ISSN 0543-5846
METABK 63(3-4) 380-382 (2024)
UDC – UDK 620.193:620.197:678.742.084.1:620.17=111

TESTING OF MECHANICAL PROPERTIES OF THE VpCI-126 POLYETHYLENE INHIBITOR FILM

Received – Primljeno: 2024-02-07
Accepted – Prihvaćeno: 2024-04-10
Original Scientific Paper – Izvorni znanstveni rad

This paper describes results of experiment carried out on the VpCI-126 polyethylene inhibitor film with the aim to examine its mechanical properties. Test samples of the film were measured to determine the thickness, and then subjected to tear, fracture and puncture in order to examine mechanical properties that justify the wide application of this film in surface protection of materials. Volatile corrosion inhibitors, like the tested polyethylene inhibitor films, form a stable and reliable hydrophobic layer on the surface of the material, which prevents development of electrochemical corrosion mechanism. Results obtained in this experiment confirm very good mechanical properties of the tested film, thus justifying wide application of inhibitor films.

Key words: corrosion, surface protection, volatile corrosion inhibitors, mechanical properties, VpCI inhibitor film

INTRODUCTION

In all exploitation phases during service life of any metal structure, corrosion causes significant losses [1, 2]. In order to prevent corrosion damages, it is necessary to apply an appropriate surface protection technology that will provide the best results against the occurrence of corrosion. Such protection technology may act as a changer of internal or external damage factors, or as a creator of a barrier between the protected material and environmental influences [3]. Protecting the material by creation of a barrier is widely used, since 75 % of metal structures are protected by organic coating [4]. However, a protective barrier on the metal surface that prevents the contact of aggressive reactants from the environment can be achieved in several ways. Vapor-phase corrosion inhibitor films (VpCI) are widely used as protectors against corrosion. In appropriate concentrations and with a high vapor pressure, volatile corrosion inhibitors form a hydrophobic layer on the surface of the material, which prevents the exchange of ions and development of electrochemical corrosion [5]. Because of their efficiency as corrosion protectors, volatile corrosion inhibitors are used in many industrial branches, such as oil and gas industry, chemical and process industry, etc [6-8]. The mentioned protection system can be applied in several ways, one of which is coating of metal products with polyethylene inhibitor film. Such film is impregnated with inhibitors, so when wrapped around a metal product, it forms a closed space into which vapors are released to provide a protective effect. In this experiment, the VpCI-126 polyethylene inhibitor film was tested to determine its mechanical properties. The obtained results proved good mechanical properties and extensive application possibilities. In addition to high-quality corrosion inhibitor, mechanical properties of a protection system have to be reliable, meaning that films have to be stable to deliver satisfactory service.

G. Pačarek, V. Štigler, Faculty of Agrobiotechnical Sciences Osijek, Josip Juraj Strossmayer University of Osijek, Croatia.
T. Šolić (tsolic@unisb.hr), Mechanical Engineering Faculty in Slavonski Brod, University of Slavonski Brod, Croatia.
M. Samardžić, Industroremont Ltd., Croatia.

EXPERIMENTAL PART

Within the experiment, test samples were made out of VpCI-126 inhibitor film and measured to determine their thickness. Then the samples were tested in a testing machine to determine the tear strength, fracture strength and elongation. Samples were also tested for fracture and puncture. The experiment was carried out on 12 samples, and the obtained results were analyzed to define the mechanical properties of the tested VpCI-126 film.

Measurement of the VpCI film thickness

Thickness of the polyethylene inhibitor film of the VpCI-126 series was measured by the FTG-ISO4593 thickness gauge (Figure 1). Out of 12 samples prepared for measurement, six samples were measured in longitudinal direction (along the direction of the fibers), while the other six samples were measured in horizontal direction (horizontally to the fibers). The film thickness can vary, so in longitudinal direction there was 0,011 mm thickness range between the minimum and maximum thickness, while in the horizontal direction the film thickness range was 0,013 mm.

Figure 1 Thickness gauge

The results obtained by measuring of the film thickness are presented in Figure 2.

