STUDY OF NEW GREEN INHIBITOR FOR PROTECTION AGAINST CORROSION IN PIPE STEEL TRANSPORTATION

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Abstract

Industrial companies are unequal in the risk of internal corrosion degradation; their level of development and their approach to this risk is different. Our objective is focused on the optimization and the reinforcement of the safety against the corrosion defects. This study will show the better knowledge of the industrial risks which decide the prevention policy that should be to be applied. Several inhibitors extracted from medicinal plants were analyzed and the results showed that the green inhibitor based on some plants is the better anti-corrosion product for API X52 and X70 steels in the 1M solution of hydrochloric acid. Its good efficiency, compared to commercial inhibitors used by oil companies in transport and storage, is demonstrated. In this new project, we set the following objectives: to provide sufficient convincing scientific evidence to replace synthetic inhibitors that are very expensive and toxic to humans and the environment; to open a new line of research, promising to develop a new family of inexpensive inhibitors from bio-sources, and to offer the new products for protection against corrosion in different branch of industry. This project has a triple objective: to fight against corrosion, to valorise the natural resource and to propose an effective product against corrosion at very competitive cost. Creating an enterprise to make the inhibitor is an evident sequel.

1. Introduction

The corrosion of metals contains multiple phenomena related to the environment in which it takes place. In terms of protection, the inhibitors constitute the specific means to fight against the corrosion. A large number of inhibitors both organic and inorganic were the subject of an investigation to study their potential for corrosion inhibition. All these studies confirmed that the organic compounds, especially those containing N, S and O, demonstrate the significant efficiency in inhibition of metal's corrosion. Unfortunately, most of usable compounds are not only expensive but also toxic. These circumstances have led to the application of natural products as ecological and harmless anticorrosion agents. Very recently, many eco-friendly corrosion inhibitors that are not harmful to the environment have been developed. Plant extracts, an easily accessible and renewable source, have become important. We were interested in corrosion protection of the pipe steels with using of our eco-friendly inhibitor; the solution of the inhibitor Romarin was abandoned, because its effectiveness has not been proven. We have determined the physical sorption of Ruta Chalpensis on the surface of the steel. Electrochemical tests data showed that it can be use as an inhibitor with a concentration of 2g / L. In this new project, we intend to continue our research on pipe steel and extend the application of our inhibitor to other industrial area. Our approach will be as following: to define the effect of extracts of natural substances by using the electrochemical tests, to determine the laws of static, dynamics and fatigue behaviour of materials under large numbers of loading depending of the concentration of the inhibitor and to integrate the influence of the temperature and time on the inhibition ability of the considered extracts. The laboratory LEM3 equipped by the number of testing machines and analyses (Tomography, MEB, ESBD, DRX, etc).The management of the project would be in the following way: well define the tasks of every partner with a date of the beginning and a date of the end and establish their responsibility. The readiness for delivery connects the time, the budget and the fall-back solutions. Discussions, essential to a better progress of the project, will be scheduled.

2. Results

The project consists of the mechanical and electrochemical characterization of the effect of natural substance extract from Ruta Chalpensis (Figure 1.a) against the corrosion of two different pipeline steels

(API 5L X52 and X65) in the 1M solution of HCl. The results showed that the immersion of our steels in hydrochloric acid induces embrittlement by hydrogen. This embrittlement is prevented by the use of corrosion inhibitor. The extract of this plant improved their effect against the degradation of mechanical properties such as fracture elongation, Charpy energy, energy of defect initiation and fracture resistance. The efficiency increases with the concentration of the inhibitor and the immersion time. The adsorption of green inhibitor and the formation of the protective layer prevent the hydrogen adsorption. We also observed the detrimental effect of the immersion of Charpy specimens in the hydrochloric acid on dynamic fracture toughness. After 3 days of immersion, the addition of green inhibitor can recover 38% of the strength due to the prevention of recombination of the adsorbed hydrogen at the optimal concentration of 5%.

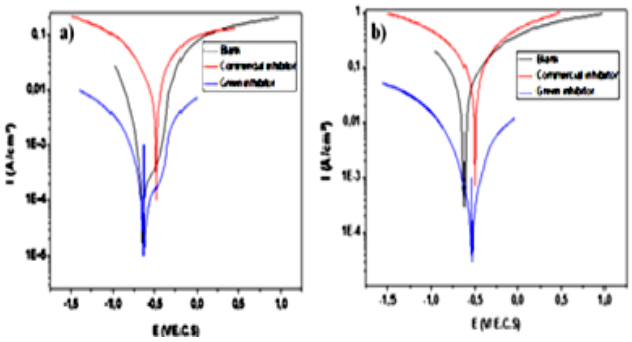


Fig.1 – Ruta Chalpensis: leaves and flowers, before and after drying. Fig.2 – Polarization curves of the API 5L X52 steel with and without addition of 0.5 g/L of the inhibitors in 1M solution of HCl: a) T = 298K; b) T = 353K.

Based on analysis of Tafel regions on the polarization curves (Figure 2) it has been found that the efficiency of the Ruta Chalpensis inhibitor for API 5L X52 steel in the 1M solution of HCl reaches its maximum value of 97.54% at a concentration of 5% at a temperature of 50 ° C, and 99.65% at a concentration of 10% at the same temperature.

