Chemical Data Collections 45 (2023) 101028

Contents lists available at ScienceDirect

Chemical Data Collections

journal homepage: www.elsevier.com/locate/cdc

Data Article

Explicit microstructural and electrochemical study of value-added carburized mild steel with coconut shell ash and $CaCO_3$ nanoparticles derived from periwinkle shell

Oyewole Adedipe [a,*], Victor Sunday Aigbodion [b,c,d], Nicholas Agbese Agbo [e], Sunday Albert Lawal [a], Oyebola Wahab Akanni Oyeladun [f], James Baba Mokwa [g], Emmanuel Toi Dauda [h]

[a] Department of Mechanical Engineering, Federal University of Technology Minna, Nigeria
[b] Department of Metallurgical and Materials Engineering, University of Nigeria Nsukka, Nigeria
[c] Africa Centre of Excellence, ACE-SPED University of Nigeria, Nsukka, Nigeria
[d] Faculty of Engineering and Built Environment, University of Johannesburg, P. O. Box 534, Auckland Park, South Africa
[e] Defence Industries Corporation of Nigeria (DICON), Kaduna, Nigeria
[f] Department of Mineral and Petroleum Resources Engineering, Kaduna Polytechnic, Nigeria
[g] Department of Mechanical Engineering, Federal Polytechnic Bida, Nigeria
[h] Department of Metallurgical and Materials Engineering, Ahmadu Bello University Zaria, Nigeria

ARTICLE INFO

Keywords:
Mild steel
Coconut shell
Periwinkle shell
Corrosion rate
Hardness values
And microstructure

ABSTRACT

The surface hardening of mild steel by carburization using periwinkle shell nanoparticles (PWSnp) as an energizer and coconut shell ash (CS) as a carburizer was investigated. For the carburization process, PWSnp:CS ratios of 0:0, 1:9, 2:8, and 3:7 were used. The hardness values, corrosion rate, and microstructure of the samples were determined. The results show a 114.1% increase in hardness values and corrosion protection efficiencies of 95.64 and 92.58%, respectively, at 3:7PWSnp:CS in 1 MH_2SO_4 and 35 wt% NaCl. Less corrosion damage was seen in carburized samples because the hard phases provided resistance to the corrosion's destructive activity. It was established that waste periwinkles shell and coconut shell can be used for surface hardening of mild steel.

Specification Table

Subject area	Materials Engineering, Physical Sciences
Compound	$H2_SO_4$, NaCl
Data category	Microstructure and Corrosion
Data acquisition	Scanning electron microscope and corrosion analyzed
Data type	Anticorrosion of carburized mild steel
Procedure	Data is with the article
Data accessibility	

* Corresponding author.
E-mail address: xoye.adedipe@futminna.edu.ng (O. Adedipe).

https://doi.org/10.1016/j.cdc.2023.101028
Received 1 March 2023; Received in revised form 6 April 2023; Accepted 14 April 2023
Available online 15 April 2023

Table 1
Chemical composition of mild steel (wt%).

Elements	C	Mn	Si	P	S	Zn	Al	Ni	Fe
%	0.16	0.35	0.15	0.0031	0.021	0.034	0.005	0.075	Balance

1. Rationale

To improve the service life of steel parts of military and civilian equipment, it is recommended that they should be made to possess not only hard and wear resistant surfaces, but tough and impact resistant cores [1] A low carbon steel of approximately 0.1% carbon is typically tough whereas a high carbon steel of about 0.9% C or more has appreciable hardness with low toughness [2]. To possess both hard and wear resistant surface, and tough inner core, steel parts require the carburization treatment so as to alter the configuration of the surface by increasing the hardness value of the steel surface [3].

