



Int. J. New. Chem., 2021, Vol. 8, Issue 2, pp 149-163.

International Journal of New Chemistry

Published online 2020 in <http://www.ijnc.ir/>.

Open Access

Print ISSN: 2645-7236

Online ISSN: 2383-188x



Original Research Article

Optimization of Corrosion Information in Oil and Gas Wells Using Electrochemical Experiments

Amir Samimi^{1,2*}, Soroush Zarinabadi³, Alireza Bozorgian¹

¹Department of Chemical Engineering, Mahshahr Branch, Islamic Azad University, Mahshahr, Iran

²Isfahan Oil Refinery Company, Gasoline Production Plant, Isfahan, Iran

³Department of Engineering, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

Received: 2019-11-08

Accepted: 2020-03-22

Published: 2021-06-01

ABSTRACT

Corrosion reactions are often complex heterogeneous reactions that are accelerated by interactions such as: common kinetic considerations, electrolyte chemical composition, mass transfer between the electrolyte and the metal surface, Different surface effects such as adsorption, desorption and surface hardness are determined. The interactions between these factors make it difficult to reproduce electrochemical data or precise conditions that cause a metal to be corroded. These are the experimental factors that must be considered when corrosion tests are being designed. Ignoring these factors can produce data that does not provide the true corrosion behavior of the test metal under study. This paper presents the relationship between the inherent errors of corrosion measurement and suggestions on how to handle variability of electrochemical data.

Keywords: Corrosion reactions, Interaction rate, Activation energy, electrochemical data.

Introduction

Corrosion reactions are often complex heterogeneous reactions whose velocity is influenced by interactions such as:

- a) Common kinetic considerations (such as activation energy)
- b) Chemical composition of electrolyte
- c) Mass transfer between electrolyte and metal surface
- d) Different surface effects such as adsorption, desorption and surface hardness are identified.

The interactions between these factors make it difficult to reproduce electrochemical data or precise conditions that cause a metal to corrode. These are the experimental factors that must be taken into account when corrosion tests and test tubes are being designed. Ignoring these factors can produce data that does not provide the true corrosion behavior of the test metal under study. For example, neglecting the neutralization of the solute resistor can produce an electrochemical corrosion rate that is under real velocity estimates and can lead to a metal structure whose thickness is insufficient to prevent fracture due to narrow corrosion [1-3].

Electrochemical Testing

Figure 1 shows a battery of electrochemical corrosion experiments involving three electrodes immersed in an electrolyte. The electrical current of a potentiostat changes a potential electrode's potential from its open-circuit potential (OCP) to the potential value specified by the potentiostat current volume. Since the electrode potential change from open circuit potential is referred to as the creation of two poles, the electric current must be simultaneously and symmetrically controlled by a test electrode when the current is provided for the inverted electrode to maintain electronic equipment and electrical neutrality[4-7]. The polarization of the tested electrodes is measured as the potential difference between the reference and the test electrodes. The reference electrode is also used to provide feedback to the potentiostat, so that the potential of the test electrode can be seen and adapted to a desired surface.

The relationship between the range of electrode potentials and their associated electrical currents, or the range of voltage frequencies and apparent resistance values can be used to characterize the corrosion behavior such as:

- If a metal becomes impermeable (not corroded)
- If pitting corrosion occurs
- Does the veneer protect against corrosion
- Does metal corrosion occur with the coating?

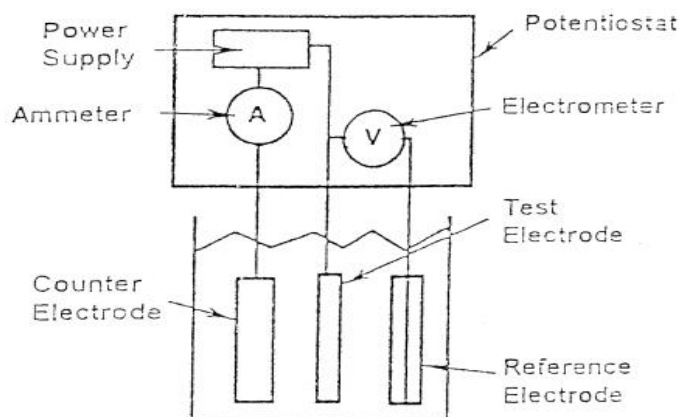


Figure 1. Schematic of the three-electrode test chamber

Potential or frequency flow data - apparent resistance can be used to determine corrosion parameters [8-11].

