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(54) Title: PROCESSES AND INSTALLATIONS FOR DYEING SYNTHETIC FIBERS AND DYED FIBERS AND FABRICS CONTAINING SAID DYED FIBERS

(57) Abstract: A process for dyeing, in particular vat dyeing, or coating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or yarns comprising or consisting of synthetic fibers or fabrics comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, said process comprising the steps of: a) providing a multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or providing at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or providing at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or of at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers; and b1) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, c1) providing an aqueous system comprising at least one lipase enzyme, in particular lipase from Candida sp., and d1) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric with the aqueous system comprising the at least one lipase enzyme, in particular lipase from Candida sp., and e1) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation; or b2) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, c2) providing an aqueous system comprising nano-sized polyurefhane particles, at least one cross-linking agent and at least one wetting agent and d2) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric, in particular said fabric, with said aqueous system comprising said nano-sized polyurethane particles, at least one cross- linking agent and at least one wetting agent and e2) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular with said powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation; or b3) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, c3) providing an aqueous system comprising at least one base, in particular an alkali hydroxide, more in particular potassium hydroxide, and optionally at least one wetting agent, and d3) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric, in particular said multitude of fibers, yarn or multitude of yarns, with said aqueous system comprising the at least one base and optionally the at least one wetting agent, and e3) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular said powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation.

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Processes and installations for dyeing synthetic fibers and dyed fibers and fabrics containing said dyed fibers

The present invention pertains to processes and installations for dyeing synthetic fibers, in particular polyester fibers and/or polyamide fibers, as well as to fibers and fabrics containing or consisting of dyed fibers, wherein said fibers are obtained or obtainable according to any of the processes of the present invention, particularly with any of the coloring installations of the present invention.

Denim jeans are regularly made from a cotton warp-faced fabric in which the weft passes under two or more warp threads. It can have a 1/2, or 2/1 or 3/1 twill structure and is woven diagonally, i.e. the twill weaving produces a diagonal ribbing. While the warp thread which generally forms the outer layer is dyed, usually with indigo, the weft thread forming the inner side of the fabric is left white. And, with common indigo dyeing processes the core of the warp threads remains white while the outer layer is colored. This phenomenon is called ring dyeing. Since indigo itself is not soluble in water (990 µg/l at 25 °C) its reduced, water-soluble form, leuko-indigo, is employed in the dyeing step. However, even the leuko-form of indigo in most cases has a rather low affinity to the fiber materials to be dyed, thereby requiring a number of repeated treatment steps. In practical use indigo is reduced under alkaline conditions with sodium dithionate to leuko-indigo. Depending on the pH of the aqueous system leuko-indigo may occur in the mono-anion form, which is present at about pH 11 and which has better ring-dyeing properties due to less pronounced penetration characteristics, or in the di-anion form. Oxidation by air converts the yellow-colored leuko-indigo back to the blue-colored indigo.

During regular use abrasion yields a fading of the threads having been ring-dyed with indigo thereby providing the well-known "used" effect of denim jeans fabrics. Abrasion or fading can be achieved by low washing fastness, an average light fastness, and a low dry- and/or wet rubbing fastness.

While on the one hand an excess of hydrosulphite should be present in the dyeing bath as sodium dithionite is sensitive to atmospheric oxygen it has also been observed that such excess of hydrosulphite may result in irregular dyeing. Usually, the indigo concentration in such dyeing vats is not above 80 g/l.

In order to improve the dyeing properties the fibers usually have to be subjected to pretreatment steps such as pre-wetting, bottom dyeing or washing.

While indigo-dyed denim fabrics are regularly made from cotton fibers there have also been attempts to manufacture blue colored denim-like fabrics from synthetic fibers. Colored synthetic fibers can be obtained by the so-called dope dyeing process. With the dope dyeing process a dye, most often in the form of a colored masterbatch, is mixed with the molten polymer forming the synthetic fiber before the fibers are extruded through spinnerets for making synthetic filaments. Dope dyeing provides synthetic fibers which are homogeneously colored throughout the cross-section of the filament. Hence, with dope dyed synthetic fibers any fading characteristics being specific for indigo-dyed denim fabrics cannot be obtained.