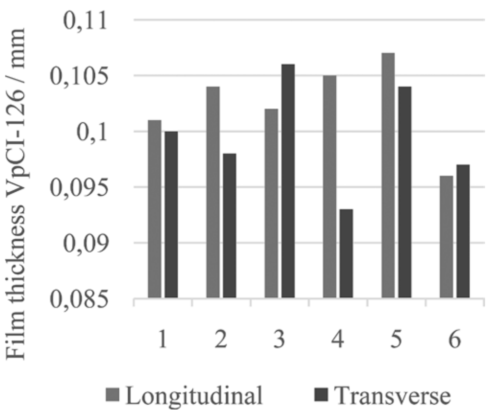

Figure 2 Thickness of test samples

The thinnest film measured in the longitudinal direction was 0,096 mm, while the thickest was 0,107 mm. The average thickness of the film in the longitudinal direction was 0,102 mm. When measured horizontally, the thinnest film had a value of 0,093 mm, while the thickest was 0,106 mm. The average thickness of the film in the horizontal direction was 0,099 mm.

Tearing test

Testing of the film to tearing was conducted on the Instron 4443 testing machine, presented in Figure 3. The test was performed by stretching the sample in the machine to measure the tear strength. Obtained measures indicated the tear strength, fracture strength and elongation of the test samples.

The highest measured strength for tearing the test sample in the longitudinal direction was 69,72 N, while the least tear strength for the same direction was 52 N. The average tear strength in the longitudinal direction of the tested film was 63,43 N. The highest measured tear strength in the horizontal direction of the test sample was 71,36 N, while the least tear strength was 51,19 N. The average strength for tearing the test sample in horizontal direction was 65,65 N. When comparing the tear strength of both directions, it was confirmed that the greater strength was required to tear the sample film in horizontal direction. Values referring to the tear strength of the samples are shown in Figure 4.

Figure 3 Tensile tester used for measuring the film tear strength

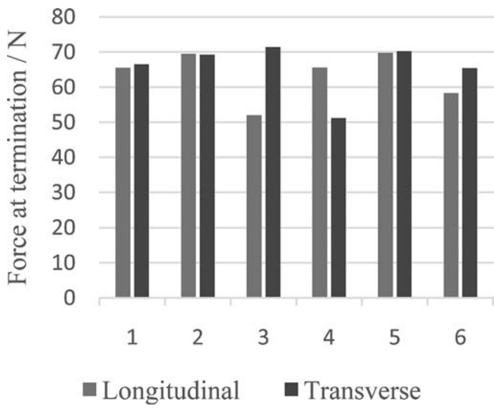

Figure 4 Tear strength of the tested film samples

The highest tensile strength of the tested film for its longitudinal direction was 26,29 N/mm^2, while the least one was 20,07 N/mm^2. Average tensile strength of the samples tested in its longitudinal direction was 24,34 N/mm^2. The highest tensile strength of the samples measured in the horizontal direction was 27,81 N/mm^2, and the least one was 21,67 N/mm^2. Average tensile strength of the tested samples in their horizontal direction was 25,88 N/mm^2. When comparing the values of tensile strength (Figure 5), it was concluded that the tensile strength measured for the horizontal direction was higher than the one measured for the longitudinal direction.

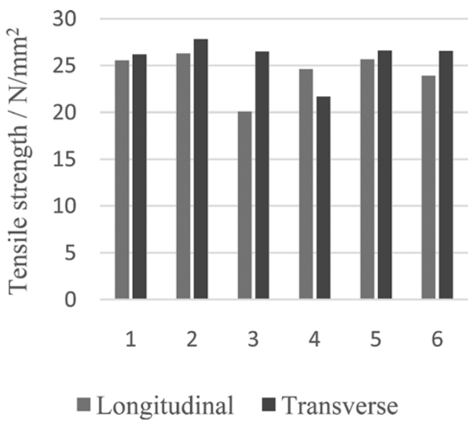

Figure 5 Tensile strength of the tested film samples

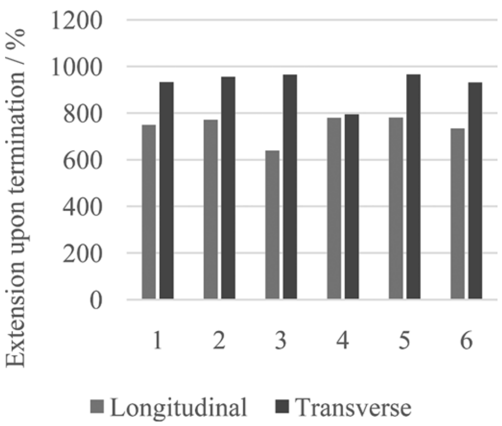

Figure 6 Percentage values referring to elongation of the samples

When measured in the longitudinal direction, elongation of the VpCI film at the fracture point was on average 377 mm, i.e. 742,1 % of the initial value, while elongation in the horizontal direction was on average 469,4 mm, i.e. 923,9 %. The Figure 6 presents values of elongation of the tested film samples.

