Research Article

Corrosion Inhibition and Adsorption Properties of Ethanolic Extract of *Calotropis* for Corrosion of Aluminium in Acidic Media

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The corrosion inhibition of aluminium in sulfuric acid solution in the presence of different plant parts, namely, leaves, latex, and fruit was studied using weight loss method and thermometric method. The ethanolic extracts of *Calotropis procera* and *Calotropis gigantea* act as an inhibitor in the acid environment. The inhibition efficiency increases with increase in inhibitor concentration. The plant parts inhibit aluminium, and inhibition is attributed, due to the adsorption of the plant part on the surface of aluminium.

1. Introduction

Aluminium is widely used in chemical industries due to its low cost and easy availability for fabrication reaction of vessel, tanks, pipeline, and boiler. Aluminium suffers from severe corrosion in aggressive environments, and it has to be protected. The corrosion of metal in aqueous solution occurs in two steps oxidation and reduction. Oxidation reaction takes place at anode, whereas reduction takes place at cathode. The cathodic reaction may be either by evolution of hydrogen or absorption of oxygen. The use of inhibitors is one of the best methods of protecting metals against corrosion [1, 2]. Most corrosion inhibitors are organic compounds having hetero atoms in their aromatic or long carbon chain. However, there is increasing concern about the toxicity of most corrosion inhibitors. The toxic effect does not only affect living organisms but also poison the environment. Due to toxicity of some corrosion inhibitors, there has been increasing search for green corrosion inhibitors [3]. Natural products of plant origin containing different organic compounds (e.g., alkaloids, tannins, pigments, organic, and amino acids) are known to have inhibitive action [4, 5]. Inhibitors in this class are those that are environment friendly, less polluting, cheap, and easily available and are obtained from natural products such as plant extracts [6]. Several studies have been carried out on the inhibition of corrosion of metals by plant extract [7–13]. Aluminium is a reactive metal to reduce the corrosion problem in these environment inhibitive effects of various naturally occurring substances like *Datura stramonium* [14], *Tannin beet root*, *Tamarind*, *Pomegranate juice*, *Saponin* [15], *Embellica officinalis*, *Terminalia bellerica*, *Mahasudarshanachurna*, *Prosopis juliflora* [16], *Caparis decidu* [17], *Adhatoda vasica*, *Vinca rosea*, *Heena* [18], *Eugenia jambolana*, *pomegranate* and *Peels* [19, 20], *Tannins*, *Caffeine*, *Prosopis cineraria* [21], and *Ficus religiosa* [22] that have been evaluated as effective corrosion inhibitors. *Calotropis* is used as a traditional medicinal plant with unique properties. *Calotropis* is used alone or with other medicine to treat common diseases. Generally, organic compounds having heteroatom O, N, and S are found to have basicity and electron density thus assist in corrosion inhibitor. O, N, and S are the active centers for the adsorption on the metal surface [23, 24]. Mass loss is determined gravimetrically, volumetrically, and radiometrically. These all are the direct measures of corrosion, and gravimetrically mass loss methods are most used for inhibitor testing.
2. Extraction of Plants and Experimental Methods

Samples of *Calotropis procera* and *Calotropis gigantea* obtained from the Maharshi Dayanand Sarswati University Botanical Garden were dried, grinded, and soaked in a solution of ethanol. After 48 hours, the sample was cooled and filtered. The filtrate was subjected to evaporation (in order to leave the sample free of the ethanol) using a rotary evaporator. The stock solution of the extract so obtained was used in preparing 0.5 N, 1.0 N H₂SO₄ for mass loss method and 3 N, 4 N, and 5 N H₂SO₄ for thermometric analysis, respectively.

Aluminium of composition (wt%) Mn (0.6), P (0.36), C (0.15), S (0.07), and Al (98.79) was used for the study. The sheet was mechanically pressed and cut to form different coupons, each of dimensions, 2.5 cm * 1.5 cm * 0.2 cm. Each coupon was degreased by washing with ethanol. The washed sample was dipped in acetone, removed, and allowed to dry in air before use. All reagents used for the study were AR grade, and deionized water was used for their preparation.

Aluminium specimens were cleaned with emery paper. The corrosion products were cleaned with Clark’s solution [25]. The weight of the specimens before and after immersion was determined using a Shimadzu balance. Specimens were suspended by glass hook; the degree of surface coverage (θ) is calculated by the formula [26]

$$\theta = \frac{(\Delta M_u - \Delta M_i)}{\Delta M_i}, \quad (1)$$

where θ is surface coverage and \(\Delta M_u\) and \(\Delta M_i\) are the mass loss of the metal in uninhibited and inhibited acids, respectively.