Since dope dyeing cannot be used to obtain synthetic fibers, yarns or fabrics with fading characteristics being specific for indigo dyed denim fabrics, it has been tried to use conventional installations for dyeing cotton fibers, yarns, or fabrics to color said fibers, yarns, or fabrics. Such a conventional installation is schematically shown in figure 1. Therein fibers, yarns, or fabrics are conveyed through several stations by rotating drums starting with an accumulator station 1, followed in series by a calender 3, a washing station 5, a ventilation station 7, three washing stations 5, a cascade of eight dyeing stations 19 each followed by a ventilation station 7, a washing station 5, a ventilation station 7, a washing station 5, a warm air ventilation station 117, three washing stations 5, a drying station 11, and a sizing station 13.

It has been found, that using such conventional installations for dyeing synthetic fibers, yarns, or fabrics with indigo leads on one hand to a low amount of dye being picked up by the fibers, yarns, or fabrics in the dyeing stations 19 and on the other hand to most of the picked up dye being washed off in the washing stations 5, such that the fading of the color is much higher than being specific for indigo dyed denim fabrics. Further to that conventional installations as shown in figure 1 require a large production area which raises manufacturing costs. In addition to that the high amount and diversity of stations increases the complexity of the installation leading to high manufacturing costs.

There has been a need for an installation that can be used for the preparation of colored polyester fibers which would allow to be used for the manufacture of denim-like fabrics

According to US 2,774,647 polyester fibers can be colored by subjecting said fibers to a dye-bath containing leuko-indigo, a reducing agent and sodium tripolyphosphate as a buffer and having a pH between 6.5 and 7.5 at a temperature in the range of 100°C to about 144°C and oxidizing the thus treated fibers with an aqueous solution comprising hydrogen peroxide.

According to US 4,369,213 prior art processes for dyeing polyester fibers with indigo failed in providing the fading characteristics and were thus not able to adequately simulate indigo-dyed cotton fibers. This, however, shall be accomplished based on the teaching of US 4,369,213 by applying to a polyester fiber a coating comprising polyvinyl alcohol and a water-soluble polyamide containing secondary amino groups in the polymer chain which have been reacted with epichlorohydrine and curing said coating. A fabric obtained from said coated polyester fibers was then treated with an aqueous alkaline leuko-indigo solution and subsequently subjected to an oxidation step by having it exposed to a stream of air. This multistep process requires the use of two different types of polymers which renders it cumbersome per se and also impractical for any recycling efforts.

There has been a need for a reliable method for the preparation of colored polyester fibers which would allow to be used for the manufacture of denim-like fabrics.

Therefore, it has been an object of the present invention to provide a method and an installation for the preparation of colored polyester fibers which is not hampered by the drawbacks of existing methods and which in particular provides colored/dyed polyester fibers having the fading characteristics which are typical for indigo-dyed denim fabrics.

According to a first aspect of the present invention a process for dyeing, in particular vat dyeing, or coating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or yarns comprising or consisting of synthetic fibers or fabrics comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, said process comprising the steps of:

a) providing a multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or providing at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or

providing at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or of at least one yarn, in

particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers; and

b1) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or

providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation,

c1) providing an aqueous system comprising at least one lipase enzyme, in particular lipase from Candida sp., and

d1) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric with the aqueous system comprising the at least one lipase enzyme, in particular lipase from Candida sp., and

e1) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation.

It has also been found to be advantageous to conduct dyeing of said pretreated fibers, yarn, multitude of yarns or fabric with said aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular with the alkaline aqueous leuko dye formulation, is conducted according to the pad-batch method.

According to another embodiment it has been found to be advantageous to conduct in step d1) the pretreatment with the at least one lipase enzyme, in particular lipase from Candida sp., according to the pad-batch method, in particular at a temperature in the range from 25 to 60°C, more in particular in the range from 30 to 50°C, and also in particular at a pH in the range from 4.5 to 9, and more particular in the range from 5 to 8.

In the meaning of present specification the term "leuko-indigo" shall be considered to be synonymous to the reduced form of indigo.