Testing of fracture and puncture

Testing of film samples for fracture and puncture was performed on the Spencer Impact Test ASTM D3420 device equipped with a pendulum of 3 200 g. When testing fracture, VpCI film was placed on clamps to make it stationary. Before starting the impact test for fracture, a crack was made on the film. The measurement was performed by swinging the pendulum of 3 200 g through the clamped specimen with sufficient force to propagate the previously made crack. Values obtained by the impact test are presented in Figure 7. Testing of film puncture was done by the same pendulum, but in this procedure, pendulum was swinging into undamaged film. Force applied to puncture the sample was read on the device scale.

Average force required to fracture the tested VpCI film in its longitudinal direction was 8,21 N, while the same force applied in horizontal direction was 19,62 N. The fracture force applied in the horizontal direction of the sample was for 239 % greater than the force applied in longitudinal direction. Average force required to puncture the film was 16,74 N, while average energy needed for puncturing the sample was 1,44 J.

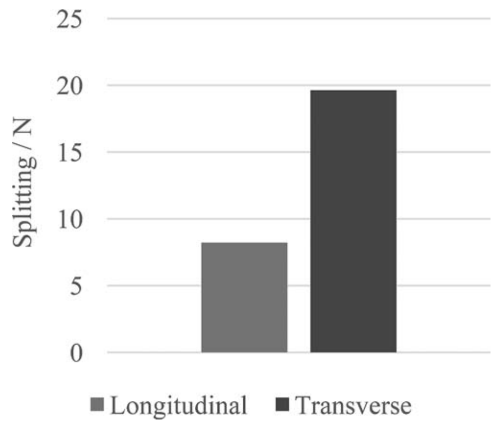

Figure 7 Force required to fracture the samples

CONCLUSION

Results obtained by performed measurements indicate the mechanical properties of the VpCI-126 film, which proved to be very good. Therefore, the tested film is suitable for extensive application in protection of metal products. The quality of the tested film is consistent in various exploitation conditions where materials need to be protected from mechanical damages. Mechanically stable film is also expected to deliver its protective effect. Since the tested film proved to be mechanically stable, volatile corrosion inhibitors will be able to provide appropriate protection when the film is wrapped around the material, because the vapor pressure will provide the protective layer. A barrier made by the inhibitory layer on the surface of material will prevent the transfer of reactants and the development of corrosion mechanisms, thus reducing the costs connected with the repair of damages.

Application of appropriate corrosion inhibitors is also recommended by the World Corrosion Organization, which states that proper corrosion prevention methods and technologies could reduce costs related to corrosion damages by up to 35 %.

REFERENCES

[1] A. O. Gadioli, L. M. de Souza, E. C. Pereira, S. N. Monteiro, A. R. G. Azevedo: imidazolium-based ionic liquids as corrosion inhibitors for stainless steel in different corrosive media: An overview, Journal of Materials Research and Technology 29 (2024), 803-823
[2] A. Al-Amiery, W. N. R. W. Isahak, W. K. Al-Azzawi: Sustainable corrosion Inhibitors: A kex step towards environmentally responsible corrosion control, Ain Shams Engineering Journal (2024), 102672
[3] NACE International: International Measures of Prevention, Application, and Economics of Corrosion Technologies Study, Texas, USA, 2016, p. 72
[4] T. Šolić, D. Marić, D. Novoselović, I. Samardžić: Optimization of Parameters for Protection of Materials by Primer Application, Coatings 12 (2022), 413
[5] E. Vuorinen, A. Botha: Optimisation of a humidity chamber method for the quantitative evaluation of vapour phase corrosion inhibitors for mild steel, Measurement 46 (2013) 9, 3612-3615
[6] L. Souza, E. Pereira, L. Matlakhova, V. A. F. Nicolin, S. N. Monteiro, A. R. G. de Azevedo: Ionic liquids as corrosion inhibitors for carbon steel protection in hydrochloric acid solution: A first review, Journal of Materials Research and Technology 22 (2023), 2186-2205
[7] A. Zhang, Y. Wang, H. Wang: Preparation of inorganic-polymer nano-emulsion inhibitor for corrosion resistance of steel reinforcement for concrete, Alexandia Engineering Journal 66 (2023), 537-542
[8] V. Alar, I. Stojanović, D. Mezdić: A Comparative Study of Green Inhibitors for Galvanized Steel in Aqueous Solutions, Metals 10 (2020) 4, 448

Note: Responsible person for English translation: Martina Šuto.