METHOD OF MAKING A TOBACCO SMOKE FILTER

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METHOD OF MAKING A TOBACCO SMOKE FILTER

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This invention relates to tobacco smoke filters and to methods of making the same. It has been determined that particle sizes in tobacco smoke range from about 0.1 to 1.0 micron in diameter, varying according to the smoking conditions, such as draft, heat, nature of tobacco, and the like. However, those particles which impart flavor and aroma, i.e., those which give the smoker satisfaction, are relatively small in size, being on the order of about 0.1 to about 0.4 micron in diameter, exist in far greater proportion in the smoke than do the larger particles which have diameters from about 0.4 to about 1.0 micron. Although the volume ratio of smaller particles is about 60% to 80% to about 20% to 60% of the larger particles, the numerical ratio is upwards of tens to one.

I have found that the larger particles are principally responsible for the color of the smoke, since they are largely composed of the tarry substance in tobacco smoke. It has been demonstrated that when the quantity of these larger particles in the smoke is reduced, smokers who are ordinarily sensitive to the toxic effects of smoking become less sensitive without noticeable impairment of the satisfaction which they derive from smoking. I have observed that exhaled smoke is substantially devoid of these larger particles which apparently lodge in the mucous surfaces of the nose, throat and lungs, together with some of the smaller particles, and are subsequently absorbed along with them, but doubtless at a slower and hence more harmful rate, thereby cumulatively aggravating toxic effects.

It is accordingly the object of this invention to provide a tobacco smoke filter of fiber in of making the same which selectively removes the aforementioned larger particles from the smoke taken into the mouth of a smoker.

In a preferred embodiment of the selective tobacco smoke filter of this invention, textile fibers of substantially uniform diameter, but of random length, are arranged heterogeneously in a semi-felted cylindrical mass affording a labyrinth of extremely fine but highly tortuous passages through which the smoke is drawn and in which its direction is sharply changed countless times in such a way that the larger particles are selectively thrown out of the smoke stream to become trapped in the passages, thereby leaving the smaller taste- and aroma-producing particles in the smoke passing into the mouth of the smoker. Preferably, the fibers are stiffened and are bound together in the aforementioned heterogeneous arrangement by a suitable inert binder, so that the filter is rendered sufficiently firm and resilient not to be readily compressed between the smoker's lips to such a degree that freedom of draw and consequent flow of smoke is materially impaired.

A preferred method of making the selective tobacco smoke filter according to this invention comprises semi-filling the random lengths of fiber in a loose web, gathering the same into a rowing having a diameter several times that of the finished filter, compressing the rowing radially, i.e., contracting it circumferentially into a rope having a fraction of the diameter of the rowing to thereby reduce the macro-voids therein to micro-voids, wrapping the rope in a tubular paper wrapper, and severing the wrapped rope into units or plugs of the desired length for incorporation in a cigarette or other smoker's article. Prior to gathering the semi-felted web of fibers into the rowing, or during the rowing formation, a thermo-responsive binding material is mixed or otherwise incorporated in or applied to the fibers and thereafter the rowing is heated to a sufficient degree to activate the binder and cause it to hold the fibers in the aforementioned heterogeneous relation and impart firmness and resiliency thereto. Preferably, but not necessary, the activation of the thermo-responsive binder is effected after the rowing has been compressed into the reduced-diameter rope, but prior to severing the same.

It will be seen that the tobacco smoke filter of this invention and the method of making the same according to this invention provide an efficient and highly selective means for removing the larger toxicity-aggravating particles without noticeably impairing the satisfaction which the smoker derives from the tobacco smoke.

