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Data Article

Data on zinc phosphating of mild steel and its behaviour

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ABSTRACT

Surface coating of A36 mild steel using zinc phosphating method was considered in this research work. The mild steel was immersed in zinc phosphating bath which was enhanced with calcium nanoparticles (obtained from snail shells and chicken eggshells). Data on zinc phosphating of the mild steel at different coating time (50 & 60 min) and coating temperatures (60 & 80 °C) was generated. To test the adhesion level of zinc on the mild steel, the coated mild steel was subjected to corrosion tests. And data on weight loss, corrosion rate and inhibition efficiency was generated. Surface morphology of the samples subjected to coating was determined through SEM analysis using SEM (JOEL-JSM 7600F). The data on the surface morphology of the samples is stored in the Mendeley Data repository with the link https://data.mendeley.com/datasets/bpbjfg5b5t/1

1. Rationale

Most metals used for construction, chemical, petrochemical, food processing facilities in the industries are liable to undergo corrosion that adversely affect the functionalities of such metals thereby reduce the metal strength and then shorten their life span [1]. A water or fuel-carrying mild steel pipe, if suffer corrosion, will lose its strength and leaks its content away from the pipes (spillage) resulting in any or combination of the followings: wastage, flooding, accident, explosion, environmental pollution, loss of lives and properties [2]. Phosphate coating can be used to prevent metal corrosion by strengthen the surfaces against corrosion attack [3]. Studies have shown that phosphating technique involving calcium-modified zinc phosphate on the metal surface is an effective mean of attaining high corrosion resistivity. Also, the use of calcium modified zinc phosphating bath provides finer grains thereby improving uniformity of the grains and coating compactness which improves the overall corrosion resistance [4]. Also, the locally sourced calcium (derived from waste materials) can be used to complement or substitute for industrial grade calcium during phosphating process [5]. Waste materials that serve as the sources of the calcium include eggshell, animal bones, periwinkle shells, snail shells etc.

Corrosion tests (weight loss method, corrosion rate and inhibition efficiency) of the coated mild steel samples are necessary in the establishment of the best coating condition of the mild steel samples that provide reliable corrosion resistance [6–7]. Scanning electron microscopy (SEM) analysis can be utilized in the study of the surface morphology of the coated and uncoated mild steels. Also, the analysis aids in the determination of the level of compactness and uniformity of the coating materials on the mild steel [8–10].

2. Procedure

Each of the mild steel samples used was cut into 2.5 cm X 2.5 cm and subjected to surface treatment using silicon carbide

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Table 1
Zinc concentrations obtained (in the bath and on mild steel) after phosphating of metal.

Sample Parameters	Zn Conc. (in the bath, g/L)	Zn Conc. (on mild steel, g/L)
St3C3T60	1.984	3.216
St4C3T60	4.288	0.912
St3C4T60	4.400	0.800
St4c4T60	4.544	0.656
St3C3T80	4.147	1.053
St4C3T80	4.908	0.292
St3C4T80	4.060	1.140
St4c4T80	4.568	0.632
Et3C3T60	3.736	1.464
Et4C3T60	2.876	2.324
Et3C4T60	3.768	1.432
Et4c4T60	4.120	1.080
Et3C3T80	4.752	0.448
Et4C3T80	3.820	1.380
Et3C4T80	4.584	0.616
Et4c4T80	3.564	1.636

Coating conditions are used to define the sample parameters.
S = snail shell nanoparticles, t3 = 50 min, C3 = 2.0 g/L (calcium concentration), T60 = 60 °C.
E = Eggshell nanoparticles, t4 = 60 min, C4 = 2.5 g/L (calcium concentration), T80 = 80 °C.

