A study of radioactive and nonradioactive aerosol behaviour

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INTRODUCTION

Aerosols belong to the most dangerous forms of radioactive and nuclear substances, due to their ability to spread. Radioactive aerosols are liquid or solid particles suspended in air with diameters ranging from 0.001 to 100 microns; these particles are either formed by a radioactive material or the radioactive material is attached to the surface of a non-radioactive particle.

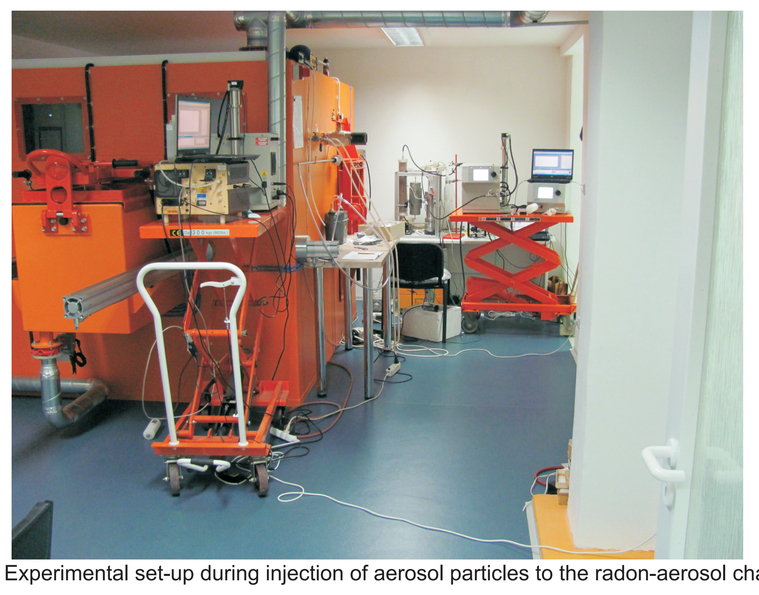

Fig. 1: Experimental set-up during injection of aerosol particles to the radon-aerosol chamber

MATERIAL AND METHODS

The experiments were carried out in a radon-aerosol chamber at SÚJCHBO (see figure 1). This chamber is a device for studying physical behaviour of radioactive and non-radioactive aerosols. The inner atmosphere of the radon-aerosol chamber is separated from the ambient atmosphere by a sophisticated air-exchange system which enables to perform the experiments at pre-defined climatic and ventilation conditions [1].

Different aerosol atmospheres were produced by three aerosol generators. Figure 2 demonstrates a common aerosol spectrum generated by a CW (Carnauba Wax) generator. The summary of main parameters of the generated particles is presented at the table 1.

Type	Carnauba wax	Ammonium sulfate	DEHS on NaCl
Indication	CW ■	AS ▲	DEHS ●
Type of generator	Carnauba wax	AGK2000	MAG3000
Mode of size distribution [nm]	180	50	2000
GSD	1,6	1,2	1,6

Tab. 1: Summary information about generating aerosol particles

Particle number size distribution in the size range 10 nm - 750 nm were measured by a Scanning Mobility Particle Sizer (SMPS 3934). It consists of two parts: an Electrostatic Classifier (EC - 3071) and by a Condensation Particle Counter (CPC 3025). An Aerodynamic Particle Sizer Spectrometer (APS - 3321) determined the size distribution over the complementary size range of 500 nm - 20 µm.

Airborne radioactivity after sampling was measured by a Canberra multichannel alpha-spectrometer (Model 7401 VR). Photon dose estimation was determined by a portable multichannel gama-spectrometer Falcon (Model 5000).

Radon and its short lived decay products were used as an inner radioactive source and a cartridge with a ^{85}Kr was used as a point source of ionization radiation.

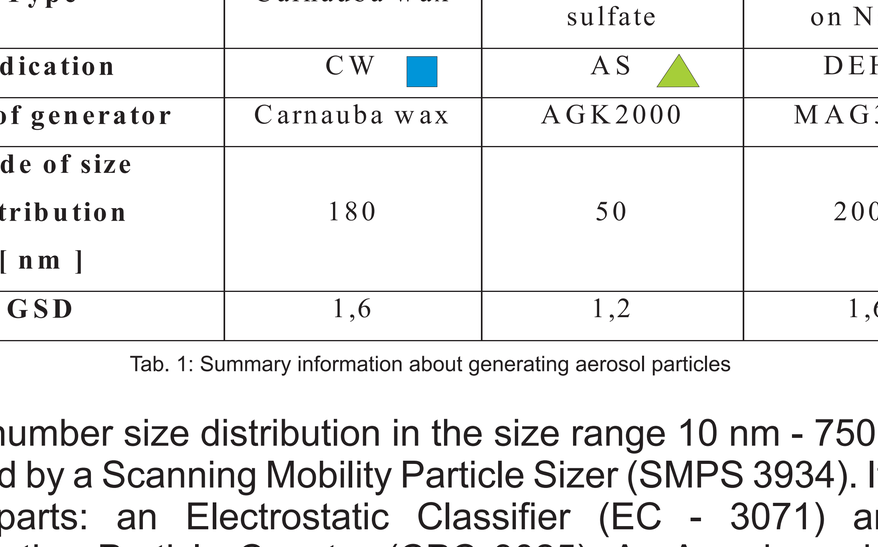

Fig. 2: Demonstration of reproducibility of aerosol production by CW generator during preliminary tests

THEORETICAL BASIS

A number of processes contribute to the charging of aerosol particles: static electrification, photoemission, thermionic emission, charging by small gas ions, and self-charging of radioactive aerosols [2]. There are two possibilities: in one case the radioactive material is embedded into an aerosol particle. In the second case the radioactivity is on the surphace of nonactive particle. There is another possibility to redistribute the charge: using a flux of photons (from „outside“ of the particle). Processes such as coagulation and/or deposition may be significantly affected by redistribution of electrostatic charge of aerosol particles.

