

Normal use levels of respirable cosmetic talc: preliminary study

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Synopsis

This preliminary study was undertaken to provide data from which a more comprehensive investigation to establish the safety in-use of cosmetic talcs could be designed. Methods for collecting and analysing respirable talc generated during the use of loose face powder and adult and baby dusting powders were established.

Respirable particles in the air were separated from larger size particles by means of a cyclone and were collected on membrane filters. The collected dust was dissolved in acid and the solution was analysed for magnesium by atomic absorption spectroscopy. From the results the concentrations of talc in the air samples were calculated.

The method was used to monitor the in-use levels of a range of cosmetic talcs. Mean concentrations in air sampled for 5 min from the start of use of Chinese grades and Italian 00000 grades of talc formulated for use as loose face powder, adult dusting powder and baby dusting powder were 0.48, 1.13 and 0.21 mg m⁻³, respectively. Higher levels were found with micronised adult dusting powder (mean concentration 1.9 mg m⁻³).

There was no evidence that the presence of perfume in the talc or the ambient relative humidity in the range 54-74% during use affected the levels of respirable talc, but high relative humidity >90% reduced the amount of respirable talc.

Utilisation des talcs cosmétiques: étude préliminaire des teneurs en talc respirable

Résumé

Ce travail préliminaire a été entrepris dans le but de fournir des éléments pour une étude plus approfondie sur la sécurité d'emploi des talcs cosmétiques.

Des méthodes ont été mises au point pour collecter et analyser le talc susceptible d'être respiré lors de l'utilisation de poudres libres pour le visage et lors du saupoudrage des bébés et des adultes.

Les particules les plus fines de l'air ont été séparées des plus grossières au moyen d'un cyclone et ont été collectées sur des filtres à membrane. La poussière recueillie a été minéralisée et on a effectué le dosage du magnésium sur la solution par spectroscopie d'absorption atomique. On en a déduit la concentration en talc dans les échantillons d'air considérés.

La méthode a été employée pour mesurer une série de talcs cosmétiques dans les conditions d'utilisation. La concentration moyenne d'échantillons d'air prélevés pendant 5 minutes après le début de l'utilisation de talc chinois et de talc italien 00000 dans les formulations de poudre de riz, de poudre pour adultes et de poudres pour bébés a été

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respectivement de 0.48, 1.13, et 0.21 mg m⁻³. Des teneurs plus élevées ont été trouvées sur une poudre micronisée pour adultes (moyenne: 1.9 mg m⁻³).

La présence de parfum dans le talc, ainsi qu'une humidité ambiante relative comprise entre 54% et 74% n'affectent pas de façon sensible les teneurs en talc respirable. Une humidité relative supérieure à 90% conduit à la diminution de ces teneurs.

INTRODUCTION

Cosmetic talc is used as adult body dusting powder, face powder and baby dusting powder. A recent review article by Hildick-Smith (1) states that although there is only limited scientific information on the biological activity of talc from which its safety can be assessed accurately the general indications are that normal exposure to cosmetic talc is not injurious to health. However, because of the increasing interest in hazards posed by dusts, data are required on the amounts of talc to which consumers are exposed during normal use.

The main objectives of this study were to devise a suitable methodology for monitoring in-use concentrations in air of respirable talc and to define some of the factors which may influence them.

Initially, methods for collecting respirable talc during in-use situations and for determining the quantities of talc collected were established. These methods were then used to determine the concentrations of respirable talc in air during the normal use of a range of different cosmetic talcs. The influence of the relative humidity during use and the presence of perfume in the talc on the respirable concentrations of talc were also investigated.

EXPERIMENTAL PROCEDURE

Materials

Chinese perfumed and unperfumed talcs, Italian 00000 grade perfumed and unperfumed talcs and Italian micronised grade unperfumed talc were supplied by the Cosmetic, Toiletry and Perfumery Association Ltd. The Chinese and Italian perfumed talcs contained 0.045 and 0.2% perfume, respectively.