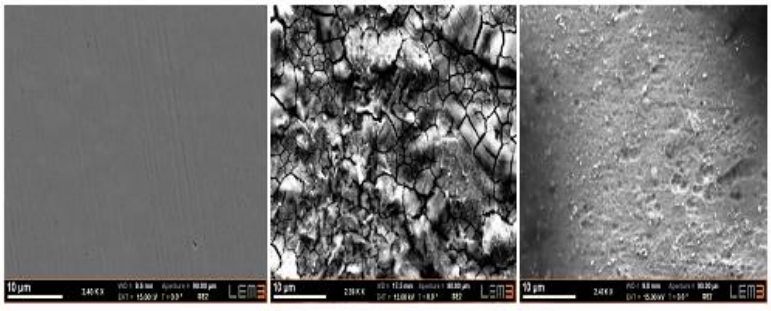
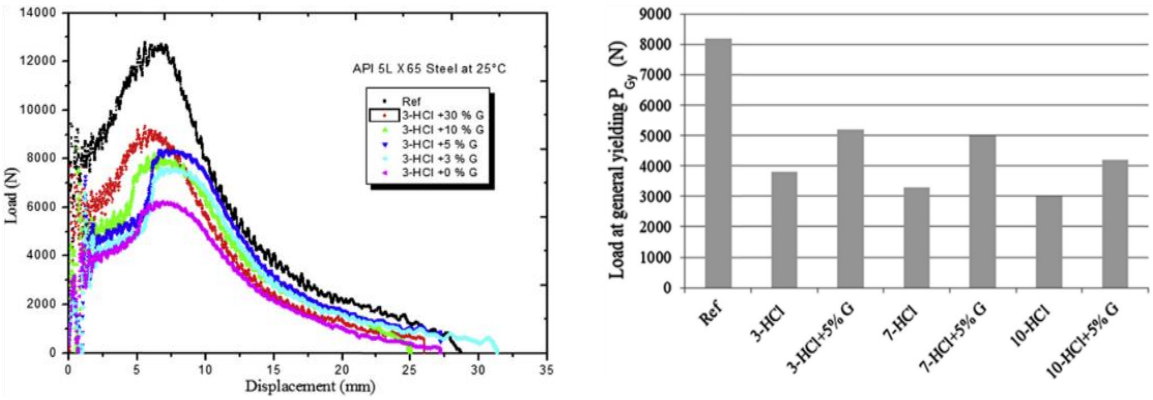


Fig.3 – SEM analysis of API 5L X52 steel: (a) after polishing, (b) after 24 h of immersion in 1M solution of HCl, (c) in the presence of 0.5 g / L of inhibitor

The observations of scanning electron microscopy (SEM) confirmed the presence of the protective layer which formed on the surface of the API 5L X52 steel (Figure 3).

Mechanical analysis

It has been found that the immersion of specimens in the hydrochloric acid solution leads to decrease more than 50% in the charge just after 3 days of immersion (Figure 4). Longer exposure in HCL causes a decrease in the PGY initiation charge.



(a) (b)

Fig.4 – (a) Typical Charpy load-displacement diagrams for specimens made of API 5L X65 steel at 25 C ; (b) the influence of different concentrations of the HCl and inhibitor.

Figure 5 shows the charge-displacement curves which obtained by Charpy tests instrumented after immersion the specimens in hydrochloric acid during 3, 7 and 10 days. The miscible characteristics of the fractured surfaces of the reference specimen (Figure 5a), suggest a strong adhesion to the ductile behaviour. Undamaged specimens show a mixed mode mechanism with more ductility. The specimens loaded with HCl (Figure 5b) show a mixed mode but with micro-voids very fragile and small. Figure 5c presents an optical microscopy with 3 days in 3% concentration of green inhibitor in the reference steel. The micrographs indicate that the ductility increases with the addition of our green inhibitor. Therefore, the fracture surface of API 65 steel became ductile due to the green inhibitor.

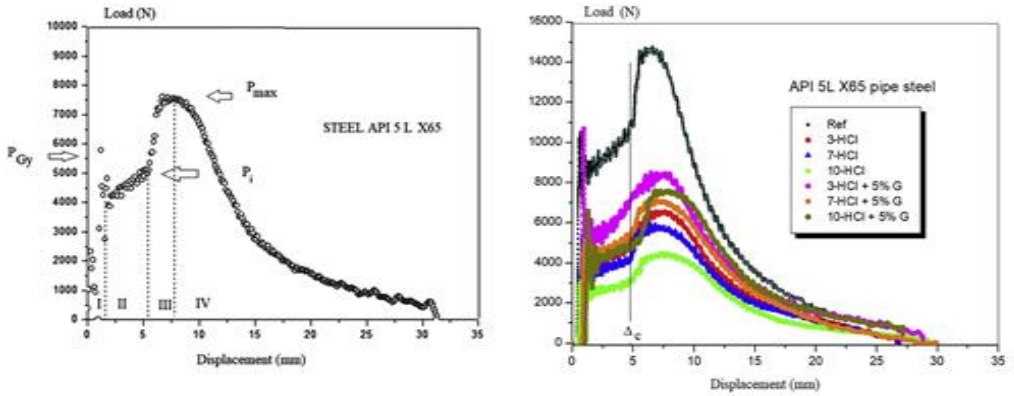


Fig.5 – Charpy charging for different baths.

3. Conclusions

the Expected impacts and opportunities deducing results for a scientific impact: New knowledge on the different mechanisms of damage to steels by corrosion and their prevention based on the specific physico-chemical effects of bio-inhibitors, Technological: Discovery of a new class of bio-inhibitors against steel corrosion, environmentally friendly, non-toxic and biodegradable, and socio-economic impact: saving oil and gas resources and avoiding environmental pollution; prospects for establishing a bio-inhibitor manufacturing company.

Acknowledgements

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