The penetration of polystyrene particles through the airways investigated by accelerator mass spectrometry

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Keywords: accelerator mass spectrometry, organic aerosols, inhalation, mice, polystyrene beads, radiocarbon.
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Reliable studies on to the particle deposition in the respiratory tract and further particle translocation are of great value not only to risk assessment of inhalation toxicology but also to improve efficiency in drug delivery of inhalation therapies. But there is an important gap in health-particle matter (PM) investigations comprising low-dose exposures with organic aerosols. Ultra-small size, ultra-low concentrations and organic matter of the aerosol have made direct detection of particles inhaled under ambient conditions impossible to date. Due to strong analytical limitations, the majority of PM health effect investigations are based on techniques that use intratracheal instillation instead of inhalation, and even when inhalation takes place, PM concentrations are much greater 100 μg/m^3. In order to detect inhaled particles in organs by direct way, e.g. by elemental analyses, investigators have to use inorganic particle matter, such as Pt, Ag, TiO_2 or radioactive labels, e.g. ^{99m}Tc, physically attached to the particles.In addition to inorganic matter, which differs from the ambient aerosol constituents, in vivo dissolution and transport of the dissolved metals and labels may cause ambiguity in particle detection. Polymeric monodisperse beads seem to be perspective model for aerosol investigations due to organic matter, nonbiodegradability, controllable size from several nm to several μm, possibility of surface modification by negative (-COOH) or positive (-NH_2) functional groups, as well as by designing core-shell structures with desirable chemistry. The attraction of polymeric beads, predominantly polystyrene (PS) ones, affects the number of studies using this technique, but again the problem of direct particle registration forces to raise the dose so that intratracheal instillation or intravenous administration are used instead of inhalation.

Accelerator mass spectrometry is firstly shown in this work to be applicable for studying the penetration of organic aerosols, inhaled by laboratory mice at ultra-low dose [1]. We synthesized polystyrene (PS) beads, composed of ^{14}C-labeled styrene, for testing them as model organic aerosols. Preparation of polystyrene beads consisted of five stages. As a source of radiocarbon we used methyl alcohol with radioactivity 40 MBq. ^{14}C-labeled polystyrene beads were obtained by emulsifier-free emulsion polymerization of synthesized ^{14}C-styrene initiated by $K_2S_2O_8$ in aqueous media. Measured activity by scintillation method of polystyrene latex was 14±2 kBq/ml, polymer content was 2.5 wt. %. According to dynamic light scattering data the polystyrene beads were 225±25nm in diameter. Aerosol particles were produced by pneumatic spraying of ^{14}C-PS latex obtained. Scanning electron microscopy showed that aerosol was bimodal with 225-nm and 25-nm in size. 5 mice inhaled ^{14}C-PS aerosol consisting of 10^3 225-nm particles per 1 cm^3 and $5{\cdot}10^3$ 25-nm particles per 1 cm^3 during 30 minutes. The ^{14}C content was measured in mice lungs, liver, heart, kidneys, brain, and excrements in 2-3 hours after exposure. AMS analysis of lungs showed that the ratio of activity of samples from five mice to that one of reference mice, not exposed to labeled aerosol, was 1.24, 1.16, 1.04, 1.00, and 1.14with deviation of 0.01.

This work was partially supported by the Russian Science Foundation, project no. 15-53-16013.

[1] E.V. Parkhomchuk et al. Ultrasensitive detection of inhaled organic aerosol particles by accelerator mass spectrometry. *Chemosphere (2016) 159, 80-88.*