PROCESS FOR THE SIMULTANEOUS TEXTURING AND DYEING OR FINISHING OF THERMOPLASTIC YARNS

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ABSTRACT

A process for the simultaneous texturizing, i.e. crimping, and dyeing or finishing of thermoplastic yarns comprising packing and compressing the yarns into a confined space through introduction of a flow of a compressed fluid heated to a temperature sufficient to set the yarns, allowing a portion of the compressed fluid to provide movement of the yarns axially in the confined space with the remainder of the fluid escaping laterally from the confined space into further annular space under a pressure lower than the pressure of the confined space, but higher than atmospheric pressure; and simultaneously introducing at least one dyeing solution or finishing agent into the confined space over the compressed yarns, such process being characterized in that the compressed yarn is continuously passed through at least one expansion zone and thereafter through at least one zone in which a further fluid is introduced under pressure. Such process allows for the simultaneous dyeing or finishing of thermoplastic yarns in a high speed texturizing process.

15 Claims, 2 Drawing Figures
This application is directed to a process for the simultaneous texturizing and dyeing or finishing of thermoplastic yarns at high speed; more particularly, the present invention is directed to the simultaneous crimping and dyeing of thermoplastic yarns at high speed in a manner not heretofore possible with conventional procedures.

Various processes have been proposed for the texturizing of thermoplastic yarns including processes involving the simultaneous texturizing and dyeing of the same. With regard to each of such processes previously proposed, a particularly difficult problem to be solved involves the setting of the crimp. This problem of setting of the crimp during texturizing of thermoplastic yarns is even more difficult when attempting to effect simultaneous texturizing and dyeing.

In the case of high speed texturizing processes it has been proposed to effect texturizing by compressing and packing a thermoplastic yarn into a confined space by means of a hot compressed fluid, at least a portion of the fluid escaping laterally into the atmosphere with the remainder providing the axial movement of the packed yarn within the confined space. In such a proposal, the hot fluid is used as a crimp inducing and heat treating agent and is generally saturated steam.

A more recent proposal has improved upon such texturizing process by providing an improvement in the heat treatment associated therewith. Such proposal, the subject of co-pending application Ser. No. 56,880 filed July 21, 1971 assigned to the assignee of this application, is one in which the hot fluid is allowed to expand, not directly into the atmosphere, but rather into a space which is maintained at a pressure higher than atmospheric pressure but, obviously, lower than the pressure of the confined space in which the thermoplastic yarn is compressed and packed. While such proposal does provide an improvement in the heat treat-ment and texturizing of the thermoplastic yarn, the same still fails to solve problems associated with attempts to simultaneously texturize and dye or finish the thermoplastic yarns.

It is additionally known that in the foregoing texturizing processes one or more dyeing solutions can be inserted in the texturizing chamber so as to effect simultaneous texturizing and dyeing of the thermoplastic yarns. It is unfortunate, however, that, particularly at high speeds, the absorption of the dyes by the thermoplastic yarns is not always sufficiently fast. Accordingly the lack of absorption of the dyes by the thermoplastic yarns in the simultaneous texturizing and dyeing of the same is a distinct disadvantage of such simultaneous processes.

In addition, it has long been recognized that at least a minimum amount of water is necessary for sufficient migration of the dyes. On the other hand, the effects of heat treatment are increased with decreasing amounts of water, thereby leading to the conclusion that lesser amounts of water provide for better development of the dyes. These inconsistent parameters have again led to certain distinct disadvantages in prior attempts and prior proposals for the simultaneous texturizing and dyeing of thermoplastic yarns.
duced into the confined space, the improvement in accordance with the present invention comprising continuously passing the compressed yarn through at least one expansion zone and thereafter through at least one zone in which a further fluid is introduced under pressure.

Still further objects and advantages of the novel process of the present invention for the simultaneous texturizing and dyeing or finishing of thermoplastic yarns will be more apparent from the following more detailed description thereof.

