



Scanning and transmission electron microscopy examinations of composite hybrid chromate and chromate phosphate conversion coatings exposed in hot 100% relative humidity environments

Peter P. Ikubanni^{a,*}, Makanjuola Oki^b, Adesoji A. Adediran^a, Sarah A. Akintola^c, Adekunle A. Adeleke^d

^a Department of Mechanical Engineering, Landmark University, PMB 1001, Omu-Aran, Kwara State, Nigeria

^b Greenfield Creations (Corrosion Consultants) Ltd, Benue Close, Agbara Industrial Estate, Agbara, 112102, Ogun State, Nigeria

^c Department of Petroleum Engineering, University of Ibadan, Ibadan, Oyo State, Nigeria

^d Department of Mechanical Engineering, Nile University of Nigeria, FCT, Abuja, Nigeria

ARTICLE INFO

Keywords:

Aluminium
Scanning electron microscopy (SEM)
Transmission electron microscopy (TEM)
Composite/hybrid coatings
Corrosion

ABSTRACT

Conversion coatings are sine qua non in the finishing of aluminium alloys. They may be put into service without coating of paints. However, for aesthetics in architectural applications, paint overcoat is common. Chromate phosphate coatings are relatively less toxic than chromate which gained the pride of place until recently. Thus, aluminium specimens coated with hybrid chromate/phosphate conversion coatings have been subjected to 100% relative humidity for 480 h at 313K in comparison to chromate coatings and bare aluminium. Scanning electron microscopy examination revealed that initial dried river bed morphologies on coated specimens were obliterated. The friable outer coatings collapsed into the cracks/environment leaving a relatively smooth surface after exposure. Additionally, transmission electron microscopy of sections before and after exposure revealed similar texture and morphological striations nearly parallel to each other throughout the length of the coatings to the metal/coating interface. These were not disrupted as well as the metal/coating interface which remained relatively smooth with no visible corrosion products after exposure. Thus, the coatings formed effective barrier between the substrate and the relatively harsh environment. From EDS, elemental compositions were the same albeit, spectral intensities remained relatively constant after humidity exposure regimes. The coatings are made up of either Cr, O and Al for chromate and Cr, P, O and Al for chromate/phosphate. At deliberately breached regions, the coatings prevented spread of corrosion and paint delamination over the substrates. On the other hand, bare aluminium was decorated with mounds of hydrated aluminium oxide/hydroxide after exposure as revealed in the SEM/TEM.

1. Introduction

Conversion coated aluminium can be put into service in a mild corrosive environment with or without a top coating of lacquer or paint. In both cases, the corrosion of the underlying aluminium substrate may occur, albeit, at scratches and/or defects in the bare or composite coatings [1–5]. Conversion coatings on aluminium usually exposed to atmospheric environment are those based on the so-called chromate-phosphate and chromate baths. The former imparts a greenish tone on aluminium while the later gives aluminium a golden yellow tint. The golden yellow tint may be washed off to a lighter shade of yellow by

immersion of the coated aluminium in hot water. This may reduce the adhesion properties [6] and corrosion protection performance [7] of the coating while in service. The non-chromium types are, however, employed in situations where there is zero tolerance to the use of chromium such as in the canning industries. Chromium compounds have been implicated as carcinogens; hence, various authors are searching widely for partial or full chromate replacements in conversion coating baths. Replacements, such as cerium [9] and other non-toxic and/or less-toxic salts based on transition element compounds have received attention from various researchers [10–15]. The corrosion performances of these alternatives were adjudged to be inferior to those

* Corresponding author.

E-mail address: ikubanni.peter@lmu.edu.ng (P.P. Ikubanni).

<https://doi.org/10.1016/j.hybadv.2023.100067>

Received 24 February 2023; Received in revised form 11 July 2023; Accepted 18 July 2023

Available online 20 July 2023

2773-207X/© 2023 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).