However, mild steel is not suitable for wholesome hardening; rather, it is suitable for case hardening by the addition of carbon to the surface (carburization) and subsequent quenching in oil, water, or brine [4,5]. Mild steel is recyclable but has low resistance to corrosion [6]. The corrosion resistance can be improved by painting, electroplating, or laser cladding. Meanwhile, the corrosion resistance, wear resistance, hardness, toughness, and stiffness of untreated mild steel are not in any way comparable with those of carburized mild steel, which implies that carburization is a practice indulged in to improve those properties of mild steel [6,7].

In recent time, eco-friendly materials that have little or no harmful impact on the environment have been considered to be used as carburization materials for mild steel to achieve the desired properties [8]. There is much research in the literature that has used eco-friendly materials for carburization. Among them are: Umunakwe [9] studied the appropriateness of palm kernel shell and coconut shell powders as carburizing agents for mild steel. It was observed that the tensile strength and hardness of the mild steel were enhanced more with the mixture of the two carburizers than using them separately. The mild steel's mechanical properties were optimized by combining 80 percent coconut shell and 20 percent palm kernel shell. Istiroyah et al. [10] conducted the carburization of AISI 316 L steel at a temperature of 600 °C and a soaking time of 480 min. Results showed that coconut shell charcoal gave a hardness improvement of 40%, while rice husk charcoal gave an improvement of only 26%. The study found that coconut shell charcoal had better carburization properties than rice husk. Ihom et al. [11] made use of charcoal produced from melon shells, rice husks, sugarcane bagasse, polyethylene, and palm flowers, whereas egg shells were used as an energizer to carburize steel with a 0.25% C content and a hardness of 30 HRC. Olufemi et al. [12] employed cow bone as the carburizer and observed that the process reduced the impact toughness of the mild steel, increased the stiffness as the carburization temperature increased, but decreased the stiffness as the temperature exceeded 900 °C. The effect of carburization on the microstructure of low-carbon or mild steel shows that there is high pearlite formation at the surface while the inner core possesses a mixture of bigger pearlite and ferrite grains. Kolawole et al. [13] investigated the carburization of mild steel using date-seed and snail shell as an environmentally friendly carburizer. Results obtained showed that date seed and snail shell were highly eco-friendly carburizing agents for mild steel. At 1000 °C carburizing temperature, tensile strength of 521 MPa and hardness of 32 HRB were measured. These were equivalent to a 52 and 31% increase in tensile strength and hardness, respectively, over the uncarburized sample. Oluwafemi [14] employed carbonized palm kernel shell as carburizer in the carburization of mild steel. It was observed that a carburizing temperature of 950 °C and a soaking time of 2 h gave the optimum mechanical properties of the carburized mild steel. Negara et al. [15] conducted carburization of low-carbon steel at a temperature of 950 °C and soaking times of 2, 4, and 6 h. consecutively. The carburizer was charcoal produced from coconut shell fibers, while the energizer was barium carbonate. They were mixed in a ratio of 80:20. Water was used to cool the samples after carburization process. The hardness and wear resistance improved as the soaking time increased. The best properties were obtained with a soaking time of 6 h. According to the literature, the use of environmentally friendly materials, for mild steel carburization, is promising. However no much work has been reported on the use of periwinkles nanoparticles (PWSnp) and coconut shell ash(CS) as carburization materials for the enhancement of corrosion rate and hardness values of mild steel. Hence, this work will report for the first time the corrosion characterization of mild steel carburized using PWSnp and CS. It is our belief that the use of periwinkle nanoparticles as energizers will enhance the rate of movement of carbon to the steel surface.

2. Procedure

2.1. Materials

The periwinkle shells (PWS) utilized in this investigation was from Nigeria's Rivers State, and the coconut shell used in this work was obtained in Edo State, Nigeria. The mild steel was obtained from Ajaokuta Steel, Nigeria. The chemical analysis of the mild steel utilized in this study is shown in Table 1.

3. Method

The PWSnp was produced using the sol-gel technique. The raw periwinkle shells were cleaned by washing and drying for 24 h in