The foregoing objects and advantages of the process of the present invention are achieved by simultaneously texturizing and dyeing or finishing a thermoplastic yarn through compression and packing of the yarn into a confined space, by means of a flow of a compressed fluid, heated to a temperature which permits the setting of the yarn, a portion of the fluid providing advancement of the yarn axially through the confined space with the remainder escaping laterally into a further space under a pressure lower than the feeding pressure but higher than atmospheric pressure, at least one dyeing solution or finishing solution being inserted into the confined space over the packed yarn, the process being particularly characterized and the improvement residing in the feature that the packed yarn passes into and through at least one zone of expansion of the fluid and thereafter into and through at least one injection zone wherein at least one further fluid under pressure is injected.

As indicated throughout the instant specification, the expression “thermoplastic yarn” is meant to embrace any continuous length of substantially unidirectional thermoplastic textile material, regardless of its specific structure, which can be utilized for textile manufacture. According the thermoplastic yarns which are simultaneously texturized and dyed or finished in accordance with the present invention may consist of one or a number of continuous filaments or of discontinuous (stable) fibers. The term “thermoplastic yarn” as employed throughout the instant specification includes such yarns obtained by spinning or extrusion of polymers, copolymers, graft copolymers, mixtures thereof, or by spinning and simultaneous extrusion of at least two of these products arranged concentrically or side-by-side or dispersed in one another to produce homogeneous or heterogeneous yarns having properties depending upon the various components. Suitable thermoplastic yarns which are utilizible in accordance with the present invention include those of natural or synthetic origin including such materials as polyesters, linear polyamides, cellulose acetate yarns, polyvinyl chloride, etc. Any of these forms of thermoplastic yarns can be advantageously employed in accordance with the instant process and the present invention is not in any way limited to any particular type or form of thermoplastic yarn.

As indicated above, the process of the present invention is applicable both to the simultaneous texturizing, i.e. crimping, and dyeing of thermoplastic filament yarns as well as the simultaneous texturizing and finishing of such yarns. The dyestuff which can be utilized in accordance with the present invention and applied to the packed yarn in the confined zone can be any of those conventionally utilized for dyeing thermoplastic yarns. For example, the dyestuff can be acid dyes, basic dyes, disperse dyes, etc., as well as conventional pigments. In this regard, the process of the present invention is not dependent upon any particular dyeing solution and any conventional dyeing solution or solutions can be advantageously utilized in accordance with the instant process.

Similarly, the finishing agents which can be utilized in accordance with the present invention include the well-known resist agents, antistatic agents, soil retardant agents, optical brightening agents, softeners, ultraviolet light absorbing agents fire proofing agents as well as a variety of other conventional finishes. Here again, the process of the present invention is not dependent upon the utilization of any particular finishing agent and any of those conventionally applied to thermoplastic yarns can be applied simultaneously with the texturizing, i.e. crimping, in accordance with the instant process.

In addition, while the foregoing and following descriptions are directed primarily to simultaneous texturizing and dyeing or simultaneous texturizing and finishing it is quite obvious that a dyeing solution and finishing solution can be simultaneously applied to the packed yarn during the texturizing operation. Accordingly, it is possible to apply separate dyeing and finishing solutions in the process of the present invention or if desired include a finishing agent in a dyeing solution. Each of these embodiments is well adapted to the process of the present invention.

In accordance with the process of the present invention, the thermoplastic filament yarns are simultaneously texturized, i.e. crimped, and dyed and/or finished are packed and compressed into a confined space through introduction of a flow of a compressed fluid, preferably steam, such compressed fluid being heated to a temperature sufficient to set the yarns. The yarn is texturized in this confined space by compression and packing under a first high pressure associated with the introduction of the compressed fluid, i.e. steam. A portion of the compressed fluid provides movement of the yarn axially in the confined space while the remainder of the compressed fluid escapes laterally into an annular space around the confined space under a pressure which is lower than the texturizing pressure but higher than atmospheric pressure. After passing through the confined space, the thermoplastic yarn which is packed or piled up then penetrates or passes into at least one zone of relaxation wherein the compressed fluid may be expanded to a lower pressure before the yarn passes into at least one zone wherein a further fluid is injected under pressure. Preferably, the yarn then passes into at least one further expansion zone under a low pressure, preferably of the same order of magnitude of the earlier expansion zone. The fluid which is injected in the injection zone is also preferably steam.

