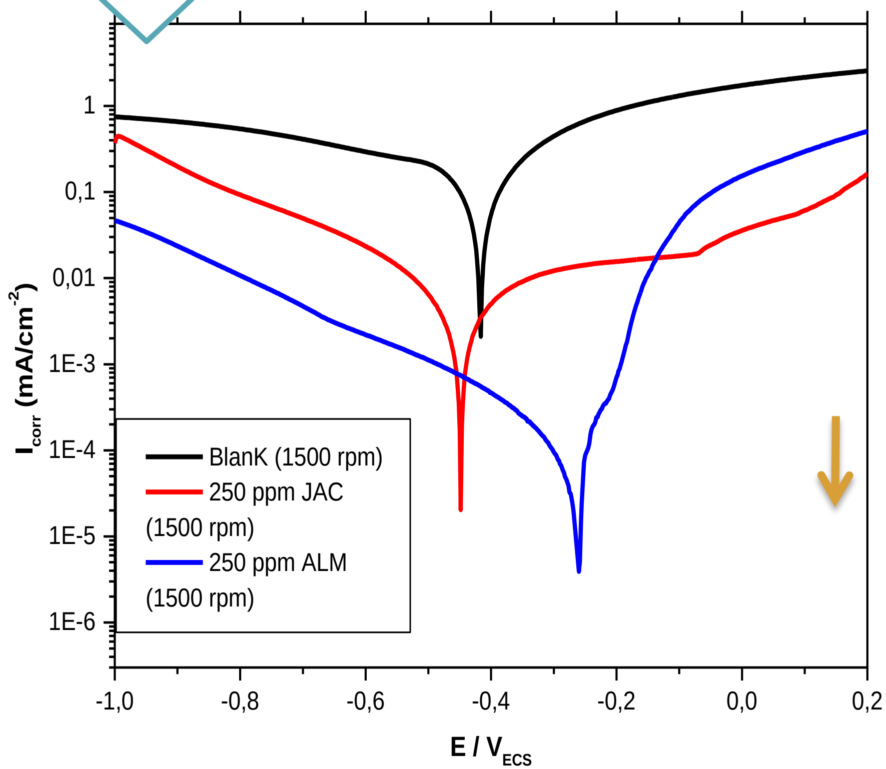


Variation of the open-circuit potential of iron in acidic rainwater solution at 250 ppm of the JAC and ALM formulations.

Rotating disc electrode effect of the JAC and ALM formulations



. Potentiodynamic polarization curves of iron substrate in the AR solution containing 250 ppm of the JAC and ALM formulations, at various rotation speeds



Mixed inhibitors

The corresponding reaction in the aerated acid rain solution at pH = 3.6 is expressed by

Eq: $O_2 + 4H + 4e^- \rightarrow 2H_2O$ (1)

$2H + 2e^- \rightarrow H_2$ (2)

$Fe \rightarrow Fe^{2+} + 2e^-$ (3)

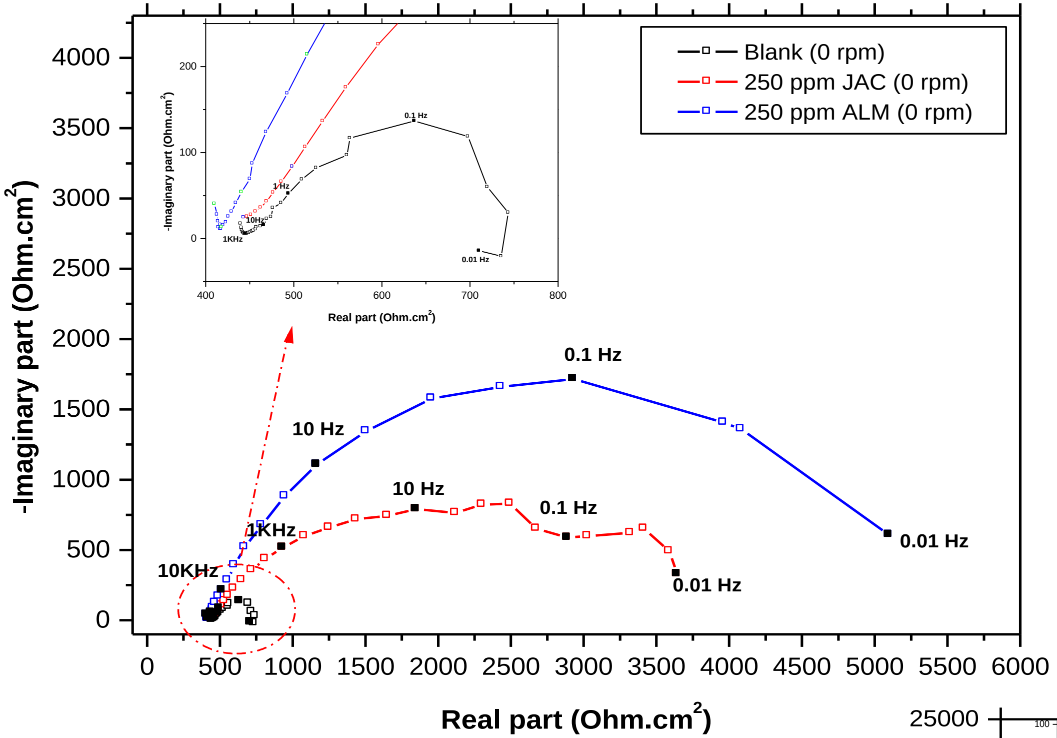
Kinetic parameters determined from polarization curves of the iron substrate in the AR solution without and with 250 ppm of the JAC and ALM formulations, respectively.