- Two-layer electrical capacitance
- Speed of corrosion
- Corrosion resistance
- Effective cladding electrical capacity and daytime resistance

What happens when the current between the test and reverse electrodes is established?

The creation of two poles of the test electrode is controlled by the potentiostat providing the electrons for the reverse electrodes. There are many factors other than the potential acetate current that can control the volume of the electrode's polarity contrasts. As:

- Chemical composition of the tested electrode
- Surface status of the test and reverse electrode
- Geometric shapes of the test and reverse electrodes
- Size of the reverse electrode
- Chemical composition of the electric double layers
- Electrolyte chemical composition

The polarity contraction of the electrode causes certain processes in the electrolyte to be able to limit the electrical current during the measurement of electrochemical corrosion, such as traffic congestion or road conditions that can create conditions where the number of outgoing machines per hour of the highway. Figure 1 contains a schematic figure of an experimental battery in which the reference electrode is ejected to allow space to show the various processes occurring during the polar opposite [12]. The electrode polarization units respond by moving between the inverted electrodes and the experiment to maintain the electrode neutrality of the electrodes and the electrolyte. Electrochemically, the active species moves to the opposite electrode and reacts with the electrons provided by the potentiostat. Potentiostat in figure 2 provides the electrons for the inverse electrode, causing the positive ions (cations) to move toward the inverse electrode. Potentiostat discharges electrons from the test electrode and the negative ions move to the test electrode [13].

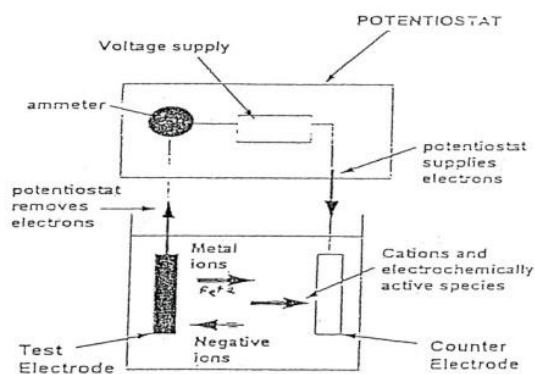


Figure 2. Fluid flow during electrode polarization

There are situations where the corrosion data does not reflect the actual corrosion because one or more of the processes shown in figure 2 do not behave ideally. Then the potentiostat will only be able to repel 1000 electrons per second from the test electrode, even if it can repel twice the number of electrons per second. The next section discusses how the properties of an electrolyte can reduce the flow rate excreted from the test electrode by a potentiostat and thereby discuss the electrochemical data and its relation to the actual corrosion behavior and velocity.

How solubility resistance affects corrosion data

Imagine how a slow-moving car would slow down other cars stuck in busy traffic, thus reducing the number of cars coming in and out of the highway every second. Slow-moving ions, like slow-moving machines, can limit the amount of electric current exerted from the electrode. In open circulation, the ions have the potential to travel short distances between the cathode and anodic sites on the metal surface rusting to maintain the metal's electrical neutrality, so the ion movement has little or no effect on corrosion. But during the electrode polarization, the ions often travel longer distances along the current paths formed by the electric field between the test electrodes and the reverse in an electrolyte. The ion velocity along these flow paths is determined by the dynamics of the ion as the charge and frictional tension of the ion as it moves across the electrolyte is the task of ion concentration. Ideally the electrolyte ions move so fast along the flow paths that the movement of the ions does not limit the potentiostat electric current. True electrolyte ions can hardly be used along potential pathways to move ions between electrodes rather than polarize the provided electrons. Subsequently the applied potential is different from the polarization potential and a method must be employed to ensure that the potentials of the electrodes tested are at the optimum level [14-16].

