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FILTER TOW OF CRIMPED CONTINUOUS POLYOLEFIN FILAMENTS

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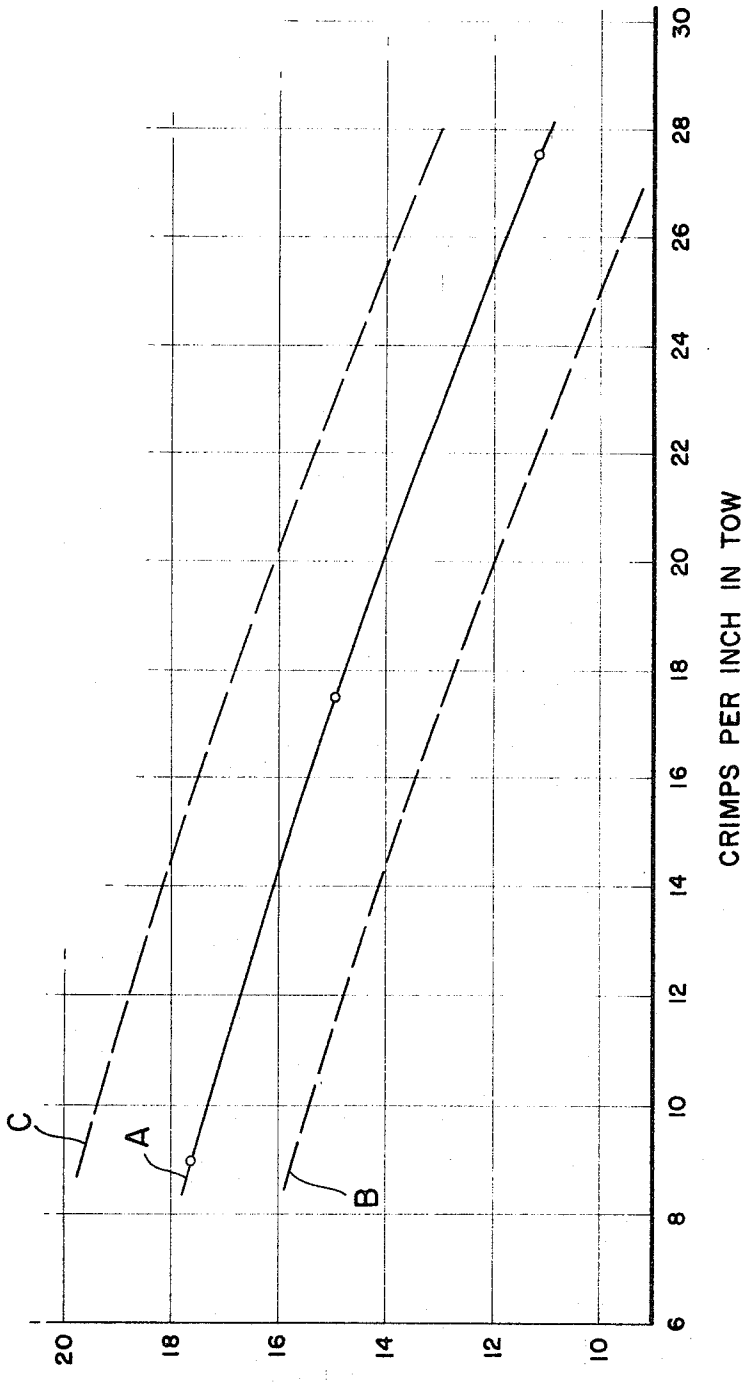

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FILTER TOW OF CRIMPED CONTINUOUS POLYOLEFIN FILAMENTS

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Continuation-in-part of application Ser. No. 65,941, Oct. 31, 1960, which is a continuation-in-part of application Ser. No. 664,157, Jan. 7, 1957, now Patent No. 2,966,157. This application May 5, 1966, Ser. No. 547,925

5 Claims. (Cl. 161—173)

ABSTRACT OF THE DISCLOSURE

The invention relates to a tow of crimped continuous filament polyolefin fibers useful for fabrication into tobacco smoke filters. The individual fibers are crimped at least 18 crimps per inch to provide effective filter elements of acceptable firmness without undue pressure drop.

