Advanced Materials Research
ISSN: 1662-8985, Vol. 367, pp 327-333
doi:10.4028/www.scientific.net/AMR.367.327
© 2012 Trans Tech Publications, Switzerland

Online: 2011-10-24

3

SEM Studies of Adhesion Property of Red Oxide Primer on Selected Metal Substrates

M.A. Bolarinwa[1,a], A.R. Adetunji[2,b] and O.O. Adewoye[3,c]

[1]Department of Industrial and Production Engineering, University of Ibadan, Ibadan, Nigeria

[2]Prototype Engineering Development Institute, Ilesa, Nigeria

[3]National Agency for Science and Engineering Infrastructure, Abuja, Nigeria

[a]mojimolati@yahoo.com, [b]aderade2004@yahoo.com, [c]oadewoye@yahoo.co.uk

(Corresponding Author*)

Key words: Adhesion property, Environmental degradation, Substrates, Red oxide primer, Metallography.

Abstract: The Scanning Electron Microscope (SEM) has been used to study the adhesion of red oxide primer on selected substrates. The substrates are stainless steel, mild steel, galvanized steel and aluminium. Twenty (20 No) specimens were prepared from the four different substrate metals and examined metallographically, after coating them with red oxide primer using different methods of application. Results showed varying degrees of adherence. The red oxide primer was able to form bonds with the different substrate metals, especially with the well cleaned, primed and subsequently painted stainless steel specimen.

Introduction

Maintenance coatings are film-forming products used in industry to give continual protection and decoration to capital assets [1]. The idea of substrate protection becomes essential due to a number of reasons: Corrosion protection of metals and alloys, corrosion protection of concrete and masonry, erosion protection of steel and concrete, heat reflection, fire endurance and maintenance of aesthetics.

Coatings serve several general functions. As architectural coatings, they usually provide a balance of protection and decoration, mostly in mild environments. Of all environmental influences that may impact negatively on substrates, the most common and destructive is corrosion. Corrosion is one of the most damaging mechanisms in many engineering structures [2]. Corrosion entails catastrophic attack on a substrate either chemically or electrochemically, through exposure to the prevailing environment. Over the years, researchers have observed that metallic corrosion represents a tremendous annual loss, which has been very detrimental to industrial equipment as a whole. The findings of Liang [3] showed that the most detrimental pollution is sulphur dioxide and chloride ion for corrosion of carbon steels and low alloy weathering steels. Likewise, metal dusting, a form of corrosion, is a major issue in plants used in the production of hydrogen-and methanol-reformer systems, and syngas (H_2/CO mixtures) systems that are pertinent to the chemical and petrochemical industries [4]. Nevertheless, frantic efforts have been in progress continuously to find effective ways of minimizing the effects of atmospheric conditions on substrates. For instance, maintenance coating has been explained as a means of protection against corrosion [5, 6, 7, 8 and 9]. In addition, Ashby [10] explained maintenance coating as a means of protecting iron and steel. Moreover, Higgins [11] and Vlack [12] both emphasized on maintenance coating as a way of preventing the oxidation of metal alloys. In order to protect substrates, a continuous barrier can be interposed between substrate's-surface and corrodent. For example, Prasad [13] indicated that environmental degradation behaviour of metals and alloys can be improved by modification of their surfaces using high energy beams. Also, the laser cladding technique is increasingly being used in the industry as a pro-active technology for corrosion and wear protection and as a reactive technology for repair of worn components [14].

In this study, the protection (coating) is based on the fundamental principle that substrates (metals) will not be exposed to adverse chemical reactions unless they are made to react with the environment. Therefore, the objective of this study is to carry out metallographic study by evaluating the degree of the adherence of some selected substrate metals; aluminium, mild steel, stainless steel and galvanized steel with the given surface maintenance coating applied, in order to determine the one with the best bonding characteristics.

Materials and Methods

Twenty specimens were prepared from 4 different substrate metals sourced from the African Regional Centre for Engineering Design and Manufacturing, ARCEDEM (Ibadan). These metals included: aluminium, mild steel, stainless steel and galvanized steel. They were sub-divided into 5 groups of 4 specimens per group to evaluate their adhesion degree by coating with red-oxide primer. The variations were as follow:

(a) Cleaned and primed only.
(b) Cleaned, primed and subsequently painted.
(c) Primed without any prior surface cleaning or preparation.
(d) Cleaned, primed and thereafter thrown with sand.
(e) As-received states to serve as control specimens.

