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MICROFOULING ON CATHODICALLY PROTECTED MILD STEEL IN SEA WATER

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ABSTRACT

The influence of cathodic protection on the rate of microfouling on mild steel was investigated in natural seawater. Cathodic protection was applied at current densities of 0.12 and 0.22 mA/cm^2 using sacrificial zinc anodes. The rate of attachment of bacteria and diatoms was observed to increase dramatically as a function of applied current, particularly during the first few days of exposure. It was also found that sulphate-reducing bacteria come into the scene as early as the fourth day while freely corroding specimens encourage SRB activity only by the twelfth day of exposure. The growth rate of calcareous deposits was also investigated to make it comparable with that of microorganisms.

Key Words: Cathodic protection, microfouling

INTRODUCTION

While the importance of calcareous deposit on the effectiveness of cathodic protection systems is generally recognised, the effect of marine organisms on the survival of the systems is poorly understood. This area warrants pioneering investigations especially since cathodic protection studies in Mandapam coast have brought out surprising results [1]. The calcareous shell-dwelling barnacles and molluscs are probably capable of utilizing the cathodic deposits for their shell growth. In addition, hydrogen embrittlement beneath marine fouling growth has also been demonstrated [2]. It is unfortuante that most electrochemical predications and theories on marine corrosion are arrived at from simple experiments using artificial seawater. Such naive techniques fail to reproduce conditions operating in a dynamic system as the marine environment.

Calcareous deposit formation is the immediate reaction accompanying cathodic protection current [3-5] While extensive literature is available on calcium precipitation, there are no published data on the attachment of micro-organisms during electrochemical polarization. It was therefore decided to study the attachment and growth rate of marine microbial films accompanying calcareous deposition under cathodic protection conditions.

MATERIALS AND METHODS

Commercially available mild steel whose composition is given in Table-I was cut into strips of 10 cm x 15 cm x 1 mm. They were fixed in wooden reepers and were finally washed in acetone prior to immersion. Where cathodic protection was applied, zinc anodes were galvanically coupled to mild steel. The current and potential values are given in Table II.

Table I: Composition of mild steel experimented

C	Mn	Si	P	S
0.1%	0.46%	0.074%	0.07%	0.028%

Table II: Open circuit potentials and current density values for the variables experimented

Variable	O.C.P. (mV vs SCE)	Applied current (mA/cm^2)
Freely corroding	−675	—
Cathodically protected	−800	0.12
Cathodically protected	−960	0.22

Bacterial counts were made on Zobelle marine agar, from swabbed areas of 1 cm^2. For enumeration of SRB, the recommended marine medium was used. Diatom counts were made on a microscope, from dilutions of swabbed 1 cm^2 areas. Calcareous deposit thickness was calculated from weight gain and surface area data.

RESULTS AND DISCUSSION

The first count/enumeration of total surface populations of bacteria and diatoms was made after eight hours of exposure. Subsequent counts were made at random intervals for a total exposure period of twelve days (288 hours). Simultaneously, calcareous deposit thickness was calculated at each interval, on duplicate sets of panels. It can be observed from Fig.1 and Fig.2 that both bacteria and diatoms sorb to cathodially protected specimens at a dramataic rate, the effect being directly proportional to applied current and electronegativity.

