Environmental Severity and Accelerated Testing

Task 2.1, Task 1:
Title: *Factors Controlling the Atmospheric Corrosion of Silver in Natural and Accelerated Test Environments*

Objectives: Quantify the kinetics of the atmospheric corrosion of silver and their dependence on critical parameters and to assess the ability of gas-phase laboratory exposures to replicate the corrosion products observed under field exposures.

Background: Silver has been used for a number of years as a measure of the corrosivity of natural environments. After exposure, cathodic reduction of the corroded silver surfaces in the laboratory has indicated the ubiquitous presence of silver chloride, even in locations far from the seacoast or other sources of chloride ion. In standard salt spray testing, there is little, if any, silver chloride formed. This paradox formed the driving force for a preliminary OUSD project that has preliminarily investigated the role of salt, humidity, ozone, and UV light on the atmospheric corrosion of silver. The proposed work seeks to build on those results and, in collaboration with Ohio State, supply quantitative answers to the paradox described above.

Technical Approach: The preliminary project has developed lab exposure and a refined cathodic reduction method that allows the films formed on silver during atmospheric exposure to be quantitatively assessed. The proposed work will have two areas of focus: (a) analysis of lab-exposed samples to generate kinetic dependencies on UV light energy and intensity, relative humidity, gaseous oxygen, and atmospherically generated HOCl, and (b) analysis of the films formed on silver exposed to natural atmospheres. The first focus area will result in quantitative relations between silver corrosion rate and the important exposure variables, whereas the second focus area will shed light on the extent to which the films formed at locations far from the seacoast are silver chloride due to transport of seasalt aerosols versus silver oxide formed by the reaction of silver with UV light and ozone (either naturally or anthropogenically generated). Specific milestones are as follows:

- *Quantification of the rates for film formation on silver as a function of UV light energy and intensity, relative humidity, gaseous oxygen, and atmospherically generated HOCl concentration.* A laboratory exposure system will be used in which silver samples will be exposed for up to 7 days to controlled levels and combinations of UV light, relative humidity, gaseous oxygen and HOCl. After the exposure, the films formed will be analyzed using cathodic reduction to determine the amount of film formed and its type. Kinetics will be developed by exposures of different times.

- *Measure the amount of film formed on silver exposed to five natural atmospheres*. Samples supplied by the University of Hawai'i, as well as samples from Battelle Memorial Institute, will be analyzed using cathodic reduction to determine the amount of film formed at each location in a given time period (in C/cm^2) and information regarding the type of film formed (based on the reduction potentials observed). These data will be compared to the rates of film formation and types of films formed in the laboratory exposure portion of this task.

Student Development Approach: A combination of graduate research assistants, post-doc and undergraduate research assistants will be used to accomplish the work. Either an M.S. or Ph.D. degree will be obtained. Student participation at the Tri-service Conference and other forums will be expected.

Suggested Collaborator Role: We will work closely with Ohio State who will be studying the effects on silver corrosion kinetics of a complementary set of variables. In addition, we expect to take advantage of some of the exposure facilities at the University of Hawai'i and samples provided by Bill Abbott to study silver corrosion produced in a range of natural environments.

DOD Payoff: As silver is used as a rapid measure of atmospheric corrosivity, the improved quantitative description of its corrosion kinetics resulting from this work will pave the way for improved accelerated laboratory tests as well as improved corrosion rate prediction. The data resulting from this work will be provided to OUSD for enhancement and validation of their current corrosion rate model as developed by Battelle.