DETERMINATION OF SIZE OF AEROSOL PARTICLES TRAPPED ON A FIBRE FILTER

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Filtration and subsequent weighing or microscopic evaluation of trapped particles is a method most commonly used to determine concentration of aerosol. The granulometric study of particles has been hitherto made only with use of membrane filters. In the present paper a process of making transparent the fibre filters by organic solvents even for very dense samples used for gravimetric determination of the aerosol concentration is described. The results are compared with those achieved during simultaneous measurement with the membrane filters.

The fibre filters are used to determine weight concentration of aerosol. However, they may be employed also for granulometric evaluation of trapped particles. According to the surface concentration of particles on a filter, a suitable procedure is needed, making use of the fact that in an organic solvent or in its vapours, the fibre structure of a filter disappears and a thin layer containing trapped particles is produced. This transparent layer allows microscopic photographing of particles trapped by the filter. It is of advantage that the same sample of the aerosol may be used both for the determination of the weight concentration and for the determination of the size of the trapped particles. Resulting distribution curves of the size of particles simultaneously taken in the atmosphere by the fibre as well as membrane filters are compared. Accordance between the distribution curves obtained using the fibre and membrane filters is satisfactory for the investigation of the atmospheric aerosol.

The problem of aerosols is at the present time involved in many fields of interest. In the last few years, properties of aerosols in the atmosphere and stratosphere have been followed particularly from the viewpoint of the environment protection. Here, the fibres increasingly assert themselves because of their favourable properties. In Czechoslovakia, the microfibre filters AFPC, made of chlorinated polyvinyl chloride and manufactured as flat analytical filters, are used to measure weight concentration of dust. The trapped particles can be dispersed in water or another liquid by a mere mechanical washing, and the suspension thus produced can be employed for microscopic evaluation of the size of particles. At the same time, however, change in shape of original aggregates, as well as loss of solutes and losses on the walls of the vessel, in which the filter is being washed, take place. The dust particles trapped inside a AFPC filter cannot be usually washed away even when using detergents.

The size of particles trapped by a membrane filter can be determined with an electron microscope, using a method for the study of the filtration surfaces[1,2]. Papers dealing with microscopic determination of size of the aerosol particles directly on the fibre surface of a filter are unknown to us. Making use of good experience with the

determination of dispersity of the dust trapped on a membrane filter[3], we tried to employ a similar procedure for Czechoslovak flat fibre filters of diameter 35 mm.

EXPERIMENTAL

It has been established that the AFPC filters dissolve readily in amyl acetate, butyl acetate, ethyl acetate, and chloroform. According to the surface concentration of particles on the filter it is necessary to choose appropriate working procedure for the preparation of the specimen for microscopy. The basic task is to produce from a nontransparent fibre filter layer a transparent layer in which particles of the entrapped aerosol are kept, if possible, in the form in which they were trapped on the filter.

Preparation of low-concentrated samples. If density of the particles on a filter is of such an extent that they are not in contact between one another and are not overlapped on the resulting microphotograph, organic vapours or directly the solvent may be let to act on the filter, provided that both nylon gauzes are beforehand removed from the filter fibres. The best results are achieved, if the fibre filter is placed on a microscope slide, treated with the drop of ethyl acetate and afterwards put for a period of 24 hours into a desiccator containing ethyl acetate. Vapours of the lat-

TABLE I

Results of Aerosol Particles Size Measurements for a Simultaneous Trapping on the Membrane (SYNPOR) and Fibre (AFPC) Filters

