iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** XII **Month of publication:** December 2025

DOI: https://doi.org/10.22214/ijraset.2025.76156

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XII Dec 2025- Available at www.ijraset.com

Effectiveness of *Origanum Vulgare* (Oregano) and *Citrus x Microcarpa* (Calamansi) Peel Extract as Rust Removers on Metal Tools

Rexton Bryan L. Dimaculangan[1], Arcelie A. Durolfo[2], Prince Richard M. Galac[3], Rosemarie Jane T. Hizola[4], Jose Cholo B. Juat[5], Cllyde L. Lilia[6], Davey Darren M. Looc[7], Bryle A. Armeza[8]
Bachelor of Sciences in Geodetic Engineering, Batangas State University the National Engineering University, Batangas City, Philippines

Abstract: ***The reliance on commercial rust removers presents a significant environmental and health hazard, necessitating the development of safer, sustainable alternatives for metal tool maintenance. This research responded to this problem by investigating natural ingredients. The study's objective was to evaluate the effectiveness of an extract derived from Origanum vulgare (Oregano) and Citrus x microcarpa (Calamansi) peel extract as a rust remover, and to analyze its advantages over chemical rust remover in terms of economic and environmental factors. A true experimental design was employed. The extract, prepared by macerating the plant material in 70% ethanol for 72 hours, was applied to rusted tools and compared against a commercial rust remover over one hour, with efficacy assessed using a qualitative rust rating scale. The extract demonstrated high efficacy, achieving a "No Rust" result on most moderately corroded tools, comparable to the control group which is the chemical rust remover. The research concluded that the Oregano-Calamansi Peel extract is a feasible, cost effective and environmentally sustainable alternative for the routine maintenance of metal tools, though its application on heavily corroded items may require complementary mechanical cleaning such as scrubbing with an abrasive brush.***

Keywords: natural rust remover, metal tool maintenance, plant extract, eco-friendly corrosion inhibitor, green chemistry, oregano extract, calamansi peel extract,

I. INTRODUCTION

Rust and corrosion commonly occur on metal surfaces that are frequently exposed to moisture and air, causing deterioration and weakening of materials, Guo et.al (2019). The study emphasized that even though chemical rust removers are effective in removing rust and restoring metal appearance, they can also pose risk or hazards to both the equipment and the environment. In recent years, environmental sustainability has transitioned from being a merely philosophical ideal to urgent global priority. However, despite the continuous efforts to promote sustainable practices, the dependence on harmful chemical products remains evident across all sectors, including engineering.

As the concept of climate change enters the world, the growing problem of environmental unsustainability has become more alarming due to the continuous rise of global chemical production. Aligned with this, the United Nations Environmental Programme (UNEP) in partnership with the World Health Organization (WHO) and Organization for Economic Cooperation and Development (OECD) , measures global chemical production, According to them, in 2016, more than 100,000 different chemical compounds are in commercial use, while only a fraction of the roughly 100,000 commercially used substances have been thoroughly or health impacts. The said statistics are expected to double in 2030.

Furthermore, in the study by Tulus et al.(2021) entitled *"Planetary metrics for the absolute environmental sustainability assessment of chemicals"*, they concluded that the production of nearly all major industrial chemicals is unsustainable. Researchers analyzed 492 widely produced chemicals and concluded that more than 99% of them violated the safe operating limits of at least one Planetary Boundary (PB) or what we call the nine global limits for environmental processes (such as climate change) that define the safe operating space for humanity. Crossing these boundaries significantly increases the risk of large-scale, irreversible environmental change, pushing Earth out of its Stable state.

In the review of Construction Fasteners (2020) entitled *"Tool Maintenance : Cleaning, Rust Prevention & Rust Removals"* notes that daily operational use of metal tools exposes them to numerous corrosion accelerators.

