International Journal on Engineering Technologies and Informatics

# Substrate Straining Adhesion Measurements and Electrochemical Investigation of Chromium Oxide Coatings Exposed to Saline and Hank's Physiological Solutions

*Mini Review*

Volume 4 Issue 4- 2023

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Article History

Received: December 01, 2023 Accepted: December 05, 2023 Published: December 05, 2023

## Introduction

Excellent adhesion strength to substrates and electrochemical stability are among the major factors that determine the durability and integrity of nanostructured thin film coating when used in a range of engineering applications to enhance the properties of the substrate materials [1-3]. Coating material that shows an excellent adhesion strength to the substrate when tested dry may exhibit poor adhesion to the substrate material on exposure to environments containing harsh solutions such as marine and desalination environments. The ingress of the corrosive fluids/ions from the solution through any possible pores in the coatings can potentially facilitate/weaken the coating/substrate interface thereby limiting the long-term durability and performance of the coating in service.

Chromium oxide thin films have previously been investigated as a protective coating on various substrates and were found to enhance their tribological properties [3-5]. However, for the coating to be used as a protective coating material in application areas such as marine and desalination environments which contains a high content of chloride ions and other corrosive species, the effect of aggressive solutions such as saline and Hank's solutions on the coating adhesion strength and corrosion behaviour need to be evaluated.

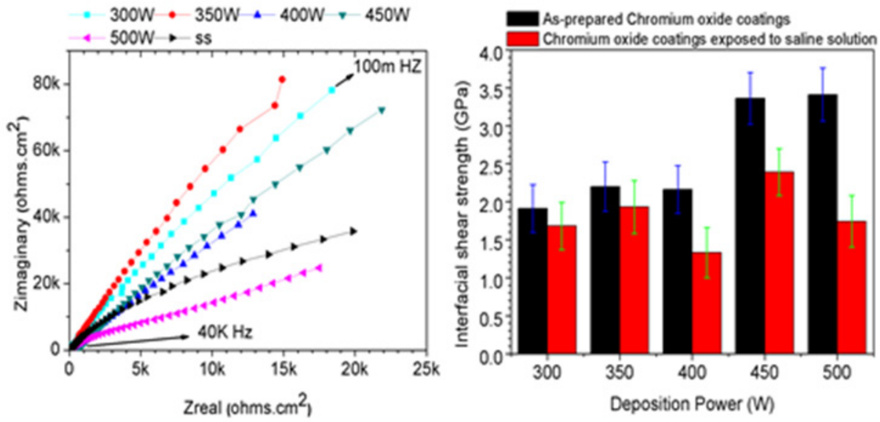
In this paper, we report the results of our investigation on the corrosion behaviour and adhesion strength of chromium oxide coatings prepared by reactive magnetron sputtering on stainless steel substrates when exposed to saline and Hank's solutions. The corrosion behaviour and adhesion strength of the coatings were determined using the Electrochemical Impedance spectroscopy (EIS) and substrate straining techniques respectively.

## Experimental Methods

The chromium oxide thin films were deposited on glass slides and 304 stainless steel substrates by reactive RF magnetron technique. The target material used was solid chromium (99.99%) whereas high purity oxygen and argon were used as the reactive and sputtering gases respectively. The deposition conditions which consist of RF powers in the range 300W - 500W, an oxygen flow rate of 10sccm and argon flow rate of 60sccm were used to prepare the coatings. The thin film deposition was carried out at ambient temperature and the process lasted for 2 hours. Prior to the adhesion test using the substrate straining technique, the coated samples were exposed to the solutions for one month. The chromium oxide coatings were subjected to an increasing tensile strain of 1%, 3%, and 5% to initiate a crack in the films and to determine the strain at which initial cracking occurred using the Instron 50KN machine. The strain at which the crack starts to appear on the coating gave the measure of the fracture strength of the films. The coated/substrate system was further strained to 10%, 15%, 20%, and 25% and the developed cracks at various strains was monitored with SEM until saturation is achieved. The average crack spacing at saturation was then used to determine the interfacial shear strength of the coatings.

## Results and Discussion

The results obtained through EIS measurements indicate that the chromium oxide coatings conferred a significant corrosion resistance on the stainless steel (Figure 1A). Although there was a reduction in the adhesion strength of the as-prepared thin films when compared to the films exposed to the physiological solutions (Figure 1B), the coatings were found to have retained adequate adhesion strength to the substrates after the adhesion test.




A B

**Figure 1**: Chromium oxide coatings prepared at various deposition conditions

A. EIS plots

B. Interfacial shear strength of the coatings.

## Conclusion

The substantial adhesion strength of the thin films and their good corrosion resistance indicate that these coatings have the potential to be used as a protective coating material on stainless steel in an environment where it is in contact with chloride solutions, e.g. marine environments.

## References

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**Citation:** Oje AM, Ogwu AA, Oje A. Substrate Straining Adhesion Measurements and Electrochemical Investigation of Chromium Oxide Coatings Exposed to Saline and Hank's Physiological Solutions. *Int J Eng Tech & Inf.* 2023;4(4):1-2. DOI: 10.51626/ijeti.2023.04.00066