Utilization of the Standard Testing Protocol Involving KCl Aerosol for Evaluating the Efficiency of Indoor Air Purifiers against Diesel Particles

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Exposure to traffic related airborne particles, including those generated by diesel emission has been shown to exacerbate the effects of existing asthma as well as increase the incidence of asthma and other respiratory conditions (HEI, 2010). The goal of a long-term study being currently conducted in the University of Cincinnati is to identify commercially available HEPA air purifiers capable of reducing the human exposure to diesel aerosol in homes to a sufficient level so that respiratory health effects can be minimized or eliminated. The manufacturers typically test a purifier efficiency with three aerosol challenges: cigarette smoke (0.1–1.1 µm), dust (0.5–3 µm), and pollen (5–11 µm). The standard testing protocols, e.g., the one established by the American National Standards Institute (ANSI) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for HVAC filters, utilize KCl particles when determining the size-dependent removal efficiency (ANSI/ASHRAE, 2012). None of the above aerosols matches the size distribution of diesel particles, and it has not been determined if the data collected with the KCl challenge aerosol can adequately describe the efficiency of indoor air purifiers against diesel aerosol pollutants. The question is not trivial because studies have shown that differences in physical properties among differing types of particles can affect their penetration through filters (He et al., 2013; Gao et al., 2014). The objective of this study is to compare the particle concentration decay and the Clean Air Delivery Rate (CADR) when testing the performance of air purifiers utilizing the diesel and KCl particles in a room-size exposure chamber. CADR describes the flow rate of contaminant free air delivered by an air cleaner (AHAM, 2006).

Diesel particles were aerosolized in a 23 m^3 chamber from a diesel fuel burning generator (Dyna-Glo Delux, GHP Group, Inc, Niles, IL, USA). The KCl aerosol was generated using a system consisting of three Collison nebulizers charged with a 20% KCl solution. The aerosols were measured non-size-selectively with a condensation particle counter (P-Trak, Model 8525, TSI Inc., St. Paul, MN, USA) and size-selectively with an aerosol spectrometer (ELPI, Dekati Ltd., Kangasala, Finland). These instruments cover the particle size range of interest (for diesel and KCl aerosols). The particle concentrations and size distributions were measured in time increments between t=0 and the "end time point" of 15–60 min, depending on the characteristics of the air purifier used for testing. The natural decay was also measured.

For the total aerosol concentration, the decay slopes obtained with diesel and KCl particles were different although this difference was not statistically significant ($p>0.05$). The CADR values obtained with the two tested aerosols based on the total concentration (measured with both the P-Trak and ELPI) were also slightly differed with $CADR_{diesel}$ being above $CADR_{KCl}$, but this difference was not significant ($p>0.05$). An example of the particle size dependent CADR values calculated for an HPA300 purifier (Honeywell Int. Inc., Morristown, NJ, USA) is presented in Table 1.

Table 1. CADR values (in ft^3/min) for different particle sizes and two test aerosols (averaged from 3 replicates).

Aerosol	**Particle Size, nm**							
	42	**81**	**108**	**170**	**260**	**400**	**650**	**1000**
KCl	294	309	313	303	304	300	312	323
Diesel	292	314	354	375	375	360	343	335

The difference between $CADR_{diesel}$ and $CADR_{KCl}$ was significant only for particle sizes between approximately of 100 to 400 nm. The differences are attributed to the properties of diesel and KCl particles relevant the aerosol evolution in the chamber and the particle penetration through the filters. The data shows the limitations of utilization of KCl data for predicting the indoor diesel exposure reduction.

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