Sample collection units

Atmospheric samples were taken using apparatus made by C.F. Casella & Co. Ltd, London (2).

A cyclone elutriator/filter head system was used for the collection of respirable dust (model A7650/1 fitted with 25 mm diameter membrane filters). The specification of the elutriator was that virtually all particles with aerodynamic diameter less than 1 µm, 50% of 5 µm particles and no particles greater than 7 µm, would be sampled. The sampled air was drawn vertically upwards thereby eliminating the majority of particles which would normally settle to the ground. In addition, an open filter holder, i.e. no elutriation (model T13070/1), fitted with a 37 mm diameter membrane filter, was used to collect total dust: in this mode of operation the filter was located in the vertical position and air was drawn in at 90° to the vertical. The pumps (model T13051/2 with built in flow rate indicator), fitted with pulsation dampers (model T13052), were located in static sampler bases and collector supports (model T13076/1). Membrane filters (0.8 µm pore size, Millipore (UK) Ltd.) were loaded into their holders using forceps in a clean laboratory and transferred to the sampling site immediately prior to the experiment. The collection units were calibrated to draw air at a rate of 1.9 l min⁻¹.

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In-use studies

Talc experiments, each on two occasions with four female subjects, were made at 1 h intervals over a half day period with the products described in Table 1. Two sample collection units were set up next to each other (distance between sample collection points about 15 cm) at face height in each location (Table 1).

Table 1. Talc product types and sampling locations

Product	Talc type	Location
Loose face powder	Chinese, unperfumed. Italian, 00000 grade, unperfumed. Italian micronised grade, unperfumed.	Washroom, 2 x 1 m fitted with hand wash basin, mirror above. Sample collection units located on shelf adjusted to face height in front of mirror. Small window open during sampling, no other ventilation.
Adult dusting powder	Chinese, perfumed. Chinese unperfumed. Italian, 00000 grade, perfumed. Italian, 00000 grade, unperfumed. Italian micronised grade, unperfumed.	Bathroom, 2.3 x 2 m, fitted with bath and hand wash basin. Sample collection units located on 1.5 m high shelf next to basin. Window closed during sampling.
Baby dusting powder	Chinese, perfumed. Chinese, unperfumed. Italian, 00000 grade, perfumed. Italian, unperfumed.	Small room, 3.7 x 2.8 m. Contained table and two chairs. Sample collection units located on table 0.8 m high next to doll's head.

Subjects, alone except during the baby dusting study when an observer was present, were instructed to use the talcs in their normal way. In the loose face powder and adult dusting powder studies, subjects were requested to stand with their faces as near as possible to the sample collection points. In the baby dusting powder studies a doll was used instead of a real baby and its head was placed alongside the sampling points. The talcs were applied from talc drums with sprinkler closures of the type commonly used by the public and in the case of face powder, by face puffs. Approximate distances from the sampling points to the user's or doll's nose were 15 cm (loose face powder), 30-90 cm (adult dusting powder) and 15-30 cm (baby dusting powder).

Both pumps were switched on simultaneously at the start of each talcing operation and run for exactly 5 min. At the end of each sampling the membrane filter from one collection unit was removed (in the clean laboratory) and replaced with a new one: the other collection unit was run consecutively over four talcing operations (total sampling time 20 min) to produce an accumulated sample. The used membrane filters were transferred immediately to 50 ml polypropylene bottles which were stoppered and retained for analysis. After each talcing operation a record was made of the period during which talc was applied, the ambient temperature and the ambient relative humidity (whirling wet and dry bulb hygrometer) and the floors and surfaces of the sampling location were cleaned with a damp cloth.

On one occasion during each of the three product use experiments, background level samples were taken 30 min before initial use and before each subsequent talcing operation.

In two experiments with Italian 00000 grade, unperfumed and Italian micronised grade talcs, additional samples were collected using filter holders normally used with the cyclone device but with the cyclone device removed (i.e. collection of respirable dust plus other dust normally separated by the cyclone) and using open filters (i.e. collection of total dust).