The pressure of the compressed fluid in at least one injection zone into and through which the packed yarn is passed is preferably high so as to exert sufficient mechanical pressure on the yarn. Generally and in a preferred manner, the pressure in at least one injection zone is substantially equal to or slightly lower than the pressure of the texturizing fluid. Generally, the pressure of the texturizing fluid is from about 4 to about 12 kg/cm², the pressure in at least one injection zone therefore being approximately 1.5 to 8 kg/cm². The pressure in the zones of relaxation and expansion of the compressed fluid are generally within the range of from about 1 to 3 kg/cm² preferably close to atmospheric
pressure. In this regard, the packed yarn may be passed into such zones of relaxation and injection under equal or differing pressures, the zones being arranged in various combinations. It should be clearly observable from the foregoing, however, that while the various zones through which the yarn passes in the process of the present invention are preferable maintained within the foregoing pressure ranges, the particular pressure for any specific zone can be varied within wide limits.

The process of the present invention allows for the texturizing and simultaneous dyeing and/or finishing of a thermoplastic yarn at high speeds. In this regard the process of the present invention can be carried with high speeds compatible with the speeds utilized in the overall process within which the texturizing process is utilized. For example, when the process is integrated into a spinning device or extruding-drawing device, the feeding means are generally between 600 and 1,500 meters per minute with the windup speeds generally within the range of 500 to 1,400 meters per minute.

The process of the present invention allows simultaneous texturizing and dyeing and/or finishing of the thermoplastic yarn at speeds compatible with the above.

When the process of the present invention is carried out in a discontinuous manner and it does not form a portion of an integrated process as described above, the feeding speeds of the yarn are generally within the range of 1,000 to 5,500 meters per minute and the windup speeds between 800 and 5,000 meters per minute. Certainly, however, slightly greater or lesser speeds for both the feed and windup of the yarn can be employed in either a discontinuous or integrated process.

It is unexpected that in accordance with the present invention the simultaneous texturizing, i.e. crimping, and dyeing and/or finishing permits a considerable reduction in the amount of water maintained on the yarn, the water present being mainly due to the aqueous dyeing solution since generally 100 grams of water are provided in the aqueous dye solutions for 100 grams of yarn. The elimination of water in accordance with the present invention provides an improvement from the viewpoint of dyeing, specifically in accordance with the present invention it is possible to obtain much better control, migration and diffusion of the dye in the thermoplastic yarns.

The device or apparatus useful in carrying out the process of the present invention includes a suction nozzle having a passage for the thermoplastic yarn and an inlet pipe for the compressed fluid; a tubular chamber which communicates with the nozzle and is perforated with apertures so as to allow escape of some of the fluid from the tubular chamber, means for injection of one or more dyeing solutions into the tubular chamber; several closed enclosures surrounding the tubular chamber at least over a certain portion thereof associated with known systems for regulating the pressure, the closed enclosures serving to provide at least one injection zone and relaxation or expansion zone, the injection zone having associated therewith at least one means for injection of a fluid under pressure; and means for guiding and checking the delivery of the treated thermoplastic yarn.

The closed enclosures forming the injection zones and zones of relaxation and expansion of the fluid may be formed of several separate enclosures placed side by-side or may be formed of a single enclosed space with water and air tight partitions. The process of the present invention can be appliedly carried out in accordance with either of these embodiments. Moreover, as indicated previously, it is a preferred feature of the present invention that the thermoplastic yarn is first passed through at least one zone of expansion, thereafter through at least one injection zone wherein a fluid under pressure is injected over the thermoplastic yarn and finally through at least one further zone of expansion.

The process of the present invention will now be described by reference to the drawings wherein:

FIG. 1 is a schematic representation of a device carrying out the process of the present invention; and

FIG. 2 is a further schematic representation of an alternative device carrying out the process of the present invention.

Referring to the figures wherein like numerals represent like elements, FIG. 1 illustrates a device carrying out the process of the present invention wherein a thermoplastic yarn 1 is inserted into a longitudinal duct 2 of a nozzle 3, a texturizing fluid, e.g. steam, being inserted through pipe 4. The thermoplastic yarn 1 penetrates into tubular chamber 5, a portion of the texturizing fluid serving to advance the yarn axially, compressing and crimping the same in tubular chamber 5. Tubular chamber 5 is perforated with apertures 6 through which a portion of the texturizing fluid escapes into a closed enclosure 7 which is maintained under a pressure lower than the pressure of the texturizing fluid but higher than atmospheric pressure by a known pressure regulating device 8.