RESULTS

The main objective of the experiments was to compare the behaviour of aerosol in a field of ionizing radiation generated by ^{85}Kr and the behaviour of aerosol particles in an environment of extreme concentrations of radon. The results of these experiments were compared with the behaviour of non-radioactive aerosols. Aerosol particles were generated in three different size classes characterized by the size mode (50 nm, 180 nm and 2 µm). Experimental results are summarized in the following figures (see figure 3, 4).

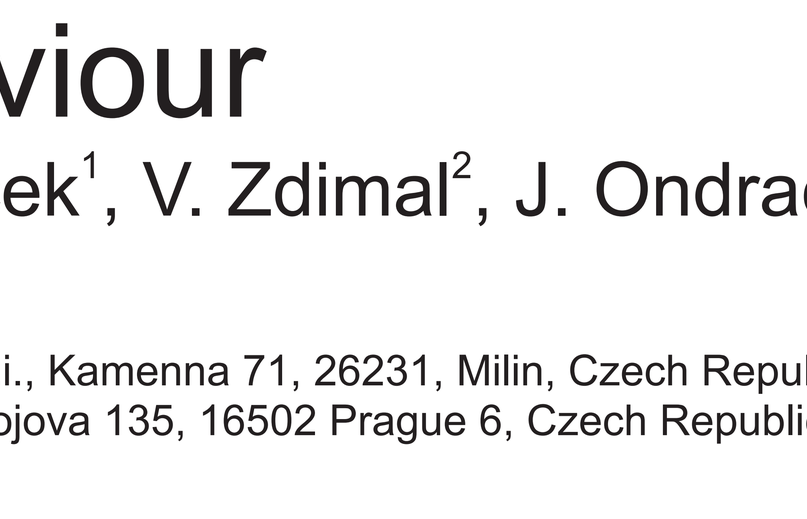

Fig. 3: The time course of the total concentration of aerosol particles in the chamber for different types of aerosol particles

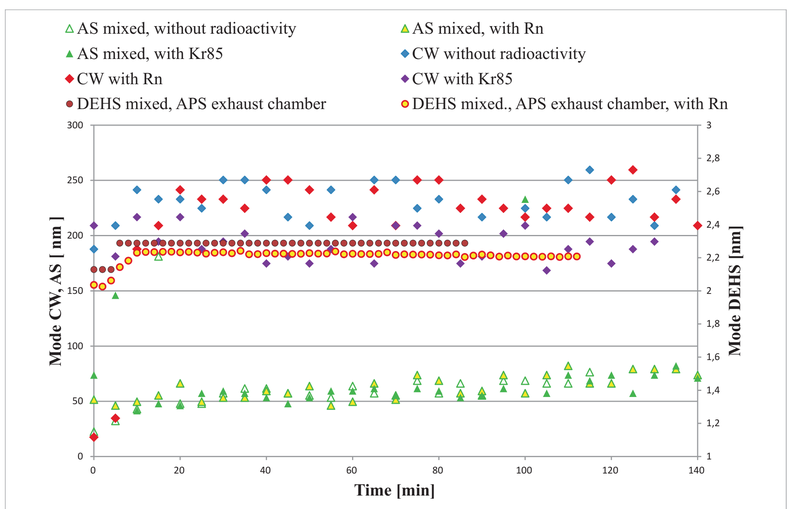

Fig. 4: The time course of size mode distributions of aerosol particles in the chamber for different types of aerosol particles

Plate-out rate of total concentration of aerosol particles depends on the type of aerosol particles. In some cases particles were influenced by radon (concentration about 1.5 MBq.m^{-3}). The dose rate coresponding to this concentration is approximately 3 µGy/s. Most of the energy the alpha particle is absorbed in the mass of air. Taking in to account number concentrations of about 5000 particles per cm^{-3} , the ratio between the mass of aerosol particles to the air mass is around 3.3E^{-6}. Flowig through ^{85}Kr neutralizer, the aerosol stream was irradiated by 15 µSv. When we compared the behaviour of aerosol particles and different exposer (Figure 4) almost no difference has been found. The same conclusion holds for the decrease of the total concentration (see Fig. 5).

Fig. 5: The time course of the total concentration of aerosol particles in the chamber for ammonium sulphate with / without Kr85 neutralizer and / without the presence of radon

CONCLUSION

In this work, we studied physical behaviour of radioactive and non-radioactive aerosols. The experiments were carried out in a radon-aerosol chamber at SUJCHBO. Three types of aerosol were generated – CW, AS and DEHS. The aerosol was filled into the chamber either as it was generated, or after charge neutralization by ^{85}Kr. In part of the experiments, the aerosol in the chamber was mixed with Rn and its short lived decay products. In other experiments it was exposed to an elevated photon stream.

It has been found that: irradiations were performed by high concentration of radon (and its decay products). In this case the non-radioactive aerosols was of course covered by radioactivity.

In the second case an elevated photon stream was used. One can predict a difference in the of behaviour of aerosols when the aerosol was charged by irraditation „from outside“. Hoewer, we did not observed any mode change or an increasing plate-out.

REFERENCES

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