For a more complete understanding of the invention, reference may be had to the accompanying drawings, in which:

FIG. 1 is a schematic diagram of the apparatus for making the filter according to the method of this invention, and illustrates the successive steps of forming the rowing, radially compressing it into a reduced-diameter rope, wrapping it in paper, heat-activating the thermo-responsive binder, cooling the rope to set the binder, and severing the rope into finished filter units or plugs;

FIG. 2 is an enlarged perspective view of one of the filter units embodying the invention and made according to the method of this invention, the tubular paper cover being shown partially unwrapped to expose the filter portion and to generally indicate its construction;

FIG. 3 represents a microscopic view of a portion of the filter of FIG. 2, and illustrates the random, heterogeneous arrangement of the fibers and the binder holding them in that arrangement by securing contacting fibers together at their points of contact, and

FIG. 4 represents a larger microscopic view of a portion of the filter made according to a modification of the resin-treating step of the fibers.

In carrying out the method of the invention, fibers of textile grade, having diameters of about 2 to about 5 denier (about 14 to about 23 microns) and of random lengths between about .03 to about 2.0 inches are stirred and mixed together so that they are highly intermingled in a heterogeneous mass with the shorter fibers lying at various angles across the longer fibers in a non-parallel arrangement to form a thin, loose, semi-felted web capable of being handled, but having little self-sustaining strength. Natural fibers of vegetable origin such as cotton, or synthetic fibers, such as cellulose acetate, acetate rayon, viscose, nylon and the like, of the aforementioned diameters and lengths, may be used alone or as mixtures of two or more of them, regardless of their nature. Where mineral fibers such as glass or asbestos fibers or their equivalents comprise the web or are admixed with the textile fibers, the diameter of such mineral fiber is on the order of 3 microns or less and in that case the labyrinthine filtration effect is augmented by impingement of the smoke particles on the fine mineral fibers or their equivalents, in the manner described in copending application Serial No. 260,187, filed December 6, 1951, by Harold W. Knudson, now Patent No. 2,761,978, issued September 4, 1956.

The semi-felted web so formed is gathered into a rowing according to usual textile practice, i.e., with the long fibers extending generally longitudinally, the quantity of the gathered fibers being such that the rowing will have a diameter several times the diameter of the ultimate filter unit or plug. For example, if the finished diameter of the filter unit is to be, say, 0.3 inch, the free diameter of the rowing would be at least twice and up to
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ten times larger, or between about 0.6 and about 3 inches in free diameter.

Inasmuch as such rovings are inherently irregular in cross-sectional density and non-uniform in arrangement of the fibers along the length of the roving, due to the manner in which the original semi-felted web is formed, it is preferred that the roving that is supplied to the plug-making machine be made up of several relatively small diameter strands formed in the same way from the semi-felted web and then combined into a single roving of the said diameter for supply to the plug-making machine. To this end, strands of the semi-felted fibers are formed in the manner described but of diameters such that when the predetermined number thereof are brought together into a single roving the latter will have the requisite diameter. By way of example, three reels 10, 11 and 12, each containing the respective strands 13, 14 and 15 to be combined, are illustrated in FIG. 1 as journalled on a suitable frame 16 and simultaneously feeding into the conical thimble or eye 17 where they are combined into the roving 18. If the free diameter of the roving 18 is to be about one inch, the diameter of the individual strands 13, 14 and 15 from which the single roving 18 is made will be about one-third inch. Similarly, if four such strands are to be combined into one inch roving 18, the strands 13, 14 and 15 would be about one-fourth inch in diameter and four corresponding reeels then used.

Preferably, the three strands 13, 14 and 15 are lightly twisted to further improve cross-sectional uniformity by averaging out the aforementioned inherent irregularities. One convenient way to effect such a light twist is to slowly rotate the gathering thimble 17 about its axis as by a suitably driven belt 19, or the like, the interior of the thimble 17 being knurled or otherwise roughened to afford a sufficiently frictional surface.