According to a second aspect of the present invention a process for dyeing, in particular vat dyeing, or coating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or yarns comprising or consisting of synthetic fibers or fabrics comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, said process comprising the steps of:

a) providing a multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or

providing at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or

providing at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or of at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers; and

b2) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or

providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation,

c2) providing an aqueous system comprising nano-sized polyurethane particles, at least one cross-linking agent and at least one wetting agent and

d2) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric, in particular said fabric, with said aqueous system comprising said nano-sized polyurethane particles, at least one cross-linking agent and at least one wetting agent and

e2) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular with said powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation;

The aqueous system comprising nano-sized polyurethane particles in a rather pragmatic embodiment is a nano-dispersion of self-cross-linking amphoteric or anionic polyether polyurethanes. These nano-sized polyurethane particles preferably have an average particle size of less than 100 nm.

According to a third aspect of the present invention a process for dyeing, in particular vat dyeing, or coating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or yarns comprising or consisting of synthetic fibers or fabrics comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, said process comprising the steps of:

a) providing a multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or

providing at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or

providing at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or of at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers; and

b3) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or

providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation,

c3) providing an aqueous system comprising at least one base, in particular an alkali hydroxide, more in particular potassium hydroxide, and optionally at least one wetting agent, and

d3) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric, in particular said multitude of fibers, yarn or multitude of yarns, with said aqueous system comprising the at least one base and optionally the at least one wetting agent, and

e3) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular said powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation.

According to a rather practical embodiment to conduct the pretreatment of the fibers, yarn, multitude of yarns or fabric with said aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular with the alkaline aqueous leuko dye formulation, according to d3) according to the pad-batch method

It has been found to be advantageous in some cases that in pretreatment step d3) the aqueous system has a pH in the range from 10 to 13, in particular in the range from 10,5 to 12,0, and/or a temperature in the range from 20 to 70°C, in particular from 30 to 60°C, more preferably, the pretreatment step d3) is conducted in such a manner that surface material of said pretreated synthetic fibers is at least partially peeled off whereby said synthetic fibers exhibit a weight reduction, in particular in the range from 5% to 35%, more in particular in the range from 10 to 30%.

According to another preferred embodiment the pretreatment step d3) further comprises subjecting the multitude of fibers to steam, in particular to saturated steam, for a period of time, in particular for 15 to 100 seconds, preferably for 30 to 60 seconds.

Satisfactory results can also be obtained in that the multitude of fibers in the pretreatment d1), d2) or d3) is subjected to the aqueous system for no more than 30 seconds, in particular for no more than 15 seconds.

It is also been found to be rather pragmatic to conduct the dyeing of said pretreated fibers, yarn, multitude of yarns or fabric with said aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular with the alkaline aqueous leuko dye formulation, according to the pad-batch method.

Dyes suitable for use with the process of the present invention comprise, in particular are consisting of, vat dyes, in particular selected from the group consisting of indigo, indigoid dyes, in particular isoindigo, indirubin and/or 6,6′-dibromoindigo, e.g. Tyrian purple, indanthren dyes, anthrachinon dyes, anthraquinone dyes, naphthalene dyes and mixtures thereof. Moreover, suitable precursor dyes comprise of consist of leuko dyes, in particular selected from the group consisting of leuko-indigo, leuko-indigoid

dyes, in particular leuko-isoindigo, leuko-indirubin and/or leuko-6,6′-dibromoindigo, e.g. leuko-Tyrian purple, leuko-indanthren dyes, leuko-anthrachinon dyes, leuko-anthraquinone dyes, leuko-naphthalene dyes and mixtures thereof.

Leuko dyes for the process of the present invention can be obtained from a corresponding vat dye by treatment in an aqueous alkaline system with a reducing agent, in particular selected from the group consisting of thiourea dioxide, sodium dithionite, sodium hydrogen sulphite, hydroxyacetone, sodium hydroxymethylsulfinate, borohydride and mixtures thereof. Hence, the leuko dye, in particular the leuko indigo dye formulation containing aqueous formulation can for example be obtained in an alkaline aqueous system containing a reducing agent such as hydrosulfite and indigo.

In a very advantageous embodiment the aqueous alkaline system containing the leuko dye is the least one aqueous precursor dye formulation.