The corrosion rate mmpy (millimeter penetration per year) is obtained by the following equation [27]:

$$\text{Corrosion rate (mmpy)} = \frac{\text{(Mass loss × 87.6)}}{\text{(Area × Time × Metal density)}}, \quad (2)$$

where mass loss is expressed in mg, area is expressed in cm² of metal surface exposed, time is expressed in hours of exposure, metal density is expressed in gm/cm³, and 87.6 is the conversion factor.

Inhibition efficiency was also determined using a thermometric technique [28]. Each specimen 2.5 cm * 1.5 cm * 0.02 cm was placed in a glass hook and immersed in a beaker containing 50 mL of test solution at 30 °C ± 0.5 °C and exposed to air. Evaporation losses were made up with deionized water. After the test specimens were cleaned with acetone [29], duplicate experiments were performed in each case, and mean values of the mass loss were calculated.

The acidic solutions (0.5 N, 1 N, 2 N, and 4 N) were prepared by using deionized water. Temperature changes were measured at intervals of one minute using a thermometer with a precision of ±0.5 °C. The temperatures increased slowly in the beginning, maximum temperature attained slowly in the beginning, maximum temperature attained

where mass loss is expressed in mg, area is expressed in cm² of metal surface exposed, time is expressed in hours of exposure, metal density is expressed in gm/cm³, and 87.6 is the conversion factor.

Inhibition efficiency (%) calculated from the mass loss method for sulfuric acid solution and inhibitors are given in Tables 1, 2, 3, and 4. It is observed that the inhibition efficiency increases with increase in the concentration of inhibitor and decreases with increases in acid strength.

The inhibition efficiency was also determined using a thermometric technique [28]. Each specimen 2.5 cm * 1.5 cm * 0.02 cm was placed in a glass hook and immersed in a beaker containing 50 mL of test solution at 30 °C ± 0.5 °C and exposed to air. Evaporation losses were made up with deionized water. After the test specimens were cleaned with acetone [29], duplicate experiments were performed in each case, and mean values of the mass loss were calculated.

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The inhibition efficiency (%) calculated from the mass loss measurement for sulfuric acid solution and inhibitors are given in Tables 1, 2, 3, and 4. It is observed that the inhibition efficiency increases with increase in the concentration of inhibitor and decreases with increases in acid strength. The corrosion rate decreases with increases in concentration of inhibitor. The maximum efficiency was obtained in low acid concentration. The inhibitors show the efficiency in this range. *Calotropis procera* shows minimum 45.00% and maximum 82.98% whereas *Calotropis gigantea* shows minimum 43.26% and maximum 82.98% for 0.5 N sulfuric acid with aluminium, but *Calotropis procera* in 1 N sulfuric acid solution shows minimum 48.58% and maximum 78.86% inhibition efficiency, and *Calotropis gigantea* shows minimum 48.69% and maximum 78.82% inhibition efficiency with latex extract illustrated by Figures 1, 2, 3, and 4.
Inhibition efficiency values were also determined by the thermometric method (Tables 5 and 6). Temperature changes for aluminium in 2 N, 3 N, 4 N, and 5 N sulfuric acid solutions were recorded at various inhibitor concentrations. However, no significance temperature changes were obtained for 1 N sulfuric acid solution. Therefore, the thermometric method was used for 2 N, 3 N, 4 N, and 5 N sulfuric acid solution. *Calotropis procera* extract shows minimum inhibition efficiency 34.15% and maximum 73.58% for 2 N sulfuric acid, but 3 N sulfuric acid shows minimum 28.83% and maximum 68.56%, while 4 N sulfuric acid shows minimum 37.43% and maximum 67.87%, and 5 N sulfuric acid shows minimum 25.21% and maximum 62.26% (Tables 7 and 8).

Generally, the adsorption of organic molecules involves O, N, and S atoms. This process blocks the active sites and hence decreases the corrosion rate. In the present study, it was assumed that the plant extract is adsorbed on the metal surface and decreases the surface area available for cathodic and anodic reaction to take place. The nitrogen, sulphur and oxygen may be responsible for the adsorption. Organic inhibitors, with active portions, contain generally large C–H chains or rings with positively charged amine nitrogen group at the one end.