They emphasize that simple contact with sweat, oil, or grease introduces organic acids and salts that act as potent electrolytes, creating local galvanic cells that rapidly speed up the oxidation process. Moreover, any abrasion or mechanical damage to the tool's surface compromises factory-applied protective coatings (like plating or paint), instantly exposing the bare, reactive metal beneath to moisture, thereby initiating localized corrosion that spreads quickly throughout the tool's structure.

Although frequent maintenance is recommended to ensure their longevity and durability of the metal tools, many people still rely on chemical-based rust removers because they are more accessible, affordable and less time-consuming. However, even though chemical products can remove rust, it may leave the metal surface unprotected, leading to faster rust recurrence, according to Muhsin (2020). As the demand for using and maintaining metal tools continues to rise, there is an increasing need to develop safer and more eco-friendly rust removal alternatives to ensure sustainable and responsible practices.

Therefore, the researchers aim to test the effectiveness of *Origanum Vulgare* (Oregano) and *Citrus x Microcarpa* (Calamansi) peel extract as natural rust removers on tools. Specifically, this study seeks to determine the combined potential of Oregano and Calamansi peel extract in removing and preventing rust as a natural, eco-friendly alternative to conventional chemical products. It also aims to assess their functionality, applicability and benefits comparative advantages over chemical-based rust removers.

The findings of this study may serve as a fundamental basis for promoting the use of natural and eco-friendly alternatives, as it addresses the growing need to replace harmful chemical rust removers to maintain metal tools. By emphasizing the need to replace harmful chemical based products, this research supports the global call for safer and more sustainable maintenance practices. The results may provide valuable information that can guide future researchers in developing or improving natural rust-removal methods that are both effective and environmentally responsible. If this research is not conducted soon, the ongoing reliance on chemical products may lead to further environmental damage, faster deterioration of tools or instruments

II. OBJECTIVES

This study sought to determine the effectiveness of *Origanum Vulgare* (Oregano) and *Citrus x Microcarpa* (Calamansi) peel extract as a rust remover on metal tools.

Specifically, it sought to answer the following questions:

1) What results can be derived from the experimentation of the combined properties of Origanum vulgare and Citrus x microcarpa in terms of:

- removing rust;
- prevent rust formation?

2) How effective are the Origanum vulgare and Citrus x microcarpa peel extract in terms of;

- functionality;
- applicability;
- product efficacy?

3) What are the advantages of using O. vulgare and C. microcarpa peel extract as an eco-friendly alternative to store-bought chemical rust removers in tools in terms of:

- environmental;
- economical?

III. MATERIALS AND METHODS

A. Research Design

The researchers will utilize a Quantitative Experimental Research Design. This design is necessary to determine the effectiveness of *Origanum vulgare* (Oregano) and *Citrus x microcarpa* (Calamansi) peel extracts as rust removers on metal tools. The experimental approach allows for the establishment of a clear cause and effect relationship by manipulating the independent variable (the plant extracts) and measuring the impact on the dependent variable (the rust removal efficiency). The study will compare the results of the treatment groups against a control group to objectively validate the efficacy of the natural solutions.

B. Subjects of the Study

The subjects of this study consist of rusted Geodetic Fieldwork Tools obtained from the equipment storage. A total of sixteen (16) rusted metal surfaces were identified across four distinct types of equipment commonly used in surveying operations. These samples were divided into two groups: eight (8) for the control group (Commercial Rust Remover) and eight (8) for the experimental group

(Oregano and Calamansi Extract). Purposive sampling was utilized to select these specific tools. The selection criteria required the tools to be made of ferrous (steel/iron) material and to exhibit a visible, uniform degree of surface oxidation (Fe2O3). This ensures the study covers the full range of equipment maintained by surveyors, from precision measurement instruments to heavy excavation tools.