No attempts were made to control relative humidity except in one experiment with Italian 00000 grade perfumed adult dusting powder when the relative humidity of the bathroom was maintained at >90% (by steam from heated water baths).

Analysis of collected samples

Principle. The collected samples were analysed for total magnesium by atomic absorption spectroscopy (AAS) and the amount of talc calculated from an experimentally determined quantity of magnesium in the talc.

Materials. 'Aristar' grades of hydrochloric acid and 42% hydrofluoric acid, 'Analar' grades of boric acid (prepared as a 5% w/v aqueous solution), lanthanum chloride aqueous solution (for AAS; 10% w/v lanthanum) and magnesium chloride standard solution (for AAS; 1 mg magnesium ml^{-1}) were obtained from BDH Chemicals Ltd. Distilled deionised water was used throughout.

Apparatus. A Varian Techtron model 1400 atomic absorption spectrophotometer fitted with a model 80 automatic Gas Control Unit and a Varian Techtron hollow cathode magnesium lamp (285.2 nm) was used. Instrument conditions were slit width 0.5 nm, lamp current 3 mA, 4 inch air-acetylene burner.

Polypropylene volumetric ware (Azlon Products Ltd.) was used for all operations involving hydrofluoric acid; otherwise standard laboratory glassware was used.

Calibration procedure. Standards for the calibration curves were prepared by adding aliquots of a standard magnesium solution to 25 ml polypropylene volumetric flasks, each containing an unused 25 mm membrane filter, followed by hydrochloric acid (2 ml) and hydrofluoric acid (0.25 ml). After standing overnight, boric acid solution (20 ml) was added and, after 0.5 h, lanthanum chloride solution (1.25 ml) and the solution made up to volume with water. The solutions were aspirated into the spectrophotometer and the absorbances recorded against a water blank, the data being recorded as a calibration curve.

The precision of analysis was calculated from twice the standard deviation (2σ) about the mean of the analyses of nine standard solutions containing $0.05 \mu\text{g ml}^{-1}$ added magnesium: the limit of detection was based on the precision of this concentration.

Determination of magnesium in talc. Approximately 25 mg quantities of each type of talc were accurately weighed in triplicate into 50 ml polypropylene bottles and analysed for total magnesium as described above (but without a membrane filter). Additionally, a range of ten known amounts (0–50 mg) of Chinese unperfumed talc was analysed in the same way.

Analysis of samples. Samples (membrane filters with collected talc) in 50 ml polypropylene bottles were treated as described for the calibration procedure (without additional membrane filter). After the addition of lanthanum chloride the solutions were transferred quantitatively to 25 ml polypropylene volumetric flasks and made up to volume with water. The absorbances of the solutions were recorded. The amounts of magnesium in the solutions were computed from the calibration curve and related to the amounts of talc in the samples using the experimentally determined magnesium content of the talcs.

Determination of talc in air. The concentration of talc in the sampled air was calculated from the amount of talc collected and the volume of air sampled.

Particle size analysis. Particle size determination was undertaken on samples of Italian 00000 unperfumed and Italian micronised grade talcs collected with and without the use of cyclones. The filter papers were cut into quarters, care being taken not to disturb the

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particles. Then each quarter was placed on DFX mounting medium (BDH Ltd, refractive index 1.515) on a clean microscope slide and allowed to clear. Further DFX was added and a cover slip was placed over each preparation.

These slides were examined using a research microscope (mag X 400) under polarised light when the talc particles were seen to be anisotropic. The particle size was measured along the greatest dimension using a calibrated eyepiece micrometer. At least 200 particles were measured from each sample.

RESULTS AND DISCUSSION

Analytical method

A sensitive analytical method was required because of the anticipated short taking and sampling times and the low fixed sampling rate of the collection device. Analysis of magnesium and/or silicon by atomic absorption spectroscopy appeared to offer adequate sensitivity and a flame atomisation technique for magnesium was optimised and used to determine the collected talc (the sensitivity for magnesium being at least two orders of magnitude greater than that for silicon). Electrothermal atomisation was investigated initially but was not pursued because the extremely high sensitivity to magnesium of this technique resulted in variable background effects.