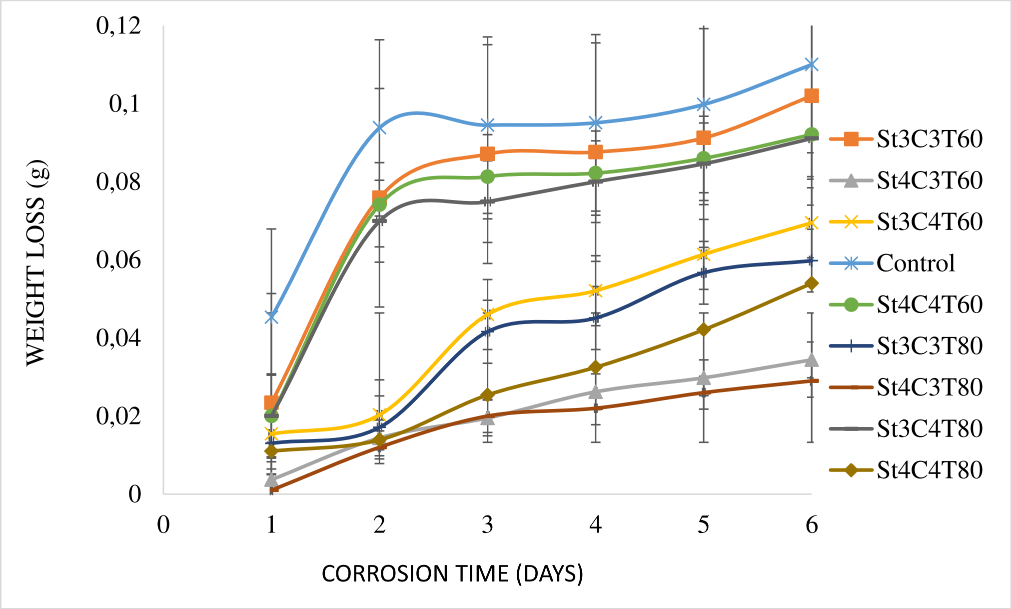

Fig. 1a. Weight loss of the uncoated and coated mild steel samples obtained from snail shell nanoparticles phosphating process.

waterproof abrasive papers of different grades, degreasing and rinsing with distilled water. Both the snail shells and eggshells were separately subjected to calcination process (at 800 °C for 4 h) to obtain nano-sized particles of CaO [11–12]. The nano-size particle was obtained through sieve analysis carried out on the particles. The range of the mesh considered was 450 nm – 750 nm. During the analysis, the particles were placed in the varied mesh sets with mechanical sieve shaker attached (different mesh sizes placed on another from largest size of 750 nm to the smallest mesh size of 450 nm). The automated mechanical sieve shaker was covered properly and rigorously shaken. The nano-size particles of $\leq$ 450 nm sizes were then collected from the mechanical sieve shaker.

The surface coating experiment of the mild steel samples was carried out in a coating bath solution containing constant concentration of 5.2 g/L of zinc phosphate, varied concentration of calcium nanoparticles (C3 of 2.0 g/L and C4 of 2.5 g/L), at different coating time (t3 and t4) and different coating temperatures (T60 & T80). The presence of calcium in the bath contributed to the surface coating of the mild steel and also enhanced both the smooth migration and distribution of zinc ions unto the metal surfaces [13–14].

The surface morphology of the samples subjected to coating (phosphating) was evaluated through SEM analysis using SEM (JOEL-JSM 7600F). To acquire the SEM images, the SEM settings had the surface area of the mild steel sample on the holder with 1cm width placed under the electron detector. The microscope was set with X-control (25 mm), Y-control (35 mm), Z-control (40 mm), tilt (900), accelerating voltage (15 kV and 20 kV), magnifications (11000x, 13000x and 15000x), horizontal field width (120, 126 and 128 μm)

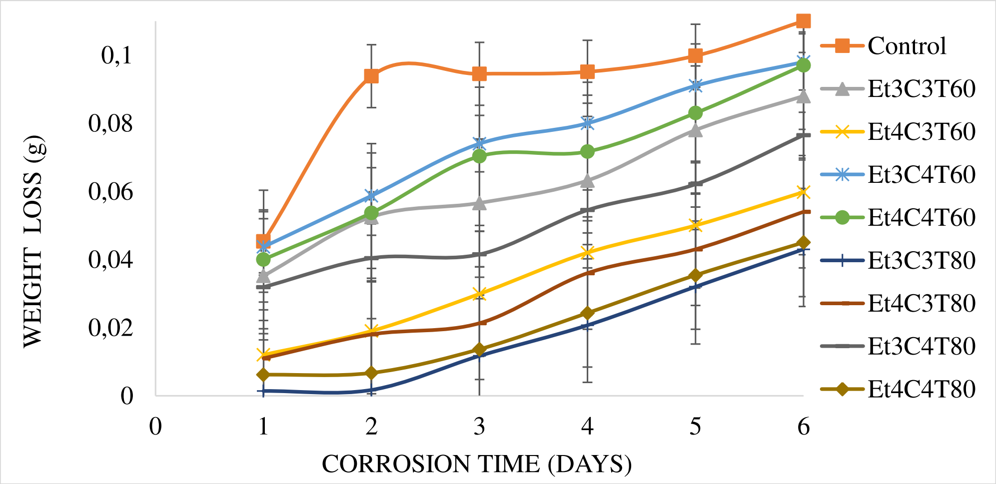

Fig. 1b. Weight loss of the uncoated and coated mild steel samples obtained from eggshell nanoparticles phosphating process.