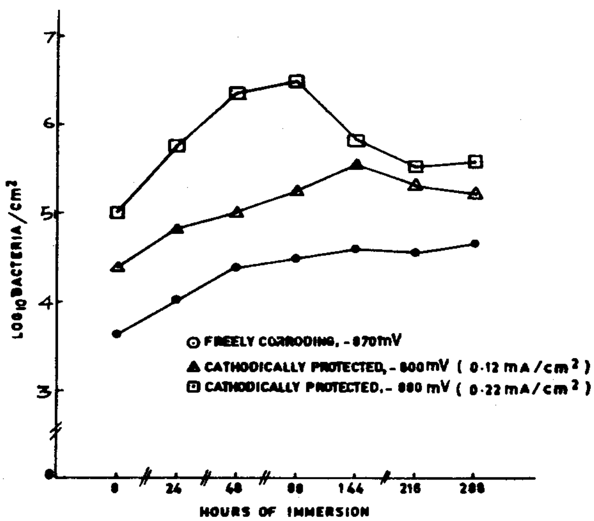


Fig. 1. Viable Bacterial Populations on Panels During 288 Hours of Immersion

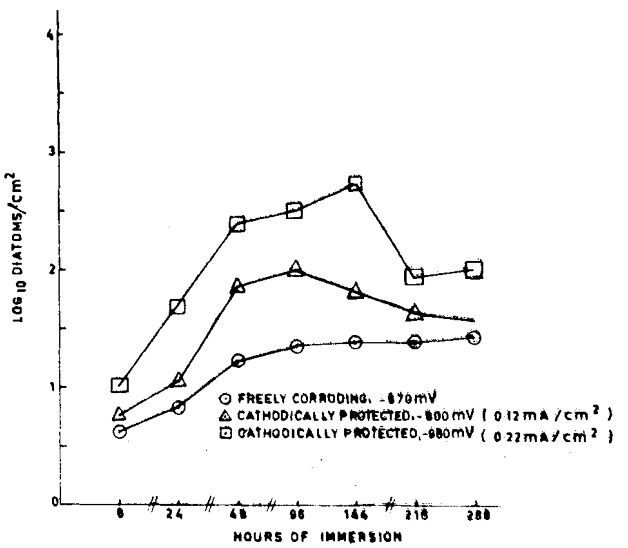
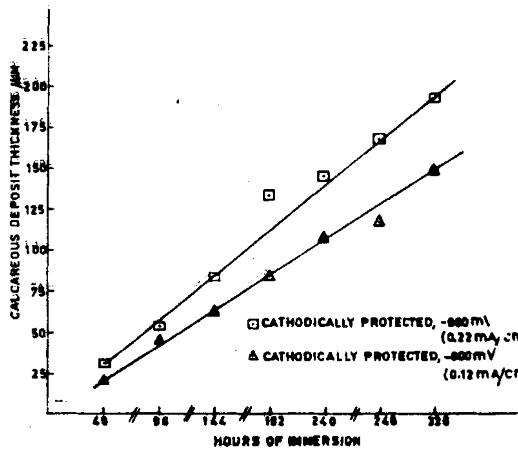


Fig. 2. Total Surface Diatom Populations on Panels During 288 Hours of Immersion



Clacareous Deposit Thickness During Various Stages of Exposure

Fig.4

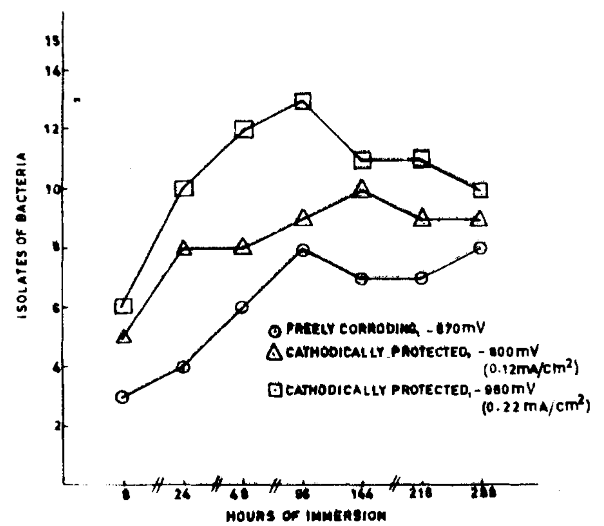


Fig. 3. Number of Bacterial Isolates on panels During 288 Hours of Immersion

Fig.3 shows bacterial isolates too to have been placed in an identical sequence. The growth rate of calcareous deposits indicated in Fig. 4 was calculated from weight gain and surface area data. While the larvae of macrofouling organism were separated from the calcareous film, no effort could be concentrated on deduction of biomass contributed by microbes. The accelerated sorption of microbes during the first few days reaches a stable state by the tenth day. The competition between microbes and calcium ion is quite evident from the results. The progressive decline in microfouling could be due to the fact photographically demonstrated elsewhere [7] that calcareous deposits entrap a considerable layer of microbes. Thus, the decline curve is steepest in conditions which are most electronegative.

It was of interest to investigate the occurrence of sulphate-reducing bacteria on cathodically protected surfaces. Quite surprising and unfortunate is the fact that SRB come into the scene much quicker under cathodic protection conditions, as early as the fourth day, wheras freely corroding specimens were not conductive to SRB growth for ten days and more. Obviously, the thick coat of microfouling along with calcareous deposits offers suitable micro-environments for SRB acativity.

We attribute the selective sorption of bacteria and diatoms on cathodic surfaces to the following fact. In experimenting with the effect of initial surface composition on microfouling, it has been found that zinc, aluminium and stainless steel are in perfect galvanic order with respect to bacterial attachment[8]. It was proposed that nutrients are sorbed to metal surfaces at a rate proportional to their electronegativity and this enhances bacterial attachment. Thus, during cathodic protection, bacteria and diatoms attach much easier and quicker than on bare steel. Accelerated rate of macrofouling is therefore, a vivid reality. Moreover, proliferation of SRB may lead to greater induction of protective current as against a low value recommended from laboratory tests for prolonged exposure.

CONCLUSION

1. Cathodic protection results in a dramatic increase in the rate of microfouling, the rate being directly proportional to applied current and electronegativity.

2. The dense mat of microbes and calcareous deposits provides favourable conditions for proliferation of sullphate-reducing bacteria under cathodic protection conditions.

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