Volume 80, Part 2, 2023, Pages 1408-1412

Data analysis of the corrosion protection behavior of ginger, tea tree and grapefruit essential oil extracts on low carbon steel in H_2SO_4 solution

Author links open overlay panelRoland Tolulope Loto [a], Edith Alagbe [b], Ayobami Busari [c]

[a] Department of Mechanical Engineering, Covenant University, Ogun State, Nigeria

[b] Department of Chemical Engineering, Covenant University, Ota, Ogun State, Nigeria

[c] Department of Civil Engineering, Federal University, Oye, Ekiti State, Nigeria

Available online 24 January 2023, Version of Record 26 April 2023.

https://doi.org/10.1016/j.matpr.2023.01.155Get rights and content

Abstract

Application of corrosion inhibitors are the most versatile corrosion prevention methods of carbon steels in corrosive environments. Research on non-toxic chemical compounds are ongoing and results from previous study have proven the effectiveness of the compounds. Data on corrosion inhibition of ginger (GG), tea tree (TR) and grapefruit (GF) oil extracts on low carbon steel in 0.5 M H_2SO_4 are presented. The extracts performed effectively with optimal values of 99.56 %, 98.17 % and 98.32 % at 2.5 % GG, 3.5 % TR and 3 % GF concentrations. Corresponding corrosion rate values are 0.28 mm/y, 1.16 mm/y and 1.49 mm/y. Corrosion rate at 0 % extract concentration is 63.33 mm/y. Performance of TR extract significantly varies with time and concentration with statistical value of 48.21 % and 23.02 %. GG and GF concentration where the only

statistically relevant factors for GG and GF performance with statistical values of 68.42 % and 73.20 %. Standard deviation data for GG extracts varied minimally from mean values compared to TR and GF extracts. Results shows 92 %, 18 % and 63 % of GG, TR and GF extracts inhibition data are above 95 % inhibition value at margin of error of 6.99 %, 10 % and 12.19 %.

Introduction

Application of ferrous alloys cuts across most industries due to their versatility, ease of fabrication, recyclability and adaptable mechanical and physical properties. Ferrous alloys are used in structural columns and beams, components parts of industrial machines and critical components requiring toughness and hardness properties etc. The industrial properties of ferrous alloys serve as the conventional standards wherewith the properties of other metallic alloys of industrial importance are compared [1], [2]. Coupled with this, the relatively low cost of ferrous alloys especially carbon steels substantially contribute to the high volume utilization of ferrous alloys. Carbon steels, despite their universal industrial application compared to other metallic alloys are prone to rapid deterioration in aqueous condition containing appreciable concentrations of Cl^-, SO_4^{2-}, $S_2O^{2-}_3$, NO_3– etc. due to the absence of passivating elements within their metallurgical structure [3]. As a result, redox electrochemical processes occurs on the heterogeneous alloy surface [4]. Invariably, the operating lifespan of the steel is severely shortened leading to plant shutdown, industrial downtime, failure of mechanical parts/components, excessive maintenance and repair cost, and industrial accidents. Chemical compounds known as corrosion inhibitors stifles the electrochemical reactions responsible for carbon steel corrosion when added to the steel's operating environment. Other actions of corrosion inhibitors include formation non-reactive chemical precipitates, adsorption unto the steel surface and alteration of the corrosive properties of the electrolyte [5]. Proven corrosion inhibitor e.g. chromates, nitrites, aniline etc. such as are toxic and unsustainable [6], [7], [8], [9], [10]. Plant extracts are promising corrosion due to their phytochemical components though experimental data show extensive investigation is necessary to further establish their corrosion inhibition properties, isolation of active components, extension of their shelf life and improved adsorption properties [11], [12], [13], [14], [15]. Essential oils extracts from plants, leaves, fruits and seeds have been investigated to assess their protection performance potentials and to delineate their highest corrosion inhibition output with respect of exposure time and extract concentration [16], [17], [18], [19], [20], [21], [22], [23]. This article computes and analyses the data outputs and statistical importance of the inhibition efficiency data for ginger, tea tree and grapefruit essential oil extracts on low carbon steel in 0.5 M H_2SO_4 solution.

Section snippets

Materials and methods

Ginger (GG), tea tree (TR) and grapefruit oil extracts purchased from NOW foods USA at 100 % purity were added individually to 0.5 M H_2SO_4 solution in volumetric concentrations of 1 %, 1.5 %, 2 %, 2.5 %, 3 % and 3.5 %. Low carbon steel (LCS) rods were cut into six separate samples for weight loss measurement. The 6 samples were washed with deionized H_2O and propanone before weight loss test. The LCS samples were inserted into each acid/extract solution (with respect to inhibitor concentration)

Coupon analysis

Experimental data for LCS corrosion rate in the presence of GG, TR and GF essential oil extracts, and extract inhibition efficiency in H_2SO_4 solution are presented in Table 1. Corrosion rate data for LCS at 0 % extract concentration is substantially greater than the values obtained at 1 % to 3.5 % GG, TR and GF extract concentration. The is due to the accelerated degradation of LCS occurring from the redox electrochemical mechanisms. At 0 % extract concentration, corrosion rate initiated at

Conclusion

Ginger, tea tree and grapefruit oil extracts effectively inhibited low carbon steel corrosion with optimal values generally greater than 98 %. Variation in corrosion rate between the inhibited and non-inhibited steel varies significantly due to effective protection mechanisms of the extract on the carbon steel in acid solution. Results also showed measurement time and concentration significantly influenced the performance of tea tree extract i.e. performance increases with time and

CRediT authorship contribution statement

Roland Tolulope Loto: Supervision, Conceptualization, Writing – original draft, Visualization, Investigation, Validation, Methodology, Data curation. **Edith Alagbe:** . **Ayobami Busari:** .