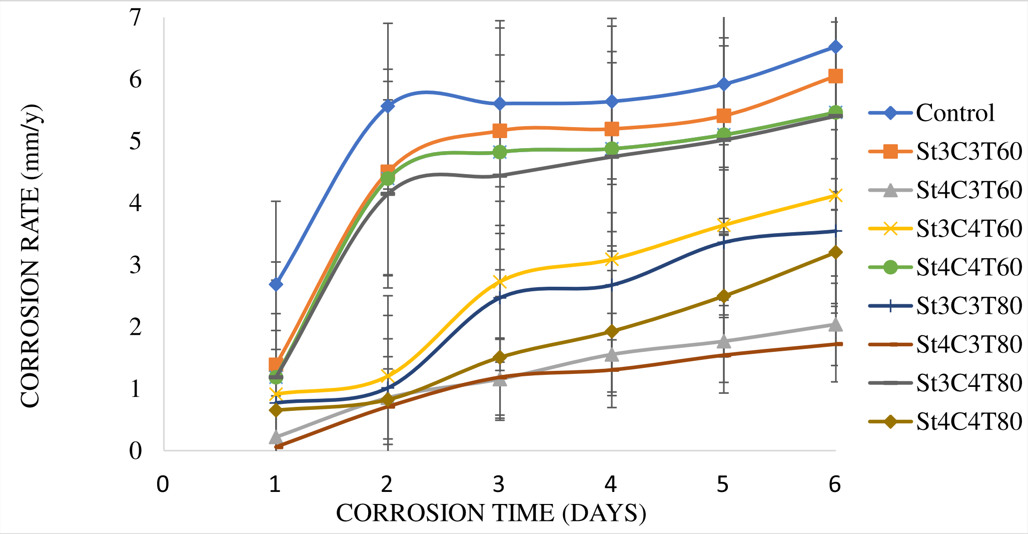

Fig. 2a. Corrosion rate (CR) of the uncoated and coated mild steel samples obtained from snail shell nanoparticles phosphating process.

with working distance of the lens to mild steel sample as 5.9 mm, 10.5 mm, 10.6 mm, 10.8 mm and 11.8 mm).

The coated mild steel samples were further subjected to corrosion tests using 3 wt% NaCl solution with varied corrosion time of 1 – 6 days. Data on weight loss, corrosion rate and inhibition efficiency were generated. Each of the experiments was carried out thrice for accuracy and the average values obtained were recorded. And the plots on weight loss, corrosion rate and inhibition efficiency were depicted with standard deviations.

3. Data, value and validation

- The data obtained is of great importance in the establishment of reliable operating conditions for the zinc phosphating (coating) of mild steel.
- Data obtained are useful to researchers, industrialists and authors in various fields involving surface treatment of metals, especially operations involving phosphating methods and other corrosion combating processes.
- The data obtained can be used in the formulation of models relating the process parameters (such as coating time, coating temperature, calcium concentration in bath solution) and the response (such as the concentration of zinc coated on mild steel). Also, model for the corrosion process can be established by relating corrosion time, corrosion temperature to corrosion rate and inhibition efficiency.