Table 1. Subjects of the Study

Description of Sample	Control Group	Experimental Group
Measurement Equipment		
Steel Levelling Rod	2	2
Excavation Tools		
Post Hole Shovel	2	2
Digging Bar	2	2
Clearing Tools		
Bolo/Machete (Blade)	2	2
Total	8	8

C. Data Gathering Instrument

In this study, the researchers used an observation checklist as the main tool to assess the effectiveness of *Origanum vulgare* (oregano) and *Citrus x microcarpa* (calamansi) peel extract as a rust remover for geodetic tools. The checklist measured rust removal, rust prevention, functionality, applicability, product efficacy and the advantages of the natural extract compared to a commercial rust remover.To measure the results clearly, the study used a rust removal rating scale. This scale helped compare the performance of the natural extract and the chemical rust remover allowing the researchers to determine which one worked better and gave more consistent results.

Table 2. Rust Removal Rating Scale

Rating	Meaning
No Effect (NE)	No rust was removed, no visible change on the tool surface.
Slight Effect (SE)	A small amount of rust was removed, light change in color or softening of rust.
Moderate Effect (ME)	A noticeable amount of rust was removed, part of the metal surface became visible.
High Effect (HE)	A large amount of rust was removed, metal surface became mostly clean and clear.

D. Data Gathering Procedure

The researchers will observe and utilize an observation checklist during the testing process to determine whether the product is effective. The collection of data will help achieve the goal of the study to produce a product free from chemicals. This method involves observing changes in rusted metal surface without human involvement, focusing on the effectiveness of the oregano and calamansi peel extract. This includes examining the color, texture, and the amount of rust removed, as well as documenting the size of the rusted portion before and after treatment with clear photographs, and comparing the reduction on the rust area. These visual and area-based observations are important for the study to evaluate whether the extract is effective as rust remover.

IV. RESULTS AND DISCUSSION

The results of the rust-removal experiment using *Origanum vulgare* (oregano) and *Citrus × microcarpa* (calamansi) peel extract were compared with a commercial rust remover. Data were collected through an observation checklist and interpreted using a rust-removal rating scale.

Table 3. Rust Removal Rating of the Control Group After 30 Mins and 1 Hour

Tool	30mins Rating	1 Hour Rating
Steel Leveling Rod	Moderate Effect	Moderate Effect
Post Hole Shovel	Slight Effect	Slight Effect
Digging Bar	Slight Effect	Slight Effect
Bolo/Machete	Moderate Effect	High Effect

The results showed that the commercial rust remover performed inconsistently across the tools. It was highly effective on the bolo but produced only minimal to moderate effects on the steel leveling rod, post hole shovel and digging bar. This suggests that its effectiveness varies depending on the tool type and rust severity, consistent with literature stating that ferrous materials react differently to corrosion due to varying oxidation levels (Dwivedi et al., 2017; Klenam et al., 2021).

Table 4. Rust Removal Rating of the Experimental Group After 30 Mins and 1 Hour

Tool	30mins Rating	1 Hour Rating
Steel Leveling Rod	Moderate Effect	Moderate Effect
Post Hole Shovel	High Effect	High Effect
Digging Bar	Slight Effect	ModerateEffect
Bolo/Machete	High Effect	High Effect

The results showed that the experimental solution produced different levels of rust removal across the tools. The steel leveling rod remained at a moderate effect, while the post hole shovel and bolo showed a consistently high effect. The digging bar improved from slight to moderate after 1 hour. These findings support literature stating that the effectiveness of plant-based rust removers depends on metal type, exposure time, and the interaction of bioactive compounds (Wang et al., 2023; Kumar et al., 2015; Fazal et al., 2022).

Table 5. Rust Formation Rating

Criteria	Rating
No new rust spots observed after drying	No
Surface stays clean after 30 mins	Yes
Surface stays clean after 1 hour	Yes
No discoloration or dark spots formed	Yes

The results showed that rust spots appeared immediately after drying, but the surface stayed clean after 30 minutes and 1 hour with no discoloration. This indicates that the treatment had limitations during the initial drying stage but formed an effective protective layer once cured. These findings align with literature explaining that moisture can cause temporary flash rusting before a protective film fully develops (Dwivedi et al., 2017).