This invention is a continuation-in-part of our co-pending application Ser. No. 65,941, filed Oct. 31, 1960, now abandoned, which is a continuation-in-part of our earlier application Ser. No. 664,157, filed Jan. 7, 1957, now U.S. Patent No. 2,966,157.

The subject of tobacco smoke filters has received considerable attention in recent years. Numerous patents and publications on this subject have appeared. In general, many of the prior art filters have been comprised of wads or masses of short filaments or granules of various materials for filter purposes. Many of the tobacco smoke filters in the prior art are made from paper or the like materials. However, the prior art filters have not been entirely satisfactory in some respects. Many of the filters are not particularly efficient and others, particularly the wad or mass-type of filters, may be objectionable because of high pressure drop.

For tobacco smoke filters, in addition to the capability of the filter to filter out certain components, there are a number of other properties that need to be taken into consideration. For example, a cigarette filter should have an acceptable feel in the smoker's mouth. That is, the filter should be firm, not only initially, but it should not get soggy or detach from the cigarette. The filter should not have such a high pressure drop that the pressure to draw smoke through the filter is noticeable to the smoker. The filter should be economical to make and capable of being made on automatic machinery or otherwise lend itself to mass production at the rapid rate required for cigarette manufacture.

In recent years certain cellulose acetate yarns have come into use to a large extent for cigarette filters and in most instances have replaced paper filters that have been used. While such yarn-type cellulose acetate material gives a cigarette filter much improved over many prior art filters and also comprises a material which works well in automatic machinery, there are now available filamentary materials such as polyolefin filaments which are of a lower cost than cellulose acetate. It is, therefore, apparent that the development of such materials in a form that they may be used for filter manufacture represents a highly desirable result.

This invention has for one object to provide a new tow material which may be efficiently and economically converted into tobacco smoke filters. Another object is to provide a material from which a cigarette filter may be made that is not only relatively firm but which does not get soggy or soft from mouth or smoke moisture. Still another object is to provide a tow material which, because of its hydrophobic properties when made into

filters, does not dry the tobacco smoke or remove certain hydrophilic vapors connected with the aroma of the smoke. Still another object is to provide a method for manufacturing polyolefin tow material and a method of making such tow into filters. Other objects will appear hereinafter.

Continuous filament tow is known to be useful for manufacturing tobacco smoke filters. Tows of continuous filament cellulose acetate are known to be particularly suitable for this purpose as is shown, e.g., in U.S. Patent No. 2,794,239. The filter products made from that tow are also known to be excellent filters as shown, e.g., in U.S. Patent No. 2,900,988.

The known cellulose ester tow comprises a plurality of substantially untwisted, elongate continuous crimped filaments which are substantially parallel. In order to fabricate cigarette filters, the tow is mechanically crimped and is then processed into the desired configuration and assembled into the cigarette product. The principal steps in the complete process include: drafting; blooming; chemical treatment; lofting; wrapping; and cutting the rod into desired lengths. The chemical treatment is necessary to give a rod of acceptable firmness from the tow.

The physical properties of the filter rod must meet certain basic criteria; it must be capable of trouble-free manufacture into filters; and, the filters so produced must be acceptable to the smoker and, of course, the filter must be effective to remove tar material and the like from tobacco smoke. The firmness of the filter rod is of fundamental importance in meeting these criteria. The continuous filter rod made from the tow is always cut during processing into filter elements. The rod must be sufficiently firm to be cuttable rapidly on automatic machinery such that, after cutting, the cut end, which may be exposed to the smoker's mouth, is free of imperfections such as loose material. The exposed cut surface should be flat and essentially perpendicular with respect to the longitudinal axis of the filter. This is a difficult requirement to meet because, irrespective of how sharp the cutting edge, the rod will deform somewhat during the cutting process. In order to be suitable for the manufacture of filters, therefore, the tow must be processable into sufficiently firm rods free of the mentioned objections and easily cut. The filter must also be of acceptable firmness to the smoker and should generally be firm enough to be capable of being processed in high-speed automatic machinery capable of manufacturing thousands of filters per hour. Of course the primary goal of the process is to obtain tobacco smoke filters and if the filters produced from a suitably firm tow rod are not suited as a filter, the tow is not useful for the manufacture of same.

