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14. ABSTRACT

Based on the experimental values of the corrosion potential and the polarization resistance it was demonstrated that iron respiration can protect steel from corrosion. A new electrochemical model that explains the mechanism of this process has been developed. This mechanism is based on the assumption that iron-reducing biofilms reduce the rates of both the oxygen reduction and the metal dissolution reactions that are involved in the corrosion of iron and mild steel.

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FINAL REPORT

GRANT #: N00014-00-1-0775

PRINCIPAL INVESTIGATOR: Florian Mansfeld

INSTITUTION: University of Southern California

GRANT TITLE: The Molecular Basis of Humic Acid Reduction and its Role in Microbiologically Influenced Corrosion (MIC)

AWARD PERIOD: 6 January 2000 - 3 April 2001

LONG-TERM GOALS: To determine how microbial biofilm communities affect the corrosion behavior of iron and mild steel.

OBJECTIVES: To identify the mechanisms of indirect mineral dissolution (mediated by microbial reduction of humic acid) and direct biofilm formation on minerals.

APPROACH: Transposon mutagenesis is used to make mutants in *Shewanella oneidensis* strain MR-1. Two separate genetic screens are performed: the first identifies mutants that are defective in their ability to reduce AQDS (a proxy for humic acid), the second identifies mutants that are defective in their ability to make biofilms on steel chips. Candidate mutants are subjected to a variety of tests to verify their phenotypes and further characterize their properties. The site of insertion of the transposon is determined. Depending on the nature of the mutation, individual mutants are studied further. Electrochemical impedance spectroscopy (EIS) has been used to compare the ability of selected mutants defective in either humic acid reduction or biofilm formation to influence the corrosion behavior of mild steel.

WORK COMPLETED: A system that allows to perform electrochemical impedance spectroscopy has been set up in Professor Newman's laboratory at Caltech. Software developed at CEEL/USC has been used to analyze impedance spectra and determine the changes in corrosion behavior due to the presence of selected mutants.

RESULTS: Based on the experimental values of the corrosion potential and the polarization resistance which is inversely proportional to the corrosion rate we have demonstrated that iron respiration can protect steel from corrosion, and we have developed a new electrochemical model that explains the mechanism of this process. This mechanism is based on the assumption that iron-reducing biofilms reduce the rates of both the oxygen reduction and the metal dissolution reactions that are involved in corrosion of iron and mild steel. We have published a paper on this discovery in Applied and Environmental Microbiology [1].

IMPACT/APPLICATIONS: Two important findings have come out of our work this past year. The first is that there appears to be a relationship between electron shuttling molecules and certain classes of antibiotics. The second is that we have shown that iron-reducing biofilms may protect iron and mild steel from corrosion. We believe that both of these findings will have a significant impact. The first, because it may change our thinking about the evolutionary basis for

antibiotics; the second, because it may have practical consequences for how the concept of microbiologically influenced corrosion inhibition (MICI) will be used as an inexpensive, environmentally friendly method of corrosion protection.

TRANSITIONS: The results obtained in this project demonstrating that *S. oneidensis* strain MR-1 can protect steel from corrosion have influenced the research carried out at CEEL/USC dealing with MIC and its inhibition (MICI). We have begun working with two *Shewanella* strains to determine their effect on the corrosion behavior of a variety of materials such as an aluminum alloy, brass and mild steel exposed to artificial seawater.

RELATED PROJECTS: I have an on-going collaboration with a group at the University of Connecticut and a group at the University of California at Irvine which evaluates the concept of corrosion control using regenerative biofilms (CCURB) and is funded by the Electric Power Research Institute (EPRI). This project is currently in Phase III in which bacteria that have been shown in Phases I and II to inhibit corrosion of materials such as mild steel, stainless steel, brass and aluminum alloys are added to side streams in power plants for long-term monitoring of the corrosion behavior of these materials.

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