12C/2003G086

Chemical speciation of iron in airborne particulate matter by XANES technique

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Introduction

As the useful research technique which observes the change and presumes source of airborne particulate matter (aerosol), receptor models, such as a Chemical Mass Balance (CMB) method, are often used. However, when a characteristic component is not contained, the source apportionment is difficult. Therefore, development of a new index and analyzing method has been required for elucidation of contribution of airborne particulate matter.

XAFS spectroscopy is one of the powerful methods for chemical speciation of samples with low elemental concentration. The abundance ratio of every chemical species can be calculated by XAFS spectroscopy combining the PLS method[1]. That is, the amount of every chemical species can be calculated from PLS result and elemental concentration. If the chemical species change with sources, the amount of chemical species can be used for a new index of receptor models.

In this study, in order to elucidate whether the XANES spectrum changes with source, the chemical species of the iron contained in airborne particulate matter with different sources were analyzed.

Experimental

The following samples were measured as the typical particles of which source is different. As vehicle exhaust particulates, the environmental standard reference material #8 "vehicle exhaust particulates" from National Institute for Environmental Studies was used. The sample was collected in a traffic tunnel. As city waste incineration ashes, BCR reference materials #176 "city waste incineration ash" from Institute for Reference Materials and Measurements was used. European Coal and Steel Community standard sample, Euro-Standard #877-1 "Furnace Dust" were used as particles about iron manufacturing industry. The rock standard sample JB-2 "basalt" from Geological Survey of Japan was used as particles of soil system. In addition, the reagents such as iron nitrate, oxide, sulfate and so on were measured as the possible chemical species in airborne particles.

The XAFS measurement was performed at BL-12C, Photon Factory, KEK, Japan[2]. The iron K-edge XANES spectra of the samples were measured in fluorescence mode using a multi-element solid state detector[3].

Results and Discussion

Iron K-edge XANES spectra of various particulate samples were shown in Figure 1. From comparison with the spectrum of various iron compounds used as reference materials, it was found that main component of NIES #8 is $Fe_2(SO_4)_3$, in addition iron (II) silicate minerals and Fe_2O_3 are contained. It is considered that $Fe_2(SO_4)_3$ and Fe_2O_3 originate from engine combustion or abrasion of an automobile material. It is considered that iron (II) is the rock origin contained in a road pavement. About BCR #176, it is considered that main component is Fe_2O_3. About Euro #877-1, the spectrum differed from the spectra of other sources. Moreover, it differed from the spectrum of series of the reference samples of iron greatly, the identification about the chemical species of the sample was difficult. From comparison with spectrum of other sources' samples, the position of absorption edge of the spectrum of JB-2 shifted to low energy side. It was found that JB-2 contains many compounds of iron (II).

In this study, it became clear that chemical species of iron contained in aerosol changes with sources. That is, chemical species of iron contained in aerosol have been explained in terms of mixture of particles from various sources.
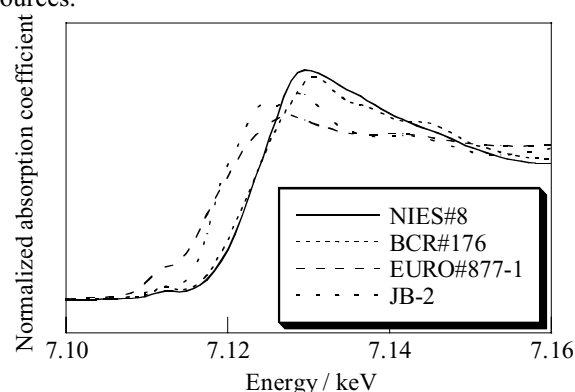

Figure 1. Iron K-edge XANES spectra of various airborne particles.

References

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