Characteristics of technogenic magnetic particles from different sources of industrial and urban emissions

Tadeusz Magiera[1], Marcin Szuszkiewicz[1,], Marzena Rachwał[1], Michał S. Bućko[2]

[1] Institute of Environmental Engineering, Polish Academy of Sciences, Zabrze, Poland
[2] Geological Survey of Finland, Espoo, Finland

Corresponding author: tadeusz.magiera@ipis.zabrze.pl

Abstract: The term Technogenic Magnetic Particles (TMPs) defines iron minerals that were produced in a wide variety of technological processes (metallurgy, fuel combustion, ceramics, cement production, coke production, etc.) in high temperatures and emitted into the atmosphere. They are mostly iron oxides with ferrimagnetic or antiferromagnetic properties. This feature makes it possible to use these minerals as a tracers of industrial pollution because their presence, even in trace amounts, in dusts, soils or sediments can be easily detected by magnetic measurements. Such physical properties also enable TMPs to be separated from urban and industrial dusts and fly ashes of different origin as well as from topsoil and sediment where the particles have been accumulated as a result of atmospheric dust deposition. The aim of this study was to use magnetic parameters in distinguishing iron-bearing minerals generated by different sources of air pollution (power industry, cement, coke, ceramic industries and biomass combustion, vehicle emission). We measured magnetic susceptibility, hysteresis loops and thermomagnetic curves of various industrial dust samples in order to assess the type, concentration and grain-size distribution of iron oxides contained in industrial dusts of different origin. In addition also SEM-EDS analysis was performed to study the morphology and chemical composition of TMPs. The results show that TMPs after hard coal combustion are magnetic spherules with magnetite as the dominant magnetic phase. In the case of lignite-combustion ashes, maghemite and/or hematite have significant contribution among the TMPs. Ceramic dusts and ashes from biomass combustion are characterized by paramagnetic properties. The ashes from the combustion of wood have higher χ values than those from the combustion of straw. Coke dusts revealed different values of S parameter from the other groups of industrial dusts, indicating more complex mineral composition of the magnetic phases, probably including also the contribution of iron sulphides. In cement dusts the leading magnetic mineral was magnetite or ferrimagnetic calcium ferrite. The TMPs emitted by vehicles are mostly multi-domain magnetite and consist of two kinds of particles. Coarser

angular particles, which are mostly composed of magnetite rich in Cr and Ni admixtures and in some cases also of metallic iron (α Fe) and these are a result of non-exhaust traffic related emission. Finer spherical particles originating from exhaust car emission composed of multi-domain and pseudo-single-domain magnetite. The research proved that industrial and urban TMPs have slightly different magnetic and mineralogical properties. Diagrams depicting the dependence of saturation remanence versus χ values and S parameter versus Mrs/χ are an effective way to distinguish groups of TMPs coming from hard coal, lignite and biomass combustion, as well as those originating from coke, cement and ceramic production. Also particles produced by road transport have different properties.

Keywords: technogenic magnetic particles, industrial dust, pollution sources