Therefore, there is a need for a reference electrode to see and provide feedback to accommodate the potential of the test electrode. The best and most ideal way to measure the potential of the test electrode during polarization is to place the reference electrode on the surface of the test electrode. However, placing the reference electrode on the surface of the test electrode blocks the movement of the ionic current to the test electrode at the point of contact and can lead to a hole-like corrosion. The reference electrode should be positioned as far as the diameter of the two reference electrodes beyond the surface of the test electrode to avoid blocking the test electrode. Unfortunately, separation of reference and experimental electrodes can cause a potential difference between them, referred to as IR drop, which prevents the actual polarization of the electrode being measured [16-20]. The electrical resistance associated with the IR drop is referred to as the neutral solution resistance and the mathematical expression of the neutral solution resistance is as follows:

$$R_{\Omega} = \frac{(d)(R_{sol})}{A} \quad (1)$$

R_{Ω} is the resistance of the neutral solution to the ohm.

D The distance between the test and reference electrodes is in centimeters.

R_{sol} The specific resistance of the solution to the ohm is in centimeters.

A: The area of the electrode is in square centimeters.

Modification of electrochemical corrosion data for unsaturated solution resistance: Current disconnection method

The current disconnection method emphasizes the fact that the volume is zero when the current is not provided by potentiostat (equal to the potentiostat current multiplied), and the means of determining how much potentiostat is neutralized due to the resistance of the solution. The potentiostat is programmed to cut off the potentiostat at certain intervals for a short time and subsequently measures the potential of the test electrode while the current is zero. The difference is between the potential of the test electrode with and without the potentiostat current. Potentiostat plans to adapt the applied voltage to the value, thereby neutralizing the resistance of the neutral solution, and potentiostat to resume or decrease the polarization of the electrode from the data set. There are situations where the solubility and potentiostat resistance and are so low that there is no need for a cut-off method to correct the potential used. Using the current cut-off in this example can generate a lot of electronic noise in the potential-flow data, as shown in the rotational polarization curve in Figure 1, 2 and 3. The stripes seen in the upper curve are the electrical noises created by the process of disconnection. Remember that the noise level for the top curve is lower when currents are 10^{-6} amps per square centimeter or more [20]. The bottom curve in figure 1 and 3 shows what the curve without interruption of current looks like. Notice how bottom curve is when the current is not cut off.

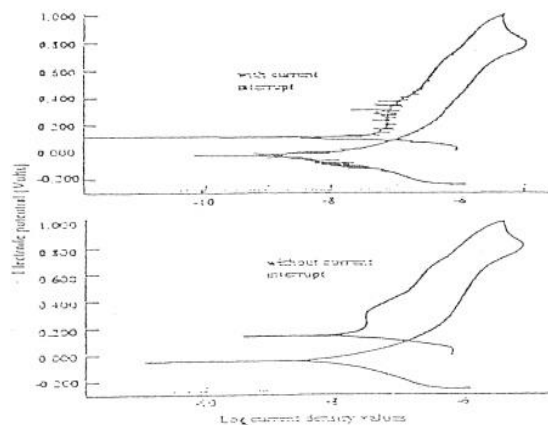


Figure 3. Noise produced by a cut off when the solute resistance and electrical current are low.

Test electrode area

The corresponding equation (equation one) shows that the solute resistance can be lowered by A) Increasing the electrode area, B) Reducing the distance between the electrodes, C) Reducing the solubility. The specific resistance of the solution can be reduced by adding aqueous solution, mineral salts. There is a limit to how a reference electrode can be tested near the surface of the electrode. Therefore, reducing the reference electrode spacing - the test does not completely eliminate the resistance of the neutralized solution.