According to another embodiment step b1), b2) or b3) comprises providing at least one, in particular non-encapsulated, powdered leuko dye, in particular powdered leuko-indigo dye, or at least one, in particular non-encapsulated, aqueous leuko dye formulation, in particular alkaline aqueous leuko-indigo dye formulation, and also at least one migration inhibitor, at least one dispersing agent, at least one wetting agent and at least one cationic polymer, in particular based on polyamide-epichlorohydrin resin, and wherein said multitude of fibers, yarn, multitude of yarns or fabric is dyed with said powdered leuko dye or said aqueous leuko dye formulation according to b1), b2) or b3).

According to a further embodiment the step b1), b2) or b3) comprises providing at least one powdered leuko dye, in particular powdered leuko-indigo dye, or at least one aqueous leuko dye formulation, in particular alkaline aqueous leuko-indigo dye formulation, and also at least one migration inhibitor, at least one dispersing agent, at least one wetting agent and at least one cationic polymer, in particular based on polyamide-epichlorohydrin resin, and and wherein said multitude of fibers, yarn, multitude of yarns or fabric is coated with said powdered leuko dye or said aqueous leuko dye formulation according to b1), b2) or b3).

Satisfactory results are in particular obtained for those embodiments in which after the pretreatment step d1), d2) or d3) the fibers, yarn, multitude of yarns or the fabric are kept at room temperature for about 14 to 36 hours, in particular for about 18 to about

24 hours, and subsequently washed. Washing can for example take place in a multi-vat-, in particular in an 8 vat-, washing machine, using a temperature in the range from 30 to 95°C, in particular in the range from 40 to 90 °C.

The pretreatment step d1), d2) or d3) is preferably carried out while said multitude of fibers, yarn, multitude of yarns or the fabric are wrapped on a roll.

The aqueous dye formulation or the at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation, used for coating in step e1), e2) or e3) preferably has a viscosity in the range from 10 to 70 Dpa•s, in particular in the range from 30 to 60 Dpa•s, determined at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

According to a suitable embodiment in step e1), e2) or e3) the dye used for dyeing or coating is a powdered leuko dye or an alkaline aqueous leuko dye formulation, in particular an alkaline aqueous leuko-indigo dye formulation.

In rather practical embodiments of the processes of the present invention the coated or dyed multitude of fibers, yarn, multitude of yarns or fabric of step e1), e2) or e3), resp., are treated with at least one oxidizing agent, in particular selected from the group consisting of oxygen, air, in particular heated air, inorganic peroxo compounds, hydrogen peroxide, potassium dichromate, sodium hypochlorite, peracetic acid and mixtures thereof. In this manner leuko dyes such as leuko indigo are effectively transformed into their respective oxidized forms.

In a more preferred embodiment the processes of present invention further comprise after the coating or dyeing step a step of subjecting the fibers, yarn, multitude of yarns or the fabric to water steam. The water steam usually can have a temperature in the range from 95 to 110°C, and in particular in the range from 98 to 102°C. Subjecting to water steam, in particular having the aforementioned temperature, preferably takes from about 1 to about 10 minutes, and preferably from about 2 to about 4 minutes.

The aforementioned step of subjecting the fibers, yarn, multitude of yarns or the fabric to an oxidizing agent, e.g. a water steam can according to favourable embodiment to be followed by a washing step, in particular in a multi-vat-, more particular in an 8 vat-, washing machine using a temperature in the range from 25 to 98°C, in particular in the range from 30 to 95 °C.

It is also possible to alternatively or additionally subject the fibers, yarn, multitude of yarns or the fabric after dyeing to at least one washing step.

The washed fibers, yarn, multitude of yarns or the washed fabric can according to a rather suitable embodiment be subjected to a drying step. Such drying step is preferably carried out at a temperature in the range from 98 to 130°C, in particular in the range from 100 to 120°C, over a time period, in particular in the range from 30 seconds to 10 minutes, more in particular in the range from 1 to 3 minutes.