On exposure of these specimens to the atmosphere for a period of eight (8) months, they were prepared metallographically and examined using the Scanning Electron Microscope (SEM) at the Central Science Laboratory of Obafemi Awolowo University, Ile- Ife. Table 1 shows the various coatings given to the substrate metals.

Table 1 Various coatings given to the Substrate metals

Treatment / Specimen	A Cleaned and Primed only	B Cleaned, Primed and Subsequently painted	C Primed without prior cleaning/ preparation	D Cleaned, Primed and manually sand blasted	E As received state
1 Stainless steel	A_1	B_1	C_1	D_1	E_1
2 Aluminium	A_2	B_2	C_2	D_2	E_2
3 Mild steel	A_3	B_3	C_3	D_3	E_3
4 Galvanised steel	A_4	B_4	C_4	D_4	E_4

Results and Discussion

The micrographs obtained from the SEM micro examination are as given in Figures 1 to 4.

Figures 1a, b, c, d and e: Respectively show stainless steel specimens: cleaned and primed only; cleaned, primed and subsequently painted; primed without any prior surface cleaning or preparation; cleaned, primed and thereafter thrown with sand and as-received states to serve as control specimen.

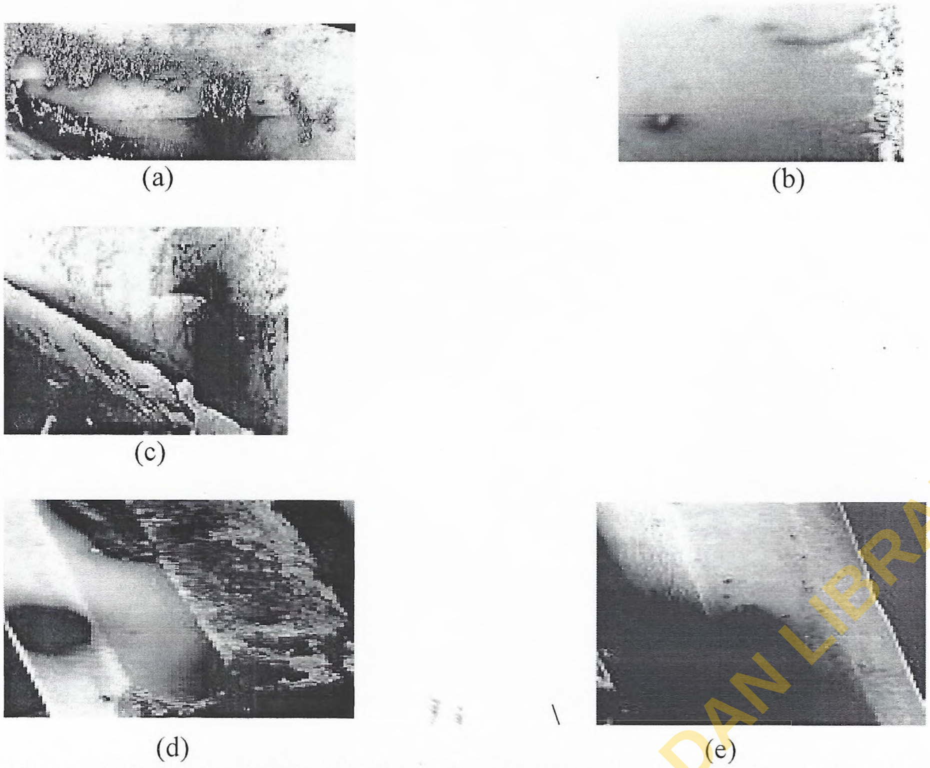

Figure 1 Stainless Steel, (a) cleaned and primed only (b) cleaned, primed and subsequently painted (c) primed without any surface cleaning (d) cleaned, primed and sand blasted (e) in the as – received state. Magnification 200x.

Figures 2a, b, c, d and e: Respectively show aluminium specimens: cleaned and primed only; cleaned, primed and subsequently painted; primed without any prior surface cleaning or preparation; cleaned, primed and thereafter thrown with sand and as-received states to serve as control specimen.