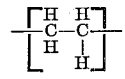
By utilizing cellulose ester tows, rods and filters of acceptable firmness and processability have been achieved by the aforementioned chemical treating or plasticizing step. It is an object of the present invention to provide a continuous filament tow which is easily processable into rods and filters of acceptable firmness without the requirement of such a chemical treating step. This and the foregoing objects as well as further objects which will become apparent from the following detailed description which includes a preferred embodiment are achieved according to the present invention by utilizing a tow made from highly crimped polyolefin filaments.

The sole drawing shows rod hardness as a function of the amount of crimp in the tow for rods of various pressure drops.

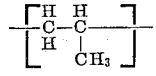
We have found that certain polyolefins may be made into a tow bundle of continuous filaments. We have found that these continuous filaments may then be highly crimped. That is, the crimping may be much greater than that heretofore applied to filamentary materials in tow

form used for filter manufacture. We have found that high crimping of the polyolefin filaments permit the obtaining of a firm filter. We have found that the crimped material of the present invention can be fabricated on existing automatic cigarette filter rod making equipment if this is desired.

The polyolefin material which we prefer to use has a molecular weight above 10,000 and below 1,000,000. Such materials are referred to in the trade as poly-alpha-olefins. Preferably the molecular weight of the polyolefin material would be between 30,000 and 200,000. The softening point of the polyolefin polymer which we prefer to use is between 85° C. and 160° C. Of the several polyolefin materials produced industrially we prefer those known as polyethylene and polypropylene. The structural repeating unit for polyethylene can be represented as:



The structural repeating unit for polypropylene can be represented as:



Either low density polyethylene, namely polyethylenes having a softening point of about 90° C. to 100° C. or high density polyethylenes which have a softening point of 110° C. to 150° C. can be used in preparing the fibers used in the filters of the present invention. The polyolefin may be stereo specific or regular or random in form.

The particular method of manufacturing the polyolefin material is not a part of the present invention and is known to the industry concerned with such manufacture. In other words, the desired polyolefin material can be obtained from a polyolefin manufacturer by giving the above specifications of molecular weight and other properties to such manufacturer. It will be noted, however, that the polyolefin material is resistant to the absorption of moisture.

After obtaining a suitable polyolefin composition it is spun into a bundle of parallel filaments which are then crimped on a textile tow crimping device. Preferably a device is used which gives a uniform crimp. The number of filaments required in the bundle of tow to make a satisfactory filter rod will depend on the desired size of the filter and on the diameter of the individual fibers in the tow and the amount of crimp the tow has been given. In general with a crimp within the range of 18 to 30 crimps per inch, it will require 3,500 to 120,000 filaments to make a standard size cigarette filter when the fibers are in the 16 to 0.5 denier per filament range. The following table illustrates how the number of filaments can vary to make standard size cigarette filters as the diameter of the fibers decreases in tows which have been crimped within the range of 18 to 30 crimps per inch.

Fiber size, d./f.:	Range of No. filaments in the rod (25.5 mm. circumference)
0.5	50,000–120,000
1	35,000– 70,000
3	16,000– 30,000
4	15,000– 25,000
8	6,000– 15,000
16	3,500– 7,500

The exact process used for spinning the polyolefin material into filaments is not a limitation on the present invention. Any of the methods known in the textile industry for preparing polyolefin filaments may be used for preparing the filaments of the present invention provided that a suitable denier is obtained.

