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Skin scales among airborne particles

By R. P. CLARK
National Institute for Medical Research, Hampstead Laboratories, Holly Hill, London NW3 6RB

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SUMMARY

The air from a house and garden in a rural area has been sampled and the size distributions of the airborne particles have been determined. The particle concentrations are shown to be generally higher indoors. Changes in the particle concentration during various activities in a small room have been shown to be greatest for particles larger than 3 μm. diameter. Stereoscan microscopic observation has shown that many of the airborne particles in rooms and some from those in outside air appear to be scales of desquamated skin. The presence of protein in many of these particles complements the microscopic observations.

INTRODUCTION

Skin scales shed from humans, some having micro-organisms attached to them, are often responsible for contamination and infection in hospital operating theatres and industrial clean rooms (Davies & Noble, 1962). These skin scales are flake-like, about 10–25 μm. across and about 1 μm. thick. They are constantly being shed from the body in great numbers (May & Pomeroy, 1973) by the general movement of the skin surface and by the rubbing actions of clothes and limbs. This, together with the proposition that skin scales shed from the body and dispersed from the human micro-environment could be a link in the chain of airborne infection (Clark & Cox, 1973), prompted the present investigation into the composition of airborne particles. A particle collection and identification system was developed that was portable and could be used in various environments. The apparatus in this system consisted of an Andersen Mini-Sampler, a Casella Cascade Impactor and a Royco Portable Particle Monitor, and these devices have been described and demonstrated elsewhere (Clark, 1973). Complementary to these samplers, Stereoscan electron and conventional light microscopy were used for particle identification in conjunction with protein staining techniques.

METHODS AND RESULTS

The presence of protein in airborne particles

The major portion of hair, nails and epidermal layers of the skin is composed of keratin; consequently a technique that shows the presence of protein in particles recovered from the air complements the microscopic observation that many of the recovered particles appear to be fragments of skin.

Table 1. *The protein content of particles collected from the air of a garden and house in a rural area*

	Percentage of particles containing protein	
	2–6 μm.	6–30 μm.
Indoor air	75%	77%
Outside air	32%	44%

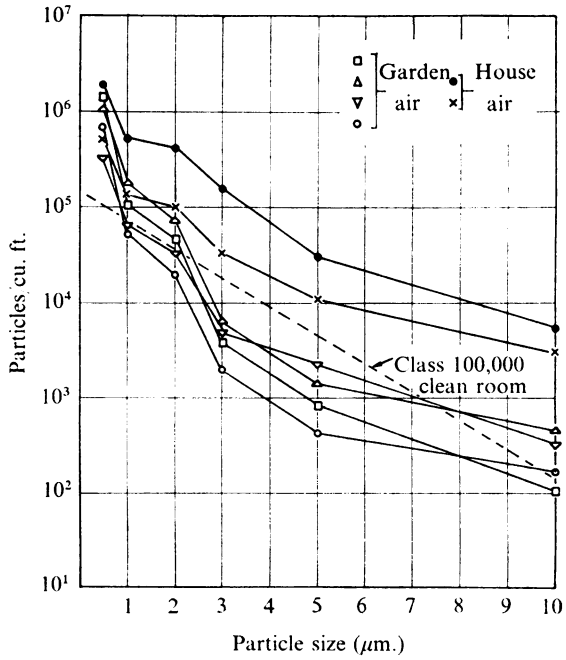

Fig. 1. Particle concentrations in a house and garden in a rural area.

Triketohydrindene hydrate (ninhydrin) solution will indicate the presence of protein in a sample of airborne particles.

If the particles are sprayed with a solution of ninhydrin in acetone and then heated to about 70° C. for some minutes, the particles containing protein show up as pink when viewed under the microscope using incident light. When this technique was applied to particles collected with the Casella Cascade Impactor from the air of a house and garden many particles containing protein were found in both room air and outside air as indicated in Table 1.

Size range of airborne particles

The Royco Portable Particle Monitor was used to size the particles in the air of a rural garden and a house in the same area. The particle monitor determined directly the particle concentration in six size ranges from 0·5 to 10 μm. diameter. Fig. 1 shows the size distributions of the particles in garden air on 4 days contrasted with particle counts made in the house on 2 days.