Table 6. Functionality Rating of the Extract

Criteria	Rating
Easy to apply	Excellent
Works without brushing too hard	Fair
Safe to handle	Excellent
Works within reasonable time	Excellent

The results showed that the extract is suitable for metal tool maintenance receiving excellent ratings in ease of application, safety, and working within a reasonable time. However, it earned a fair rating for 'works without brushing too hard,' indicating that scrubbing is still needed for tougher rust. These findings support literature stating that plant-based inhibitors are safe and eco-friendly (Arevalo et al., 2013) but may require physical assistance because compounds like those in oregano act more as protective agents than strong rust-dissolvers (Wierdak, 2025).

Table 7. Applicability Rating

Criteria	Rating
Safe for metal tools	Yes
Suitable for repeated use	Yes
Does not damage the surface	Yes
Easy to store	Yes

The results showed that the oregano and calamansi-peel extract is highly appropriate for regular use, meeting all criteria for tool maintenance. It is safe for metal surfaces, suitable for repeated application, does not cause damage and is easy to store. These findings align with studies showing that oregano extract forms a protective, non-damaging film on metal surfaces (Dhaundiyal et al., 2019) and that calamansi peel compounds create a stable adsorbed layer suitable for long-term use (Arguelles et al., 2020). This literature supports the extract as a safe, gentle and reliable option for routine tool maintenance.

Table 8. Product Efficacy Rating

Criteria	Rating
Overall Performance	Good
Speed of rust removal	Excellent
Lasting rust protection	Good
Consistency results across trials	Good

The results showed that the Citrus x microcarpa and O. vulgare extract achieved a 'Good' overall rating as a rust remover, including lasting rust protection and consistency across trials. It also received an 'Excellent' rating for speed in rust removal, indicating reliable and effective performance. These findings align with studies showing that calamansi's citric acid rapidly dissolves iron oxides (Arevalo et al., 2013) and that oregano's antioxidants such as thymol and carvacrol, help slow oxidation (Walasek Janusz, 2025). This supports the extract's effectiveness as a rust-removal solution.

Table 9. Environmental Comparison of Control and Experimental Group

Criteria	Oregano-Calamansi Extract	Chemical Rust Remover
Natural ingredients	Yes	No
Non-toxic	Yes	No
No harmful fumes/smell	Yes	No
Safe for skin contact	Yes	No
Safe for disposal	Yes	No
Biodegrable	Yes	No

The results showed that the Oregano–Calamansi Extract is significantly safer and more environmentally friendly than the chemical rust remover. The extract met all six criteria, being natural, non-toxic, odor-free, safe for skin contact, biodegradable and safe for disposal while the chemical remover failed all categories, indicating toxic ingredients, harmful fumes, safety risks and poor environmental impact. These findings are supported by Kumar et al. (2015), who note that plant extracts are biodegradable and safer than synthetic inhibitors, and by Soltani et al. (2021), who highlight oregano's natural, food-grade compounds such as thymol and carvacrol. Fazal et al. (2022) further emphasizes that biodegradable plant extracts are sustainable alternatives to hazardous chemical inhibitors.

Table 10. Economic Comparison of Control and Experimental Group

Criteria	Oregano-Calamansi Extract	Chemical Rust Remover
Low cost of ingredients	Yes	No
Easy to prepare locally	No	No
Affordable for students	Yes	No
Requires small amount per use	Yes	No
Long-term cost effectiveness	Yes	No

The results showed that the Oregano–Calamansi Extract has a strong economic advantage over the chemical rust remover. It uses low-cost ingredients, is affordable for students,
needs only a small amount per use and is more cost-effective long term. The chemical remover failed these criteria, making it more expensive and less efficient. Both products were not easy to prepare locally. These findings align with Dehghani et al. (2024) and Wang et al. (2023), who note that plant-based inhibitors are affordable, require small doses, and offer sustainable, cost-effective performance.