The Area of the Inverted Electrode

Reducing the area of the inverted electrode, or reducing the access to the surface of the inverted electrode, reduces the room for electro-chemically active reduction of electrons and restricts the electric current of the potentiostat discharged from the test electrode. Large surface area inverted electrodes, such as platinum deposited, are often used to reduce the current limitation of the electrode area. The inverting electrode, whose geometric area is at least twice the area of the test electrode, is often used when it is not feasible to use deposited platinum reverse electrodes.

Geometric shape of the test electrode

Electrical neutralization of the polarized electrode is maintained by the movement of positive and negative ions along the current paths maintained by an electric field between the test electrodes and the polarized inverse in an electrolyte. Electrochemically active species can also move along flow paths, especially when ions resemble hydrogen ions (figure 4 and 5). The

current density for this simple geometry is the total electric current of the potentiostat divided by the area of the electrode (amps).

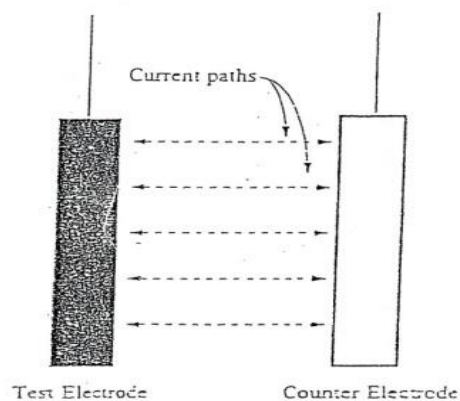


Figure 4. Ionic flow paths for simple electrode geometry

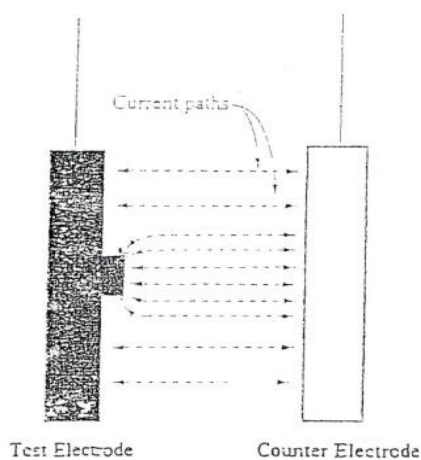


Figure 5. Ionic current flows for complex electrode geometry

Variability of electrochemical corrosion data

The variability of the data will be observed even when the experimental factors discussed so far have been taken into account for this experimental design. Data variability often makes it difficult to use electrochemical corrosion data to get conclusions about what kind of corrosion behavior or velocity is expected from a real system. Figures 4, 5 and 6 contain examples of electrochemical variability. Figure 6 contains 30 repetitive anodic polarization curves of 1018

type non-coated soft steel and contains 99 spectra of repetition spectra of electro-chemical resistivity of the coated metal specimens.