The lightly twisted roving 18 is then uniformly compressed radially to the rope 21 having the desired diameter of about 0.3 inch in the tapering cone 20 leading to the plug-making machine of the general type shown in my Patent No. 2,793,572, issued May 28, 1957. As there described, the rope 21 is wound on a spool 22, such as cigarette paper, supplied from spool 23 to the wrapping mechanism schematically shown at 24 in FIG. 1. The seam of the relatively tubular paper wrapper 25 is sealed at 26, and, subject to certain preferred intermediate steps, may then be severed into units 27 of about three inches long by the flying knife mechanism indicated at 28. These units 27 are cut into shorter lengths, assembled with tobacco and again severed to form the filter of a cigarette, each filter having a length of about one-half inch and the diameter of the finished cigarette, which may be about 0.5 inch, the diameter of the rope 21 in the given example.

The purpose of the radial compression of the roving 18 from a free diameter to a fraction thereof into the rope 21 is to reduce the macro-voids therein to micro-voids, so that all tortuous passages therethrough have a minimum diameter less than the diameter of the large particles, i.e., those larger than 0.4 micron in diameter. However, it is not the diameter of the passages that selectively precludes passage of the larger particles, but rather, it is the highly tortuous nature of these passages formed between the fibers that performs that function, augmented by impingement of the smoke particles on fine fibers having diameters on the order of the smoke particle diameters, in cases where a small proportion of such fine fibers are incorporated in the filter in the manner described in said Knudson patent. Primarily, the reduction in diameter afforded by reducing cone 20 is to enhance the tortuous nature of the passages, although, secondarily, not through or continuous passages, then which have a minimum diameter capable of passing any measurable quantity of the larger particles. An incidental purpose of compressing the roving into a rope is to hold the filter securely in its tubular wrapper 25.

The random, heterogeneous arrangement of the fibers constituting the radially compressed plug 21 is generally illustrated in FIG. 2, from which it will be seen that a labyrinth of myriad highly tortuous passages is formed through the interior of the tubular wrapper 25, as shown partially unwrapped in FIG. 2. It is intended that for a filter made of glass fibers of three micron diameter, a plug of about one-half inch in length and the diameter of a cigarette contains approximately two miles of fiber and approximately 54% miles of air passages, the latter considered for comparison, the colon fibers are formed of 3 microns. With the ratio of approximately 2 to 54% of solid fiber material to passages or voids between the fibers, it is evident that the void portion of the plug is extremely finely subdivided, so as to be an effective filter to remove up to the desired physiological amount of harmful solids and yet afford a satisfactory draw and the conduction of the desirable aroma and taste components of the cigarette smoke.

Although a gross filtering efficiency of 40 to 50 percent offers measurable physiological advantages to the smoker in the filter of this invention, the larger particles are removed to a measurably greater extent, thereby greatly enhancing its physiological advantages. In case the filter is made of textile fibers or a mixture of them, or a mixture of them with mineral fibers, the proportion given in the foregoing example would be altered commensurately. However, the given example indicates the extremely fine subdivision of the void portion obtained in the filter of this invention.

The degree of the reduction in size of the macro-voids is dependent upon the amount of radial compression which takes place between the initial roving 18 and the finished rope 21 and plug 27. Consequently, a larger diameter roving suffers a greater reduction of the macro-voids than does a smaller diameter roving, and in this way, the passage size can be predetermined with reasonable accuracy, and also size can also be predetermined by a preselection of the diameter of the filter in the range of between about two and about twenty-nine microns, for example, and by a choice of the quantity of such fibers employed.

Although the fibers need not be of uniform diameter, it has been found that passage regulation by radial compression is facilitated when the fibers are of uniform diameter, but of indifferently varying length within the aforementioned length range. In any case, the fibers should be of a fineness such as to be silky and not prickly to the tongue or skin, even when of short length. Generally speaking, the fibers should be materially less in diameter than the diameter of human hair, as described in Betts Patent No. 2,327,991.

In order to give the plug 27 resiliency and the whole mass integral form and proper firmness when the roving has been radially compressed in the plug-making machine to a fraction of its free diameter, I may apply a binder in liquid form to the semi-felted web fibers by means of a fine mist-like spray prior to gathering the web together into the roving or strands 13, 14, 15. The liquid may be resin dissolved in a solvent vehicle or a slurry of finely-divided resin in water. The extent of this application of binder applies between 15% by weight, and the binder preferably is of the thermo-setting type, such as a phenolic-formaldehyde. The moist web is then gathered into the roving or strands, as described.