Particularly good and reliable results can also be obtained with the processes of the present invention in which after dyeing (first dyeing step), and optionally after the at least one washing step, the fibers, yarn, multitude of yarns or fabric are treated with at least one aqueous electrolyte solution containing at least one cationic electrolyte, in particular at least one cationic polyelectrolyte. As a rather suitable cationic electrolyte poly(diallyldimethyl ammonium chloride) is used. Said treatment with the at least one aqueous electrolyte solution containing at least one cationic electrolyte can in rather suitable embodiments be conducted at a pressure in the range from 60 to 120 bar, particular in the range from 70 to 100 bar. And, treating the fibers, yarn, multitude of yarns or fabric with the aqueous electrolyte solution can in most cases be followed by at least one washing step. Particularly satisfactory results are obtained by subjecting the thus treated and optionally washed fibers, yarn, multitude of yarns or fabric to another dyeing step (second dyeing step) with said at least one aqueous dye formulation. Again, it has been found to be advantageous to conduct the dyeing step by use of the pad-batch method, which is optionally followed by at least one washing step. It has been found to be advantageous that the dye in the first dyeing step and/or in the second dyeing step is a powdered leuko dye, in particular powdered leuko-indigo dye, or an aqueous leuko dye formulation, in particular an alkaline aqueous leuko-indigo dye formulation. According to another rather suitable embodiment the dye in the first dyeing step and/or in the second dyeing step is a reactive dye or a powdered leuko-indigo dye or an aqueous leuko-indigo dye formulation.

Accordingly it has been found to be most suitable that after the dyeing step e1), e2) or e3) (first dyeing step), and optionally after the at least one washing step, the fibers, the yarn, the multitude of yarns or the fabric are treated with at least one aqueous electrolyte solution containing at least one cationic electrolyte, in particular at least one cationic polyelectrolyte, and optionally subsequently subjected to at least one washing step, and are subsequently subjected to another dyeing step (second dyeing step) with at least one powdered dye or with at least one powdered precursor dye, in particular

with a powdered leuko dye, or with at least one aqueous dye formulation or with at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, in particular according to the pad-batch method, which is optionally followed by at least one washing step.

The processes of the present invention preferably further comprise after the dyeing or coating step at least one drying step, in particular comprising subjecting the dyed or coated fibers, yarn, multitude of yarns or fabric to a temperature in the range from 100 to 175°C, in particular in the range from 120 and 160°C, over a period of time, in particular in the range from 5 seconds to 5 minutes.

It is also rather advantageous in terms of repeatable and reliable results to additionally or alternatively subject the fibers, yarn, multitude of yarns or fabric after the dyeing or coating step, in particular after the coating step, to at least one fixation step. Said fixation step preferably comprises subjecting the dyed or coated and optionally dried fibers, yarn, multitude of yarns or fabric to a temperature in the range from 160 to 220°C, more in particular in the range from 170 to 200°C, for a period of time, in particular in the range from 30 seconds to 5 minutes, more in particular the range from 1 to 3 minutes. Regularly heated gas, and more preferably heated air can be used for the fixation step.

In the processes of the present invention the at least one aqueous dye formulation, in particular the aqueous indigo dye formulation, used for coating, in particular following step d2), said fibers, yarn, multitude of yarns or fabric, in particular said fabric, comprises at least one dye, in particular the vat dye, in particular said (unreduced) indigo dye, or the precursor dye, in particular said leuko-indigo dye, and more in particular the vat dye, in particular said (unreduced) indigo dye, at least one binder, in particular a cross-linkable acrylic binder, at least one thickener and optionally at least one softening agent, in particular a nano-silicone-based softening agent.

Usually, the coating step in the processes of the present invention is conducted by way of knife coating or by way of rotary printing. Knife coating, however, is particularly preferred.

And, according to another embodiment in the processes of the present invention the aqueous dye formulation, in particular the aqueous dye formulation used for dyeing, comprises at least one organic coloring substance as a dye, preferably a non-ionic dye, more preferable an (unreduced) indigo dye, and optionally at least one dispersing

agent. Said dispersing agent can suitably be selected from the group consisting of alkyl sulphates, alkylaryl sulphonates, fatty alcohols, condensation products of amines and ethylene oxide, condensation products of naphthalene sulphonic acid and formaldehyde, lignin sulphonate and mixtures thereof.

Surprisingly, reliable and a satisfactory result are accomplished with those processes of the present invention in which

the at least one aqueous dye formulation, in particular the aqueous leuko dye formulation and more in particular the aqueous leuko-indigo dye formulation, has a pH in the range from 10 to 13, in particular in the range from 10,5 to 12,5.