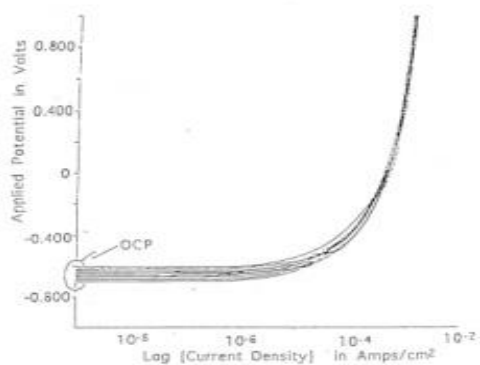


Figure 6. Variability in electrochemical corrosion anodic polarization data

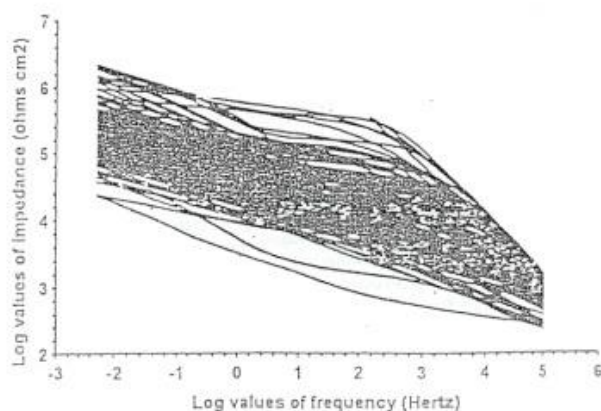


Figure 7. Variability in spectral data of electro-chemical apparent resistance

The range of values of current density and open current potential are shown in Figure 7. However, all test electrodes come from the same batch and at the same time the test electrolyte for each of the test batteries flows from the same source. The range of apparent resistivity values for the coated metals is shown in Figure 7, although all of the test electrodes were of the same batch production and the test electrolyte of deionized water was 18 ohms and the degree of reactive potassium chloride. Variability in corrosion data can originate from (a) measurement errors, (b) chemical variability on the surface of an electrode, (c) local coating of chemical variability, and (d) inherent variability in nature. Changes in corrosion data corrupt engineer or scientist with two practical questions:

- How much repetition should be done for each metal environmental variable?
- How such data should be analyzed?
- How many iterations for each electrolyte metal variable?

It is very difficult to answer the question about the number of repetitions required for each metal-electrolyte variable. The error in the mean value (for the normally distributed data) for the repeated measures group is estimated from Equation 2.

$$Er^* = \frac{z\sigma}{n} \quad (2)$$

Er^* The difference between the correct average and the estimated average is from the group of duplicates.

σ The standard deviation is the duplicates (2).

n The number of measurements is repeated.

Z The level of statistical confidence is desirable.

Equation 2 shows that errors are reduced by a) increasing sample size b) standard deviation c) accepting lower statistical confidence.

Optimization of images from industrial radiography for the detection of corrosion and sediment in oil and gas transmission pipelines Location domain method:

In the image processing toolbox, there are four types of image. The image type determines how the content software treats the data for each pixel as its corresponding gray levels. These four types are: binary, indexed images, gray area and RGB. A gray area image is a matrix whose values represent brightness intensities in the range of zero to 255. Content software sees a gray-level image as a two-dimensional matrix with pixel elements. In this section, the input color image will be grayed out for further processing.

Draw an image histogram and adjust it:

An image histogram is a demonstration of how brightness values are distributed throughout the image. The histogram information helps in selecting the appropriate optimization operation. If the histogram of an image is clustered around small values, it can be spread over a wider range to improve image contrast. This is called a histogram adjustment.

Change the image class:

In the Matlab software, with the filter command, different linear filters can be applied to the image with the desired window sizes. The output values of the filter function are of type double. The most important issue in this respect is to get out of bounds, in which case the Matlab software changes them according to the input image class. If the input image type is unit8 and negative values are created in the filter output, these negative values are automatically changed to zero. In many cases this is not desirable. It is advisable to convert the image type from unit8 to the correct sign type before performing a convolution, correction or other math operation. In this section, the initial image class is converted from unit8 to the double class.

$$Er^* = \frac{z\sigma}{n} \quad (3)$$

Er^* The difference between the correct average and the estimated average is from the group of duplicates.

σ The standard deviation is the duplicates (3).

n The number of measurements is repeated.

Z The level of statistical confidence is desirable.

Fourier transform is the representation of an image as a set of different views with different amplitude, frequency and phase. Fourier transform plays an important role in many aspects of image processing including filtering, compression, optimization, retrieval and image analysis. In the software, Fourier Transform Fast (FFT) algorithms are used to capture the Fourier transform of an image. It should be noted that in most cases, the Fourier transform of an image is a log domain. Logarithms represent a much wider range. In order to be able to see the Fourier transform more clearly and to reduce the interference effects, one can add the original image to zero 1 and extend the DFT. This part of the image is taken for later processing of the Fourier

transform. The pre-processing step involves determining the image size, designing the required filters, and the last step of the post processing figure involves calculating the actual part, cropping a part of the image, changing the image class.