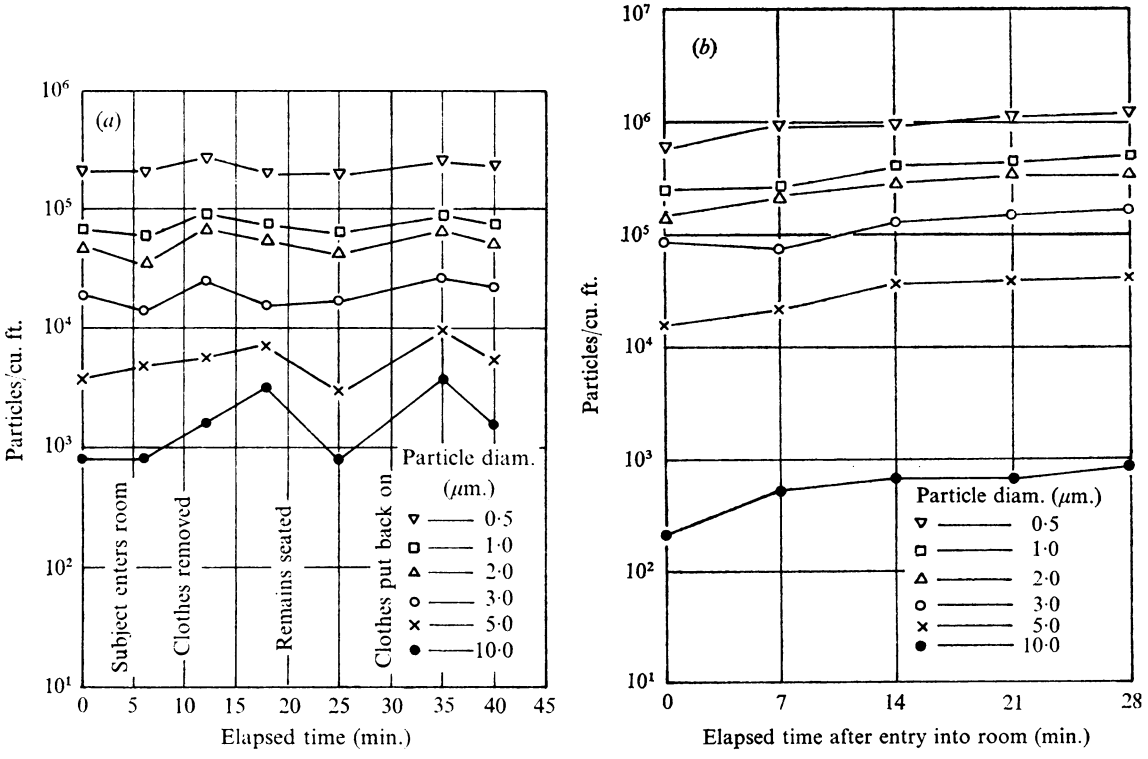

Fig. 2(*a*) Variation of particle concentrations during various activities in a room of 450 ft.^{3}. (*b*) The increase in particle concentration in a room of 450 ft.^{3} after a subject enters and slowly walks around.

The concentrations in the house air were consistently about 10 times as high as those in garden air for particles larger than 3 μm.

In these observations the garden air was found to be cleaner than a class 100,000 clean room (U.S. Fed. Stand.).

Particle counts within a small room

Particle concentration variations during various activities within a room having a volume of 450 ft.^{3} (12,800 l.) were recorded. The doors and windows of the room were closed for several hours before each test to allow the background particle counts to stabilize. Fig. 2(*a*) shows the changes in particle concentration as the subject entered the room, removed his clothes and then remained seated quietly. After 23 min. the subject replaced his clothes and again remained seated. The result is that the concentration of the larger particles varies much more than that of the smaller sizes. The concentration of particles greater than 3 μm. diameter is seen to rise considerably with the activities of removing and replacing the clothes. Fig. 2(*b*) shows the result when the subject entered the room and slowly walked around; once again the greatest change in the concentration occurred for the larger particle sizes.

Microscopic examination of the airborne particles

The Andersen Personal Sampler was used to collect samples from various environments at an air-flow rate of 1·4 l./min. (0·05 ft.^{3}/min.). When used with a battery-operated pump the sampling nozzle may be attached to the clothing to sample the air from the subject's micro-environment. The samples deposit on a series of four anodized aluminium disks and the smallest particles (less than 0·3 μm. diameter) are collected on a paper filter. The particles collected on the sampling disks were observed with the Stereoscan electron microscope and were prepared for microscopy by vacuum coatings, first of carbon and then gold.

Plate 1A shows particles recovered from room air and the sample is seen to contain a large number of particles which closely resemble skin scales.