Organic corrosion inhibitors may function as follows:

1. chemisorption of the molecule on the metallic surface;
2. complexing of the molecule with the metal ion which remains in solid state;
3. neutralising the corrodent;
4. adsorbing the corrodent.

They offered large coverage due to the long hydrocarbon chain and by the presence of –OH group, being hydrophilic in nature; the –OH group counteracted the effects of chain length and ensured higher solubility.

Cathodic inhibitors slow down the reaction taking place at cathode (i.e., H₂ evolution).

For example, organic inhibitors like amine substituted urea’s heavy metal soap and so forth decreases H₂ evolution process. Aluminium salts deposits on cathode help in decreasing the O₂ absorption process.

### 4. Absorption of Oxygen

This type of corrosion occurs generally in aqueous solution.
### Table 1: Mass loss data for aluminium in 0.5 N sulfuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis procera*.

| Inhibitor concentration | Mass loss (gm) | Inhibition efficiency (%) | Corrosion rate (mmpy) | Surface coverage (θ) |
|-------------------------|----------------|---------------------------|-----------------------|---------------------|
| Uninhibited             | 1840           |                            | 33.1                  |                     |
| Leaves                  |                |                           |                       |                     |
| 0.12                    | 1012           | 45.00                     | 18.2                  | 0.4500              |
| 0.24                    | 872            | 52.60                     | 15.7                  | 0.5260              |
| 0.36                    | 653            | 64.51                     | 11.7                  | 0.6451              |
| 0.48                    | 487            | 73.53                     | 8.77                  | 0.7353              |
| 0.60                    | 348            | 81.08                     | 6.27                  | 0.8108              |
| Latex                   |                |                           |                       |                     |
| 0.12                    | 987            | 46.35                     | 17.7                  | 0.4635              |
| 0.24                    | 856            | 53.47                     | 15.4                  | 0.5347              |
| 0.36                    | 641            | 65.16                     | 11.5                  | 0.6516              |
| 0.48                    | 465            | 74.72                     | 9.43                  | 0.7472              |
| 0.60                    | 313            | 82.98                     | 5.64                  | 0.8298              |
| Fruit                   |                |                           |                       |                     |
| 0.12                    | 1026           | 44.23                     | 18.4                  | 0.4423              |
| 0.24                    | 898            | 51.39                     | 16.1                  | 0.5119              |
| 0.36                    | 674            | 63.36                     | 12.1                  | 0.6336              |
| 0.48                    | 465            | 74.72                     | 8.38                  | 0.7472              |
| 0.60                    | 338            | 81.63                     | 6.09                  | 0.8163              |

### Table 2: Mass loss data for aluminium in 0.5 N sulfuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis gigantea*.

| Inhibitor concentration | Mass loss (gm) | Inhibition efficiency (%) | Corrosion rate (mmpy) | Surface coverage (θ) |
|-------------------------|----------------|---------------------------|-----------------------|---------------------|
| Uninhibited             | 1840           |                            | 33.1                  |                     |
| Leaves                  |                |                           |                       |                     |
| 0.12                    | 1023           | 44.40                     | 18.4                  | 0.4440              |
| 0.24                    | 851            | 53.73                     | 15.3                  | 0.5373              |
| 0.36                    | 634            | 65.54                     | 11.4                  | 0.6554              |
| 0.48                    | 465            | 74.72                     | 8.38                  | 0.7472              |
| 0.60                    | 327            | 82.22                     | 5.89                  | 0.8222              |
| Latex                   |                |                           |                       |                     |
| 0.12                    | 951            | 48.31                     | 17.1                  | 0.4831              |
| 0.24                    | 833            | 54.72                     | 15.0                  | 0.5472              |
| 0.36                    | 627            | 65.92                     | 11.3                  | 0.6592              |
| 0.48                    | 442            | 75.97                     | 7.96                  | 0.7597              |
| 0.60                    | 316            | 82.82                     | 5.69                  | 0.8282              |
| Fruit                   |                |                           |                       |                     |
| 0.12                    | 1044           | 43.26                     | 18.8                  | 0.4326              |
| 0.24                    | 875            | 52.44                     | 15.7                  | 0.5244              |
| 0.36                    | 653            | 64.51                     | 11.7                  | 0.6451              |
| 0.48                    | 482            | 73.80                     | 8.68                  | 0.7380              |
| 0.60                    | 319            | 82.66                     | 5.74                  | 0.8266              |
### Table 3: Mass loss data for aluminium in 1.0 N sulfuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis procera*.

