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Influence of Break Wear Particles on Radon Progeny Behavior in Indoor Air

FAKULTA EKOLÓGIE
A ENVIRONMENTALISTIKY

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Abstract

Recent studies indicate that brake wear particles (BWPs) generate large quantities of highly charged aerosol particles, predominantly negatively charged. As traffic-related aerosols represent a major fraction of urban air pollution, their admission indoors may influence the behavior radon decay products. The inhalation dose from radon progeny depends strongly on their attachment to aerosols, which determines their mobility and deposition in the respiratory tract. While the effects of laboratory aerosols (e.g., sulfate, NaCl, or latex particles) on radon progeny have been extensively investigated, little is known about their interactions with real-world anthropogenic aerosols, such as BWPs.

BWPs are characterized by a broad size distribution, high surface area, and electrical charging caused by triboelectric processes. These properties may significantly alter the equilibrium factor and unattached fraction of radon progeny, thus affecting indoor exposure conditions. Furthermore, their metal-rich composition suggests possible synergistic toxicological effects when co-deposited with alpha-emitting radionuclides. The potential impact of BWPs on radon progeny attachment, mobility, and dose distribution represents an important but so far unexplored research field with both radiological and public health implications.

This paper presents a new research project aimed at studying the properties of brake wear particles. The proposed study aims to investigate the influence of break wear particles on radon progeny behavior in indoor air.

Keywords: break wear particles, radon progeny, equilibrium factor

Introduction

Recent research of the electrical properties of brake wear particles [1] suggest, that a large ammount of highly charged aerosol particles is formed, with signifficantly more negative charged particles than positive. Relativelly high fraction of the urban air aerosol particles originate from traffic [2–4], and this polluted air enters the indoor environment via ventillation. Another signifficant health risk in the indoor air comes from radon and its decay products [5]. It is reasonable to assume, that highly charged break wear particles can have an important effect on the behaviour of radon and its progeny in the indoor air. However, very little is known yet on this topic.

Inhalation of radon progeny is a key pathway of exposure to natural radioactivity, with the effective dose largely determined by the behavior of alpha-emitting decay products in the respiratory tract [5]. A crucial factor is the interaction of freshly formed short-lived radionuclides (Po-218, Pb-214, Bi-214) with atmospheric aerosols [6]. These radionuclides initially form nanometer-sized 'unattached progeny', which can deposit efficiently in the lungs, but within seconds they may attach to existing aerosol particles, producing 'attached progeny'[7, 8].

The presence of ionized aerosol particles in the air significantly affects the behavior of radon decay products [9]. Ionized particles enhance the attachment rate of freshly formed radionuclides, thereby reducing the fraction of unattached progeny, which are otherwise highly mobile and have a high probability of deposition in the deeper regions of the respiratory tract.

The electrical charge of aerosol particles influences both the **rate** and the **efficiency** of attachment of radon progeny. Freshly formed radon decay products are typically generated in a charged state (positive ions), and their attachment to aerosol particles is enhanced when the particles carry an opposite charge due to electrostatic attraction [7]. Neutral particles can also serve as attachment sites, but the probability is lower compared to charged particles. Conversely, if both progeny ions and aerosol particles have the same polarity, the attachment rate decreases due to electrostatic repulsion. By increasing the proportion of attached progeny, ionized aerosols alter the size distribution and mobility of radon progeny, leading to different deposition patterns in the respiratory system [10] and consequently influencing the effective radiation dose.

In experimental studies of radon behavior in air, artificially generated aerosols are frequently employed to control particle concentration and size distribution [11]. Commonly used systems include sulfate aerosols and sodium chloride aerosols, both of which are stable and can be easily produced by atomizing aqueous solutions. Smoke aerosols, such as paraffin [12] or oil smoke (and historically cigarette smoke [13]), are also applied to investigate the attachment of radon progeny to ultrafine particles [14]. In addition, monodisperse latex (polystyrene) spheres with well-defined particle diameters are widely used in fundamental attachment studies [15], while metal oxide aerosols (e.g., ZnO, TiO_2) are occasionally utilized for specific experimental purposes. These artificially produced aerosols enable systematic investigation of how particle size, concentration, and charge affect the transition between unattached and attached radon progeny and their subsequent behavior in the atmosphere.

Conclusion

Although the behavior of radon progeny in relation to controlled laboratory aerosols (e.g., sulfate, NaCl, or monodisperse latex particles) has been extensively studied [11–14], little is known about their interactions with real-world anthropogenic aerosols such as brake wear particles (BWPs). BWPs are abundant in urban environments [16], characterized by a wide size distribution from ultrafine to coarse particles, high surface area, and frequent electrical charging due to triboelectric processes[1]. These properties suggest that BWPs could significantly modify the attachment dynamics of radon decay products, thereby altering the equilibrium between unattached and attached fractions. Moreover, their metal-rich composition raises the possibility of combined toxicological effects when co-deposited with alpha-emitting progeny in the respiratory tract. To date, however, the influence of brake wear particles on radon progeny attachment, mobility, and dose distribution has received very limited attention, highlighting an important research gap with both radiological and public health relevance.

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