. Moreover, beneficial results can also be obtained by use of aqueous dye formulations, in particular aqueous leuko dye formulations and more in particular the aqueous leuko-indigo dye formulation, which exhibit a density at 25 °C in the range from 0,6 to 1,5 g/ml, in particular in the range from 0,8 - 1,2 g/ml.

The aqueous dye formulations, in particular the aqueous leuko-indigo dye formulations, which are used for dyeing with the processes of the present invention preferably comprise at least one dye, in particular leuko-indigo dye, at least one silicone, in particular nano-silicone, at least one binder, in particular a crosslinkable acrylic binder, at least one thickener, at least one defoamer, at least one amine, in particular ammonia, and water.

According to an alternative embodiment the at least one aqueous dye formulation, in particular the aqueous (unreduced) indigo dye formulation, to be used for dyeing comprises at least one dye, in particular (unreduced) indigo dye, at least one silicone, in particular nano-silicone, at least one binder, in particular a crosslinkable acrylic binder, at least one thickener, at least one defoamer, at least one amine, in particular ammonia, and water.

Alternatively, the aqueous dye formulation can comprise the indigo dye, at least one base, at least one wetting agent and optionally at least one carrier agent. The wetting agent to the extent used with the processes according to the invention advantageously comprises at least one anionic phosphoric acid ester.

According to another embodiment warp or rope coating or warp or rope dyeing is used for coating or dyeing, resp., of the pretreated multitude of fibers, yarn, multitude of yarns or the pretreated fabric with the at least one powdered dye, in particular the

powdered vat dye, and more in particular said (unreduced) indigo dye, or the precursor dye, in particular said leuko-indigo dye, and more in particular the vat dye, in particular said (unreduced) indigo dye, or with the at least one aqueous dye formulation, in particular the alkaline aqueous leuko dye formulation.

In particular in order to reduce or eliminate the shrinking properties of the dyed or coated fibers, yarn, multitude of yarns or fabrics the processes of the present invention can further comprise a sanforizing step of the at least one dyed fibers, yarn, multitude of yarns or fabric, in particular of the dyed fabric, after the fixation step.

In some further embodiments it has been found to be pragmatic that the fibers, yarn, multitude of yarns and/or the fabrics are subjected to a cationization step after the pre-treatment step and prior to the coating or dyeing step, in particular prior to the fixation step.

For fixation in the fixation step the coated or dyed fibers, yarn, multitude of yarns or fabric, in particular the dyed fibers or fabric, are preferably treated with at least one aqueous formulation containing at least one condensation product of an aliphatic polyamine and epihalohydrine, in particular epichlorohydrine. This is in a preferred embodiment carried out simultaneously with heated water steam treatment. Said aqueous formulation containing the at least one condensation product preferably has a pH value in the range from 3 to 6, particular in the range from 3,5 to 5. Simultaneously or alternatively the temperature of said aqueous formulation can be in the range from 40 to 95°C, and in particular in the range from 55 to 85°C. And, suitable condensation products of the aliphatic polyamine and epihalohydrine can comprise a cationic reaction product of a homopolymer of diallylamine, a homopolymer of N-methyl-diallylamine or a copolymer of diallylamine and N-methyl-diallylamine with epihalohydrine, in particular with epichlorohydrine.

Preferred polyester fibers used with the processes of the present invention, either for the multitude synthetic fibers, the yarn or multitude of yarns made from or comprising synthetic fibers or the fabric made from or comprising said synthetic fibers, said yarn or said multitude of yarns include polyethylenterephthalate fibers. It is also possible to employ and step a) or A) a mixture of synthetic fibers, in particular polyester fibers and/or polyamide fibers, and cotton fibers and/or at least one yarn, multitude of yarns or at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, and cotton fibers.

In an advantageous embodiment the multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, e.g. multi- or bicomponent fibers, or said fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, e.g. multi- or bicomponent fibers, pretreated according to step d3) exhibit after said pretreatment step a tensile strength which is less than the tensile strength of said fibers prior to the pretreatment step, in particular not more than 20 % less the tensile strength of said fibers prior to the pretreatment step and more in particular not more than 10 % less the tensile strength of said fibers prior to the pretreatment step, measured in each case at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

In a preferred embodiment the synthetic fiber of the multitude of fibers or of the yarn or of the multitude of yarns or of the fabric is a multicomponent fiber, in particular a bicomponent fiber. The multicomponent fiber, in particular the bicomponent fiber can be selected from the group consisting of a solid or hollow side-by-side fiber, a sheath-core fiber, an islands-in-the-sea fiber (matrix-fibril) and a segmented-pie-structure fiber.