Kinetic parameters determined from polarization curves of the iron substrate in the AR solution without and with inhibitors					
Without Rotation speed (0 rpm)	**E_{corr} ($mV_{/SCE}$)**	**I_{corr} ($\mu A/cm^2$)**	**$-\beta c$ ($mVdec^{-1}$)**	**βa ($mVdec^{-1}$)**	**IE (%)**
AR Solution (pH=3.6)	-512.1±0.9	75.57±0.10	271.1±0.8	103.2±0.7	-----
250 ppm of JAC	-457.4±0.6	2.51±0.07	97.3±0.4	111.1±0.8	96.7±0.2
250 ppm of ALM	-384.2±0.7	2.03±0.05	89.5±0.3	128.4±0.4	97.3±0.1

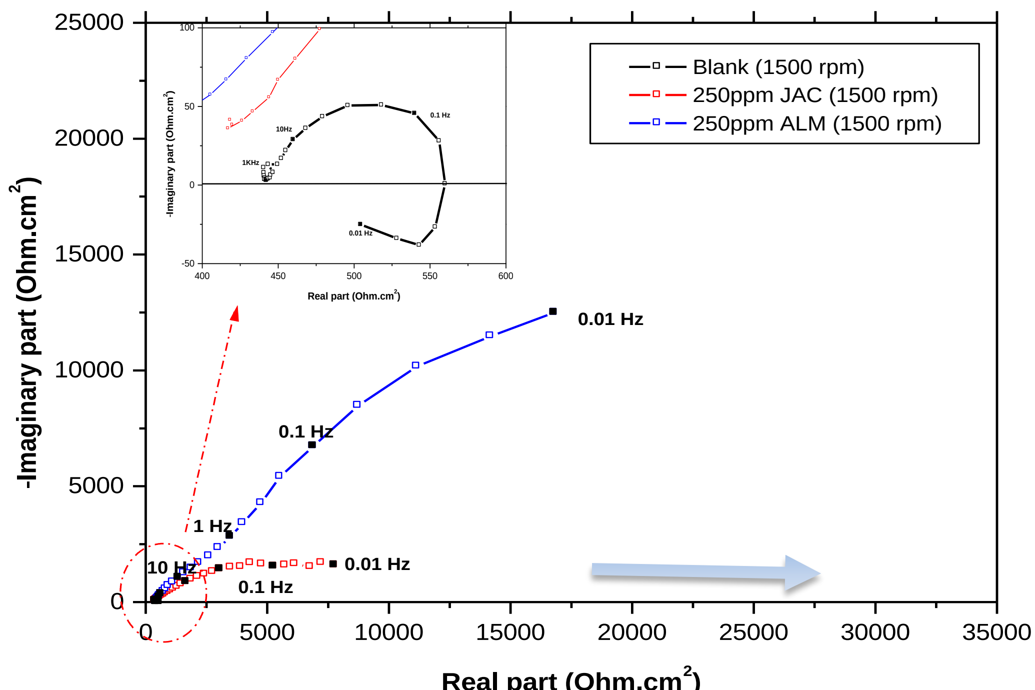
Current density (I_{corr})

