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Influence of Bacterial Biofilm on the Corrosive Processes in Electronic Equipment

Authors : Iryna P. Dzieciuch, Michael D. Putman

Abstract : Humidity is known to degrade Navy ship electronic equipment, especially in hot moist environments. If left untreated, it can cause significant and permanent damage. Even rigorous inspection and frequent clean-up would not prevent further equipment contamination and degradation because of the constant presence of favorable growth conditions for many microorganisms. Generally, relative humidity levels of less than 60% will inhibit corrosion in electronic equipment, but because NAVY electronics often operate in hot and humid environments, prevention via dehumidification is not always possible. Currently, there is no defined research that fully describes key mechanisms which cause electronics and its coating degradation. The corrosive action of most bacteria is mainly developed through (i) mycelium adherence to the metal plates, (ii) facilitation the formation of pitting areas, (iii) production of organic acids such as citric, iso-citric, cis-aconitic, alpha-ketoglutaric, which are corrosive to electronic equipment and its components. Our approach studies corrosive action in electronic equipment: circuit-board, wires and connections that are exposed in the humid environment that gets worse during condensation. In our new approach the technical task is built on work with the bacterial communities in public areas, bacterial genetics, bioinformatics, biostatistics and Scanning Electron Microscopy (SEM) of corroded circuit boards. Based on these methods, we collect and examine environmental samples from biofilms of the corroded and non-corroded sites, where bacterial contamination of electronic equipment, such as machine racks and shore boats, is an ongoing concern. Sample collection and sample analysis is focused on addressing the key questions identified above through the following tasks: laboratory sample processing and evaluation under scanning electron microscopy, initial sequencing and data evaluation; bioinformatics and data analysis. Preliminary results from scanning electron microscopy (SEM) have revealed that metal particulates and alloys in corroded samples consists mostly of Tin (< 40%), Silicon (< 4%), Sulfur (< 1%), Aluminum (< 2%), Magnesium (< 2%), Copper (< 1%), Bromine (< 2%), Barium (<1%) and Iron (< 2%) elements. We have also performed X 12000 magnification of the same sites and that proved existence of undisrupted biofilm organelles and crystal structures. Non-corrosion sites have revealed high presence of copper (< 47%); other metals remain at the comparable level as on the samples with corrosion. We have performed X 1000 magnification on the non-corroded at the sites and have documented formation of copper crystals. The next step of this study, is to perform metagenomics sequencing at all sites and to compare bacterial composition present in the environment. While copper is nontoxic to the living organisms, the process of bacterial adhesion creates acidic environment by releasing citric, iso-citric, cis-aconitic, alpha-ketoglutaric acidics, which in turn release copper ions Cu++, which that are highly toxic to the bacteria and higher order living organisms. This phenomenon, might explain natural “antibiotic” properties that are lacking in elements such as tin. To prove or deny this hypothesis we will use next - generation sequencing (NGS) methods to investigate types and growth cycles of bacteria that from bacterial biofilm the on corrosive and non-corrosive samples.

Keywords : bacteria, biofilm, circuit board, copper, corrosion, electronic equipment, organic acids, tin
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