How to use the Violet Tool box

As explained in full in the preceding section, the violet or wavelet is actually a sinusoidal wave whose variations are limited, with the mean being zero. Violet is a valuable tool in analyzing various signals such as speech signals, images, music and so on. Compared to the Fourier transform, it can be stated that the Fourier signal, which by converting the primary signal to a set of sine signals with different frequencies, shows good signal properties over a period of time, in the case of non-stationary signals 1 over a period. When it changes a lot, it doesn't work. However, the wavelet transform provides a suitable response for these signals. Therefore, wavelet transform as a powerful tool in the expression of signal properties is of particular importance. One of the important features of wavelet conversion is the ability to analyze the signal locally, while the Fourier transform does not. For example, consider a continuous sinusoidal wave that has been broken at one time. If we take this signal for the Fourier transform and the wavelet transform, it can be seen that the discontinuity is not specified in the Fourier coefficients, whereas in the graph obtained from the wavelet coefficients this characteristic is shown in the form of two peaks. Digital images are exposed to different types of noise. The noise source can be in the digital imaging device, or if the scanned sample image is an analogue image, damage to the film and printing problems may be the source of the noise. Electronic transmission of the image can also cause noise. So eliminating noise from the image is one of the main goals of image optimization. To remove noise from the image, the nature of the noise must first be recognized and then noise eliminated by spatial or frequency methods. What is important in noise removal is to remove as much noise as possible from the image. Most types of noise recorded in images include shock and Gaussian noises. The method used is particularly attractive. The idea behind this method is to perform three independent transforms on the gray surface of each input pixel. The three outputs then enter the red, green, and blue guns of the color TV display separately. This method produces a composite image whose color content is modulated by the nature of the conversion functions. Note that these conversions convert the image gray level values, but are not location-dependent.

Conclusion

In this study, more than forty radiographic images of oil and gas pipes (with inner diameter between 19-154 mm and outer diameter between 23-175 mm and with different sizes of corrosion and sealant) were tested, two standard pieces and then from various processes, very small corrosions of 1.5 mm were also detected and their defects were clearly distinguished from each other. The standard parts mentioned above are made in artificial form. In the figures shown in this chapter, although the digitized image of the tube is of poor quality and defective areas are not clearly identified, the processed images reveal the corrosion processed parts very carefully. In the gray-scale images, the darker areas indicate the possibility of corrosion and the lighter parts indicate the possibility of sedimentation, and in the color images, the darker blue areas indicate the possibility of corrosion and the darker areas indicate the possibility of sedimentation. At this stage, following the above processes, the use of skilled people in the field to detect pipeline faults is associated with a near zero error. According to the figures and figures in the article, it can be said that the corrosion data are not normally distributed, but instead are logarithmically distributed. The statistical functions in the handheld calculators are normally distributed for the data. It is subsequently recommended that the corrosion data be returned to the logarithm prior to the use of the manual calculator statistical functions to calculate mean values. The pipeline has an error close to zero. Using arithmetic statistical functions on non-returned data can lead to inaccurate mean values. Fortunately, the electrochemical corrosion software reports most of the current values in logarithms and makes the corrosion currents reversible before calculating the mean values. There is an easier way to analyze corrosion data than to calculate mean values. And that is the scatter chart. The scatter charts allow the data to be analyzed without turning it into another, computing mean values or assumptions about what kind of probability density function (statistical distribution) should be used to compute mean values. An easier way to analyze corrosion data than to calculate values also allows scatter charts to see infinite values. Infinite values contain important corrosion information. Infinite values such as low corrosion resistance, or high corrosion rate can cause initial damage to fuzzy structures. Infinite values can be discarded from the data if they are the result of measurement errors or known experimental errors. Non-parametric statistical experiments can be used to determine whether the results of the two variables are the same without having to a) specify what kind of

statistical distribution is for the data, or b) use large number of iterations until normal statistical tests can be applied to the data. For example, the Whitney man test can determine whether the corrosion currents for stainless steel types 304 and 316 are statistically identical when the number of repeated measurements for each grade is small. Normal statistical experiments require more patterns for the same determination. Return analysis is the most common type of statistical analysis used for corrosion data. Recursive analysis should always be accompanied by a) variance analysis and b) residual analysis. The reported equations (models) without these two statistics are not properly validated and should be looked at with suspicion.