Preferably, the multicomponent, in particular the bicomponent fibers are made of poly(ethylene)terephthalate and polyethylene naphthalate, nylon-6,6 and polycyclohexylenedimethylene terephthalate (PCT), polypropylene and poly(butylene)terephthalate, nylon-6 and copolyamides, polylactic acid and polystyrene, polyacetal, in particular polyoxymethylene, and polyurethane, copolyesters and HD-polyethylene or copolyesters and LLD-polyethylene, polyolefins, in particular polypropylene, and polyamides.

The core-sheath bicomponent fibers preferably are made of a polyester core, in particular a poly(ethylene)terephthalate core, and a copolyester sheath, or of a polyester core, in particular a poly(ethylene)terephthalate core, and a polyethylene sheath or of a polypropylene core and a polyethylene sheath or of a polyamide core, in particular nylon-6,6, and a polyolefin sheath, in particular a polypropylene sheath. And, the islands-in-the-sea bicomponent fibers are preferably comprising a polyolefins matrix, in particular polypropylene matrix, and polyamide, in particular polyamide fibrils, embedded in the matrix.

The yarn made of or comprising synthetic fibers suitably is a textured and/or an oriented yarn selected from the group consisting of a Low Oriented Yarn (LOY), Medium Oriented Yarn (MOY), Partially Oriented Yarn (POY), High Oriented Yarn

(HOY) and Fully Oriented Yarn (FOY). A yarn can usually be considered to represent a long continuous length of interlocked fibers. Yarns are thus typically made from a multitude of fibers, e.g. from synthetic fibers or from a mixture of natural and/or synthetic fibers. A yarn can be a so-called spun yarn or a filament yarn.

Among the above yarns those yarn or those multitude of yarns are preferred which represent or comprise yarns which are textured and partially oriented yarns. Textured yarns can for example be produced by the so-called false-twist coiling method, the stuffer-box crimping method, the air-jet texturing method, the knit-de-knit crinkling method and the gear crimping method.

The particle size of the powdered dye, in particular the particle size of the powdered indigo dye, as provided in step b1), b2), b3) or B) preferably is below 10 μm, and in particular in the range from 1 to 5 μm.

The multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, yarn, multitude of yarns or the fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, pretreated according to step d3) exhibit after said pretreatment step a tensile strength which is less than the tensile strength of said fibers prior to the pretreatment step, in particular not more than 20 % less the tensile strength of said fibers prior to the pretreatment step and more in particular not more than 10 % less the tensile strength of said fibers prior to the pretreatment step, measured in each at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

In preferred embodiments of the process of the present invention it is provided that

- a fabric prepared from synthetic fibers or from a yarn or a multitude of yarns comprising or consisting of synthetic fibers is subjected to pretreatment step d1), d2) or d3), in particular d2), and pretreated fabric is coated according to step e1), e2) or e3), respectively; or that

- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are formed into a fabric, and said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively; or that

- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are dyed according to step e1), e2) or e3), resp.; or that

- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are dyed according to step e1), e2) or e3), resp., said fibers, yarn or yarns are formed into a fabric, and said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively; or that

- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are formed into a fabric, said fabric is subjected to pretreatment step d1), d2) or d3), in particular d2), and in the following said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively; or that

- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are dyed according to step e1), e2) or e3), resp., and are in the following formed into a fabric, said fabric is subjected to pretreatment step d1), d2) or d3), in particular d2), and in the following said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively.

It is been found with the present invention that the pretreatment processes including lipase enzymes (c1)/d1)), nano-sized polyurethane particles (c2)/d2)), and base treatment (c3)/d3)) can be successfully combined with electrostatic dyeing methods using electrolytic solutions, with fabric coating methods, with warp coating and warp dyeing processes to furnish dyed synthetic fibers, yarn, multitude of yarns and fabrics, in particular indigo dyed polyester fibers and/or polyamide fibers and fabrics.

