



In situ Raman spectroscopy study of corrosion products on the surface of carbon steel in solution containing Cl^- and SO_4^{2-}

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ABSTRACT

Corrosion products of carbon steel in a simulated solution containing Cl^- and SO_4^{2-} were investigated by in situ Raman spectroscopy with a self-designed device. The results of Raman test and the SEM/EDS analysis of samples in different immersion times indicate that the corrosion products on the surface of the carbon steel consist of double rust layers, i.e. a porous outer layer (lepidocrocite $\gamma\text{-FeOOH}$) and a compact inner layer (magnetite Fe_3O_4). Aggressive ions such as Cl^- and SO_4^{2-} promote corrosion leading to the formation of lepidocrocite $\gamma\text{-FeOOH}$. Weight loss vs. time curve was also measured to study the effects of corrosion products. Corrosion products on a parallel sample were tested by Raman spectroscopy in air environment, which shown a distinct result from the one of in situ test.

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1. Introduction

The initial corrosion products formed on the surfaces of metals can influence the subsequent corrosion process significantly [1], and the knowledge of rust layer composition and structure on the surface of iron is very important in order to understand the corrosion process so that proper protection methods can be found [2]. Therefore, many methods have been used to study corrosion products, such as X-ray diffraction (XRD) and scanning electron microscopy (SEM).

Raman spectroscopy is playing an increasingly important role in the study of corrosion due to its remarkable advantages such as easy sampling and in situ measurement. With Raman spectroscopy, Neff and coworkers [3,4] studied the ancient rust scales on archaeological iron artifacts. Reguer and coworkers [5] investigated the Cl^- containing corrosion products. Nie and coworkers [6] worked on the corrosion of carbon steel in seashore salty soils with different water contents. However, the study on corrosion behavior of carbon steel in solution containing SO_4^{2-} and Cl^- has been hardly reported.

Oxygen and water are two important factors in metal corrosion processes in specific aqueous solutions, which cause the corrosion of metals. However, many Raman tests of corrosion products are carried out in air [7,8]. Thus, the results may not reflect the corrosion behavior under solution as corrosion products may change when the surface of the sample dehydrate and adsorb more oxygen in air.

In this paper, the corrosion products on the surface of carbon steel samples were directly tested by Raman spectroscopy under solutions containing SO_4^{2-} and Cl^- with a self-designed device. Combined with SEM/EDS analysis, the in situ Raman spectra were used to clarify the evolution of corrosion products. The effects of SO_4^{2-} and Cl^- on corrosion behavior of carbon steels were also investigated.

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