In tubular chamber 5, thermoplastic yarn 1 forms a pile of packed yarn 9 which is subjected, in this case, to the action of two dyeing solutions coming from tank 10 divided into compartments 11 and 12, the dyeing solutions being introduced over the packed yarn 9 through pipes 13 and 14. While two dyeing solutions are illustrated in FIG. 1, it is quite obvious that one or more dyeing solutions can be utilized or, a finishing solution can be employed alone or together with another finishing solution or in combination with one or more dyeing solutions. Each of these embodiments is well within the scope of the present invention.

As seen in FIG. 1, tubular chamber 5 thereafter passes through a first expansion or relaxation chamber 15 equipped with a regulating system or means capable of maintaining the pressure in the chamber to allow expansion and escape of the texturizing fluid. The texturizing fluid escapes from tubular chamber 5 into the first expansion or relaxation chamber 15 through apertures 17. While only one expansion or relaxation chamber 15 is shown in FIG. 1, it is quite possible as indicated previously that the tubular chamber may pass through one or more expansion or relaxation chambers or zones.

After passing through the expansion or relaxation chamber 15, tubular chamber 5 then passes into a zone or chamber 18 equipped with a pressure regulating device 19 and a fluid injection means, not shown, the fluid being injected into chamber 18 through pipe or tube 20. The compressed fluid, preferably the same as the texturizing fluid, i.e. steam, is introduced into injection chamber 18 through pipe or tube 20 and passes over packed yarn 9 by passing through apertures 21. Again, while a single injection zone or chamber 18 has been
3,751,778

shown in FIG. 1, as indicated previously, one or more of such injection chambers can be utilized in carrying out the process of the present invention.

After passing through injection zone or chamber 18, tubular chamber 5 passes through a further expansion or relaxation chamber 22, generally of the same configuration and type as expansion or relaxation chamber 15. Such further relaxation chamber 22 is also equipped with a known pressure regulating device 23 and the fluid escapes into the relaxation or expansion chamber 22 through apertures 24. As seen in FIG. 1, the packed yarn which progresses through tubular chamber 5 by the action of the texturizing fluid is guided when it leaves relaxation or expansion chamber 22 by means of a driven roller 26 and non-driven roller 27, the means for driving the roller not being shown. In addition, as previously indicated, the process of the present invention can be carried out in a discontinuous manner or as a portion of an integrated process. Other necessary elements of the integrated process or discontinuous process including delivery and windup means for the thermoplastic yarn are conventional and not shown in the figures.

FIG. 2 illustrates a further device or apparatus carrying out the process of the present invention, the apparatus of FIG. 2 differing from that of FIG. 1 only in that the means for guiding and controlling the packed yarn 9 comprises a tube 28 with apertures 29 open to the atmosphere. Again, the conventional delivery and windup means, etc., are not shown.

Again, with regard to FIG. 2, it is pointed out that while the same illustrates passage of tubular chamber 5 through a single expansion or relaxation zone or chamber, an injection zone or chamber and thereafter through a further expansion or relaxation zone or chamber, it is quite obvious that one or more of each of these zones can be utilized in carrying out the process of the present invention.

The present invention will now be described by reference to the following examples. In such examples, "CI" refers to "Color Index", 2nd Edition, 1956 and supplement, published by "Society of Dyers and Colorists" and the "American Association of Textile Chemists and Colorists". Such examples are presented for purposes of illustration only and the present invention is in no way to be deemed as limited thereto.

EXAMPLE 1

In carrying out this example a device according to FIG. 1 was used, with the following characteristics:

length of the unit formed by the closed container 7 and the chambers or chests 15, 18, 22
length of the closed container 7
length of each of chest 15, 18, 22
diameter of the tubular chamber 5

The fluid used is saturated steam.

