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PROCESS FOR FILTERING WITH POLYTETRAFLUOROETHYLENE FIBERS

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This invention relates to a process and more particularly to a process for filtering suspended particles from gaseous media.

Liquid and solid particles are conventionally removed from gaseous media in which they are suspended by passing the media through a septum such as, for example, woven and non-woven fabrics of silk, cotton, wool and the like. With this known procedure, however, the septa become plugged with the material being filtered. Also, known septa have poor chemical and heat resistance and do not efficiently remove particles of submicron size.

I have found a method for removing suspended particles from gaseous media which is vastly more effective than known procedures. This method can be used to remove efficiently very fine particles of corrosive liquids and solids at high temperatures.

The process of this invention comprises passing a gaseous medium containing suspended particles through a non-woven septum of polytetrafluoroethylene fibers thereby removing the particles from the medium.

One preferred type of septa which can be used in the process of this invention is the felt-like sheets of polytetrafluoroethylene disclosed in my copending application Serial Number 436,014, now Patent No. 2,893,105, issued July 7, 1959. These felt-like sheets can be made by first forming a loose batt consisting of polytetrafluoroethylene fibers, a substantial portion of which are retractable. The loose batt is conveniently formed with multiple cards or garnets arranged along the sides of a movable belt to deposit successive layers of filamentary material on top of one another on the batt. Next, the fibers in the batt are needle punched to forcibly orient some of the fibers substantially perpendicular to the batt and give the batt added strength. Finally, the needle-punched batt is heated, for example, at 300 to 327° C., to retract the fibers and shrink the resulting felt-like product. If desired, the retraction step can be omitted.

Other septa can be prepared by laying one or more loose batts of polytetrafluoroethylene fibers on one or more batts of such fibers as, for example, those of glass, asbestos, wool, cotton, flax, jute, nylon, metal, viscose rayon, cellulose acetate, polyethylene terephthalate, polyethylene, polyacrylonitrile, polyvinylidene chloride and copolymers thereof. This composite is less expensive than septa composed entirely of polytetrafluoroethylene fibers; however, the layer which does not contain polytetrafluoroethylene may limit the use of the finished septa at high temperatures and with corrosive liquids and gases. Also, these multi-layer septa remove suspended particles somewhat less efficiently than do septa of equal thickness and porosity composed entirely of polytetrafluoroethylene fibers. Preferably, the layer of polytetrafluoroethylene fibers in the septa is faced downstream so that it does the final cleaning of the gaseous medium being filtered. Blends of polytetrafluoroethylene and one of the aforementioned fibers can also be used; however, such blended septa, although they are more effective than conventional septa, are less effective than the aforementioned multi-layer setpa or septa composed entirely of polytetrafluoroethylene fibers.

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Reinforced septa can be prepared by placing an open scrim of, for example, polytetrafluoroethylene, glass or steel, between two batts of polytetrafluoroethylene fibers, then needle punching the resulting layers.

Although it is usually most convenient to use self-supporting, needle-punched sheets for the septa in the process of this invention, loose fibers held, for example, between two screens can also be used.

The size and denier of the fibers used in the septa are not critical. For needle-punched felt-like septa of polytetrafluoroethylene, fibers 1.5 to 8 and preferably 3.5 to 6 inches long and from 3 to 10 denier are usually used; however, yarns of polytetrafluoroethylene of several hundred denier and monofilaments can also be used. Monofilaments can be made into nonwoven sheets by laying down a loose batt of the monofilaments, for example, with an air jet, then needle-punching the loose batt. Combinations of monofilaments and staple can also be used.

The velocity with which the medium containing the dispersed particles is fed through the septum of polytetrafluoroethylene fibers is not critical; usually, however, since the penetration of particles increases slightly with the velocity of the medium, the superficial feed rate is about from 5 to 30 feet per minute.

As shown in the following examples, the process of this invention is 10 to 20 times more effective than other known methods for removing suspended particles from gaseous media. The process of this invention can be used to remove both solid and liquid particles of submicron size; it even can be used to remove bacteria and other micro-organisms from gaseous media. The process of this invention can also be used to remove hot corrosive materials from gaseous media; it can, for example, be used to remove hydrofluoric acid from the off-gas flowing between processing tanks and vacuum pumps in polytetrafluoroethylene manufacture.

This application is a continuation-in-part of my copending application Serial Number 436,014 filed June 11, 1954.

The following examples are intended to illustrate the invention and not to limit it in any way. Parts and percentages are by weight unless otherwise specified.

Example I

An aerosol consisting of about 0.1 grain per cubic foot of zinc sulfide particles ranging in size from 0.1 to 3 microns and suspended in air was passed through a series of heat-shrunk, needle-punched, non-woven sheets. Each of the sheets except the one made of wool was prepared in a manner similar to the preferred method of preparing polytetrafluorethylene septa described hereinbefore and in my copending application Serial No. 436,014. The wool septa was prepared by conventional wool felting procedures.

The concentration of zinc sulfide in the aerosol entering and leaving the filter was determined with a Sinclair-

Phoenix forward-scattering photometer which measured the intensity of light scattered by the particles of zinc sulfide. For a given size distribution, the intensity of the scattered light is proportional to the concentration of particles. Also, the concentration of zinc sulfide was measured by passing the medium through an AA millipore filter membrance, then measuring the change in weight of the membrane.