The optimum medium for dissolving talc samples and the membrane filter was found by experiment. Lower magnesium recoveries were found if smaller volumes of hydrochloric acid or hydrofluoric acid alone were used.

In atomic absorption spectroscopy, absorption due to magnesium is suppressed by the presence of silicon. This effect can be overcome or minimised by the addition of a 'releasing agent' such as lanthanum to the analyte. However, addition of lanthanum chloride to a solution containing hydrofluoric acid causes precipitation of lanthanum fluoride and it was therefore necessary to complex excess hydrofluoric acid with boric acid before the addition of lanthanum (3).

Figure 1 shows typical calibration curves obtained with solutions of magnesium in water, reagent matrix and reagent matrix plus (dissolved) membrane filter. Separate experiments showed that the small background absorbances (approx. 0.02 for the reagent matrix; approx. 0.04 for the reagent matrix plus membrane filter) were due mainly to the boric acid and the membrane filter.

The magnesium contents of each type of talc, determined on 25 mg quantities, were as follows. Chinese grade, perfumed: 17.5% (three determinations giving 17.0, 17.5 and 18.0% Mg); Chinese grade, unperfumed: 17.3% (17.1, 17.2, 17.3 and 17.7%); Italian 00000 grade, perfumed: 17.3% (15.9, 16.4, 18.0 and 19.0%); Italian 00000 grade, unperfumed: 17.3% (17.2 and 17.4%); Italian micronised grade, unperfumed: 18.3% (17.4, 18.5 and 18.9%). The results of the experiment in which different amounts of Chinese grade, unperfumed talc were analysed are shown in Fig. 2. From the slope of the graph the magnesium content was found to be 17.5% (coefficient of correlation = 0.997). As expected with talcs containing different associated materials (4) these values are lower than the theoretical magnesium content (19.23%) based on the empirical formula $Mg_3Si_4O_{10}(OH)_2$ and were consistent with a lower silicon content (26.5 and 28%, c.f. theoretical value 29.6%) of Chinese unperfumed talc obtained by us using colorimetry (5) and atomic absorption spectroscopy. Taking an average magnesium content of 17.5% the sensitivity of the method (defined as the concentration of magnesium required to produce 1% absorption at 285.2 nm) was $0.05 \mu\text{g ml}^{-1}$. The precision of analysis at the $0.05 \mu\text{g ml}^{-1}$ concentration was $0.005 \mu\text{g ml}^{-1}$ and

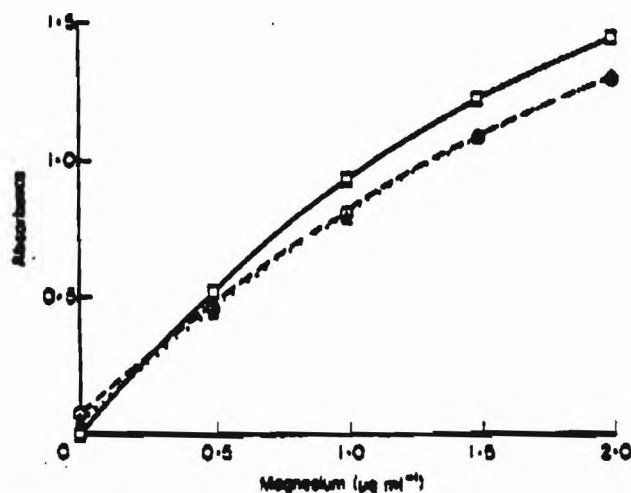


Figure 1. Typical calibration curves for magnesium. (○) Aqueous standards; (●) standards including reagent matrix; (○) standards including reagent matrix and blank membrane filter.