| Inhibitor Concentration | Mass loss (gm) | Inhibition efficiency (%) | Corrosion rate (mmpy) | Surface coverage (°) |
|-------------------------|----------------|---------------------------|-----------------------|---------------------|
| Uninhibited             | 2460           |                           | 44.3                  |                     |
| Leaves                  |                |                           |                       |                     |
| 0.12                    | 1242           | 49.51                     | 22.3                  | 0.4951              |
| 0.24                    | 935            | 61.99                     | 16.8                  | 0.6199              |
| 0.36                    | 721            | 70.69                     | 12.9                  | 0.7069              |
| 0.48                    | 663            | 73.04                     | 11.9                  | 0.7304              |
| 0.60                    | 548            | 77.72                     | 9.87                  | 0.7772              |
| Latex                   |                |                           |                       |                     |
| 0.12                    | 1263           | 48.58                     | 22.7                  | 0.4858              |
| 0.24                    | 931            | 62.15                     | 16.7                  | 0.6215              |
| 0.36                    | 748            | 69.59                     | 13.4                  | 0.6959              |
| 0.48                    | 625            | 74.59                     | 11.2                  | 0.7459              |
| 0.60                    | 520            | 78.86                     | 9.37                  | 0.7886              |
| Fruit                   |                |                           |                       |                     |
| 0.12                    | 1186           | 51.78                     | 21.3                  | 0.5178              |
| 0.24                    | 958            | 61.05                     | 17.2                  | 0.6105              |
| 0.36                    | 712            | 71.05                     | 12.8                  | 0.7105              |
| 0.48                    | 643            | 73.86                     | 11.5                  | 0.7386              |
| 0.60                    | 574            | 76.66                     | 10.3                  | 0.7666              |

### Table 4: Mass loss data for aluminium in 1.0 N sulfuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis gigantea*.

| Inhibitor concentration | Mass loss (gm) | Inhibition efficiency (%) | Corrosion rate (mmpy) | Surface coverage (°) |
|-------------------------|----------------|---------------------------|-----------------------|---------------------|
| Uninhibited             | 2460           |                           | 44.3                  |                     |
| Leaves                  |                |                           |                       |                     |
| 0.12                    | 1262           | 48.69                     | 22.7                  | 0.4869              |
| 0.24                    | 957            | 61.09                     | 17.2                  | 0.6109              |
| 0.36                    | 734            | 70.16                     | 13.2                  | 0.7016              |
| 0.48                    | 641            | 73.94                     | 11.5                  | 0.7394              |
| 0.60                    | 523            | 78.73                     | 9.42                  | 0.7873              |
| Latex                   |                |                           |                       |                     |
| 0.12                    | 1244           | 49.43                     | 22.4                  | 0.4943              |
| 0.24                    | 950            | 61.38                     | 17.1                  | 0.6138              |
| 0.36                    | 763            | 68.98                     | 13.7                  | 0.6898              |
| 0.48                    | 619            | 74.83                     | 11.1                  | 0.7483              |
| 0.60                    | 521            | 78.82                     | 9.39                  | 0.7882              |
| Fruit                   |                |                           |                       |                     |
| 0.12                    | 1164           | 52.68                     | 20.9                  | 0.5268              |
| 0.24                    | 934            | 62.03                     | 16.8                  | 0.6203              |
| 0.36                    | 727            | 70.44                     | 13.1                  | 0.7044              |
| 0.48                    | 651            | 73.53                     | 11.7                  | 0.7353              |
| 0.60                    | 543            | 77.92                     | 9.78                  | 0.7792              |
Table 5: Thermometric reaction for aluminium in 2 N and 3 N sulphuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis procera*.

