Among the most important aspects of aerosol pollution study is the understanding of their role as condensation nuclei in the atmospheric processes and their influence on human health as risk inhalant particles. A detail discussion needs knowledge for quantitative description of their sources, transport, composition, size distribution and morphology, as well as laboratory and field tests of their activity. Electron microscope studies carried out by some of the authors for many years [1-3] aim the characterization of atmospheric dusts from Sofia and other representative industrial or tourist regions of Bulgaria. The present work combines the electron microscope analysis of dust particles from a busy traffic crossing of Sofia (Bulgaria) with investigations and quantitative characterization of their ice nucleation activity. All microscopic investigations in this study are performed on EPMA JXA-733 and SEM JSM-5300, JEOL.

The maximum of size distribution is at particles with diameter less than 2 µm (Fig. 1a). The typical for atmospheric aerosols elements Si, Ca, Fe, Al, S, K, Cl, Ti, Mg and Na are present in the integral spectrum of this sample (Fig. 1b) as well as some metals like Mn, Cu and Zn, related to industry.

Fig. 1 Size distribution (a) and elemental content (b) of the atmospheric dust particles.

Fig. 2 Micrographs and spectra of atmospheric dust particles: (a) Fe and (b) WCoFeTi.
The investigated atmospheric dust consists of different particles characterized morphologically by their shape, habitus, facing, porosity, agglomeration, etc. Their origin is either natural (the so-called dust-soil-mineral aerosols) or due to human activities (the so-called technological pollutants). The method of analysis of individual particles provides important information about their morphology and chemical composition that otherwise cannot be obtained by “bulk” analysis methods. All particles containing chemical elements with an average atomic number higher than that of the predominant soil ones are almost easily detected in the COMPO-type image because of their characteristic “shining”. Microphotographs of such metal (metal oxide) containing particles and their corresponding spectra are shown in Fig. 2. The spherical particles of almost pure Fe (Fig. 2a) are monoliths with smooth surface and diameters varying from 1 to 50 µm. The particle in Fig. 2b is an irregular shaped agglomerate of about 15x20 µm that contains W, Co, Fe and Ti.

The freezing temperature dependence of $N_0$ water drops (each with volume $v = 1 \text{ mm}^3$) is determined when they are cooling at constant rate $q \ [\text{Ks}^{-1}]$ (Fig. 3). The process is observed through an automatically recording computer controlled TV camera [4]. In case of mononuclear mechanism, the number of nuclei in these $N_0$ drops will be equal to the number $N$ of frozen drops. Then at independent freezing of the drops, the steady-state nucleation rate $J \ [\text{m}^{-3}\text{s}^{-1}]$, 

$$J(T) = \frac{q}{v} \frac{d}{dT} \ln[1 - \frac{N(T)}{N_0}],$$

reduces to finding the temperature derivative of the experimentally obtained $\ln(1 - N/N_0)$ using the method of smooth approximation of data [4].

Following the classical nucleation theory [5], the detailed analysis of results with seeded drops shows at least three types of active centers acting in the investigated temperature interval. The most active centers play role over about $-10^\circ\text{C}$, the other are active at about $-15^\circ\text{C}$ and at the less active dominates below about $-20^\circ\text{C}$. Physical parameters like activity, “wetting” angle and specific surface free energy are found as a quantitative measure of these aerosol-introduced active centers together with that for pure water drops.

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References: