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Thermomagnetic and Mineralogical Analyses of Industrial Dust and Fly Ashes Originating from Different Kinds of Industrial Processes

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Abstract

Industrial emissions are very important source of technogenic magnetic particles (TMPs) – mainly, oxides and hydroxides of Fe. TMPs introduced by Magiera *et al.* (2011, 2013), thanks their specific mineral and magnetic properties, and well developed specific surface area, are characterized by an affinity for some elements like heavy metals. They are generated in a wide variety of high temperature industrial processes where different iron minerals, present in raw materials, fuels and additives are transformed to highly magnetic iron oxides. TMPs are emitted to the atmosphere and then deposited on the soil, plant, and building surfaces.

The main objective of the research was identification of iron and manganese minerals (mainly oxides and hydroxides) occurring in TMPs. For the purpose of this study fly ashes from two power plants, dusts from non-ferrous metal smelting and two steelworks were collected and subjected to magnetic (bulk magnetic susceptibility and temperature dependence of magnetic susceptibility) and mineralogical (Mössbauer spectroscopy and scanning electron microscopy with energy dispersive spectroscopy – SEM/EDS) analyses.

The χ of fly ashes was at the level of 1000–1300 × 10^{-8} m^3kg^{-1}. Dusts originated from electrofilters were characterized by very diversified values of magnetic susceptibility. The highest values were obtained for furnace bottom ashes from coal-fired power plant (above 10000 × 10^{-8} m^3kg^{-1}) and the lowest – for dusts from non-ferrous metal smelting (below 1000 × 10^{-8} m^3kg^{-1}). Thermomagnetic analyses revealed differences between samples from particular industries. Inflection at 580 °C of the curve of TMPs emitted by power plants indicated that magnetite was the main magnetic phase. In case of non-ferrous metal smelting

additional curve deflection at 130 and 210 °C occurred relating to intermediate titanomagnetite (Vahle and Kontny 2005).

Mössbauer spectra showed that the magnetic phase accounted for 50–70% of fly ashes samples (mainly ferrihydrite and hematite), for 47–57% of bottom ashes (mainly ferrihydrite, magnetite and magnesioferrite), and for more than 90% dusts from electrofilters (mainly magnetite and maghemite). The smallest content of magnetic phase was characterized by steel dust from non-ferrous metal smelting: 11–30%. The main compound present in these dusts were franklinite, γ-FeZn and goethite.

SEM analysis revealed that the main components of fly ashes were glaze (mullite and quartz), quick cokes, calcium sulfates and spherical aluminosilicates with inclusions of Fe and Mg oxides. Iron and manganese were the main elements in almost all dust samples, however, the zinc and lead, as well as cadmium and copper prevailed in samples of dusts coming from Zn and Pb works.

Keywords: magnetic susceptibility, SEM, Mössbauer spectroscopy, TMPs, dusts.

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