As indicated above, in accordance with the preferred embodiments of the present invention, a high degree of crimp is imparted to the tow of parallel filaments. There are various types of crimping apparatus that may be used. Examples of satisfactory crimping devices are described in the following U.S. Patents: 2,090,669, 2,311,174, 2,505,618, 2,698,970, 2,734,228, 2,734,229, 2,734,251, 2,740,992 and 2,749,233. Most of the commercial crimping devices for textile tows are of the "Stuffing-box" type, although in some instances the "gear type" is used. Both of these types are discussed in the patents listed above. We prefer the "stuffing-box" type of textile tow crimping apparatus since it readily permits putting in a range of crimp from about 18 crimps per inch up to, for example, 40 or 60 or even more crimps per inch of an amplitude between about 0.10 inch and 0.01 inch.

By crimps per inch we mean the number of convolutions per inch of fiber length. By amplitude of crimps we mean the height of each convolution normal to the longitudinal axis of the fiber.

It is apparent from the foregoing that the actual length of a fiber segment which is expressed in terms of crimps per inch, depending upon the number of crimps and the amplitude thereof, may, for example in a segment of one inch length in a crimped form, actually occupy 1¾ to 2 inches or more when in an uncrimped condition. We have found that there is considerable filling capacity added to the tow of the present invention when it is given a high degree of crimp and with the filaments of the present invention excellent firmness is imparted to the resultant filter from this high degree of crimp alone.

The highly crimped filaments of polyolefin produced as above described and in the form of continuous filaments can readily be fed into existing automatic filter-making machinery. In such machinery a bundle of the crimped filaments is formed into a filter element, which element is enclosed in a paper wrapper and cut into segments, which segments feed into cigarette machines to apply the filter to the cigarette.

By providing the polyolefin tow with a high degree of crimp of at least 18 crimps per inch, and preferably at least 25 crimps per inch, we have found that excellent filters of suitable firmness can be made on automatic machinery from the tow without the use of a chemical treatment or plasticizing step. It has been found that the high degree of crimp imparted to the tow permits the omission of the plasticizing step previously necessary to obtain filters of acceptable firmness. These features of the invention will be further understood in light of the examples which follow.

EXAMPLE I

Polyethylene filters.—A drafted, high-density polyethylene yarn of 5.0 denier per filament was prepared by melt spinning polyethylene using a 50-hole spinnerette with 0.30 mm. openings. The drafted yarn had a strength of 2.9 grams per denier, a stretch of 30% and a softening point around 115° C. It was plied into the tow (16,000 filaments) of the present invention and a portion of the tow was crimped on a crimper as above referred to which produced 25 crimps per inch, all in a direction perpendicular to the length of the fibers. The crimped tow as produced may be baled for future use, or the tow may be fed directly into filter manufacture.

In accordance with this example, the crimped polyolefin tow was fluffed out to a width of 12 inches and fed into a filter rod-making machine which produced filter rods wrapped in cigarette paper. The rods were 90 mm. in length and 25.5 mm. in circumference. After being heated for 10 seconds at 120° C. the rods were quite firm and had an average pressure drop (resistance to draw) of 9.3 inches at an air flow rate of 17.5 ml. per second. Two of the rods were cut into lengths of 15 mm. and these filter tips were attached to 10 king size cigarettes (brand A) which had been shortened by 15 mm. These filter tipped cigarettes were smoked to butt lengths of 35 mm. on an automatic smoking machine similar in design and operation to the one described by J. A. Bradford,

W. R. Harlan and H. R. Hanner of Ind. and Eng. Chem. 28, 836–839 (1936). The smoke which passed through the filter was collected and analyzed for nicotine and tar content. The results of this smoking test and the pressure drop of the filtered cigarettes before smoking are shown in Table 1.

EXAMPLE II

Polypropylene filters.—A drafted polypropylene yarn of 4.8 denier per filament was prepared by melt spinning polypropylene using a 50-hole spinnerette with 0.30 mm. openings. The drafted yarn had a strength of 4.7 grams per denier, an elongation of 35% and a softening point around 126° C. It was plied into a tow (16,700 filaments) in accordance with the present invention and given 28 crimps per inch. As indicated in Example I, the tow may be packaged as in the form of compact bales.