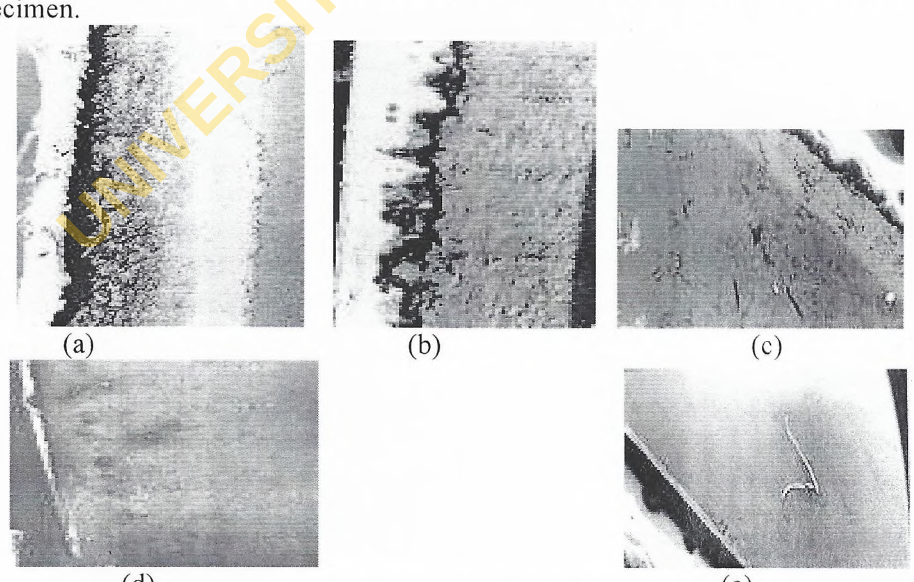

Figure 2: Aluminium, (a) cleaned and primed only (b) cleaned, primed and subsequently painted (c) primed without any surface cleaning (d) cleaned, primed and sand blasted (e) in the as – received state. Magnification 200x

Figures 3a, b, c d and e: Respectively show the mild steel specimens: Cleaned and primed only; cleaned, primed and subsequently painted; primed without any prior surface cleaning or preparation; cleaned, primed and thereafter thrown with sand and as-received states to serve as control specimen

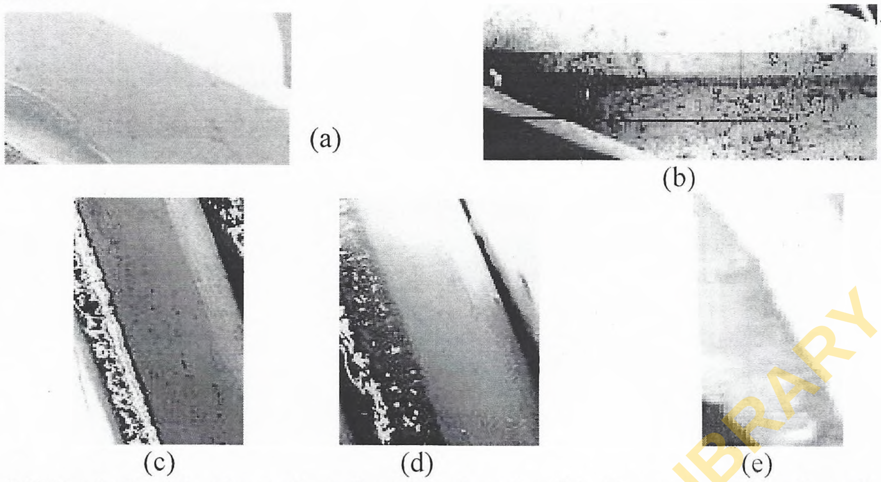

Figure 3: Mild steel, (a) cleaned and primed only (b) cleaned, primed and subsequently painted (c) primed without any surface cleaning (d) cleaned, primed and sand blasted (e) in the as – received state. Magnification 200x

Figures 4a, b, c, d and e: Respectively show aluminium specimens: Cleaned and primed only; cleaned, primed and subsequently painted; primed without any prior surface cleaning or preparation; cleaned, primed and thereafter thrown with sand and as-received states to serve as control specimen.