With this device, a polyhexamethylene-adipamide (Nylon 66) yarn, with tetralobed cross-section, 2,300 dtex/136 filaments, is texturized and dyed simultaneously, under the following conditions:

Yarn feeding speed into nozzle 3
Absolute steam feeding pressure at the inlet of the texturizing chamber
Absolute pressure of steam inside of closed enclosure 7
Absolute feeding pressure in chest 18

The packed yarn is dyed by bringing in contact with it an aqueous solution of brilliant polar blue R A W L (CI 61 585), with a concentration of 40 g/l, and a rate of flow of 70 cm/s/mm, and an aqueous solution of milling yellow 2 R (CI 25 135), with a concentration of 40 g/l, and a rate of flow of 70 cm/s/mm.

The amount of water brought in by these aqueous solutions is 73 percent with respect to the weight of the yarn.

To point out the influence of the process according to the invention, the moisture content of the yarn in terms of weight was measured.

At the entrance of the texturizing device, the moisture content of the yarn is 17%
At the outlet of the closed container 7 36%
At the outlet of chest 15 26.3%
At the outlet of chest 22 23%

The presence of chests 15, 18 and 22 therefore causes a lowering of the moisture content of:

\[(36 - 23)36 \times 100 = 36\%\]

The mechanical properties of the yarn are as follows:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance (g/dtex)</td>
<td>2.4</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>42%</td>
</tr>
<tr>
<td>Elasticity 30% Crimp</td>
<td>10.1 half-</td>
</tr>
<tr>
<td></td>
<td>crimps per cm.</td>
</tr>
</tbody>
</table>

The elasticity is measured by the following test.

A skein of 10 meters of yarn to be tested is treated for 5 minutes at 130°C. In saturated steam in a steam oven. Then a load of 0.045 g/dtex (0.05 g/den) of the yarn prior to texturizing is applied on a length of 50 cm of yarn taken from said skein. A length L₁, of yarn is then measured. The load is then replaced by another smaller load of 0.0009 g/dtex (0.001 g/den) of the yarn prior to texturizing. This load is maintained for 1 hour, then the length L₂ of the yarn is measured.

The elasticity is given by the formula:

\[\left(\frac{L_1 - L_2}{L_1}\right) \times 100\]

The value indicated corresponds to the average or mean of six tests.

The foregoing example clearly shows the applicability of the process of the present invention to the simultaneous dyeing and texturizing of the thermoplastic yarn at high speeds. The process allows good dye absorption and good fixation of the dye on the yarn.

EXAMPLE 2

With the device used in Example 1 and illustrated in FIG. 1, a Nylon 66, 2,300 dtex/120 filament yarn is texturized and simultaneously a dyeing inhibitor or a resist agent is applied to the yarn.

The operating conditions are as follows:

Yarn feeding speed in nozzle 3
Absolute steam feeding pressure at the inlet of the texturizing chamber
Absolute pressure of steam inside closed enclosure 7
Absolute feeding pressure in chest 18

The treated yarn is wound up directly at a winding speed of 840 m/min. Chests 15 and 22 are non-condensing type (free exhaust).

The resisting agent used is an aqueous solution at 20 g/liter of a product known commercially under the name of "Sandospace R" which is a colorless organic
substance containing a sulfonic group and a reactive group, and which is capable of modifying the appearance of polyamide fibers for acid and cationic dyes.

This solution is injected through three nozzles with a flow of 130 cm³ per nozzle, for 265 g of yarn per minute.

The treated yarn is knitted and the knit obtained is dyed at 98°C with pH 5, buffered with 2 percent of Sandogene NH (SANDOZ) and 0.8 percent of a blue acid dye CI 61,125. The shade obtained is a very pale blue approaching total resist.

Spotted effects, i.e. with resisting in places, can be obtained by using only one of the three nozzles: in this case, 130 cm² of "Sandospace R" is fed once for 265 g of yarn per minute.

A knitted article made from the same yarn, without any inhibitor, and dyed under the same conditions, has a deep blue shade.

EXAMPLE 3

The texturizing is effected under the same conditions, and with the same yarn, as in Example 2, an antistatic agent being injected.

The product used is an aqueous solution at 38 g/liter of a product known in commerce under the trademark "Tetronics 908" (UGINE-KUHLMA), which is a polyoxyalkylene-tetrol with tertiary-amino functions which has then been sulfonated to permit its fixation on the polyamide.

It is injected onto the yarn through three nozzles at the rate of 120 cm³ per nozzle for 265 g of yarn per minute.

The antistatic property is then measured by means of the Rotschild electrometer.