Some of the crimped tow was fluffed out to a width of 12 inches and fed into a filter rod-making machine which compacted it into a tight bundle and wrapped it with white paper having a thickness of 0.10 mm. The resulting filter rods were quite firm due to the heavy paper wrapper. They were 90 mm. in length and 25.7 mm. in circumference; their average pressure drop was 9.1 inches. Two of the plugs were cut into lengths of 15 mm. and these filter tips were attached to 10 king size cigarettes (brand A), shortened by 15 mm. These filter tipped cigarettes were smoked to butt lengths of 35 mm. on the automatic smoking machine and the collected smoke was analyzed for nicotine and tar content. The results of this test are listed in Table 1.

TABLE 1

Type of Cigarette Smoked to 35 mm. Butt (85 mm. in length)	Av. Pressure Drop of Cigarettes (in H_2O)	Mg. Tar in Smoke (10 cigarettes)	Mg. Nicotine in Smoke (10 cigarettes)	Percent Tar Removed By Filter	Nicotine Removed By Filter
Rrand A, no filter	3.2	17	26		
Brand A, polyethylene filter Example I.	4.1	120	19	29	27
Brand A, polypropylene filter Example II.	4.1	124	19	27	27

In Example 1 the rods were heated to ensure adequate firmness. The following examples demonstrate that excellent firmness can be obtained by using tow having a high degree of crimp of more than 18 or 25 crimps per inch without the use of heat whereas less crimped tow cannot be fabricated into comparable filters.

EXAMPLE III

Polypropylene was melt spun and drafted into continuous filaments of 6 denier filament. Part of the yarn was converted (plied) into a tow of 98,000 total denier (16,300 filaments) and the tow was crimped in a stuffer box-type crimper to 8–10 crimps per inch. The tow was then converted to thin paper wrapped filter rods (25 mm. circumference) which were cut into 17 mm. filters. The filters had a pressure drop of 1.7 inches which is quite acceptable to a smoker. Pressure drops of more than 2.5 become unacceptable and, accordingly, the value of 1.7 was decided upon as a basis upon which to compare highly crimped tow of the present invention with lower crimped tow. The filters were attached to standard cigarettes (68 mm.) and the cigarettes were automatically smoked to butt lengths of 30 mm. using a smoking machine (type B) as described by Touey and Mumpower in Tobacco Science 5, pp. 31–35, 1961. The percentage of tar removed by the filters was obtained by the photofluorometric procedure described by McConnell, Mumpower and Touey in Tobacco Science 4, pp. 55–61, 1960.

EXAMPLE IV

Another part of the spun polypropylene yarn was converted into a tow of 85,000 total denier (14,200 filaments) and the tow was crimped 16–18 crimps per inch. This tow was also converted to paper wrapped filter rods (25 mm. circumference) which were subsequently cut into 17 mm. filters having a pressure drop of 1.7. The filters were attached to standard cigarettes (68 mm.) and the cigarettes were automatically smoked to butt lengths of 30 mm. The percentage of tar removed by the filters was obtained by the photofluorometric procedure.

EXAMPLE V

A third part of the yarn was converted into a tow of 76,000 total denier (12,600 filaments) and the tow was crimped to 25–30 crimps per inch. This tow was also converted to paper wrapped rods (25 mm. circumference) which were cut into 17 mm. filters having a pressure drop of 1.7. The filters were attached to standard cigarettes (68 mm.) and the cigarettes were automatically smoked to butt lengths of 30 mm. The percentage of tar removed by the filters was obtained by the photofluorometric procedure. Listed below are the results obtained for Examples III–V.