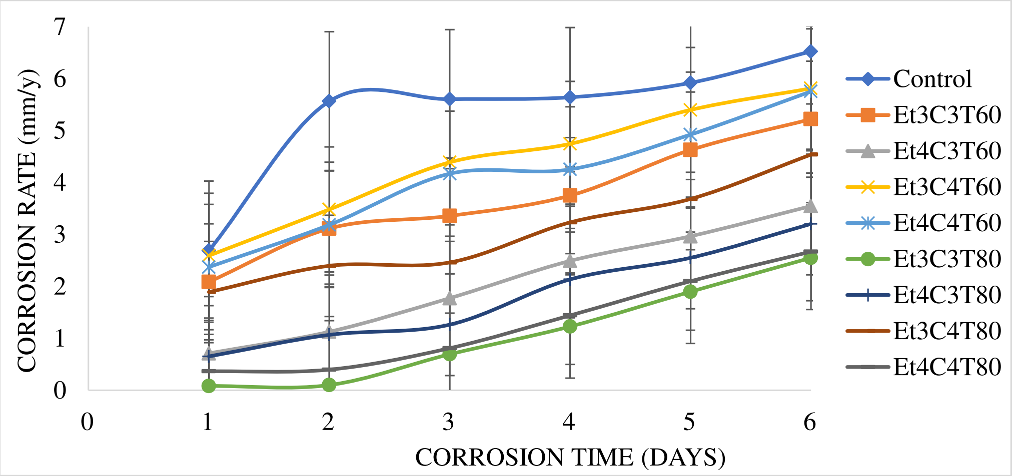

Fig. 2b. Corrosion rate (CR) of the uncoated and coated mild steel samples obtained from eggshell nanoparticles phosphating process.

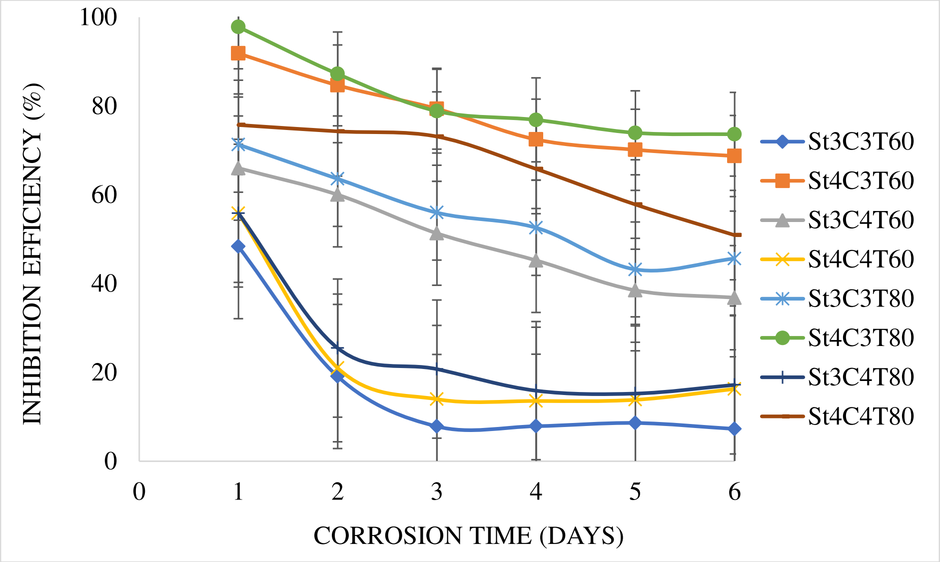

Fig. 3a. Inhibition efficiency of the uncoated and coated mild steel samples obtained from the snail shell nanoparticles phosphating process.

- The data obtained could be used to study the adsorption mechanism of zinc particles on the surface of the mild steel by establishing an appropriate adsorption isotherm that correctly predict the adsorption process.
- The data obtained revealed comparative analysis of the coating enhancement behaviour of the two calcium-rich waste material sources required during coating process

It is important to note that coating (zinc phosphating) process was performed on each metal sample before subjecting each of the samples to corrosion test. Also, each sample is identified by the coating conditions that it was subjected to. For example **St3C3T60, S** represents coating bath solution with snail shell calcium nanoparticle, **t3** represents coating time of 50 min, **C3** means 2.0 g/L calcium concentration in coating bath solution and **T60** connotes 60 °C coating temperature. For **Et4C4T80, E** stands for coating bath solution containing eggshell calcium nanoparticle, **t4** represents coating time of **60 min, C4** means 2.5 g/L calcium concentration in coating bath solution and **T80** connotes 80 °C coating temperature.

Table 1 revealed the concentrations of zinc obtained (in the coating bath and on metal samples) after the phosphating process at different coating times (50 and 60 min), coating temperatures (60 and 80 °C), using different sources of calcium (snail shells and eggshells).