Kinetic parameters determined from polarization curves of the iron substrate in the AR solution without and with inhibitors					
With Rotation speed (1500 rpm)	**E_{corr} ($mV/_{SCE}$)**	**I_{corr} ($\mu A/cm^2$)**	**$-\beta c$ ($mVdec^{-1}$)**	**βa ($mVdec^{-1}$)**	**IE (%)**
AR Solution (pH=3.6)	-418.3±0.8	100.42±0.09	278.4±0.7	176.3±0.9	-----
250 ppm of JAC	-449.4±0.8	1.77±0.03	110.1±0.5	140.4±0.9	98.2±0.4
250 ppm of ALM	-260.1±0.7	0.07±0.01	178.6±0.6	54.8.±0.9	99.9±0.3

Inhibition efficiency (IE)



Impedance diagrams of iron substrate in the AR solution without and with 250 ppm of the JAC and ALM formulations at various rotation speeds



Electrochemical data derived from the EIS spectra of the iron substrate in the AR solution without and with 250 ppm of the JAC and ALM formulations, respectively.

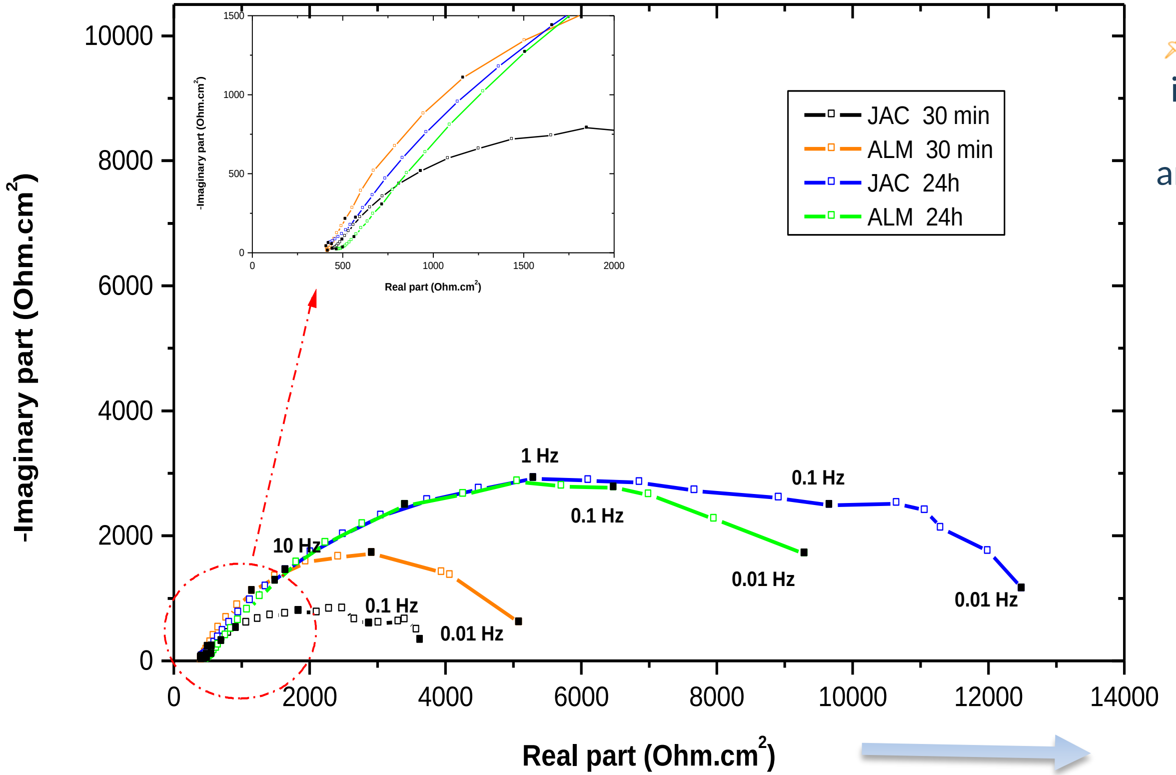
The Capacities

Electrochemical data derived from the EIS spectra of iron of the iron substrate in the AR solution without and with inhibitors							
Without Rotation speed (0 rpm)	**R_s (Ohm.cm²)**	**C_{HF} (µF/cm²)**	**R_{HF} (Ohm.cm²)**	**C_{BF} (µF/cm²)**	**R_{BF} (Ohm.cm²)**	**R_p (Ohm.cm²)**	
AR solution (pH=3.6)	433.1±0.9	82.15±0.16	164.3±0.6	702.10±0.26	203.4±0.6	367.1±0.8	
Inhibitors	**R_s (Ohm.cm²)**	**C_f (µF/cm²)**	**R_f (Ohm.cm²)**	**C_d (µF/cm²)**	**R_t (Ohm.cm²)**	**R_p (Ohm.cm²)**	**I E(%)**
250 ppm JAC	415.2±0.6	3.78±0.06	474.1±1.1	103.04±0.19	3036.4±2.8	3510.2±5.6	89.5±0.1
250 ppm ALM	424.3±0.7	6.92±0.03	1944.3±2.3	67.53±0.32	3124.2±1.9	5068.1±3.1	92.8±0.1