Plate 1B shows some skin scales attached to the skin surface and the similarity between these and the airborne particles is clearly seen.

Samples from the outside air contain some particles which have the appearance of skin scales mixed in with many other kinds of particles, many of which are very difficult to identify microscopically. Some particles which appear as skin scales seem to be more fragmented than those collected from room air.

In view of the prevalence of particles very similar in appearance to skin scales it is not surprising to find that 'house dust' is largely composed of these skin-like particles. Stereoscan pictures of house dust confirm this and examination of vacuum cleaner dust also reveals a great number of particles resembling skin scales. It is interesting to note that few small fibres are collected in the room air. They appear to sediment fairly quickly and many more are recovered from house and vacuum-cleaner dust. This observation contrasts with experiments by Pressley (1958), who found that the airborne dust in hospitals consisted essentially of cellulose fibres. Plate 2A shows some vacuum-cleaner dust which contains some flat and twisted cotton fibres as well as many scale-like particles.

The Mini Sampler was used on a journey on the London Underground system, Northern Line. The stations on this line are heavily contaminated as evidenced by the hazy appearance of the air, and the concentrations of all the particle sizes on the sampler disks were at least 10 times greater than in samples from room air. Plate 2B shows some of these collected particles; many are scale-like and appear similar to the skin particles. Under the light microscope all these particles appeared black and this could have been due to carbon dust and other small particles deposited on the larger sizes. However, in the case of these samples as with other heavily contaminated particles, the protein-staining technique using ninhydrin is ineffective. This is probably because the coating on the particles prevents the penetration of the ninhydrin to any protein.