V. CONCLUSIONS

Based on the results of the study, the following conclusions were drawn:

1) The oregano and calamansi extract is effective in removing rust, showing moderate to high results within thirty (30) minutes and one (1) hour of use.
2) The extract provides short-term rust prevention after drying, and although slight rust appeared during the drying phase, no new rust formed after thirty (30) minutes and one (1) hour.
3) The extract showed consistent rust-removal performance across most tools tested, indicating its reliability for routine cleaning of common metal tools and equipment.
4) The oregano and calamansi extract is safer for users and the environment because it is natural, non-toxic, biodegradable , and produces no harmful fumes unlike chemical removers.
5) The extract is more economical and cost-efficient than commercial rust removers, as its low-cost ingredients and minimal required amount per use make it practical for students and users with limited resources.

VI. RECOMMENDATIONS

Based on the study's findings and conclusions the following recommendations are provided for the practical application of the Oregano-Calamansi extract and for future research directions:

1) The Oregano-Calamansi extract is most suitable for preventive maintenance on general tools rather than for restoring heavily corroded items or precision instruments.
2) Users should pair the extract with abrasive pads or wire brushes for maximum efficiency, particularly on uneven tool surfaces.
3) Although made from low-cost ingredients, the extraction process is cumbersome, so future studies should develop a pre-packaged, shelf-stable version.
4) Future research should incorporate natural corrosion inhibitors into the extract to prevent rust spots during drying and create a true one-step cleaning solution.
5) Future studies should examine its chemical interactions with specific metal alloys to develop targeted usage guidelines.
6) Future research should complement qualitative observations with quantitative data, such as corrosion rate measurements, to enable rigorous comparison with commercial rust removers.

VII. ACKNOWLEDGEMENT

The researchers express their deepest gratitude and appreciation for the following individuals who guided the completion of this study:

To Sir Bryle Armeza, professor for Chemistry for Engineers, for granting permission and opportunity to utilize the laboratory facility, which were essential for the completion of this study. Also, for his expert guidance in this research paper and most importantly, his constant encouragement in the group to do their best. They truly deeply appreciate the time, effort, and support he has given..

To Laboratory Personnel of Batangas State University, for their valuable technical assistance and guidance throughout the experimental phase of this research. Their support ensured the smooth execution of the laboratory activities;