Electrochemical data derived from the EIS spectra of iron of the iron substrate in the AR solution without and with inhibitors							
With Rotation speed (1500 rpm)	**R_s (Ohm.cm²)**	**C_{HF} (µF/cm²)**	**R_{HF} (Ohm.cm²)**	**C_{BF} (µF/cm²)**	**R_{BF} (Ohm.cm²)**	**R_p (Ohm.cm²)**	
AR solution (pH=3.6)	400.1±0.3	217.35±0.18	62.3±0.4	3197.10±3.22	66.4±0.3	69.1±0.8	
Inhibitors	**R_s (Ohm.cm²)**	**C_f (µF/cm²)**	**R_f (Ohm.cm²)**	**C_d (µF/cm²)**	**R_t (Ohm.cm²)**	**R_p (Ohm.cm²)**	**I E(%)**
250 ppm JAC	361.3±0.5	0.186±0.014	2102.1±1.6	54.64±0.09	8472.4±3.5	10574.2±4.1	99.3±0.2
250 ppm ALM	444.3±0.8	2.732±0.023	7284.5±1.3	17.14±0.21	27002.2±4.2	34286.1±2.2	99.8±0.1

The Resistances

Immersion time effect of the JAC and ALM formulations



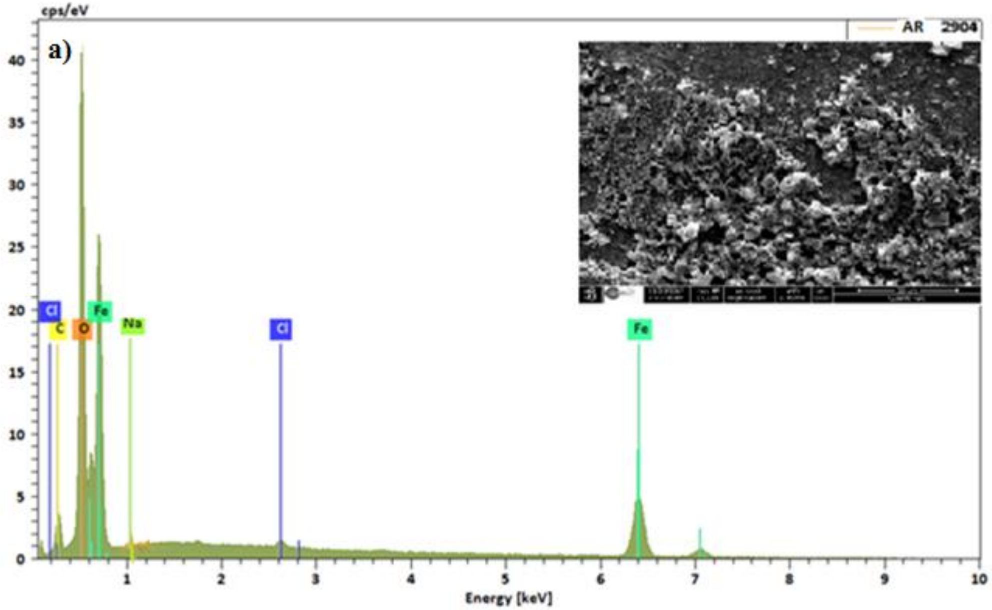
Nyquist impedance diagrams of iron electrode in the AR solution containing 250 ppm of the JAC and ALM formulations at different immersion time.

Electrochemical impedance parameters determined from Nyquist plot of iron substrate in the AR solution containing 250ppm of the JAC and ALM inhibitors at different immersion time.