The roving or strands, either separately or after combination into the roving, with or without prior drying, is then passed through a heating zone where it is heated to a temperature sufficient to cure or set the resin. The degree of heating employed and the length of time for exposure thereto vary according to the semi-felted web without undue discoloration of the binder. Each filter is ensheathed in a thin film of resin, which renders it resilient. The resin coating is indicated at 33 in FIG. 4 as enveloping each fiber. As an incident to the resin
curing, the points of contact of adjacent fibers are secured together by the binder. When the roving is compressed radially into the reduced diameter rope in the cone 28, the rope 21 is firm but resilient. The inherent flexibility of the resin-coated fibers enables them to flex spring-like during compression. It will be understood that the diameter of the fibers 31 will be increased slightly by the thickness of the coating 33.

A different but preferred mode of binding the fibers together is effected during the plug-making operation, and that is done by adding the dry binder, in uncured or inactive condition, either in the form of a dry powder, staple or filaments. One convenient way of incorporating the thermo-responsive binder is to mix it with the fibers during semi-felted in the web before the latter is formed into the roving 18 or roving-forming strands 13, 14, 15. Preferably, the binder in dry form is incorporated in the roving or strands either by mixing the fine powder or the staple in the web prior to its formation into the roving or strands, or as continuous filaments in the roving or strands 13, 14, 15 when the web is gathered into such roving or strands. In this way, greater uniformity of distribution of the thermo-responsive resin throughout the eventual rope and consequent uniform activation of the binding points are obtained. Thus, as the semi-felted web is gathered into the roving or roving-forming strands, a plurality of filaments of thermo-responsive material are fed into and thus are distributed throughout the roving or strands. The volume of resin to fiber by weight is between about 10% to about 25%, depending on the gauge of the thermo-responsive filaments.

Preferably, such binder staples or filaments are larger in diameter than the filter fibers and may be from about 2 to about 8 denier, i.e., on the order of about 14 to about 29 microns diameter. Any suitable thermo-plastic resin in the form of powder, staple or filament, having a fusion point below about 300°F, the scorching temperature of the paper wrapper 25, and above a dead storage temperature of about 150°F and being otherwise inert as well as odorless and tasteless will serve the purpose. Examples are vinlylidene chloride, vinyl copolymer, polyethylene, polypropylene, and their equivalents which are variously identified by the trade names "Pias-Tec," "Vinylon," "Polythene," "Lucite," "Lustron," "Dyneil," and the like. Alternatively, the thermo-responsive resins may be applied in a liquid suspension or slurry and sprayed on the web prior to gathering the web into a tobacco composition. The binder previously described, but deferring the setting or thermo-activation of the binder until after the roving is formed into the rope 21.

Assuming that the binder is of the thermo-setting type, the paper-wrapped rope, after the seam of the paper wrapper 25 is sealed at 26, is passed through a heating zone indicated at 29 in FIG. 1, wherein the resin is heated to the curing or setting temperature to bind the fibers together in the manner described. The heating means of heating zone 29 may be of any desired type, but in order that the heating zone 29 is not inordinately long for use with modern high-speed plug-making machinery, a quick and penetrating heat is preferred, such as that induced by a high-frequency induction coil, in the field of dielectric plates, infra-red ray heat emitting coils, or the like, through, between or adjacent which the wrapped rope passes.

Where the binder is of the thermo-plastic type, such as vinyl chloride, vinyl chloride-acetate copolymer, methyl methacrylate or other acrylic resin and the like, the heat softened resin must be cooled before7 severing at 28 and to that end, the wrapped rope is cooled in a suitable cooling zone 60, which may be a refrigerating coil, through refrigerating coils, or the like. Although cooling is not essential where thermo-setting resins are used as a binder, cooling down before severing at 28 is nevertheless preferred. Cooling may be rendered unnecessary by applying the resin-activating heat after the rope has been severed into the shorter lengths 27.