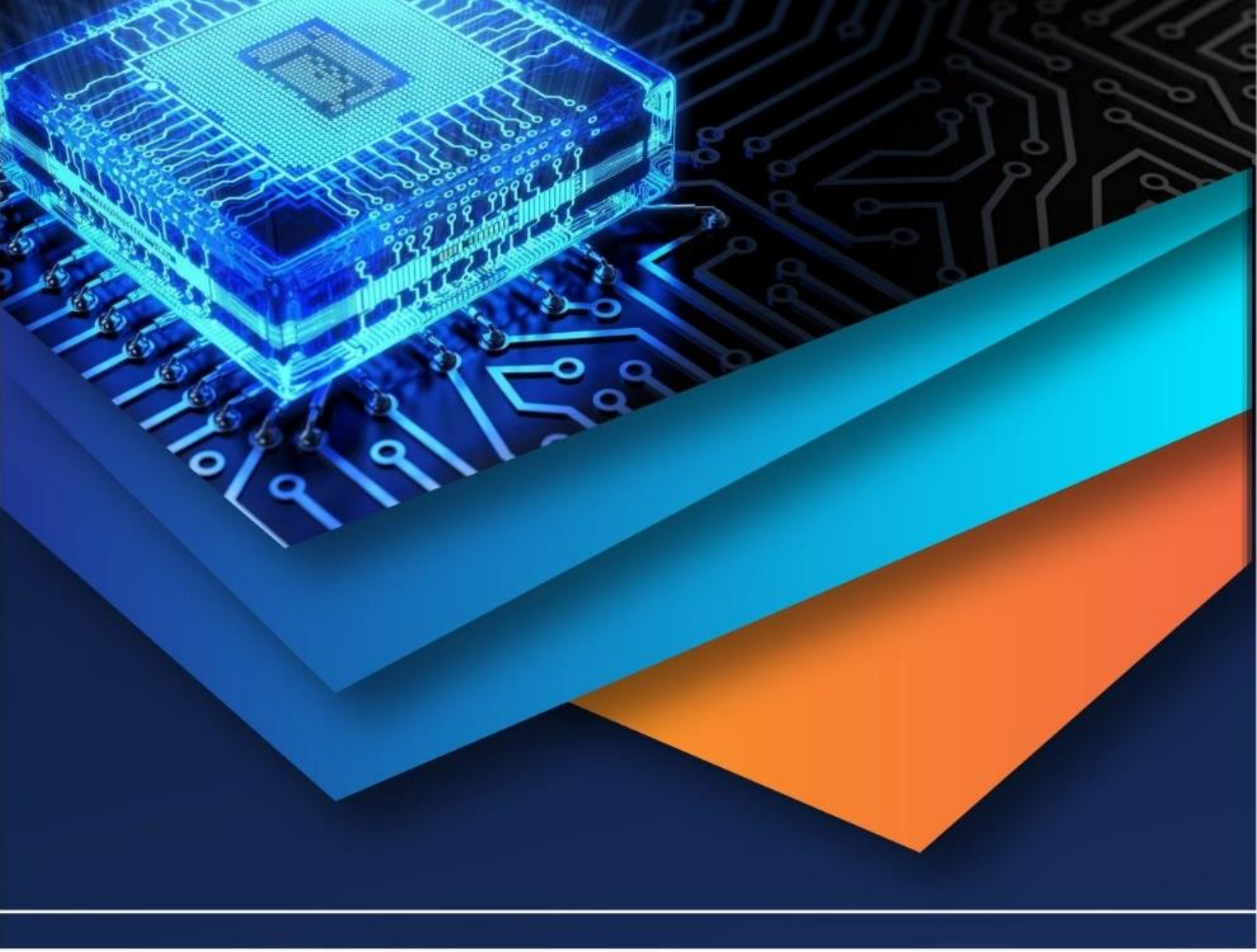
To Galac Family, for their exceptional hospitality. Their generosity in allowing to use their residence as a workspace for some of the research activities and providing critical, immediately needed materials that were unavailable to at the time was invaluable to the progress of this study; To their families and friends, for their unwavering support and understanding throughout this research project were important to achieve our ultimate goal . Their encouragement and motivation gave strength when needed, they are profoundly appreciated for becoming figures of positivity for us student researchers; and

To the field that relies on metal tools, the true inspiration for this work. Their needs and the pursuit of effective solutions served as the driving force and motivation that allowed to successfully conclude this action research.

REFERENCES

[1] Arevalo, M. J., Mabaquiao, J. M., Roco, J. S., & Alipio, A. T. (2013). Ecofriendly alternative solutions for rust removal. Journal of Business, Logistics, and Maritime Studies (JBLFMS) Research. Retrieved from https://books.openbookpublishers.com/10.11647/obp.0453.15.pdf
[2] Arguelles, G., Torres, M., Wu, B., Olay, J., Ong, R.,. (2020). (Calamansi) Citrofortunella Microcarpa Rind Extract As Plant Derived Green Corrosion Inhibitor For Mild Steel In 1.0M Hcl. IOP Conference Series: Materials Science and Engineering. 778. 012007. 10.1088/1757-899X/778/1/012007. https://www.researchgate.net/publication/341088116_Calamansi_Citrofortunella_Microcarpa_Rind_Extract_As_Plant_Derived_Green_Corrosion_Inhibitor_For_Mild_Steel_In_10M_Hcl

