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Measuring Aerosol Particle Behaviour due to Human Activity for Re-Exposure Evaluation

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Introduction

The transport and fate of indoor aerosols have been extensively studied both experimentally and theoretically, see *Andersson et al. '04, Lai '02, Karlsson et al. '02,* for example. Less attention has been given to the subsequent behaviour of deposited aerosols. For example, deposited aerosol can be spread from one surface to another through the processes of resuspension and contact transfer. The process of surface to surface contact will usually involve human activity. A study was conducted with the aim of quantifying the mass transfer efficiency of deposited particles when various soft and hard surfaces come in contact. The surfaces used were 100 % cotton, synthetic fleece, plastic laminate and brass. Contact transfer efficiencies ranging from 2 to 45 % were observed. Other observations include an increase in the mass transferred with increased surface roughness. An increase in the applied pressure between the two surfaces in contact leads to two pressure regions, with a transition pressure between the two that depends upon the surface types. Time of contact and contaminant loading appear to have little to no effect on the mass transfer efficiency.

Background

Following an accidental or deliberate release of hazardous materials, such as radioactive or infectious species, to the atmosphere, there is a risk of exposure of large population groups and individual persons who reside both indoors and outdoors. Current dosimetric models focus on aerosol inhaled while initially airborne, with some reference to particles deposited on the human body, but secondary inhalation following resuspension is not considered. Additionally, there is a significant gap in published literature regarding the transfer of deposited contaminants between clothing and rigid surfaces (e.g. furnishings) via contact. The spread of particles by contact transfer is an important factor in assessing the pathway of contamination and is necessary in order to design effective countermeasures.

Materials and Methods

Experiments were carried out to quantify the percentage transfer of particles to and from hard and soft surfaces which are typically found in a home or office. Other variables investigated include the applied pressure, contact time and contaminant loading. The two soft surfaces chosen were 100% cotton, which a popular clothing fabric, and a synthetic fleece (100% polyester), which had a much rougher surface than the cotton. The hard surfaces chosen include plastic laminate and brass. The range of pressure values chosen correspond to pressures expected from resting a forearm on a desk, to sitting on a surface with full body weight.

The surfaces to be contaminated were first exposed to aerosols generated from polydisperse fluorescein powder. Contact was then made between the contaminated surface and a clean surface for a specified length of time and contact pressure. Both the contaminated and receiving surfaces were then analysed using a fluorimeter (Turner model TD-700) to determine the proportion of the original deposited mass transferred to the receiving surface.

Results

A matrix of four variables was investigated; different surface pairs, applied pressure, contact time and contaminant loading. Among these, the variable with the greatest influence on mass transfer efficiency was the choice of surface pairs. The lowest mass transfer efficiency was observed for transfer from contaminated fleece to plastic laminate, ~ 2 %, and the highest efficiencies were seen for transfers from the two hard surfaces, brass and plastic laminate, to fleece, 41 and 30 % respectively. While these initial experiments were not designed to investigate the details of the transfer process, the data suggest that the surface texture of the fleece both enhances the transfer of particles from the other surfaces to the fleece and inhibits particle transfer from contaminated fleece. *Table 1* contains a summary of the mass transfer efficiencies between the various surfaces at constant time and pressure.

Receiving Surface	*Contaminated Surface*			
	Brass	**Plastic Laminate**	**Cotton**	**Fleece**
Plastic Laminate	9.6 ± 1.0	3.5 ± 0.4	7.2 ± 0.8	2.1 ± 0.2
Cotton	10.6 ± 1.1	3.4 ± 0.4	3.1 ± 0.3	5.0 ± 0.5
Fleece	41.0 ± 3.2	30.4 ± 2.9	8.4 ± 1.0	8.2 ± 0.9

Table 1. Mass transfer efficiencies between various surfaces with a contact time of 1 min and contact pressure of 891 Pa.

When investigating the transfer percentage between various surfaces with increased pressure, it became apparent that the data could be described as having two pressure regimes, one at low pressure and one at high pressure where the mass transfer efficiencies are relatively constant as a function of applied pressure within each regime. A transition pressure region connects the two pressure regimes. The transfer percentages for the various surface pairs and the transition pressures are summarised as follows:

Surface		**Transfer Efficiency (%)**		**Transition Pressure (Pa)**
Contaminated	Receiving	Low P	High P	
Cotton	Cotton	3	8	3500
Fleece	Fleece	8	16	1750
Cotton	Fleece	6	11	1000
Plastic laminate	Fleece	12	30	900

Table 2. Summary of results for transfer rate with increased pressure experiments

The length of time the clean and contaminated surfaces are in contact appears to have no effect on the fraction of contaminant transferred between them. This is providing there are no external forces e.g. 'rubbing' of the two materials etc. The contact time ranged considerably from 2 seconds to 1 hour.

Conclusions

Overall, the observed mass transfer efficiencies of 2 – 45 % are very significant numbers in terms of aerosol transport in the environment. If an indoor environment is contaminated – especially if that contamination goes unnoticed - the contamination could be quickly spread and in large quantities, via the process of contact transfer. These transferred aerosol particles could become resuspended into the air due to human activity and are thus a potential for inhalation exposure. These experiments were designed as an initial quantitative exploration using a limited number of surfaces and study variables. Two variables not studied here that may be important are the effects of surface charge and different aerosols, especially biological aerosols. These results also suggest that additional studies should be conducted to better understand the details of the transfer process or processes.

References

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