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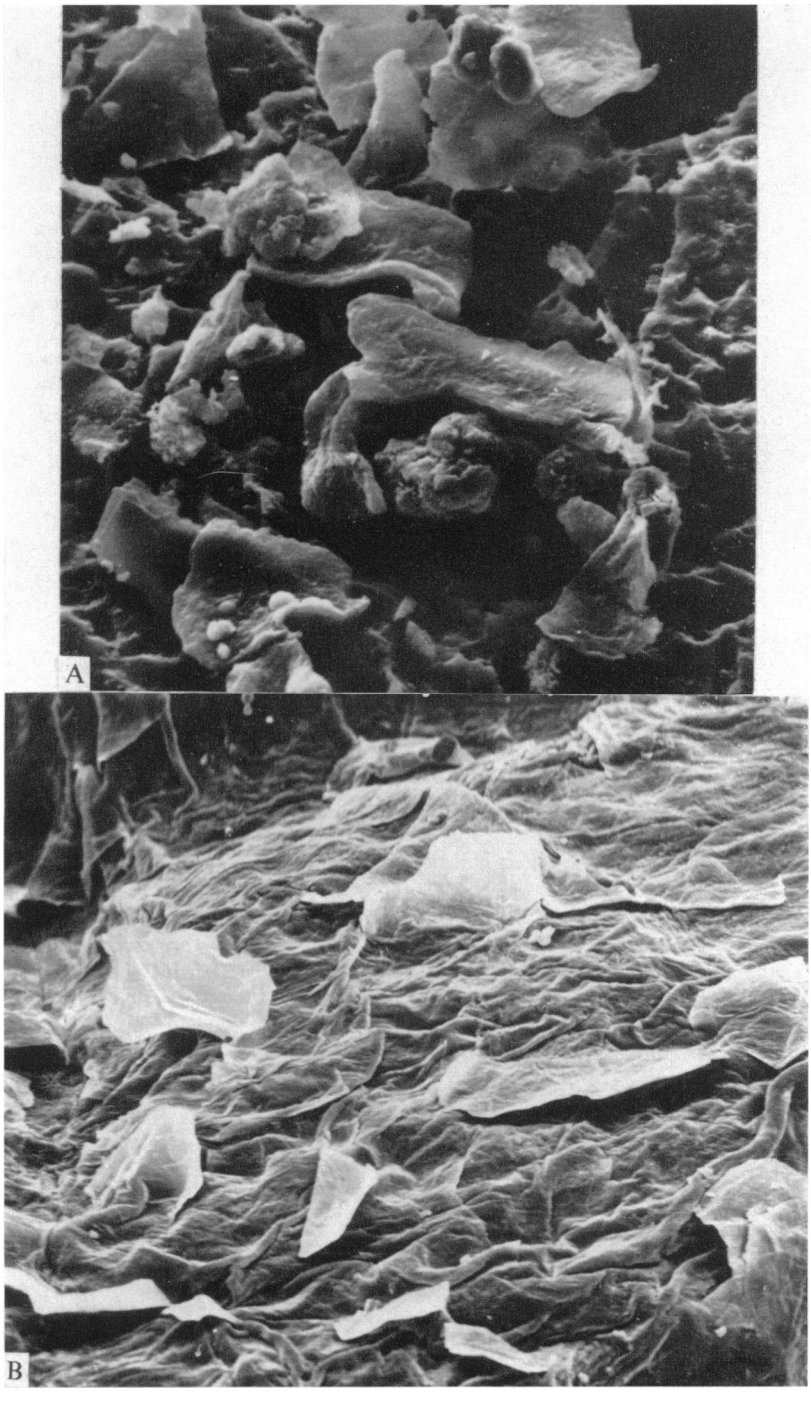
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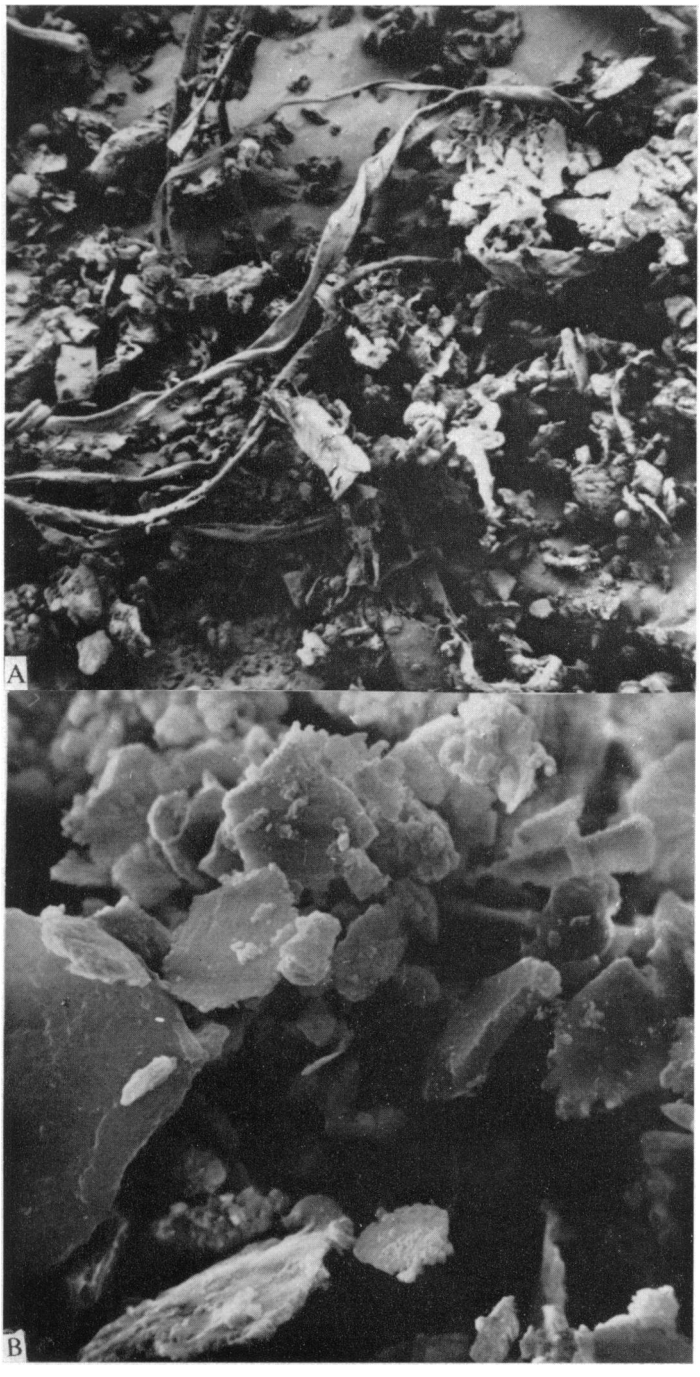
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EXPLANATION OF PLATES

PLATE 1

(A) Skin scales recovered from room air. × 819.

(B) Skin scales on the body surface which are partly detached. × 2410.

PLATE 2

(A) A sample of vacuum-cleaner 'dust', showing many flaky particles and cotton fibres. × 115.

(B) A sample of the heavily contaminated particles from the air of the London Underground system. × 2520.