[3] Bagaudin, Z. M. (2024). GEODETIC ASPECTS IN CONSTRUCTION AND ENGINEERING SURVEYS. Вестник науки, 2(10 (79)), 556-562. https://cyberleninka.ru/article/n/geodetic-aspects-in-construction-and-engineering-surveys
[4] Barbu, C. A., Fierascu, I., Semenescu, A., & Cotrut, C. M. (2025). Critical Review regarding the Application of Plant Extracts as Eco-Friendly Corrosion Inhibitors—A Sustainable Interdisciplinary Approach. Molecules, 30(18), 3722. https://doi.org/10.3390/molecules30183722
[5] Ecofriendly alternative solutions for rust removal. (2013). In Time Journals of Biological Sciences and Technology. https://research.jblfmu.edu.ph/repo/file_repository/ExternalPublication/pdf_International/Arevalo/Ecofriendly%20Alternative%20Solutions%20for%20Rust%20Removal.pdf
[6] Dehghani, A., Ghahremani, P., Mostafatabar, A. H., & Ramezanzadeh, B. (2024). Plant extracts: Probable alternatives for traditional inhibitors for controlling alloys corrosion against acidic media—A review. Biomass Conversion and Biorefinery, 14(6), 7467-7486. https://link.springer.com/article/10.1007/s13399-022-02893-4
[7] Dhaundiyal, P., Bashir, S., Sharma, V., & Kumar, A. (2019). An investigation on mitigation of corrosion of mildsteel by Origanum vulgare in acidic medium. Bulletin of the Chemical Society of Ethiopia, 33(1), 159. https://doi.org/10.4314/bcse.v33i1.16
[8] Dwivedi, D., Lepková, K., & Becker, T. (2017). Carbon steel corrosion: a review of key surface properties and characterization methods. RSC Advances
[9] Fazal, B. R., Becker, T., Kinsella, B., & Lepkova, K. (2022). A review of plant extracts as green corrosion inhibitors for CO2 corrosion of carbon steel. Npj Materials Degradation, 6(1). https://doi.org/10.1038/s41529-021-00201-5
[10] Guo, S., Si, R., Dai, Q., You, Z., Ma, Y., & Wang, J. (2019). A critical review of corrosion development and rust removal techniques on the structural/environmental performance of corroded steel bridges. Digital Commons @ Michigan Tech. https://digitalcommons.mtu.edu/michigantech-p/31/
[11] Hamidi, D., Husni, E., Yeni, F. (2021). Chemical Contents Profile of Essential Oil from Calamansi (Citrus microcarpa Bunge) Peels and Leaves and Its Antibacterial Activities. https://www.researchgate.net/publication/365193467_Chemical_Contents_Profile_of_Essential_Oil_from_Calamansi_Citrus_microcarpa_Bunge_Peels_and_Leaves_and_Its_Antibacterial_Activities
[12] Ihamdane, R., Tiskar, M., Outemsaa, B., Zelmat, L., Dagdag, O., Berisha, A., Berdimurodov, E., Ebenso, E. E., & Chaouch, A. (n.d.). Essential Oil of Origanum vulgare as a Green Corrosion Inhibitor for Carbon Steel in Acidic Medium. Arabian Journal for Science and Engineering. https://doi.org/10.1007/s13369-023-07693-0
[13] Kumar, Ashish & Bashir, Sumayah. (2015). Review on Corrosion inhibition of Steel in Acidic media. 8. 974-4290. https://www.researchgate.net/publication/321826047_Review_on_Corrosion_inhibition_of_Steel_in_Acidic_media
[14] Libretexts. (2021, February 20). 12.2: Experiments. Social Sci LibreTexts. Retrieved December 2, 2025, from https://socialsci.libretexts.org/Bookshelves/Sociology/Introduction_to_Research_Methods/Book%3A_Principles_of_Sociological_Inquiry__Qualitative_and_Quantitative_Methods_%28Blackstone%29/12%3A_Other_Methods_of_Data_Collection_and_Analysis/12.02%3A_Experiments?.com