Limits of class D, μ	Number of particles		Rel. frequency, %		Cumulative frequency, %	
	SYNPOR	AFPC	SYNPOR	AFPC	SYNPOR	AFPC
0·2—0·5	63	59	11·80	11·20	11·90	11·20
0·5—1·0	176	142	33·10	27·40	44·90	38·60
1·0—1·5	146	139	26·50	26·60	71·40	65·20
1·5—2·0	102	75	18·90	14·30	90·30	79·50
2·0—2·5	33	49	6·10	9·30	96·40	88·80
2·5—3·0	8	24	1·50	4·60	97·90	93·40
3·0—3·5	4	15	0·70	2·90	98·60	96·30
3·5—4·0	3	7	0·60	1·30	99·20	97·60
4·0—4·5	1	2	0·20	0·40	99·40	98·00
4·5—5·0	2	2	0·40	0·40	99·80	98·40
5·0—5·5	—	2	—	0·40	—	98·80
5·5—6·0	1	2	0·20	0·40	100·00	99·20
6·0—6·5		—		—		—
6·5—7·0		3		0·60		99·80
7·0—7·5		—		—		—
7·5—8·0		—		—		—
8·0—8·5		1		0·20		100·00
	$\Sigma = 539$	$\Sigma = 522$				

ter provide swelling and stepwise dissolution of filter fibres so that after evaporation of the solvent a thin varnish layer with suspended aerosol particles adheres to the slide. The weight of the filter fibres is smaller than that of the reinforcing nylon network which is removed at the beginning of the process and amounts for a filter of diameter 35 mm to approx. 60 mg. The thickness of the layer containing the dust particles is therefore rather thin for us to be able to provide microphotographs of the particles by means of an optical microscope. By examining a set consisting of several hundreds of trapped particles it is possible to construct a distribution curve of the particles by size.

Treatment of samples of high surface concentration. Daily investigation of the dispersity of aerosol requires a separate measuring set providing suction of by about 1 to 2 orders smaller amount of air than a set designed for gravimetric determination of the aerosol concentration. Technical difficulties connected with this led us to an experiment to utilize directly a dense sample for the size determination of the trapped solid particles. The surface concentration of dust on a filter is in these cases usually of the order of 1 mg/cm^2 of the filtration surface so that the filter is covered with a continuous layer of a grey or black mass. By the treatment described above, individual particles cannot be distinguished, as can be seen in Fig. 1*, in which the line segment denotes length of 10 μ. The sample is usually completely nontransparent. The procedure commonly used in the treatment of the membrane filters, *i.e.* dissolution in an organic solvent and formation of a film by pouring on water or glass surface, gave no satisfactory results. Losses on the vessel walls and on the bottom, as well as formation of aggregates of the particles took place. For that reason, we elaborated the following procedure allowing use of a dense aerosol sample both for the gravimetric determination and for the measurement of the size of aerosol particles.

A quarter of the AFPC fibre filter 35 mm in diameter is laid on a microscope slide and several drops of ethyl acetate are added. After making the filter transparent, further microscope slide is attached and the viscous suspension produced by dissolution of the filter is spread between two slides by pushing and moving both slides against one another. After two hours, the slides are separated from one another and the solvent is let to evaporate. On spreading mass of the filters on the slide surface, the resulting film containing suspended dust particles is thin enough and the concentration of the particles is decreased to such extent that individual particles may be seen on the microphotograph. A proof for this is given in Fig. 2* which involves the same sample as is that presented in Fig. 1*.

RESULTS AND DISCUSSION

In order to study reproducibility of the method and to compare results with the values obtained by a common determination of dispersity of the dust entrapped on the membrane filter, a simultaneous measurement with the membrane filter Synpor 6 and fibre filter AFPC was made. The filters employed were 35 mm in diameter and the flow volume amounted to 1·9 and 31 litres of air within 1 min for the membrane and fibre filters, respectively. For the fibre filter, a higher flow volume was used so that a dense sample to be spread between the slides may be prepared. Both samples were taken on January 25th, 1973 in front of a ledge of the balcony placed on the 2nd floor of the Institute of the Physics of the Atmosphere, Czechoslovak Academy of Sciences, Prague. A full line in Fig. 3 shows cumulative frequency of the

* See insert facing this page.

FIG. 1
The Fibre Filter AFPC with Trapped Atmospheric Dust
Made Transparent by addition of ethyl acetate drops.