| Inhibitor concentration | Reaction number (RN) 2 N | Reaction number (RN) 3 N | Inhibition efficiency (%) | Inhibition efficiency (%) |
|-------------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Uninhibited             | 1.26                    | 1.91                    |                           |                           |
| Leaves                  |                         |                         |                           |                           |
| 0.12                    | 0.81                    | 35.65                   | 127                       | 33.63                     |
| 0.24                    | 0.76                    | 39.21                   | 1.20                      | 37.13                     |
| 0.36                    | 0.70                    | 44.27                   | 1.15                      | 39.69                     |
| 0.48                    | 0.51                    | 59.53                   | 0.80                      | 58.07                     |
| 0.60                    | 0.40                    | 67.83                   | 0.67                      | 64.60                     |
| Latex                   |                         |                         |                           |                           |
| 0.12                    | 0.83                    | 34.15                   | 1.26                      | 34.05                     |
| 0.24                    | 0.78                    | 37.94                   | 1.25                      | 34.67                     |
| 0.36                    | 0.71                    | 43.32                   | 0.95                      | 50.08                     |
| 0.48                    | 0.54                    | 57.15                   | 0.84                      | 51.33                     |
| 0.60                    | 0.41                    | 67.43                   | 0.76                      | 62.66                     |
| Fruit                   |                         |                         |                           |                           |
| 0.12                    | 0.78                    | 38.02                   | 1.38                      | 27.83                     |
| 0.24                    | 0.71                    | 43.40                   | 1.32                      | 31.07                     |
| 0.36                    | 0.64                    | 49.01                   | 1.11                      | 41.67                     |
| 0.48                    | 0.48                    | 61.34                   | 0.75                      | 60.63                     |
| 0.60                    | 0.34                    | 72.96                   | 0.59                      | 69.03                     |

Table 6: Thermometric reaction for aluminium in 4 N and 5 N sulphuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis procera*.

| Inhibitor concentration | Reaction number (RN) 4 N | Reaction number (RN) 5 N | Inhibition efficiency (%) | Inhibition efficiency (%) |
|-------------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Uninhibited             | 2.48                    | 3.10                    |                           |                           |
| Leaves                  |                         |                         |                           |                           |
| 0.12                    | 1.58                    | 36.36                   | 2.27                      | 26.83                     |
| 0.24                    | 1.55                    | 37.37                   | 2.05                      | 33.86                     |
| 0.36                    | 1.50                    | 39.38                   | 1.92                      | 38.11                     |
| 0.48                    | 1.02                    | 58.61                   | 1.60                      | 48.32                     |
| 0.60                    | 0.89                    | 63.87                   | 1.20                      | 61.15                     |
| Latex                   |                         |                         |                           |                           |
| 0.12                    | 1.46                    | 41.19                   | 2.42                      | 21.84                     |
| 0.24                    | 1.40                    | 43.64                   | 2.11                      | 31.89                     |
| 0.36                    | 1.26                    | 49.12                   | 2.08                      | 32.89                     |
| 0.48                    | 1.12                    | 54.87                   | 1.84                      | 40.56                     |
| 0.60                    | 0.94                    | 61.83                   | 1.48                      | 52.19                     |
| Fruit                   |                         |                         |                           |                           |
| 0.12                    | 1.44                    | 41.95                   | 2.09                      | 32.57                     |
| 0.24                    | 1.32                    | 44.01                   | 1.94                      | 37.31                     |
| 0.36                    | 1.22                    | 50.80                   | 1.87                      | 39.47                     |
| 0.48                    | 1.01                    | 59.17                   | 1.53                      | 50.48                     |
| 0.60                    | 0.81                    | 67.33                   | 1.18                      | 61.95                     |
Table 7: Thermometric reaction for aluminium in 2 N and 3 N sulphuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis gigantea*.

| Inhibitor concentration | Reaction number (RN) 2 N | Inhibition efficiency (%) | Reaction number (RN) 3 N | Inhibition efficiency (%) |
|-------------------------|--------------------------|----------------------------|--------------------------|----------------------------|
| Uninhibited             | 1.26                     |                             | 1.91                     |                             |
| Leaves                  |                          |                            |                          |                            |
| 0.12                    | 0.82                     | 34.75                      | 1.28                     | 33.94                      |
| 0.24                    | 0.76                     | 39.21                      | 1.19                     | 38.43                      |
| 0.36                    | 0.69                     | 45.27                      | 1.14                     | 40.31                      |
| 0.48                    | 0.52                     | 58.53                      | 0.81                     | 59.23                      |
| 0.60                    | 0.39                     | 68.53                      | 0.67                     | 64.60                      |
| Latex                   |                          |                            |                          |                            |
| 0.12                    | 0.82                     | 35.19                      | 1.27                     | 35.24                      |
| 0.24                    | 0.77                     | 38.94                      | 1.15                     | 39.47                      |
| 0.36                    | 0.72                     | 44.32                      | 0.94                     | 53.08                      |
| 0.48                    | 0.54                     | 57.25                      | 0.83                     | 57.73                      |
| 0.60                    | 0.40                     | 68.53                      | 0.72                     | 62.66                      |
| Fruit                   |                          |                            |                          |                            |
| 0.12                    | 0.79                     | 38.89                      | 1.37                     | 28.83                      |
| 0.24                    | 0.70                     | 44.60                      | 1.31                     | 32.37                      |
| 0.36                    | 0.64                     | 49.01                      | 1.10                     | 42.37                      |
| 0.48                    | 0.47                     | 62.56                      | 0.78                     | 60.63                      |
| 0.60                    | 0.35                     | 73.58                      | 0.58                     | 68.56                      |

