BACTERIALLY ASSOCIATED CORROSION OF ALUMINUM SURFACE IN THE AIR

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SUMMARY

In a process of precision machining, corrosion of the surface of a precisely cut aluminum piece caused by bacteria was observed. A bacterium, Alcaligenes denitrificans, accumulated aluminum within the cell in granular form.

INTRODUCTION

With the progress of technology, corrosion of metallic surface would bring about a vital problem to a system such as an electronic system with microelectronics controller. When microfabricated printed circuits were not used for electronic circuits, such a problem could be ignored. However, several problems of such systems have now been found to be caused by bacterially associated corrosion (Iverson, 1987). Nevertheless, the problem of bacterially associated corrosion in industrial fields has so far been rather neglected. On the other hand, bacterial accumulation of metals has been well known and utilized in mining industry for collecting specific metal with use of specific bacteria. Generally metals are thought to be injurious for bacteria except for the small amount necessary for biological functioning, which exist as trace elements in bacterial cells. We found that Alcaligenes denitrificans, which is very common bacterium living in our biosphere, made a finely machined surface of aluminum piece corrode by accumulating aluminum from the surface and made particles consisted of aluminum compound in/on the cell.

EXPERIMENTAL METHODS

A surface of aluminum parts for a microelectronics system was obtained by precision cutting with use of conventional water-soluble cutting emulsion. Several days after the machining, the surface was gradually corroded in the air. A drop of water with which the corroded surface was washed put on a copper sheet mesh for electron microscopic observation. After evaporating the water from the surface of sheet mesh, we observed it by an electron microscope equipped with an energy-dispersive X-ray spectroscopic analysis system (EDX) without staining.

RESULTS AND DISCUSSION

Many bacteria which had particles with high electron density in/on cells were observed as shown in Fig. 1. In EDX spectra from each particle, aluminum peak was observed as shown in Fig. 2. In this spectrum, all copper peaks are overlapped with those from the copper sheet mesh used. The spectrum indicates that bacteria can be active and accumulate aluminum in/on the cells even without water but with ambient humidity. The bacterium is identified as Alcaligenes denitrificans, which is gram negative, aerobic and nonfermentative and can be
easily found in the general biosphere. It has been reported that bacteria and algae have some polyphosphate bodies in cells when their environmental condition changes toward the worse for their living (Jensen et al., 1982; Sakurai et al., 1990 and 1993). Under such a condition, bacteria easily accumulate metallic ions and the metallic ions are bound to polymetaphosphate molecules, which construct the polyphosphate bodies. Judging from EDX spectra obtained from the particles in/on this bacterial cells as shown in Fig. 2, the particles are somewhat different from the polyphosphate bodies. No phosphorus peak is observed. Several metallic and non metallic elements such as Fe, Cl, S, Si, Mg and Al, some of which are probably contained in the cutting bit and the cutting emulsion used or in the aluminum specimen as impurities, construct particles which seem to be bound rather on the surface of the bacterial cell. Our preliminary work indicates that Al, among these metals, is considerably difficult to be accumulated by general bacteria which are easily seen in our biosphere. The observed corrosion of the surface of burnished metal plate could be prevented by illuminating the surface with ultraviolet rays in the machining process.

Figure 1. Electron microscopic photograph of *Alcaligenes denitrificans* found on the surface of the aluminum parts of a microelectronics system. Bar shows 1 μm.

Figure 2. EDX spectrum from a particle in/on the bacterium shown in Fig. 1.

REFERENCES