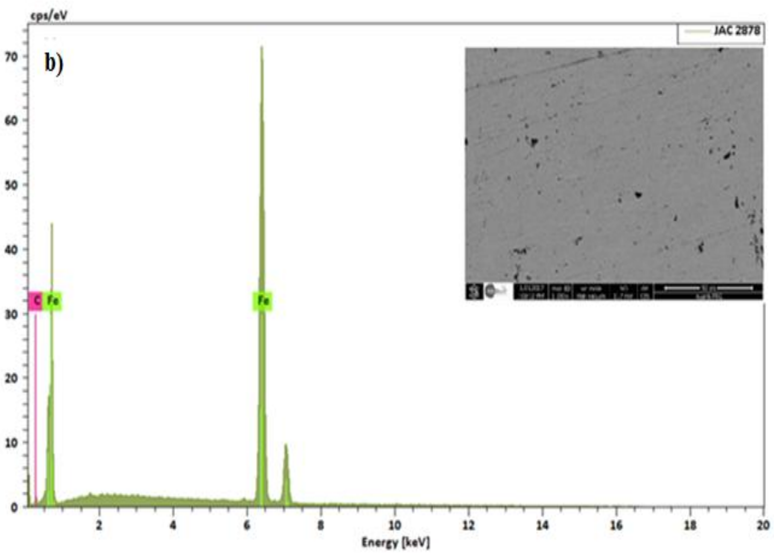
Immersion time	Inhibitors	R_s (Ohm.cm²)	C_f (µF/ cm²)	R_f (Ohm.cm²)	C_{dl} (µF/ cm²)	R_t (Ohm.cm²)	R_p (Ohm.cm²)
30 min	JAC	415.2±0.4	3.78±0.04	474.5±0.3	103.04±0.53	3036.3±1.9	3510.2±3.3
	ALM	424.1±0.3	6.92±0.07	1944.4±2.3	67.53±0.33	3124.2±2.3	5068.1±1.1
24h	JAC	448.3±0.3	1.65±0.03	2501.1±1.2	21,07±0.09	10012.4±4.3	12512.9±5.3
	ALM	476.2±0.5	5.12±0.09	2627.3±1.3	26.58±0.12	7936.1±1.5	10564.5±4.7

Surface Analysis

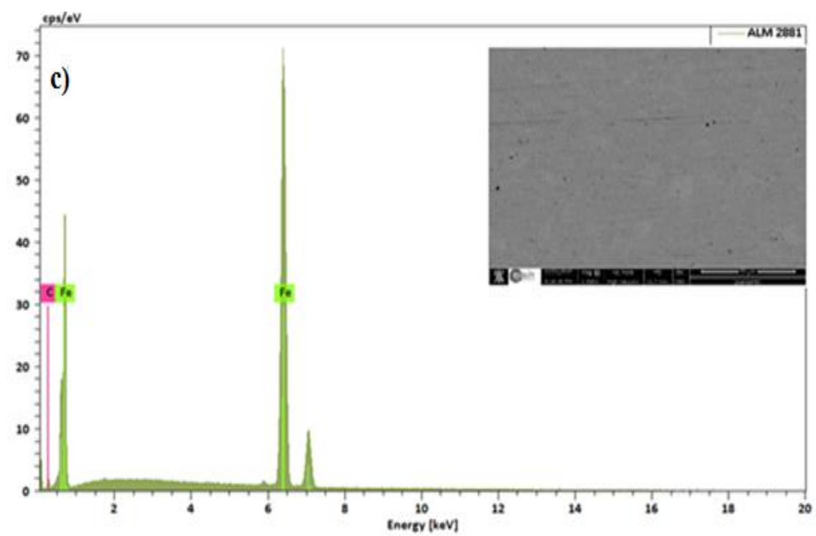
SEM and EDX spectrum of iron samples after 24 hours of immersion time



a) Immersed in a AR solution (pH=3.6)



b) Immersed in an acid solution at 250 ppm in JAC formulation



c) Immersed in an acid solution at 250 ppm in ALM formulation

Conclusion

- Fatty acid analysis has shown that ***Jatropha curcas*** and ***Aleurites moluccana*** seed oils are a major source of unsaturated fatty acids.
- According to obtained results and the potentiodynamic polarization plots demonstrated that JAC and ALM can effectively reduce the corrosion current density as a function of the concentration and rotation speed, indicating the mixed type protection character.
- The both formulations indicated the same behavior and results deducted from the polarization plot, proving that the inhibition efficiency is mainly due to the influence of unsaturated fatty acids.
- The hydrodynamic effect sharply influences the current density and the polarization resistance values, as well as the inhibitors's ability to protect iron against corrosion in an acidic solution. In the presence of the two formulations, the Inhibition efficiency increases considerably. However, this effect is more pronounced for the ALM formulation.
- The EIS plots were affected by the two studied variables, the sizes of the loops increased with the increase in the immersion time, which is more evidence for the JAC formulation.
- The good inhibitory effect of JAC and ALM attribute to the formation of a protective barrier composed of the fatty acid molecules on the metal surface.

Thank you
for your attention