Table 8: Thermometric reaction for aluminium in 4 N and 5 N sulphuric acid with ethanolic extract of leaves, latex, and fruit of *Calotropis gigantea*.

| Inhibitor concentration | Reaction number (RN) 4 N | Inhibition efficiency (%) | Reaction number (RN) 5 N | Inhibition efficiency (%) |
|-------------------------|--------------------------|----------------------------|--------------------------|----------------------------|
| Uninhibited             | 2.48                     |                             | 3.10                     |                             |
| Leaves                  |                          |                            |                          |                            |
| 0.12                    | 1.57                     | 37.43                      | 2.24                     | 28.83                      |
| 0.24                    | 1.54                     | 38.37                      | 2.03                     | 35.33                      |
| 0.36                    | 1.48                     | 41.47                      | 1.95                     | 37.21                      |
| 0.48                    | 1.01                     | 59.61                      | 1.66                     | 50.48                      |
| 0.60                    | 0.88                     | 64.87                      | 1.22                     | 60.75                      |
| Latex                   |                          |                            |                          |                            |
| 0.12                    | 1.48                     | 42.19                      | 2.36                     | 25.21                      |
| 0.24                    | 1.37                     | 45.34                      | 2.14                     | 31.37                      |
| 0.36                    | 1.24                     | 50.52                      | 2.08                     | 32.89                      |
| 0.48                    | 1.09                     | 56.54                      | 1.82                     | 42.56                      |
| 0.60                    | 0.91                     | 62.83                      | 1.46                     | 53.19                      |
| Fruit                   |                          |                            |                          |                            |
| 0.12                    | 1.43                     | 41.77                      | 2.10                     | 32.57                      |
| 0.24                    | 1.33                     | 44.81                      | 1.95                     | 37.22                      |
| 0.36                    | 1.21                     | 51.83                      | 1.81                     | 43.39                      |
| 0.48                    | 1.06                     | 58.17                      | 1.55                     | 51.43                      |
| 0.60                    | 0.82                     | 67.05                      | 1.17                     | 62.26                      |
The corrosion of aluminium and aluminium alloys precede through the following elementary reactions:

**Anodic reaction**

\[ \text{Al} \rightarrow \text{Al}^{3+} + 3e^- \]

**Cathodic reaction**

\[ \text{O}_2 + 2\text{H}_2\text{O} + 4e^- \rightarrow 4\text{OH}^- \quad \text{neutral/alkaline medium} \]
\[ 2\text{H}^+ + 2e^- \rightarrow \text{H}_2 \quad \text{acidic medium} \]  

(5)

All metals above the hydrogen in electrochemical series have a tendency to get dissolve in acidic solution releasing hydrogen.

It has been observed that the fruit extract of *Calotropis procera* and *Calotropis gigantea* has maximum inhibition efficiency compared to the latex and leaves extracts. This process increased the absorptivity of the fruit extract on the corroding site of the metal. This explained that the higher inhibition efficiency displayed by the latex for mass loss method and fruit extract for thermometric method in 0.60% inhibitors concentration.

### 5. Surface Analysis

Surface analysis of metal by Scanning Electron Microscopy was carried out on Model-ZEISS EVO 50. The surface morphological characteristics of the blank and inhibited aluminium were analyzed at magnification of 2.0 KX operated at an accelerating voltage of 20 KV. Scanning electron microscopy reveals that plant extract adsorbed on metal surface and increased the smoothness of aluminium that decreases the metal surface for corrosion attack (Figure 6). SEM provides a two-dimensional projection or a two-dimensional image of a sample. SEM of aluminium in sulphuric acid (uninhibited) is showed by Figure 5.

### 6. Conclusion

From the study, the following conclusions are made:

(i) ethanol extract of *Calotropis procera* and *Calotropis gigantea* is a good inhibitor for the corrosion of aluminium in \( \text{H}_2\text{SO}_4 \);

(ii) the inhibitor action results in a reduction of surface roughness due to corrosion processes.

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