Whatever binder and method of activating the same are employed, the fibers are held together by the binder in the aforementioned compressed, heterogeneous arrangement, which is generally illustrated in FIG. 3, which is an enlargement of a section of FIG. 2, and in which the fibers constituting the filter are designated 31 and the binder is designated 32. It will be observed that the ratio of gross passage volume to gross solid volume indicated by FIG. 3 is very large. I have calculated the ratio to be on the order of 25 to 1 where glass fibers on the order of about 3 microns diameter are used, thereby indicating that the porosity of the filter volume is high so as not to impair the draw, notwithstanding the high degree of filtering efficiency of the filter in selectively removing the larger particles from the smoke drawn therethrough.

Instead of wrapping the rope 21 in the paper 25, equivalent wrapping or conforming means such as cellophane or a sprayed coating of molten resin, a resin slurry or solution or the like may be employed to hold the rope 21 in its confined form after the resin envelope has been cured, set, or dried in the manner described in connection with the previously described embodiment of the invention applied hereinafter or in the appended claims applies equally well to a sheet material wrapper and a plastic wrapper applied and formed in situ in the manner described.

Although a preferred embodiment of invention is described in connection with cigarette filters, it is equally applicable to cigar and pipe use as well as for gas mask and other respirator cartridges, being made in the proper diameter for that purpose. It is accordingly to be understood that the invention is not limited to the uses described herein, but is susceptible of changes in form and detail within the scope of the appended claims.

I claim:
1. A method of making cylindrical tobacco smoke filter units, which comprises mixing fibers of random lengths between about .03 and about 2.0 inches to form a heterogeneous mass, gathering said mass into an elongated roving having a diameter in excess of the diameter of the finished filter unit and having macro-voids between said fibers, radially compressing the roving into a ropc having approximately the diameter of the finished filter unit to reduce the macro-voids to micro-voids, wrapping the rope with sheet material, and severing the rope into filter units.
2. A method of making cylindrical tobacco smoke filter units, which comprises mixing fibers having diameters between about two and about twenty-nine microns into a heterogeneous mass, gathering said mass into an elongated roving having a diameter two to ten times the diameter of the finished filter unit and having macro-voids between said fibers, radially compressing the roving into a rope having approximately the diameter of the finished filter unit to reduce the macro-voids to micro-voids, wrapping the rope with sheet material, and severing the wrapped rope into filter units.
3. A method of making cylindrical tobacco smoke filter units, which comprises mixing textile fibers of between about two and about five denier diameter and of random lengths in excess of .03 inch into a heterogeneous elongated roving having a diameter in excess of the diameter of the finished filter unit and having macro-voids between said fibers, radially compressing the roving into a rope having approximately the diameter of the finished filter unit to reduce the macro-voids to micro-voids, wrapping the rope with sheet material, and severing the wrapped rope into filter units.
4. A method of making cylindrical tobacco smoke filter units, which comprises mixing textile fibers of a substantially uniform diameter between about two and about five denier and of random lengths to form a heterogeneous mass, gathering said mass into an elongated rov-
ing having a diameter in excess of the diameter of the finished filter unit and having macro-voids between the fibers, radially compressing the roving into a rope having approximately the diameter of the finished filter unit to reduce the macro-voids to micro-voids, wrapping the rope with sheet material, and severing the wrapped rope into filter units.

5. A method of making cylindrical tobacco smoke filter units, which comprises mixing textile fibers of a substantially uniform diameter between about two and about five denier and of random lengths with other fibers having a diameter up to about 3.0 microns to form a heterogeneous mass, gathering said mass into an elongated roving having a diameter in excess of the diameter of the finished filter unit and having macro-voids between the fibers, radially compressing the roving into a rope having approximately the diameter of the finished filter unit to reduce the macro-voids to micro-voids, wrapping the rope with sheet material, and severing the wrapped rope into filter units.

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