The septa used in the process had the following properties:

Run	Fibers	Fiber, Denier	Wt., Oz./Sq. Yd.	Thickness, In.	Ave. Pore Radius, Microns
1	2.5-inch polytetrafluoroethylene staple.	6.7	56	0.118	34
2	Polytetrafluoroethylene mono-filaments.	6.7	44	0.124	33
3	Wool	--------	22	0.129	38
4	2.5-inch polyacrylonitrile staple.	3.0	26	0.129	38
5	2.5-inch polyethylene terephthalate staple.	3.0	18	0.106	48

The following results were obtained when each of the aforementioned septa were used as described above.

Run	Fiber	Superficial Vel., Ft./Min.	Pressure Drop Through System, In./H_2O	Percent of Particles Passing Through Septum
1	2.5-inch polytetrafluoroethylene staple.	11.4	0.35	0.26
2	Polytetrafluoroethylene monofilaments.	11.1	0.26	0.29
3	Wool	10.9	0.23	2.4
4	2.5-inch polyacrylonitrile staple.	11.1	0.24	3.6
5	2.5-inch polyethylene terephthalate staple.	10.9	0.10	13

The results above show that the process of removing the zinc sulfide particles by passing the aerosol through a septum of polytetrafluoroethylene fibers is about from 10 to 50 times more effective than passing the same aerosol through a septum made of fibers conventionally used in filters.

Example II

Room air having a dust concentration of 1.24×10^{-4} grains per cubic foot was passed through a nonwoven, needle-punched and heat-shrunk sheet of polytetrafluoroethylene fibers at a superficial velocity of 10.8 feet per minute. The septum weighed 56 oz./sq. yd. and was 0.118 inch thick. The fibers used in the septum were 6.7-denier, 2.7-inch staple. During 143 hours of continuous operation, an average of only 4.4% of the dust went through the filter. When the same air is passed through similar non-woven septa made of fibers such as wool, there is no noticeable reduction in the concentration of the dust.

Example III

Three non-woven needle-punched sheets were prepared. One sheet was prepared from 1.5-inch long, 6.7-denier polytetrafluoroethylene fibers. The second septum was prepared by laying a batt of the aforementioned polytetrafluoroethylene fibers on a batt of equal weight of 3 denier polyethylene terephthalate staple, then needle punching the resulting layup. The third sheet was a commercial wool felt manufactured by Western Felt Co. and designated "Western 8550." An aerosol having a concentration of 0.03 grains per cubic foot and consisting of 0.3-micron particles of di(2-ethyl hexyl)phthalate suspended in air was passed through each of the septa. The polytetrafluoroethylene side of the polyethylene terephthalate/polytetrafluoroethylene septum was faced downstream. The following results were obtained.

Fibers	Wt., Oz./Sq. Yd.	Thickness, In.	Superficial Velocity, Ft./Min.	Pressure Drop, In. H_2O	Percent of Aerosol Passing Through System
Polytetrafluoroethylene	33	0.135	5.7	0.046	3.4
			15.2	0.100	6.7
			30.4	0.200	15.1
Polytetrafluoroethylene/polyethylene terephthalate	29	0.148	6.2	0.042	20.6
			14.6	0.118	26.5
			27.5	0.223	34.0
Wool	22	0.132	6.0	0.110	60.8
			12.0	0.240	70.4

Example IV

The aerosol described in Example III was passed upward through a bed of loose 4.5-inch, 6.7-denier polytetrafluoroethylene fibers at a superficial velocity of about 20 feet per minute. The bed of fibers was about 10 inches deep and had a density of 3.0 pounds per cubic fot and an average pore radius of 326 microns. Less than 0.008% of the di(2-ethyl hexyl)phthalate particles in the aerosol passed through the bed.

The process just described was repeated using a bed of about 16 denier glass fibers. The bed of glass fibers had a depth of 10 inches and a density of 3.0 pounds per cubic foot. About 70% of the particles in the aerosol passed through this bed of glass fibers.

The decontamination factor, a term often used to express the efficiency of a filtering process, is the reciprocal of the pressure drop across the septum, in inches of water, times the percent of particles passing through the septum. If the di(2-ethyl hexyl)phthalate aerosol of this example is run through each of the aforementioned beds until a given decontamination factor is reached, for example, 3.6, the bed of polytetrafluoroethylene fibers will last about 20 times longer than the bed of the aforementioned glass fibers.

I claim:

1. A process for filtering particles suspended in a gaseous medium which comprises passing said medium containing said particles through a non-woven septum of polytetrafluoroethylene fibers.

2. A process for filtering particles suspended in a gaseous medium which comprises passing said medium containing said particles through a non-woven, heat-shrunk, needle-punched sheet of polytetrafluoroethylene fibers.

3. A process for filtering particles suspended in a gaseous medium which comprises passing said medium containing said particles through at least two non-woven septa, the last of which is of polytetrafluoroethylene fibers.

4. A process for filtering particles suspended in a gaseous medium which comprises passing said medium containing said particles through a non-woven septum of polytetrafluoroethylene fibers at a superficial velocity of about from 5 to 30 feet per minute.

5. A process for filtering liquid particles from a gaseous medium which comprises passing said medium containing said liquid particles through a non-woven septum of polytetrafluoroethylene fibers.

6. A process for filtering solid particles from a gaseous medium which comprises passing said medium containing said solid particles through a non-woven septum of polytetrafluoroethylene fibers.

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