Fig. 1a showed the weight loss of the uncoated and coated mild steel samples obtained from the snail shell nanoparticles phosphating process while the weight loss of the uncoated and coated mild steel samples obtained from the eggshell nanoparticles

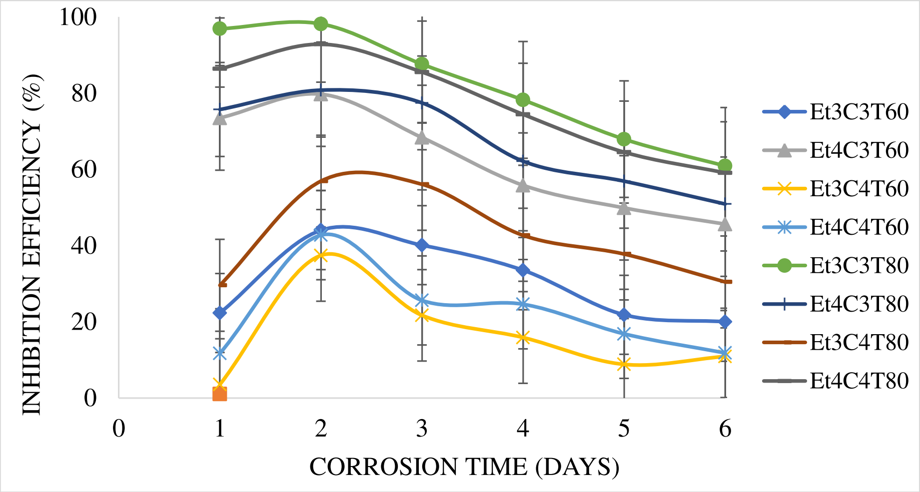

Fig. 3b. Inhibition efficiency of the coated mild steel samples obtained from the eggshell nanoparticles phosphating process.

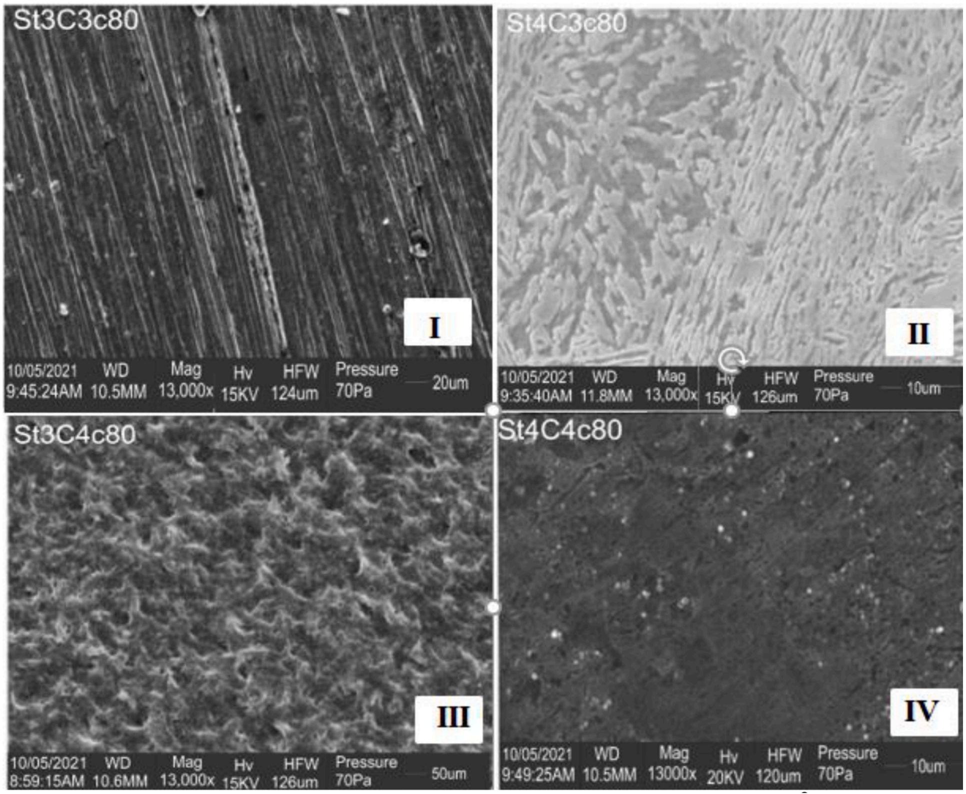

Fig. 4. SEM images of the coated mild steel at coating temperature of 80 °C using different concentration of snail shell calcium nanoparticles (C3 &C4) at different coating time (t3 & t4) (i) St3C3T80, (ii) St4C3T80, (iii) St3C4T80, (iv) St4C4T80.

phosphating process were presented in Fig. 1b.