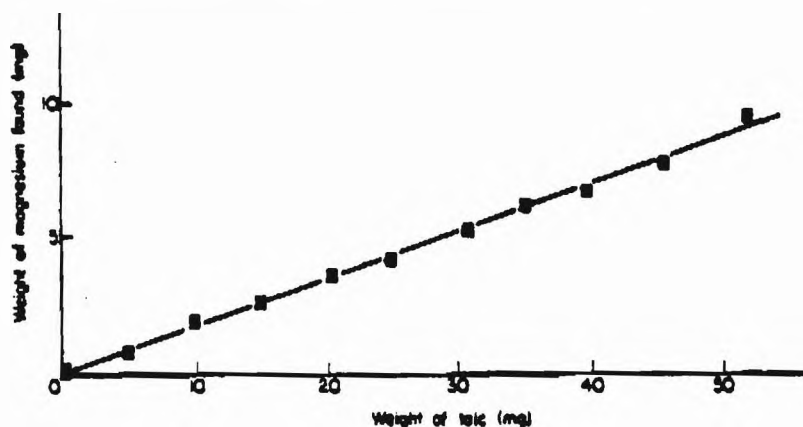


Figure 2. Analysis of magnesium in Chinese unperfumed talc by atomic absorption spectroscopy.

the limit of talc (in 25 ml solution) was 1 µg (0.714 µg rounded up). The limits of detection of talc in single and accumulated air samples were set at 0.1 and 0.05 mg m⁻², respectively.

In-use studies

The results of the monitoring of concentrations of respirable talc in air from each product type during the in-use studies are given in Table II which quotes mean data and ranges. The individual results from the ninety-nine separate talcing operations showed that there was wide variation in talcing times and in respirable dust levels generated by the same volunteer using the same product on different occasions.

Background levels of respirable talc during the talcing operations were determined with one type of loose face powder, two types of adult dusting powder (Italian 00000 and Italian micronised) and one type of baby dusting powder. When the relative humidity was between 54 and 74% detectable background levels of respirable talc were only found in experiments with Italian micronised talc. However, a single experiment at high humidity (>90%) with Italian 00000 grade dusting powder produced detectable background levels (Table II).

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Table II. The levels of respirable talc (mean values in parentheses)

Product	Talc type	Number of talcings operations*	Talcings time (s)	Ambient temperature (°C)	Relative humidity (%)	Respirable talc collected (mg m ⁻³)	Respirable (talc so- cumulated during four operations), (mg m ⁻³)	Background level of respirable talc† (mg m ⁻³)
Loose face powder	Chinese	8	15-26 (19)	16-18.5 (18)	64-68 (67)	<0.1-1.1 (0.5)	0.1, 0.2	<0.1
	Italian	8	10-25 (17.5)	14-20 (18)	64-71 (66)	<0.1-0.8 (0.4)	0.1, 0.1	-
	Italian, micronised	8	10-20 (16)	16-17 (16.5)	68	0.3-1.7 (1.0)	0.4, 0.4	-
Adult dusting powder	Chinese, perfumed	8	31-74 (47)	20-21 (20.5)	62-74 (69)	0.3-2.6 (1.4)	0.3, 1.0	-
	Chinese, unperfumed	8	15-57 (36)	17.5-22 (20)	60-74 (68)	0.5-1.8 (1.1)	0.4, 0.5	-
	Italian, perfumed	8	15-80 (43)	16.5-19.5 (18)	61-74 (68)	0.4-1.7 (0.9)	0.6, 0.3	-
	Italian, unperfumed	8	27-71 (46)	16-19 (17.5)	55-70 (63)	0.5-2.6 (1.1)	0.7, 0.7	<0.1
	Italian, unperfumed†	3	32-54 (48)	22-24 (23)	92-100 (97)	0.2-0.8 (0.5)	0.4	<0.1-1.0
	Italian micronised, unperfumed	8	31-78 (51)	19-21 (20)	54-68 (62)	0.6-3.3 (1.9)	2.5, 1.3	0.6-1.6
Baby dusting powder	Chinese, perfumed	8	15-60 (30)	19-22 (20)	63-70 (65)	<0.1-0.9 (0.3)	0.3, 0.1	-
	Chinese, unperfumed	8	15-45 (28)	13-24 (19)	67-72 (69)	<0.1-0.7 (0.2)	0.2, 0.05	-
	Italian, perfumed	8	15-36 (28)	20-22 (21)	60-70 (65)	<0.1-0.3 (0.1)	0.1, 0.05	<0.1
	Italian, unperfumed	8	15-35 (25)	12-22 (18)	58-68 (64)	<0.1-0.5 (0.2)	0.1, 0.05	<0.1