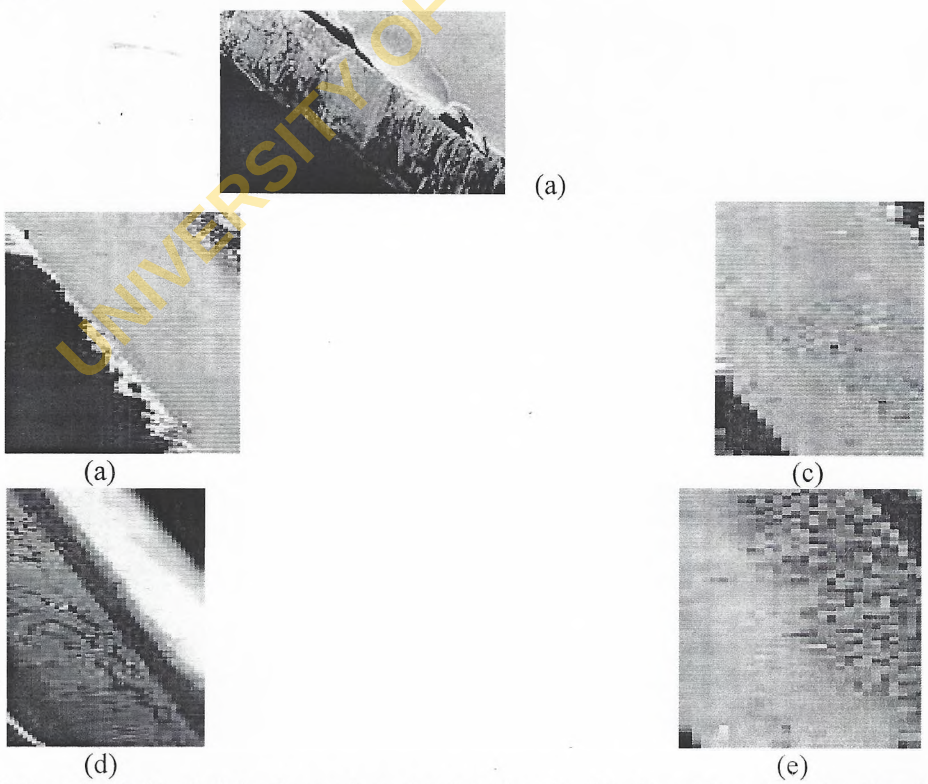

Figure 4 Galvanized Steel, (a) cleaned and primed only (b) cleaned, primed and subsequently painted (c) primed without any surface cleaning (d) cleaned, primed and sand blasted (e) in the as – received state. Magnification 200x

The results obtained indicate that on using the same primer throughout, all the specimens of stainless steel, mild steel, galvanized steel and aluminium could retain the primer on their various surfaces, although with varying degrees. From observations recorded during the etching process, all the stainless steel specimens took longer time to etch, so that etching was repeated for several times in each case before any microanalysis could be made. This was also observed in the case of aluminium. However, it did not take so long a time during etching compared to that taken by the stainless steel specimens. The last two sets of specimens, that is, galvanized steel and mild steel specimens were easily etched.

This in essence indicates that the adherence was highest in stainless steel specimens, with the applied coating, followed by aluminium.

An interesting observation was made at this junction. From the theoretical knowledge of galvanized steel, that is, steel that had been initially coated on manufacture; one would expect it to display outstanding thickness and sharpness. By comparing it with the last set of mild steel specimens, the reverse however happened to be the case. The plates revealed that mild steel specimens have strong adherence for red-oxide primer and were thus able to show sharper and thicker interfacial boundaries better than those obtainable from the galvanized steel specimens. Thus, with the use of red – oxide primer, the interfacial contact became more pronounced in the mild-steel specimens and therefore resulted in better interfacial boundaries as observed in them. Table 2 shows the summary of the results of the 20 specimens being analyzed.

Conclusion

The metallography of the bonding (adhesion) of red-oxide primer on stainless steel, aluminium, galvanized steel and mild steel have been assessed. With varying degrees of contact, hence, adherence, the red – oxide primer bonded with the four (4) metal substrates selected. The stainless steel specimen properly cleaned, primed and painted will have the best protection against corrosion and oxidation of all the substrate samples, followed by the aluminium specimen that was also properly cleaned, primed and painted. The mild steel specimens examined showed stronger adherence for red – oxide primer than the galvanized steel specimens, hence will be better protected than galvanized steel specimens. Red – oxide primer is durable because of its ability to give good adhesion when surface has been cleaned or prepared according to specifications, thus its general and almost all-round universal acceptance in the painting industry.