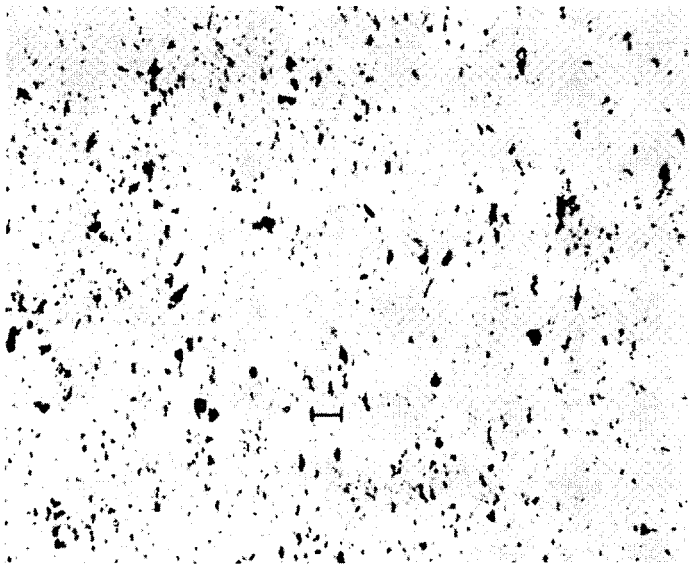

FIG. 2
The Same Fibre Filter with Aerosol as in Fig. 1
Made transparent by spreading in ethyl acetate between two microscope slides.

particles trapped on the AFPC fibre filter. The broken line denotes occurence of particles of various size, found during the classical treatment of a membrane filter Synpor 6. The graph shows that, when using both filtration materials, the final representation of particles by size was within common observational errors due to the microscopic technique. For judgement of the dispersity of natural dust in the air, the agreement is quite satisfactory. In Table I, numerical values of comparison of the first couple of filters are given. Determination of the weight concentration as well as of the size of the particles from one sample of the aerosol trapped on the fibre filter is significant for examining particles of aerosol in natural as well as industrial atmospheres. In the measuring method used until now, it would be necessary to take dense samples, containing more than 1 mg of the trapped dust, on the fibre filters, and low-concentrated samples on the membrane filters, this requiring two series of pumps, filter holders, gas-meters of various types, and higher operational and material expenses. In addition, our method allows to evaluate back, from a series of the measurements, the samples kept in a good state. This is significant, for example, when following contamination of the air, due to unusual reasons of the breakdown character. The progress in the experimental investigation of stratospheric aerosols involves checking of the collecting impact methods used until now. Under these conditions, filtration was shown to be several times more effective than the impact[4]. The fibre filters are preferred to the membrane filters, because of their lower resistance of filtration and higher mechanical strength. The suggested procedure of measuring the dispersity of particles trapped on the fibre filter can be applied to samples set aside after evaluation of the daily weight concentration of dust. Moreover, it can be applied, where the membrane filters or some of the automatic apparatus for measurements of the aerosol particles size cannot be for technical reasons used.

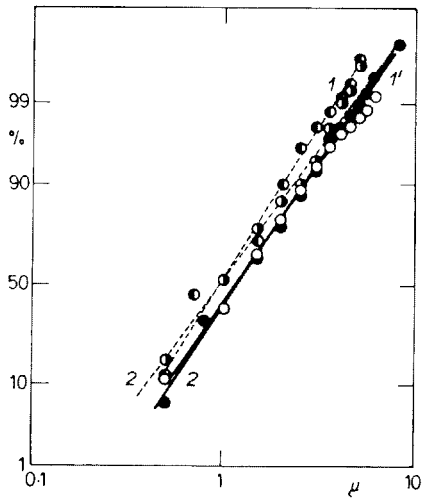

FIG. 3

Comparison of Size of Particles Trapped Simultaneously by Two Couples of the Membrane (broken line) and Fibre (full line) Filters

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