Fig. 2a revealed the corrosion rate (CR) of the uncoated and coated mild steel samples obtained from the snail shell nanoparticles phosphating process while Fig. 2b showed the corrosion rate (CR) of both the uncoated and coated mild steel samples obtained from the eggshell nanoparticles phosphating process.

Figs. 3a and 3b gave the inhibition efficiency of mild steel (coated) obtained from the snail shell and eggshell calcium nanoparticles phosphating process respectively.

Fig. 4 showed the SEM images of the coated mild steel at coating temperature of 80 °C with coating bath solution containing snail

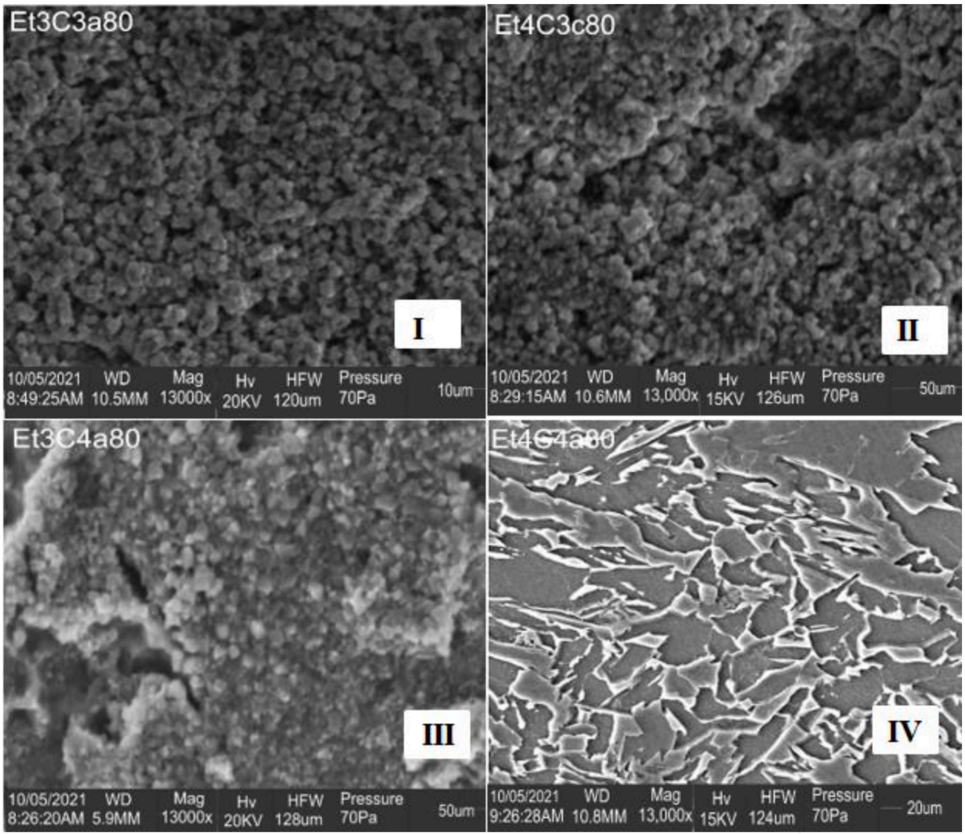

Fig. 5. SEM images of the coated mild steel at coating temperature of 80 °C using different concentration of eggshell calcium nanoparticles (C3 &C4) at different coating time (t3 & t4) (i) Et3C3T80, (ii) Et4C3T80, (iii) Et3C4T80, (iv) Et4C4T80.

shells calcium nanoparticles (C3 &C4) at different coating time (t3 & t4) while Fig. 5 showed the SEM images of the coated mild steel at coating temperature of 80 °C with coating bath solution containing eggshell calcium nanoparticles (C3 &C4) at different coating time (t3 & t4).

CRediT authorship contribution statement

S.N. Ezekiel: Conceptualization, Writing – original draft, Methodology, Investigation. **A.A. Ayoola:** Conceptualization, Writing – original draft, Supervision. **B. Durodola:** Methodology, Conceptualization. **O.A. Odunlami:** Writing – review & editing. **A.V. Olawepo:** Writing – review & editing.

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.

Please find as appropriate that the authors involved in the manuscript titled DATA ON ZINC PHOSPHATING OF MILD STEEL AND ITS BEHAVIOUR declare no conflict of interests.

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Competing Interests

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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