Table 2 Results of the 20 specimens under analysis in descending order

Specimen	Position	Remarks
B1	1st	Thickest interfacial boundary with distinct and unique sharpness.
D1	2nd	Fine interfacial boundary with distinct sharpness.
A1	3rd	Fine interfacial boundary and sharpness.
B2	4th	Reduced thickness and sharpness, unlike specimen A1 above.
D2	5th	Reduced thickness and sharpness.
A2	6th	Reduced thickness and sharpness.
B3	7th	The mild steel specimen exhibiting better interfacial contact, hence interfacial boundaries than its galvanized steel counterpart.
D3	8th	Mild steel exhibiting reduced interfacial contact and interfacial boundaries.
A3	9th	Mild steel exhibiting reduced interfacial contact and interfacial boundaries than D3 above.
B4	10th	Galvanized steel exhibiting reduced interfacial contact and interfacial boundaries.
D4	11th	Galvanized steel exhibiting reduced interfacial contact and interfacial boundaries than B4 above.
A4	12th	Galvanized steel exhibiting reduced interfacial contact and interfacial boundaries than D4 above.
C1	13th	Lack of intimate contact, hence formation of thin interfacial boundaries.
C2	14th	Lack of intimate contact, hence formation of thin interfacial boundaries.
C3	15th	Lack of intimate contact, hence formation of thin interfacial boundaries.
C4	16th	Lack of intimate contact, hence formation of thin interfacial boundaries.
E1	17th	Lacked contact formation.
E2	18th	Lacked contact formation.
E4	19th	No contact is observed.
E3	20th	No contact is observed.

References

[1] G. H. Brevoort, A. H. Roebuck, Simplified Method for Calculating Cost of an Applied Painting System, 19 (1980) 24-32.

[2] R.M. Pidaparti, K. Koombua, I. Abdelsayed, H. Sharma, Degradation Experiments and Analysis of Corrosion Damage, Intl. J. Damage Mech. 19 (2010) 197-210.

[3] C. Liang, Atmospheric Corrosion of Steels in China, J. Electrochem. 7 (2001) 215-219.

[4] Z. Zeng, K. Natesan, Symposium on Materials in Clean Power Systems, Intl. J. Hydrogen Energy 32 (2007) 3640-3647.

[5] R.P.M. Procter, Effects of Metallurgical Structure on Corrosion, in: Corrosion, 2nd ed., L. L. Sheir, (ed.) Newnes - Butterworth, Boston, Massachusetts, 1976, pp. 33-51.

[6] V. R. Pludek, Design and Corrosion Control, John Wiley and Sons Inc. New York, 1977.

[7] B. M. Bever, Encyclopaedia of Material Science and Engineering, Vol. 1 Pergamon Press, NewYork, 1978.

[8] M. G. Fontana, N.D. Greene, Corrosion Engineering, 2nd edn. McGrawHill, New York, (1978).

[9] J. A. Collins, Failure of Materials, in: Mechanical Design, John Wiley and Sons Inc. NewYork, 1981.

[10] F. M. Ashby, D.R.H. Jones, Engineering Materials, 2 BPC Wheatons Press, Great Britain, 1986.

[11] R. A. Higgins, Properties of Engineering Materials, Chaucer S Press Ltd. Suffolk, Bungay, 1977.

[12] H. van Lawrence Vlack, Materials for Engineering Concepts and Applications, Addiso Wesley Publishing Company Inc. Philippines, 1982.

[13] N. H. Prasad, R. Balasubramaniam, Processing of Advanced Materials, J. Materials Processing Tech. 68 (1997) 117-120.

[14] M. Rombouts, J. Meneve, D. Robberecht, E. Geerinckx, J. Gedopt, Laser Cladding: A Versatile Proactive and Reactive Technology, J. Asset Mgt. & Mtce. 24 (2011) 6, 8, 10.

Advances in Materials and Systems Technologies III
10.4028/www.scientific.net/AMR.367

SEM Studies of Adhesion Property of Red Oxide Primer on Selected Metal Substrates
10.4028/www.scientific.net/AMR.367.327

DOI References

[2] R.M. Pidaparti, K. Koombua, I. Abdelsayed, H. Sharma, Degradation Experiments and Analysis of Corrosion Damage, Intl. J. Damage Mech. 19 (2010) 197-210.
10.1177/1056789508098586
[4] Z. Zeng, K. Natesan, Symposium on Materials in Clean Power Systems, Intl. J. Hydrogen Energy 32 (2007) 3640-3647.
10.1016/j.ijhydene.2006.08.050
[13] N. H. Prasad, R. Balasubramaniam, Processing of Advanced Materials, J. Materials Processing Tech. 68 (1997) 117-120.
10.1016/S0924-0136(96)00018-0