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The author is grateful to Covenant University Ota, Ogun State, Nigeria for their support for this project.

References (23)

- R.T. Loto

  Comparative study of the pitting corrosion resistance, passivation behavior and metastable pitting activity of NO7718, NO7208 and 439L super alloys in chloride/sulphate media
  J. Mater. Res. Techn.
  (2019)
- R.T. Loto

  Study of the synergistic effect of 2-methoxy-4-formylphenol and sodium molybdenum oxide on the corrosion inhibition of 3CR12 ferritic steel in dilute sulphuric acid
  Results Phys.
  (2017)
- C.A. Loto *et al.*

  Effect of dextrin and thiourea additives on the zinc electroplated mild steel in acid chloride solution
  Int. J. Elect. Sci.
  (2013)
- R.T. Loto *et al.*

  Effect of P-phenylediamine on the corrosion of austenitic stainless steel type 304 in hydrochloric acid
  Int. J. Elect. Sci.
  (2012)
- Y. Li *et al.*

  Berberine as a natural source inhibitor for mild steel in 1 M H_2SO_4
  Appl. Surf. Sci.
  (2005)
- G. Quartarone *et al.*

  Inhibitive action of gramine towards corrosion of mild steel in deaerated 1.0 M hydrochloric acid solutions
  Corros. Sci.
  (2012)
- C.A. Loto *et al.*

  Synergistic effect of tobacco and kola tree extracts on the corrosion inhibition of mild steel in acid chloride
  Int. J. of Elect. Sci.

(2011)
- K. Boumhara *et al.*

  Artemisia Mesatlantica essential oil as green inhibitor for carbon steel corrosion in 1 M HCl solution: electrochemical and XPS investigations
  J. Ind. Eng. Chem.
  (2015)
- D. Dwivedi *et al.*

  Carbon steel corrosion: a review of key surface properties and characterization methods
  RSC Adv.
  (2017)
- P. Zarras, J.D. Stenger-Smith, Corrosion processes and strategies for prevention: An Introduction, inHandbook of Smart...

View more references

Cited by (5)

- Principles and theories of green chemistry for corrosion science and engineering: design and application
  2024, Green Chemistry

  Show abstract

- Electrochemical, Thermodynamic, and Surfaces Investigations on The Use of Mentha Piperita Essential Oil as A Green Corrosion Inhibitor for Carbon Steel in 1 M HCl Solution
  2024, Analytical and Bioanalytical Electrochemistry

- Corrosion inhibition by fruit extracts-Inhibition of corrosion of mild steel in simulated concrete pore solution prepared in sea water by an aqueous extract of apple juice-A Case study
  2024, Materials Protection

- Experimental study of the impacts of sustainable corrosion inhibitor on aluminum in diesel biodiesel ethanol blends
  2024, Biofuels

- Impact of material selection on the efficiency of the crushing unit low-medium carbon steel
  2023, E3S Web of Conferences

View full text

Part of special issue

Second Global Conference on Recent Advances in Sustainable Materials 2022
Edited by
M Seenuvasan, D M Sangeetha

Other articles from this issue

- Influence of E-Coli on workability and strength characteristics of self-consolidating geopolymer concrete based on GGBFS, flyash and alccofine
  2023
  L. Nishanth, …, Dr. Debasish Kar
- The electrochemical degradation, wear behavior and machining of metal matrix composites based on 6xxx aluminum alloy with ceramic particulate reinforcements; a brief review
  2023
  Abdullah Yahia Hassan, …, Rajasekaran Saminathan
- Lithium ion battery thermal management by using coupled heat pipe and liquid cold plate
  2023
  Umesh Chavan, …, Pravin Hujare

View more articles

Recommended articles

- Chemical composition, antioxidant and antimicrobial activities of essential oil extracted from *Myrceugenia euosma* (O. Berg) D. Legrand (Myrtaceae)
  South African Journal of Botany, Volume 159, 2023, pp. 35-42
  Lilian Monique Spegiorin Cavalheiro, …, Fábio Antônio Antonelo
- Cold pressed grapefruit (*Citrus paradisi* L.) oil
  Cold Pressed Oils, 2020, pp. 497-513
  Buket Aydeniz-Guneser, Onur Guneser
- Aromatherapies using *Osmanthus fragrans* oil and grapefruit oil are effective complementary treatments for anxious patients undergoing colonoscopy: A randomized controlled study
  Complementary Therapies in Medicine, Volume 34, 2017, pp. 165-169
  Hideaki Hozumi, …, Souichi Tomimatsu

Show 3 more articles

Article Metrics