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Inhibition of Gram-negative and fungi strains of microbes inducing microbiologically-influenced-corrosion by *Tectona grandis* capped Fe-nanoparticle

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ABSTRACT

In this paper, the inhibition effect by *Tectona grandis* Capped Fe-nanoparticle on the growth of Gram-negative and fungi strains of microbes (that are known to induce microbiologically-influenced-corrosion of metals) was investigated. For the study, two Gram-negative and two fungi strains of microbes were employed, with comparison of the inhibition performance by the Fe-nanoparticle material (for which leaf-extract from *Tectona grandis* was employed as precursor) with what obtained from use of an antibiotic chemical control. Results showed that while the Gram-negative and fungi strains of microbes for the study were resistant to the control antibiotic chemical, they all exhibited sensitivity to the biomaterial-based Fe-nanoparticle, which well inhibited their growth. The results from this paper therefore support recommendation on the usage of the Fe bio-synthesized nanoparticle for inhibiting microbiologically-influenced metallic corrosion in environments infested by the Gram-negative and fungi strains of microbes employed in this paper.

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1. Introduction

Microbiologically-influenced-corrosion (MIC) is the form of corrosion that is insidiously caused by the metabolic activities of microbial colonies that could include bacteria and fungi, among other strains of microbes [1,2]. These forms of corrosion, especially, on metallic materials for industrial systems such as energy materials for oil and gas explorations, or for chemical as well as food processing installations, are usually attended with low likelihood of detection despite being characterized with high corrosion rates that affects structural integrity of metallic materials [2–6]. Thus, MIC attacks ensue in unprecedented but catastrophic materials failure and/or in maintenance needs that gulp huge costs globally [2,3]. Microbiologically-influenced-corrosion cost up to 10% of corrosion costs for all metals, with specific annual cost amounting to ZAR400 million in the Republic of South Africa and about $17 billion in the United States [2]. This, therefore, necessitates search for means of mitigating the menace of MIC against materials in their industrial or engineering applications. For such MIC mitigations, proposed methods include surface modification techniques that employ constituents-bearing techniques for dissuading pioneering strain of microbe from initial metallic surface attraction and subsequent attachment before furthering secondary strain colony formation of biofilms [7–10]. Such constituents-bearing materials have included use of nanoparticle materials, especially, the environmentally-friendly produced plant-extract capped materials example of which include *Tectona grandis* (*T. grandis*) capped Fe-nanoparticle (Fe-NP) [11]. While this material had been recently employed on the growth inhibition of some Gram-positive and Gram-negative strains of microbes inducing MIC in [11], there is dearth of study on the effect of *T. grandis* capped Fe-NP on *Salmonella typhii* (a Gram negative) and fungi strains inducing MIC. This paper therefore investigates inhibition of two Gram-negative, i.e. *Pseudomonas aeruginosa* (for comparison) and *Salmonella typhii*, as well as two fungi, i.e. *Saccaromyces cerevisiae* and *Aspergillus niger*, strains of microbes by *T. grandis* capped Fe-NP.

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2. Experimental

Gram-negative, *Pseudomonas aeruginosa* (*P. aeruginosa*), *Salmonella typhii* (*S. typhii*) and fungi, *Saccaromyces cerevisiae* (*S. cerevisiae*), *Aspergillus niger* (*A. niger*) strains of microbes for the study were obtained from culture collection of the Biotechnology Unit of Department of Applied Biological Sciences, Covenant University, Ota, Ogun State, Nigeria. Each of these test-isolates were prepared and then seeded on nutrient agar plates following standard procedures from the literature [7,11–13]. By these, also, 1 g of *T. grandis* capped Fe-NP, prepared as per reported study [11], which had been mixed in Dimethyl sulfoxide (DMSO: C_2H_6OS), have 0.2 ml dispersed into a 9 mm well that was bored into the microbial seeded agar plates [7,11]. For a control test-system, 10 µg Gentamicin was used following the application procedure employed for the *T. grandis* capped Fe-NP [7]. From these test-systems, zones of microbial growth inhibition were measured from the agar plates, after the plates had been incubated for 24 hrs at 37 °C [11].

3. Results and discussion

The zones of microbial growth inhibition measurements by the *T. grandis* capped Fe-NP, relative to that obtained via the Gentamicin (control chemical) are presented for the Gram-negative strains of microbes in Fig. 1. In the figure linear plots for directly interpreting the zone of inhibition of the tested strains relative to set standards in the literature [14] are included. These, therefore, show that while *P. aeruginosa* (in agreements with reported studies [11,15]) and *S. typhii* were resistant to the control antibiotic (Gentamicin) both of these strains of Gram-negative microbes were sensitive to the *T. grandis* capped Fe-NP. By these results, the Fe-NP, developed from using *T. grandis* leaf-extract precursor, inhibited the growth of the Gram-negative strains of microbes employed in this study.

Likewise, the zones of microbial growth inhibition measurements by the *T. grandis* capped Fe-NP, relative to that from using Gentamicin, for the fungi stains of microbes are presented Fig. 2. From the linear plot of set standards of sensitivity and resistance criteria, which were also included in the Fig. 2, the fungi strains of microbes for this study exhibited resistance to Gentamicin but were sensitive to the *T. grandis* capped Fe-nanoparticle material. The *T. grandis* capped Fe-NP successfully inhibited the growth of the fungi strains, *S. cerevisiae* and *A. niger*.