* Four subjects used on two separate occasions.

† Measured before each talcing operation.

‡ High humidity experiments.

With the exception of the micronised talc, the experimental data do not indicate any major differences between the levels of respirable dust generated during the use of the different varieties of each product type. Therefore, all data from each type of Chinese grade and Italian 00000 grade talc have been averaged, taking non-detectable readings as 0.1 mg m^{-3} , to give the following mean atmospheric concentrations during the 5 min sampling times of respirable talc (number of observations in parentheses):

Loose face powder:	0.48 mg m^{-3} (16)
Adult dusting powder:	1.13 mg m^{-3} (32)
Baby dusting powder:	0.21 mg m^{-3} (32)

These figures suggest that the greatest quantity of respirable dust is generated during adult dusting operations. By comparison, the mean value for micronised adult dusting powder was 1.9 mg m^{-3} . A recent separate study using a different technique showed that the average respirable dust exposure of infants during normal talc dusting by mothers was $0.10 \text{ mg min}^{-1} \text{ m}^{-3}$ (1).

There was no evidence with any of the products that an ambient relative humidity between 54 and 74% influenced the level of respirable talc. However, at high relative humidity ($>90\%$) a noticeably smaller quantity of respirable dust (Italian 00000 grade, perfumed) was collected. This result is attributed to an increased tendency of dust particles to aggregate in very moist atmospheres.

There was no evidence with any of the products that the presence of perfume influenced the level of respirable talc.

It is of interest that the amount of accumulated respirable talc (i.e. collection unit run consecutively during four talcing operations) were generally less than the mean from individual talcing operations (Table II). In fact, the complete data show that of the twenty-four groups of four consecutive talcing operations, in only five groups did the cumulative figure equal or exceed marginally the total of the four individual results while in eleven groups the cumulative figure was less than 50% of the aggregate. We offer no satisfactory explanation for this unexpected result. The possibility of (i) inter-collection device variation due to inherent geometrical features (the same cyclone, but not necessarily the same pump, was used for all accumulated samples), (ii) greater spurious contamination during the four individual talcing operations (when the collection device was assembled and taken apart and the sample transferred four times) compared with the single accumulated sample, and/or (iii) effects due to electrostatic charging of the filter and holder require investigation in another study. Such work is necessary in order to define sample collection reproducibility.

Additional data from those experiments with Italian 00000 unperfumed and Italian micronised products are given in Table III when respirable talc, total talc (using filter holders with cyclone device removed) and total talc (using open filter) were measured. In this case results for each talcing operation are given. As expected, removal of the cyclone resulted in an increase in the amount of dust collected and demonstrates the effectiveness of the cyclone cover. Even greater quantities of talc were collected using open filters.

A limited number of particle size distribution analyses were done with unperfumed Italian 00000 and micronised grade talcs. The results (Fig. 3) show that the majority of particles measured were between about 1 and $8 \mu\text{m}$ and demonstrate the difference between the micronised and 00000 grade products and the efficiency of the cyclone device. Of course, particle size distribution of talc from different sources will be expected to vary because of differences in production techniques.