References

- [1] A. Samimi, K. Kavosi, S. Zarinabadi, A. Bozorgian, *Prog. Chem. Biochem. Res.*, 3, 7 (2020).
- [2] J. Mashhadizadeh, A. Bozorgian, A. Azimi, *Eurasian Chem. Commun.*, 2, 4 (2019).
- [3] D. Mohammadnazar, A. Samimi, *J. Chem. Rev.*, 1, 252 (2019).
- [4] A. Samimi, S. Zarinabadi, A.H.S. Kootenaei, A. Azimi, M. Mirzaei, *S. Afr. J. Chem. Eng.*, 31, 44, (2020).
- [5] M.E. Bidhendi, Z. Asadi, A. Bozorgian, A. Shahhoseini, M.A. Gabris, S. Shahabuddin, R. Khanam, S. Rahman, *RSC Advances*, 6, 80 (2016).
- [6] I. Ali, W.A. Wani, *Synth React Tnorg M Journal*, 43, 1162 (2013).
- [7] T. Bedassa, M. Desalegne, *Int. J. New. Chem.*, 7, 47 (2020).
- [8] A. Samimi, S. Zarinabadi, AHS. Kootenaei, A. Azimi, M. Mirzaei, *J. Chem. Rev.*, 1, 164 (2019).
- [9] S.V. Mousavi, A. Bozorgian, N. Mokhtari, M.A. Gabris, H. Rashidi, W.A. Wan Ibrahim, *Mic J*, 1, 145 (2019).

- [10] S. Kumer, M. Ebrahimikia, M. Yari, *Int. J. New. Chem.*, 7, 74 (2020).
- [11] M. Noormohammadi; M. Barmala, *Int. J. New. Chem.*, 6, 289 (2019).
- [12] K. M. Elsherif, A. Zubi, A. Najar, E. Bazina, *To Chem.*, 1, 214 (2018).
- [13] A.P. Arumugam, G. Elango, S. Guhanathan, *Int. J. New. Chem.*, 6, 1 (2019).
- [14] K.M. Elsherif, A. Najar, H. Shuwat, and E. Bazina, *J. App. Chem. Sci. Int.*, 7, 181 (2016).
- [15] M. Shamsipur, F. Nasri, A. Taherpour, *J. Incl. Phenom. Macrocycl. Chem.*, 78, 429 (2014).
- [16] T. Bedassa, A. Gure, N. Megersa, *J. Anal. Chem.*, 70, 1199 (2015).
- [17] A.D. Archivio, M. Fanelli, F.P. Mazzeo, *Talanta.*, 71, 25 (2007).
- [18] M. A. Farajzadeh, S. E. Seyedi, M. S. Shalamzari, T. M. Bamorowa, *J. Sep. Sci.*, 32, 3191 (2009).
- [19] A. Bozorgian, Z. Arab Aboosadi, A. Mohammadi, B. Honarvar, A. Azimi, *Eurasian Chem. Commun.*, 2, 420 (2020).
- [20] S. Mekonen, A. Ambelu, B. Negassa, P. Spanoghe, *Regul. Toxicol. Pharmacol.*, 87, 64 (2017).

How to Cite This Article

Amir Samimi, Soroush Zarinabadi, Alireza Bozorgian, "Optimization of Corrosion Information in Oil and Gas Wells Using Electrochemical Experiments" *International Journal of New Chemistry*, **2021**, **8(2)**, **149-163**; DOI: 10.22034/ijnc.2020.116946.1066.