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Corrosion potentials of metals and alloys as influenced by microbiological slime in seawater

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The influence of marine microbiological film formation on the free corrosion potentials of some alloys has been investigated. 304 and 316 stainless steels, and 3004 aluminium show considerable ennoblement of potentials in natural seawater compared to sterile seawater and 3% sodium chloride solution. Mild steel, copper and titanium have been found to be less susceptible to this effect. Galvanic currents measured between different couples in natural seawater are quite different from those obtained in the microbe-free situations. Results of the experiments, particularly of aluminium-mild steel couple, provide reasons for the consideration of microbiological component of seawater in predicting galvanic corrosion behaviour of certain alloys. The validity of conventional 3% NaCl tests is critically examined and results are discussed.

Key words: Corrosion potentials, metals and alloys, influence of microbiological slime in seawater

INTRODUCTION

Among the metals and alloys used in marine services, the behaviour of stainless steels alone has been well documented with respect to microbiological slime [1-3]. This study was motivated by the lack of information on the performance of other materials in natural and bacteria-free seawater, and to provide possible explanation on the ennoblement of corrosion potentials.

MATERIALS AND METHODS

The experiments were performed in the laboratory by running natural and natural but autoclave-sterilized seawater. Commercially available zinc, 3004 aluminium, mild steel, 304 and 316 stainless steels and copper were cut into test specimens of size 50 × 5 cm and mounted in conventional polethylene holders. The different materials were held in separate tanks where sea-water of each type flowed at a rate of about 5l.h.$^{-1}$. During the course of experiments which lasted 30 days, the corrosion potentials were monitored throughout. On termination after exposure for 30 days, the corrosion loss and wet weight of microfouling were measured.

RESULTS AND DISCUSSION

In either of the seawater environments, the trend in free corrosion potentials were unchanged for zinc, mild steel and copper. The behaviour of aluminium and the stainless steel, on the other hand were far different showing very wide fluctuations in corrosion potentials under the situation where microbiological slime developed, i.e. in natural seawater. The range of potentials observed in the two environments for all the metals are summarized in Table I.

The range of potentials measured during various stages of exposure on aluminium and stainless steel in natural seawater is plotted in Fig. 1.

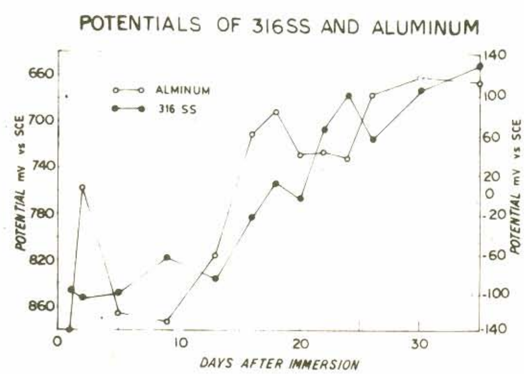

Fig. 1: Range of potentials of aluminium and stainless steel

It may be observed that ennoblement of corrosion potentials in aluminium is encouraged at a considerably

TABLE–I: The range of corrosion potentials for metals and alloys in two seawater environments and the wet weight of microbiological slime generated after 30 days

Metals	Potential range (mV vs SCE)		Microbial slime ($g.cm^{-2}$)
	Natural seawater	Sterile seawater	
Zinc	-1010	-1000	Not measurable
Aluminium	-880 to -665	-900 to -920	4.34
Mild steel	-670 to -710	-670 to -700	Not measurable
Stainless steel 316	-110 to +130	-100 to -140	3.13
Copper	-105 to -140	-125 to -150	Not measurable

early period of immersion than in stainless steel. A plausible explanation could be the fact that microfouling developed at a quicker rate on aluminium than on stainless steel. Similar results on microfouling behaviour have been obtained by others [4] who have explained the role of electronegativity in bacterial attachment. The development of an inner tier anaerobic bacteria is a characteristic feature in marine microfouling [5] and based on these results this appears to be responsible for the ennoblement of corrosion potentials.The ennoblement phenomenon for which no reason has so far been provided can be explained by cathodic depolarization brought about by sulphate reducing bacteria. Although this theory of bacterial corrosion has gone outdated and is not supported by the results on mild steel of the present study and of those obtained elsewhere [6], it appears that a lookout for the role of this phenomenon in passive alloys where, in fact, depolarization occurs in seawater could be a valid and promising approach. One good reason to support this view could be the fact that Dexter [3] observed ennoblement of potential in stainless steel as early as third day in polluted seawater, whereas in the present study and that of Scotto [1] in clean seawater it took about one week's time to record appreciable ennoblement. Finally it is worth mentioning that the classification of metals based on macrofouling by Efird [7] holds good for microfouling effects also, the active and toxic-film forming metals were least affected whereas the passive alloys were the materials sensitive to microfouling.

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