Separate experiments were done to determine the amounts of talc typically applied during use. Subjects who had taken part in the earlier experiments were asked to use the talc in their normal way. An independent observer recorded talcing times and the number of

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Table III. Use levels of respirable and total talc

Panel number	Talc application order	Ambient temperature (°C)	Ambient relative humidity (%)	Talc application time (s)	Respirable talc (mg m ⁻³)	Total talc (cyclone removed) (mg m ⁻³)	Total talc (open filter) (mg m ⁻³)
Italian 00000 grade, unperfumed							
1	1	18.3	54	32	1.5	4.7	26
2	2*	19	54	48	0.8	4.1	27
3	3	18.5	57	45	0.5	2.7	8
4	4	19	-	32	0.6	4.8	26
Italian micronised grade, unperfumed							
5	1*	17	68	78	0.2	3.3	17
6	2	19	62	28	1.3	6.0	10

* An additional respirable sample was collected and examined for particle size distribution.

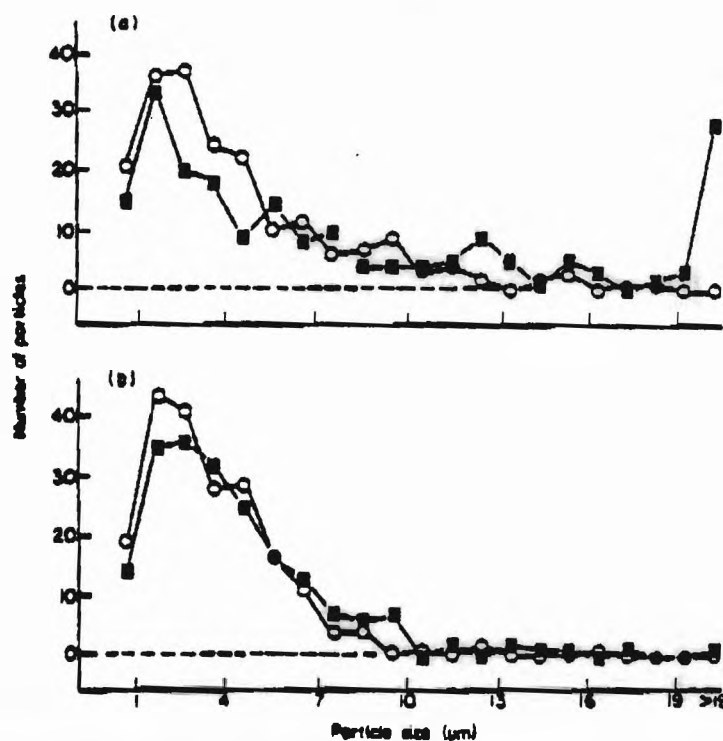


Figure 3. Particle size distribution. (a) Italian 00000 grade unperfumed talc; (b) Italian micronised grade talc. (o) Collected with cyclone; (s) collected without cyclone.

times the container was shaken. In each loose face powder experiment the powder puff was dipped only once into the talc. The amount of talc used was determined by weighing the container before and after each subject's application. The results (Table IV) show considerable variation in the amount of talc applied by different individuals.

Table IV. Summary of talc use parameters (mean values in parentheses)

Product	Talc type (all unperfumed)	Number of talcing operations	Talcing time (s)	Number of shakes	Weight of talc used (g)
Loose face powder	Chinese	4	12-22 (17)	-	0.08-0.22 (0.12)
	Italian 00000	4	13-20 (16)	-	0.03-0.15 (0.09)
	Italian, micronised	4	14-29 (19)	-	0.04-0.09 (0.06)
Adult dusting powder	Chinese	8	16-40 (27)	18-80 (41)	7-12.5 (10)
	Italian 00000	8	15-40 (27)	21-76 (39)	5-12 (8.3)
	Italian, micronised	8	18-65 (31)	19-131 (56)	2.5-9 (4.5)
Baby dusting powder	Chinese	4	9-29 (19)	7-40 (22)	0.5-5 (3.3)
	Italian 00000	4	10-32 (21)	8-41 (24)	0.5-6 (2.9)

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