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MÖSSBAUER SPECTROSCOPIC CHARACTERIZATION OF DUST PARTICULATES FROM A CEMENT FACTORY AND THERMAL POWER PLANT

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Abstract

In this paper we present the study of dust particulates collected from six different location in the areas surrounding cement factory in central India and Thermal Power Plant. It is analyzed by Mössbauer spectroscopy that the iron exists in the chemical state of structural iron (Fe^{2+}, Fe^{3+}).The analysis of the ^{57}Fe Mö ssbauer Spectra recorded at room and liquid nitrogen temperatures, showed that iron species in all samples consisted of Fe_2O_3, Fe_3O_4, $Fe_2(SO_4)_3$ and Fe^{2+} high spin state but their proportions were different in different sites, dependent of each environmental condition. Mö ssbauer spectra recorded at both 300K and 78 K show the differences in the phase composition of iron containing ambient air dust particulates from cement factory. In addition, the transformation of iron compound in air was discussed.

Introduction: Iron is the major constituent of the whole earth (35.0 %) and the fourth major constituent of the earth's crust (4.5 %). The atmosphere contains less than 0.0001 % by mass of iron, however, airborne particulate matter is composed of 1.0 to 5.0 % by mass of iron (**Mahieu B, 1976**). Since large amounts of iron are mobilized in the earth's crust, atmospheric Fe is generally assumed to be soil derived (**Chang G, 2003, Gradel T E, 1985**). It is clear that anthropogenic emissions may also account for iron emissions into the atmosphere, however, models of identification of air pollution sources are lacking of consistency to explain the origin and occurrence of iron. Various industrial operations of the civilized world emit dust, gases, vapours and mist **(Lung Chi Chen, 2009**). The air inside a factory building can be polluted by released of contaminants from industrial processes to the air of the workroom (**Kopcewicz B., 1991**). Air pollution is persistent upon strongly nowadays because of its adverse effects on human health **(Schwartz J**.,2001). With increasing industrialization, many inorganic pollutants are continuously loading the atmosphere causing serious health hazards. Mossbauer spectroscopy can used to study that information from Fe. Mössbauer spectroscopy is particularly useful for studying the iron content and provide information regarding the structural and chemical aspects of the iron atoms in iron containing compounds.

In order to know the source of pollutants and quality of atmospheric environment around an industrial area, it is essential to have an accurate analysis of various components. The identify the various pollutants and their amounts is important to evaluate its health effects and toxic stresses. The aim of the present work was study the Mössbauer Spectroscopy of ambient air dust particulate samples and to know their phase composition.

Materials and Methods: Samples:

Ambient air dust particulates were collected from six different locations around the cement factory and thermal power plant located in Central India, by NEERI, Nagpur. Samples were collected using High Volume Sampler with preweighed glass fiber filter paper of size 20cm x 25cm with a average flow rate of 1.5m^3/min. The samples were dried in a desiccator. A fine powder of the dust particulate was scratched using a Teflon coated spatula to avoid the metal contamination.

The Mössbauer spectra were recorded on transducer driven Mössbauer spectrometer in constant acceleration mode (ELCENT) at room temperature. A ~5 mCi ^{57}Co(Rh) source was used. The spectrometer was calibrated using a natural iron foil. The isomer shift values were reported with respect to metallic iron. The spectra were fitted with Lorentzian line shapes by using least square fitting procedure.

Result and Discussion: Mössbauer Spectra recorded at room temperature and 78K spectra of the samples collected from Cochin city and nearby industrial area are shown in Fig.1. In the spectrum at room temperature, there are two components with quadrupole splitting doublet besides small contribution from the background (Fig.1A). In the spectrum at 78K there is a component with magnetic hyperfine splitting sextet besides the component already appearing at RT. This result indicates that the iron particles in the particulates are very small, showing a superparamagnetic behavior at RT and partly ferromagnetic at 78K. Such behavior of the particles shown in Mossbauer spectra typically belongs to ultrafine ferromagnetic or antiferromagnetic particles due to magnetic spin relaxation. The result showed that iron compounds in all samples consists of Fe_2O_3, Fe_3O_4 and Fe^{2+} high spin state but their proportions were different at different sampling sites, depending on environmental condition. The relative concentration of iron oxide in sample is higher than the one in commercial and suburban districts. In order to study the transformation of iron compound the samples collected from different locations were taken Mössbauer spectra. The transformation of Fe_3O_4 to Fe_2O_3 was found. The spectra at 78 K appear much stronger magnetic hyperfine splitting sextet than the one at 293K. It means that the iron particles contained in air particulates are small, showing a supermagnetic behaviour at room temperature and ferromagnetic partly at 78K.

Such behaviour of the air particulates particles appearing in a Mössbauer spectrum typically belongs to ultrafine ferromagnetic or antiferromagnetic particles due to magnetic spin relaxation. The

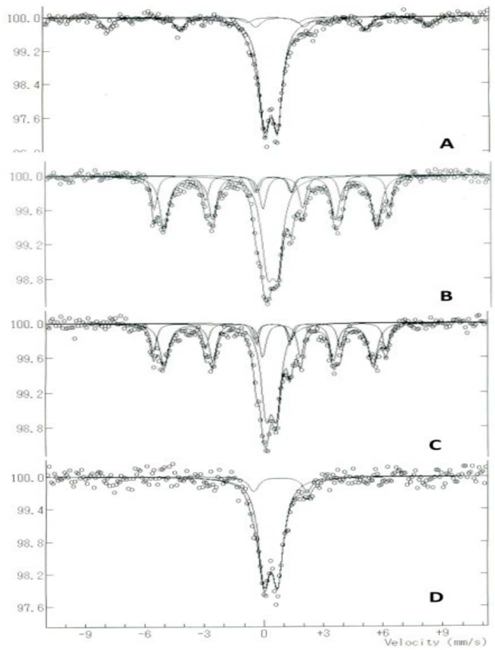

Fig.1. Mossbauer spectra of Ambient dust particulate matter at (A) Coachin city and (D) surrounding area of city at room temperature and (B) Coachin city and (C) surrounding area of city at 78K.

Mössbauer spectra were fitted by two doublets and two magnetic sextets at room temperature, and one more sextet was added at 78K. From it is found that the intensity of doublet and sextets components do not change with sites and temperature. All samples shows two doublets with large small quadrupole splitting and multiple sextets. Based on the hyperfine parameters, i.e., isomer shift (δ), quadrupole splitting(ΔE_Q), the doublet with larger quadrupole splitting was assigned to paramagnetic ferrous iron. Also, the doublet with small quadrupole splitting was assigned to paramagnetic ferric iron. Since the magnetic field H_{eff} of the magnetic hyperfine sextet was 515 kOe at room temperature, the sextet was attributed to kind of iron oxides like hematite. Assuming the same Debye- Waller factors for all iron compounds and neglecting saturation effects, the relative intensities of the compounds in the same samples were measured using area method. The relative area of Fe_3O_4 in the sample Coachin city is higher than the sample surrounding area of city while the relative area of α-Fe_2O_3 in the sample surrounding area of city is higher than the sample from Coachin city.

Conclusion

In order to control air pollution effectively, it is necessary to understand in detail its physical and chemical processes that govern its formation and transport. The Mössbauer spectroscopy is a very useful technique for identification of iron-containing phases in environmental samples.

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