TABLE 2

	Crimps Per Inch	Rod Hardness	Rod Press. Drop, In. H_2O	Press. Drop 17 Mm. Filter, In. H_2O	Percent Tar Removed	No. of Filaments	Rod Weight, Gms.
Example:							
III	9	17.7	6.2–6.8	1.7	29	16,300	.926
IV	17.5	15.0	6.0–6.8	1.7	28	14,200	.880
V	27.5	11.1	5.8–6.8	1.7	31	12,600	.805

Rod hardness is the degree to which a ½ inch diameter plunger distorts a rod when a plunger loaded with a 347.5 gram weight is applied to the surface of the rod held on a horizontal position on a flat platform. This degree of deformation or indentation is measured in 0.1 mm. increments. Thus, the lower the value, the harder is the filter. A filter rod cannot be cleanly cut into filter segments unless its hardness value is less than 12 to 13. Accordingly, filter rods which have hardness values about 12 or 13 are not suitable for fabrication into filters and tow which yields such soft rods is not sutiable for making filters.

Curve A of FIGURE 1 shows rod hardness as a function of tow crimp for filters having an equal pressure drop which, in the case of Examples III–V, is 1.7 inches. The curve clearly shows that for filters of this acceptable pressure drop, it is required to use a high degree of crimp to obtain suitable rod hardness. If low crimps of below 18 are used, rod hardness values of much worse than

the maximum acceptable values of 12–13. It is quite surprising to note from Table 2 that less amount of highly crimped tow was needed to produce a harder rod of equal pressure drop. This fact is evident from the values for rod weight given in the table which show that a less firm rod having a pressure drop of 1.7 made from tow having only 9 crimps per inch requires about 15% more polypropylene by weight, than needed to make firm rods from highly crimped tow according to the present invention. It is even more surprising to note that this result is not achieved at a sacrifice in filter efficiency because the filter made from highly crimped tow removes more tar than the filter of equal pressure drop but of lower crimp. It should also be noted that tar removal values at the low pressure drop of 1.7 are excellent. These examples clearly demonstrate that a firmer filter and a more effective filter can be made from polyolefin by using a highly crimped tow and that that filter will require less polyolefin than a less efficient and less firm filter of equal pressure drop.

The firmness of rods made from less crimped tow can, of course, be increased by adding more filaments but, in this case, the pressure drop will also increase. Curve B represents a plot of rod hardness as a function of tow crimp for filters of a higher pressure drop while curve C shows the same data for filters of lower pressure drop. The same relationship will hold and, accordingly, the invention still requires high crimping for acceptable rod hardness irrespective of the pressure drop of the filter. Pressure drop will, however, establish the minimum crimp required to ensure acceptable rod firmness. For acceptable pressure drops, the minimum value for tow crimp according to the invention has been found to be about 18 crimps per inch, with 25 crimps per inch being preferred because higher crimps can achieve better tar removal even at every low pressure drops. The maximum amount of crimp is not evidently important. However, since excessive crimping may weaken or damage the fibers, it is preferabe to limit the crimp to 60 or perhaps 40 crimps per inch.

What is claimed is:

1. A continuous filament tow useful for the manufacture of tobacco smoke filters comprising from 3,500 to 120,000 crimped, continuous filaments of a plasticizer-free poly-alpha-olefin, each filament having a denier of from 0.5 to 16, the filaments of the tow being generally parallel and disposed in generally planar configuration in ribbon form and having from 25 to 60 crimps per inch of filament whereby the tow is capable of being fabricated into a paper-wrapped tobacco filter element rod having a circumference of 25 mm., a length of 17 mm., a pressure drop of 1.7 inches of water at an air flow rate of 17.5 ml. per second, and a hardness value of less than 13 as herein defined, said filter elements thereby being more firm and requiring less material than filters made from the same type of tow having less than 25 crimps per inch.

2. A continuous filament tow according to claim **1** wherein the filaments have from 25 to 40 crimps per inch.

3. A continuous filament tow according to claim **2** wherein the poly-alpha-olefin is polyethylene.

4. A continuous filament tow according to claim **2** wherein the poly-alpha-olefin is polypropylene.

5. A continuous filament tow according to claim **1** wherein the crimped filaments are derived from yarn having a strength of at least 2.0 grams per denier.

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