[15] Leica Geosystems. (2021). User Manual: FlexLine TS03/TS07/TS10 https://docs.onepointsurvey.com/pdf/Leica-FlexLine-TS03-TS07-User-Manual.pdf
[16] Nurzyńska-Wierdak, R., & Walasek-Janusz, M. (2025). Chemical composition, biological activity, and potential uses of oregano (Origanum vulgare L.) and oregano essential oil. Pharmaceuticals, 18(2), 267. https://www.mdpi.com/1424-8247/18/2/267
[17] Muhsin, N. (2020). Review on engineering methods in treatment of chemical rust. Journal of Research in Engineering and Applied Sciences, 6, 49–53. https://www.researchgate.net/publication/347430188_Review_on_Engineering_Methods_in_Treatment_of_Chemical_Rust
[18] Oniga, I., Pușcaș, C., Silaghi-Dumitrescu, R., Olah, N. K., Sevastre, B., Marica, R., ... & Hanganu, D. (2018). Origanum vulgare ssp. vulgare: Chemical composition and biological studies. Molecules, 23(8), 2077. https://www.mdpi.com/1420-3049/23/8/2077
[19] Pasumbal, S. (2019). Investigating the effectiveness of Calamansi (Citrus microcarpa) rind extract as a green corrosion inhibitor for mild steel in acidic media [Unpublished undergraduate thesis/project]. (Inferred from the content discussing green corrosion inhibitor, Langmuir adsorption, and 1.0M HCl).
[20] Ramones, E., Flor, J. C., Lacar, K., & Ortiz, E. (n.d.). Calamansi (Citrofortunella Microcarpa) and Kamias (Averrhoa Bilimbi) as main active ingredient for rust remover.https://www.scribd.com/presentation/690848398/RESEARCHPPT
[21] Soltani, S., Shakeri, A., Iranshahi, M., & Boozari, M. (2021). A review of the phytochemistry and antimicrobial properties of Origanum vulgare L. and subspecies. Iranian journal of pharmaceutical research: IJPR, 20(2), 268. https://pmc.ncbi.nlm.nih.gov/articles/PMC8457725/
[22] Sheydaei, M. (2024). The use of plant extracts as green corrosion Inhibitors: A review. Surfaces, 7(2), 380–403. https://doi.org/10.3390/surfaces7020024
[23] Tulus, V., Pérez-Ramírez, J., & Guillén-Gosálbez, G. (2021). Planetary metrics for the absolute environmental sustainability assessment of chemicals. Green Chemistry, 23(24), 9881–9893. https://doi.org/10.1039/d1gc02623b
[24] The Effectiveness of Citrus Microcarpa (Calamansi) Peel With Vinegar As Rust Remover On Metals. (n.d.). [Unpublished research paper]. Scribd. https://www.scribd.com/document/827606517/THE-EFFECTIVENESS-OF-CITRUS-MICROCARPA-CALAMANSI-PEEL-WITH-VINEGAR-AS-RUST-REMOVER-ON-METALS
[25] United Nations Environment Programme. (n.d.). Chemical. Beat Pollution. Retrieved November 20, 2025. https://www.unep.org/beatpollution/forms-pollution/chemical
[26] Wang, X., Chen, L., Yang, F., Xiang, Q., & Liu, J. (2023). Corrosion inhibition mechanism and extraction technology of plant corrosion inhibitors: a review. Journal of Adhesion Science and Technology, 37(21), 2919-2943. https://www.tandfonline.com/doi/abs/10.1080/01694243.2023.2172993
[27] Zaczek-Peplinska, J., & Kowalska, M. E. (2022). Application of non-contact geodetic measurement techniques in dam monitoring. Archives of Civil Engineering, 63(3). https://repo.pw.edu.pl/info/article/WUT6ed4be77b2f54e7aa341df5059958566/



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY