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# BLENDS OF CELLULOSE ACETATE AND POLYOLEFIN FIBERS IN TOW FORM

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## ABSTRACT OF THE DISCLOSURE

A filter material intermediate for preparing improved tobacco smoke filter elements therefrom wherein said filter intermediate consists of a tow blend of crimped continuous filaments of a polyolefin and crimped continuous filaments of a cellulose ester, the tow being further characterized in that the cellulose ester filaments comprise 15–90% of the combination and are susceptible to being fused together at random points of contact by the addition of high boiling organic ester type plasticizers.

This application is a continuation-in-part of our earlier application Ser. No. 65,941 filed Oct. 31, 1960 now abandoned.

This invention relates to an improved type of material useful for filter manufacture. In particular, it relates to a cigarette filter material consisting of a crimped textile tow of a blend of cellulose acetate fibers and poly-alpha-olefin fibers.

As set forth in said earlier application, a wide variety of fibrous materials have been suggested as filters for cigarette smoke. Thus, such products as crepe paper, cotton wads, asbestos fibers, and various cellulose derivatives have been attached to the ends of cigarettes for removing nicotine, tar and other undesired constituents from tobacco smoke. One of these materials which has attained wide acceptance in the cigarette industry is a crimped tow of cellulose acetate fibers as described in the Crawford-Stevens patents such as U.S. 2,794,239 and 3,017,309. Such a material has a pronounced processing advantage over prior art filter materials. One of the more important of these is the rapidity at which a bale or roll of the crimped tow can be continuously converted to filter rods on equipment well established in the cigarette filter trade. Another is the ease at which the crimped continuous fibers can be fused together (at random zones or spots) by the addition of a plasticizer as glycerol triacetate, a nonvolatile, nontoxic, nonodorous plasticizer to form a rigid filter rod.

Fibers of cellulose acetate as a filter material, however, have one disadvantage over fibers from the synthetic polymers. Due to the nature of cellulose acetate, it cannot produce a very fine fiber when spun by the commercially used methods and we have found in the filter art that a fine fiber is frequently a more effective filter than a coarse fiber. Thus, for example, a fine fiber of cellulose acetate is considered commercially as one having a diameter of about 13 to 17 microns. This corresponds to about 1.6 to 3 den./fil. The reason for this limiting diameter size is that cellulose acetate fibers in some instances cannot be drafted (drawn down) to any appreciable extent during or after the spinning operation and the fineness of the fiber depends on the fineness of the spinneret holes. In fact, the more economical tows of cellulose acetate have a fiber diameter of 17 microns or more since little difficulty is encountered in spinning such fibers through the larger spinneret holes.



Some noncellulose synthetic fibers, on the other hand, can be economically drafted during or after their manufacture to diameters of 13 microns and lower. Hence, they offer the possibility of producing finer denier tows than does cellulose acetate. One relatively inexpensive group of noncellulosic fibers are particularly good in this respect. They are the melt spun fibers of the poly-alpha-olefins as illustrated by the polyethylenes, polypropylenes, polybutenes, etc. In our U.S. Patent 2,966,157, for example, crimped tows of polyethylene and polypropylene are illustrated as materials for the manufacture of filters. Not only can finer denier filaments be produced from these polymers but the filaments are also stronger than those of cellulose acetate. Thus, they can be given a higher degree of crimp without destroying their strength. This is particularly true of the finer fibers.

Although polyolefin fibers have the aforementioned advantages over cellulose acetate fibers of being stronger and capable of being produced with a finer diameter, nevertheless they also have some disadvantages. Perhaps one of the most troublesome of these is the fact that polyolefin fibers cannot be fused together with glycerol triacetate or with any conventional plasticizer to form rigid filters when wrapped in the conventional cigarette paper wrapper. Instead a heat treatment, or a glue, or a heavy paper wrap is employed to obtain a rigid rod. A heat treatment means an additional step after the rods have been prepared whereas the plasticizer application technique for bonding cellulose acetate tow is performed on the filter rod-making machine. Glues are a disadvantage because they make the surface of the fibers tacky and they adhere to various parts of the filter-making equipment. Heavy paper wrappings are satisfactory from the standpoint of producing a rigid filter rod but the rods are more difficult to cut on the rapidly moving filter-making machine and a heavy paper wrap is more difficult to seal with the conventional glues used by the cigarette industry. This is particularly so when one considers that in a filter rod-making process economy demands extremely rapid speeds.

After extended investigation we have found how many of the aforementioned type of disadvantages may be minimized or overcome. We have discovered a new tow comprised of a combination of polyolefin and cellulose ester filaments as will be described hereinafter.

One object of this invention is to provide a new type of crimped textile tow for filter materials. Another object is to disclose a crimped tow of a blend of continuous filaments of both fine and relatively coarse fibers. A further object is to disclose a tow of mixed fibers which can still be bonded with a harmless, nonvolatile, organic plasticizer such as glycerol triacetate which is so widely accepted in the filter industry today. Other objects will appear hereinafter.

In the broader aspects of the present invention these objects are accomplished by blending continuous filaments of fine denier polyolefin fibers with coarser denier continuous filaments of cellulose acetate fibers into the form of a tow and crimping the tow to produce the filter material. In effect with such a combination one attains the advantage of a plasticizer bondable tow of cellulose acetate fibers and a tow of fine denier polyolefin fibers without their accompanying disadvantages. Thus, the tow contains finer denier fibers than normally possible with cellulose acetate and yet the tow can still be bonded with triacetin, a generally accepted filter tow bonding agent.

The types of cellulose acetate polymer employed to make the cellulose acetate fibers can be any of the commercial types which are capable of being wet spun, dry spun, or melt spun. The preferred types are the partially hydrolyzed cellulose acetates with an acetyl content of

36–41% and the substantially completely acetylated cellulose triacetates with an acetyl content of 43 to about 44.5%. The polyolefin polymers are those with a molecular weight above 10,000 and below 1,000,000 and having a softening point between 80° and 180° C. Such polymers can be readily melt spun by commercial processes and easily drafted into fibers with diameters of less than 17 microns and even less than 10 microns. For example, it is possible to produce a polyethylene or a polypropylene filament of 1 den./fil. (12 microns diameter) and lower, whereas as indicated the economically practical limit for a cellulose acetate fiber is abou 1.6 den./fil. (13 microns). Also, fibers of cellulose acetate are weaker fibers than the polyolefins and this is particularly so when one tries to make a tow of coarse and fine denier cellulose acetate fibers.

The amount of continuous polyolefin filaments in the crimped tow of the blend of fine denier polyolefin filaments and heavier denier cellulose acetate filaments of the present invention depends on several factors such as the number of crimps/inch given to the tow, the pressure drop desired for the filter, the total number of continuous fibers, their diameters, etc. However, in order to insure that the tow can be bonded with a plasticizer, the upper limit of polyolefin fibers should not be more than 90% of the total number of fibers. In order to obtain a significant advantage over a cellulose acetate tow filter in terms of the amounts of nicotine, tar, etc. removed by the filter the minimum number of polyolefin fibers in the tow should not be below 5%. The preferred number of polyolefin fibers in the tow is between 10% and 85%. Any method known to the textile art for blending two different continuous filaments into the form of a tow and subsequently crimping the tow can be employed to produce the tows of this invention.

In our U.S. Patent 3,033,212 a filter of cellulose acetate filaments in the form of a crimped tow and containing very fine discontinuous fibers of a polyolefin was disclosed. However, this type of a filter containing two kinds of fibers as just indicated is not the equivalent of the filter material of this invention. For example, in order to produce the filter disclosed in our patent a means of spraying a hot melt onto the opened tow has to be employed. Aside from the inconvenience and cost this addition to the filter-making assembly makes, it is also possible to produce a considerable overspray of the fine fibers. The overspray adheres to the walls of the spray booth soon making it difficult for the operator of the equipment to observe and thus control the process. Another problem of such a filter was that a low-molecular-weight polyolefin polymer was used in order that the melted polymer would be fluid enough to be sprayed. Such lower molecular weight polyolefins—i.e., below a molecular weight of about 6,000 and preferably in the order of 1,000–2,000—may have a waxy odor and greasy feel. This is frequently objectionable to the smoker. A third problem is the polyolefin wax fibers in the tow filter are not continuous and thus can dislodge from the filter rod when it is cut into smaller segments. This can cause contamination of the filter tips with loose fibers which ultimately may reach the smoker's mouth.

Such conditions obviously do not exist when a tow of continuous polyolefin filaments and continuous cellulose acetate filaments are used as in the present invention. Another problem in producing a filter of mixed fibers by spraying a hot melt of a polyolefin onto a cellulose acetate tow is the danger factor of heating the wax to a high temperature to make it fluid and sprayable. The crimped tow of this invention therefore has decided advantages and is an improvement over a tow containing a melted wax in the form of short, fine cobweb-like fibers as disclosed in our patent just referred to.

A further understanding of the present invention will be had from a consideration of the following examples.



## EXAMPLE I

Continuous filaments of 5 den./fil. (22 microns diameter) cellulose acetate (39.6% acetyl) were blended with continuous filaments of 1 den./fil. (12 microns diameter) polyethylene to form a tow consisting of 9,800 filaments of cellulose acetate and 3,000 filaments of polyethylene. The tow was passed through a textile crimper which crimped it (17 crimps/inch). It was then processed into filter rods on the equipment described in the Crawford-Stevens patents aforementioned. During the process 10% glycerol triacetate was sprayed on the bloomed-out tow immediately before it was recompacted and converted to paper-wrapped rods of 25 mm. circumference. This caused the finished rods to harden within the conventional cigarette paper wrapper in about an hour. This was due to a coalescence of the cellulose acetate fibers in the tow at random spots or points along the filter rod's length. The rods were cut into 15 mm. segments, placed on 85 mm. cigarettes (Brand A) which had been shortened to 70 mm. to compensate for the length of the filter, and the filter cigarettes were smoked on an automatic smoking machine. The percentages of smoke solids (tar) removed by the filter are listed in the table. This method of smoking filter cigarettes and determining the efficiency of the filter (percent smoke solids or "tar" removed by the filter) is well described by W. V. McConnell, R. C. Mumpower, and G. P. Touey in "Tobacco Science," vol. 4, pp. 55–61 (1960). The 15 mm. filter rods were also measured for pressure drop or resistance to draw before they were placed on the cigarettes. The average pressure drop of the filters is shown in the table. This method for determining pressure drop in inches of water at an air flow rate of 17.5 ml./sec. is described by Touey in "Analytical Chemistry," vol. 27, pp. 1788–1790 (November 1955).

## EXAMPLE II

A tow of 6,000 continuous filaments of 8 den./fil. (29.3 microns diameter) cellulose triacetate (43.8% acetyl) and 10,000 filaments of 0.7 den./fil. (approx. 8 microns diameter) polypropylene was prepared, crimped, (18 crimps/inch) and converted to filter rods. The rods were cut to 15 mm. filter lengths and the filters placed on the Brand A cigarettes. Using the procedures described above, the filters and the filter cigarettes were tested for pressure drop and filter efficiency. The results are shown in the table.

## EXAMPLE III

A tow of 10,500 continuous filaments of 4 den./fil. (approximately 20 microns diameter) cellulose acetate (37.5% acetyl) and 62,000 continuous filaments of 0.5 den./fil. (less than 8 microns diameter) polypropylene was prepared, crimped (18 crimps/inch) and converted to filter rods. These rods were cut to 15 mm. filter lengths and the filters placed on the Brand A cigarettes. The filter cigarettes were then tested for filter efficiency (percent total particulate matter or "tar" removed by the filter) and the filters were tested for pressure drop by the published procedures mentioned above.

## EXAMPLE IV

Example I was repeated with the exception that the 1 den./fil. polylefin filaments were melt spun from a polybutene rather than polyethylene. The 15 mm. filters were tested for pressure drop and the filter cigarettes were tested for filter efficiency by the published procedures mentioned in Example I.

## EXAMPLE V

The following filters (15 mm.) were prepared from crimped tows of 100% cellulose acetate. They served as control filters so that a comparison of filter efficiency and

pressure drop could be made with the filters of the other examples:

(a) 28,000 filaments of 1.6 den./fil.
(b) 27,000 filaments of 3.0 den./fil.
(c) 22,000 filaments of 5.0 den./fil.
(d) 11,000 filaments of 8.0 den./fil.

The finished filters were of satisfactory firmness (as was the filters of the other examples) because a plasticizer (glycerol triacetate) was added (10%) to the opened or bloomed-out tow during one stage of the fabrication of the filter rods from the tow. The efficiency of these filters and their average pressure drops are shown in table.

TABLE.—COMPARISON OF CELLULOSE ACETATE TOW FILTERS WITH TOWS FROM A BLEND OF CELLULOSE ACETATE AND A POLYOLEFIN

| Filter material | Av. pressure drop of filter (inches) | Percent [1] filter efficiency |
|---|---|---|
| 5 den./fil. cell. acetate, 9,800 filaments; 1 den./fil. polyethylene, 3,000 filaments (Example I) | 2.8 | 48 |
| 8 den./fil. cell. triacetate, 6,000 filaments; 0.7 den./fil. polypropylene, 10,000 filaments (Example II) | 2.5 | 44 |
| 4 den./fil. cell. acetate, 10,500 filaments; 0.5 den./fil. polypropylene, 62,000 filaments (Example III) | 2.9 | 51 |
| 5 den./fil. cell. acetate, 9,800 filaments; 1 den./fil. polybutene, 3,000 filaments (Example IV) | 2.8 | 47 |
| 1.6 den./fil. cell. acetate, 28,000 filaments (Example V) | 3.4 | 47 |
| 3.0 den./fil. cell. acetate, 27,000 filaments (Example V) | 2.9 | 32 |
| 5 den./fil. cell. acetate, 22,000 filaments (Example V) | 2.7 | 26 |
| 8 den./fil. cell acetate, 11,000 filaments (Example V) | 1.4 | 17 |

[1] Percent total particulate matter (nicotine and tar) removed by the filter as measured by the photofluorometric procedure. McConnell et al., "Tobacco Science," vol. 4, pp. 55–61, 1960.

The above results are thought to clearly indicate how the filters from the tow of the present invention with the fine fibers produce a more effective filter. They either gave the same percentage removal of total particulate matter (tar) as the finest fiber of cellulose acetate (1.6 den./fil.) but at a lower pressure drop or they give a higher removal value than a medium size cellulose acetate fiber (3 to 5 den./fil.) at a similar pressure drop.

## EXAMPLE VI

Crimped (17 crimps/inch) tows each containing 11,000 fibers were made from melt spun polyethylene, polypropylene and polybutene fibers. These three tows were sprayed with glycerol triacetate (15%) as they were fabricated into filter rods on the equipment described in the Stevens-Crawford patents. The conventional light weight cigarette paper wrapper was used to wrap the filter rods.

The filter rods remained soft because the plasticizer was relatively inert to the polyolefin fibers. Heavy denier fibers were used in this example to illustrate that even heavy denier fibers of a polyolefin are not capable of making a firm filter rod.

Accordingly, it is believed apparent from the preceding description that we have provided a new and useful tow comprised of cellulose ester continuous filaments blended with polyolefin continuous filaments. The filaments may be crimped to a high degree usually in excess of 12 crimps per inch and in many instances 17 crimps per inch or higher. In our preferred embodiment and as fully explained above, the polyolefin filaments would be of a finer denier than the cellulose ester filaments and preferably present in the tow blend in a smaller quantity than the cellulose ester filaments. This is illustrated in table wherein the 9,800 cellulose ester filaments are blended with the 3,000 polyolefin filaments.

The cellulose ester filaments of the present invention may be exactly the same in composition and structure as the filaments making up the Crawford and Stevens tow of said Patent 2,794,239. Hence, extended description herein pertaining to the cellulose ester filaments is unnecessary.

The blend tow of the present invention may be packaged as a ball warp as shown in said Patent 2,794,239 if desired. However, we prefer to package our blend tow by traversing into a bale form. Our blend tow is compressed in a bale to a density greater than 24 pounds per cubic foot. The bale is then wrapped in a moisture proof wrap comprised of polyethylene sheeting or aluminum foil or a combination. Then, cardboard and burlap or comparable materials may be applied as the outer wrap. The wraps are held in place by suitable enclosing strap members which do not have hooks or other protrusions which would penetrate into the bale and damage the blend tow. Our blend tow even if packaged at the high density referred to appears to be less subject to damage in shipping and will withdraw rapidly and readily from the bale package.

Further information concerning the polyolefin fibers which may be used in the present blend tow may be had by reference to our published U.S. Patent 2,966,157 referred to above or in our companion application Ser. No. 65,941. However, the particular source of the polyolefin fibers used in the tow blend of the present invention is not a limitation thereon.

While in the above examples we have described the use of glycerol triacetate as the plasticizer, this is not a limitation on our blend tow. Such plasticizer is preferred and useful since it is one of the bonding mediums frequently used in the cigarette filter industry. Other plasticizers may be used such as triethyl citrate, bis(methoxy ethyl)phthalate, methylphthalylethylglycollate, dimethylphthalate, diethylphthalate and the incompletely esterified acetates of glycerol such as glycerol diacetate and glycerol monoacetate. Acetate esters of polyethylene glycols may also be used as plasticizers.

While in the above description we refer to fibers, this term is used herein substantially synonymous with the term filaments. As indicated above, the particular method used to blend the cellulose ester filaments or fibers with the polyolefin filaments or fibers to produce the blend tow of the present invention is not a limitation. We prefer to blend by procedures along the lines generally outlined below.

Random blend the polyolefin and cellulose ester fibers may be made prior to the crimping operation. This gives a uniform distribution of the two fibers in the resulting tow. This is accomplished by arranging the spinning cabinets in such a manner that the individual "ends," consisting of 50 to 1,000 filaments per end, of each type of fiber can be plyed together. The number of such spinning cabinets will be governed by the number and size of fibers in the final tow.

Another manner of blending the two types of fibers is to wind them on parallel packages of yarn. Then arrange the packages in a random order on a textile creel and withdraw the individual ends without twisting the fiber. Finally, the desired tow is crimped and baled in the usual manner.

The total denier of our blend may vary from above 30,000 to usually less than 200,000. The denier per filament will usually fall within the range of .5 to 16.

We claim:

1. As an article of manufacture a new intermediate for the preparation of plasticizer bonded tobacco smoke filter elements which article consists of a plasticizer bondable tow blend of crimped continuous filaments of a polyolefin and crimped continuous filaments of a cellulose ester, the filaments being of a denier per filament not greater than 16 and the total denier of the tow blend being not greater than 200,000, the tow being further characterized in that the cellulose ester filaments comprise 15–90% of the combination and are susceptible to being fused together at random points of contact by the addition of high boiling organic ester type plasticizers wherein the polyolefin filaments are of a finer denier than the cellulose ester filaments.

2. The article of manufacture of claim 1 wherein the

crimped continuous cellulose ester filaments are essentially comprised of cellulose acetate of a denier between 1.6 and 8 and the crimped continuous polyolefin filaments are from the group consisting of filaments of polyethylene and polypropylene of a denier smaller than the cellulose acetate filaments.

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