The results of inhibition on the growth of the Gram-negative and fungi strains of microbes inducing MIC, in this study, support recommendation of Fe-NP biomaterial developed from using *T. grandis* natural plant as precursor for MIC control applications, especially, in environments that are known to contain the strains of Gram-negative and fungi microbes that were employed in this work. However, this would require adequate microbiological investigations for isolating the strains of microbes constituting environmental colony in the MIC medium, as well as needs for further studies on the effective inhibition of other strains of microbes that were not included in the present report.

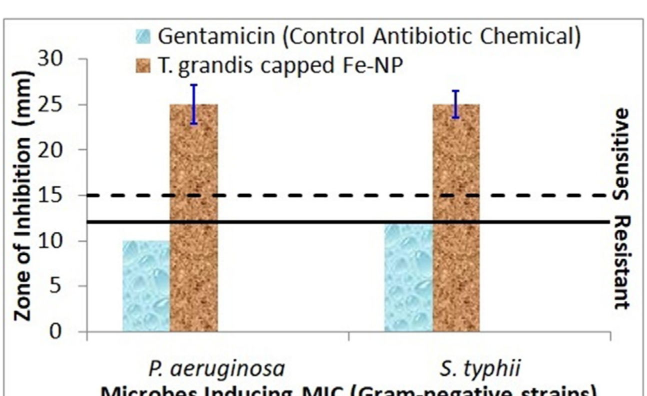

Fig. 1. *T. grandis* based Fe-nanoparticle inhibition, relative to Gentamicin control, on Gram-negative strains of microbes inducing.

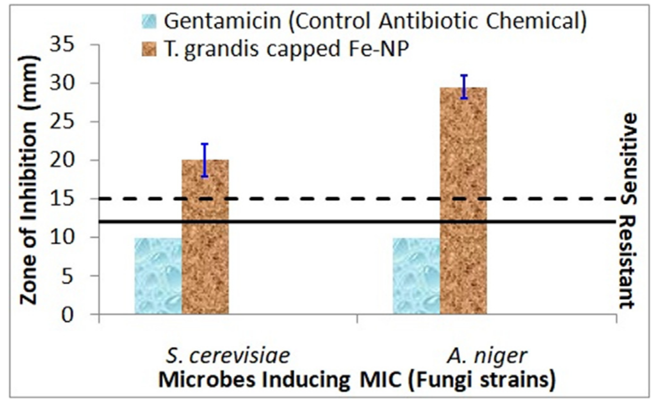

Fig. 2. *T. grandis* based Fe-nanoparticle inhibition, relative to Gentamicin control, on Fungi strains of microbes inducing MIC.

4. Conclusion

In this paper, the inhibition of the growth of two Gram negative and two fungi strains of microbes by *T. grandis capped* Fe-nanoparticle material had been studied. Results from the study show that *T. grandis* Fe-NP inhibited growth of Gram-negative and fungi strains of microbes known to induce MIC attacks. This suggests that the plant-extract capped nanoparticle can be useful as additive in MIC control applications for mitigating the menace of MIC and promoting durability of materials in microbial prone environments.

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References

[1] K.A. Zarasvand, V.R. Rai, Int. Biodeterior. Biodegrad. 87 (2014) 66–74.
[2] S.E. Coetser, T.E. Cloete, Crit. Rev. Microbiol. 31 (2005) 213–232.
[3] L.A. Jain, C. Williamson, J.R. Spear, D.L. Olson, B. Mishra, R.D. Kane, in: CORROSION 2015, NACE International, Houston, TX, 2015, Paper No. 5708.
[4] N. Bolton, M. Critchley, R. Fabien, N. Cromar, H. Fallowfield, J. Appl. Microbiol. 109 (2010) 239–247.
[5] I.B. Beech, J. Sunner, Curr. Opin. Biotechnol. 15 (2004) 181–186.
[6] B.W. Christ, J. Fire. Prot. Eng. 16 (2006) 105–130.
[7] J.O. Okeniyi, A.P.I., Popoola, E.T., Okeniyi, T.F. Owoeye, D.K., Akinlabu, O.S. Taiwo, O.J. Ige, in: CORROSION 2018, NACE International, Houston, TX, 2018, Paper No. 10916.
[8] D. Sun, M. Babar Shahzad, M. Li, G. Wang, D. Xu, Mater. Technol. 30 (2015) B90–B95.
[9] J. Xia, C. Yang, D. Xu, D. Sun, L. Nan, Z. Sun, Q. Li, T. Gu, K. Yang, Biofouling 31 (2015) 481–492.
[10] H. Kanematsu, H. Ikigai, M. Yoshitake, Int. J. Mol. Sci. 10 (2009) 559–571.
[11] J.O. Okeniyi, O.A. Omotosho, M.A. Inyang, E.T. Okeniyi, I.T. Nwaokorie, E.A. Adidi, T.F. Owoeye, K.C. Nwakudu, D.K. Akinlabu, O.O. Gabriel, O.S. Taiwo, in: AIP Conf. Proc. AIP Publishing, 1814 (2017) 020034.
[12] G.U. Akpan, G. Abah, B.D. Akpan, Int. J. Eng. Sci. 2 (2013) 39–45.
[13] B. Mahesh, S. Satish, World J. Agric. Sci. 4 (2008) 839–843.
[14] R. Franklin, M.D. Cockerill III, Clinical and Laboratory Standard Institute 31 (2011) 68
[15] J.O. Okeniyi, G.S. John, T.F. Owoeye, E.T. Okeniyi, D.K. Akinlabu, O.S. Taiwo, O.A. Awotoye, O.J. Ige, Y.D. Obafemi, in: Proceedings of the 3rd Pan American Materials Congress, Springer International Publishing, Cham, 2017, pp. 21–31.