Characterization of Corroded Cultural Iron Properties

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The corrosion products of iron swords from burial mounds contain $\alpha$-FeOOH, $\gamma$-FeOOH, Fe$_3$O$_4$, and amorphous iron hydroxides. The determination and infrared spectroscopy after separation of ground samples into magnetic and non-magnetic parts by a handy magnet and successive dissolution of specific components by several acids is introduced. The magnetic corrosion products contain mainly Fe$_3$O$_4$, while nonmagnetic samples are predominantly composed of $\alpha$-FeOOH. The content of $\alpha$-FeOOH in the corrosion products from the iron swords is much greater than that of atmospheric corrosion products.

The surface chemistry of FeOOH microcrystals should play an essentially important role in the conservation of the cultural properties from burial mounds. The crystal and surface structures and surface activities for H$_2$O and SO$_2$ of each FeOOH polymorph are explained. Surface hydroxyls on the predominant crystal faces of FeOOH are especially important, causing high adsorption activities for H$_2$O and SO$_2$.

The FeOOH microcrystals exhibit n-type semiconductivity. The electrical conductivity increases with the rise of temperature and is sensitive to impurities and to the surrounding atmosphere. The dc electrical conductivity at room temperature in dry air is $2\sim3\times10^{-9}$ ohm$^{-1}$ cm$^{-1}$. The electrical conductivity increases markedly with adsorption of H$_2$O and SO$_2$. High electrical conductivity of the oxide layer due to adsorption of H$_2$O and SO$_2$ accelerates the corrosion reaction on the iron surface. Also FT-IR examinations show that chemisorption of SO$_2$ on FeOOH surfaces creates SO$_3^{2-}$ and SO$_4^{2-}$, which should induce further corrosion. High surface activity of FeOOH crystals is a serious barrier for the preservation of the corroded cultural properties.

Simple surface modification of FeOOH crystals with titanates can change from hydrophilic to hydrophobic surfaces. The titanation leads to marked decrease in the electrical conductivity and in the amount of H$_2$O adsorption. The titanation of corroded cultural properties should prohibit further corrosion. The preservation method with the titanate coating for the iron-based corroded cultural properties is proposed.