According to this method, the period of half discharge of a sheet previously charged with 100 volts is measured. The following results are obtained:

<table>
<thead>
<tr>
<th></th>
<th>Time of half-discharging</th>
</tr>
</thead>
<tbody>
<tr>
<td>untreated yarn</td>
<td>560 seconds</td>
</tr>
<tr>
<td>antistatic-treated yarn</td>
<td>100 seconds</td>
</tr>
</tbody>
</table>

It can be seen from the above examples that the process of the present invention effectively allows the simultaneous crimping and dyeing or finishing of thermoplastic textile yarns. The yarns which are obtained in accordance with the process of the present invention can be advantageously utilized in the production of fabrics, knitted fabrics, non-woven articles, etc., utilized in the production of floor coverings, wall coverings, upholstery, clothing, etc., as they are produced through the process of the present invention or after further processing.

While the present invention has been described primarily with reference to the foregoing exemplifications it should be understood that the present invention is in no way to be deemed as limited thereto but, rather, must be construed as broadly as all or any equivalents thereof.

What is claimed is:

1. In a process for the simultaneous crimping and dyeing thermoplastic filament yarns at high speeds comprising packing and compressing said yarns into a confined space by introduction of a flow of a first compressed fluid, said first compressed fluid being heated to a temperature sufficient to set said yarns; allowing a portion of said first compressed fluid to provide movement of said yarns axially in said confined space, the remainder of said fluid escaping laterally from said confined space into a further space under a pressure lower than the pressure of said confined space, but higher than atmospheric pressure; and simultaneously introducing at least one dyeing solution into said confined space over the compressed yarns, the improvement wherein the compressed yarn passes through at least one expansion zone and thereafter through at least one zone in which a second fluid is introduced under pressure.

2. The process of claim 1 wherein said first and second fluids are the same fluid.

3. The process of claim 2 wherein said first and second fluids are steam.

4. The process of claim 1 wherein said compressed yarn passes through at least one expansion zone; thereafter through at least one zone in which said second fluid is injected and thereafter through at least one further expansion zone.

5. The process of claim 1 wherein said at least one dyeing solution additionally contains a finishing agent.

6. The process of claim 1 wherein said compressed yarn passes through a first expansion zone wherein said first compressed fluid expands under a pressure close to atmospheric pressure; thereafter said compressed yarn passes through an injection zone wherein said second fluid is injected under a high pressure substantially equal to the pressure of the first texturizing fluid, and finally said compressed yarn passes through a further expansion zone maintained at a pressure substantially the same as said first expansion zone.

7. The process of claim 6 wherein said first and second fluids are the same fluid.

8. The process of claim 7 wherein said first and second fluids are steam.

9. In a process for the simultaneous crimping and finishing thermoplastic filament yarns at high speeds comprising packing and compressing said yarns into a confined space by introduction of a flow of a first compressed fluid, said first compressed fluid being heated to a temperature sufficient to set said yarns; allowing a portion of said first compressed fluid to provide movement of said yarns axially in said confined space, the remainder of said fluid escaping laterally from said confined space into a further space under a pressure lower than the pressure of said confined space, but higher than atmospheric pressure; and simultaneously introducing at least one finishing solution into said confined space over the compressed yarns, the improvement wherein the compressed yarn passes through at least one expansion zone and thereafter through at least one zone in which a second fluid is introduced under pressure.

10. The process of claim 9 wherein said first and second fluids are the same fluid.

11. The process of claim 10 wherein said first and second fluids are steam.

12. The process of claim 9 wherein said compressed yarn passes through at least one expansion zone; thereafter through at least one zone in which said second fluid is injected and thereafter through at least one further expansion zone.

13. The process of claim 9 wherein said compressed yarn passes through a first expansion zone wherein said first compressed fluid expands under a pressure close to atmospheric pressure; thereafter said compressed yarn passes through an injection zone wherein said sec-
ond fluid is injected under a high pressure substantially equal to the pressure of the first texturizing fluid, and finally, said compressed yarn passes through a further expansion zone maintained at a pressure substantially the same as said first expansion zone.

14. The process of claim 13 wherein said first and second fluids are the same fluid.

15. The process of claim 14 wherein said first and second fluids are steam.

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