The problem underlying the present invention has also been solved by dyed synthetic fibers, in particular dyed polyester fibers and/or dyed polyamide fibers, or dyed yarn, or dyed multitude of yarns or dyed fabric obtained or obtainable according to one of the processes according to the present invention as described above.

The problem underlying the present invention has also been solved by coated synthetic fibers, in particular coated polyester fibers and/or coated polyamide fibers, or coated yarn, or coated multitude of yarns or coated fabric obtained or obtainable according to one of the processes according to the present invention as described above.

The polyester fibers and/or polyamide fibers are selected from the group consisting of polyethylenparticule terephthalate (PET) fibers and poly-1,4-cyclohexylene-dimethylene terephthalate (PCDT) fibers.

The fibers, yarn, multitude of yarns and fabrics obtained according to the processes of the present invention exhibit excellent crocking properties as well as a sufficient tensile strength and tear resistance.

According to a fourth aspect of the present invention an installation for dyeing or coating, in particular for indigo-dyeing or indigo-coating, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, is provided, said installation comprising:

x) a coloring station, in particular a coating station or a dyeing station, wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said coloring station, and

w) a drying station, wherein before, in particular directly before, said fibers, yarn, multitude of yarns, or fabric enter the coloring station, said fibers, yarn, multitude of yarns, or fabric is/are conveyed through said drying station such that said powdered dye or aqueous dye formulation is applied to dried fibers, a dried yarn, a dried multitude of yarns, or a dried fabric within the coloring station.

After leaving the drying station, said fibers, yarn, multitude of yarns, or fabric preferably have/has a moisture content less than 1 wt.-%, preferably less than 0,5 wt.-%, more preferably less than 0,25 wt.-% of the fiber's, yarn's, multitude of yarn's, or fabric's dry mass. The amount of dye formulation being picked up in the subsequent coloring station is preferably at least 80 %, more preferably at least 70 %, most preferably at least 60 % and/or preferably maximally 90 %, more preferably maximally 80 %, most preferably maximally 70 % of the fiber's, yarn's, multitude of yarn's, or fabric's dry mass.

In some embodiments said drying station comprises at least one, preferably at least two, or four, or six heated drum/s and/or preferably maximally fourteen, more preferably maximally twelve, or ten, or eight heated drums, the drums preferably conductively heat said fibers, yarn, multitude of yarns, or fabric being conveyed over said drum/s by a surface temperature, said surface temperature preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130°C and/or preferably maximally 140°C, more preferably maximally 130°C. It has been found advantageous to bring said fibers, yarn, multitude of yarns, or fabric in contact with the heated surface of said drum/s for at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or preferably maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds.

While being conveyed over said heated drums, said fibers, yarn, multitude of yarns, or fabric is/are preferably in contact in circumferential direction with at least 150 degree, more preferably with at least 180 degree, most preferably with at least 210 degree and/or preferably with maximally 330 degree, more preferably with at least 300 degree, most preferably with at least 270 or 240 degree of the heated surface.

In a preferred embodiment said drying station comprises at least one stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or preferably maximally 180 °C, more preferably maximally 160 °C, most preferably maximally 145 °C, or about 140 °C. Preferably said fibers, yarn, multitude of yarns, or fabric is/are conveyed for at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or preferably maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds through said stenter.

It has been found advantageous to complement an installation of the present invention by a ventilation station through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed before entering the drying station. Within such ventilation station said fibers, yarn, multitude of yarns, or fabric is/are dried by air, said air preferably has a temperature of at least 20 °C and/or of maximally 40 °C, more preferably of about 25 °C. In a preferred embodiment said fibers, yarn, multitude of yarns, or fabric is/are preferably conveyed for at least 300 seconds, more preferably for at least 600 seconds

and/or preferably for maximally 1200 seconds, more preferably for maximally 900 seconds through said ventilation station. In a preferred embodiment, the fibers, yarn, multitude of yarns, or fabric is/are conveyed over at least 6, or at least 8, or at least 10 and/or over maximally 16, or maximally 14, or maximally 12, most preferably over 9 rotating drums within the ventilation station. These drums are preferably arranged in two lines, being substantially parallel to each other, wherein said lines of rotating drums preferably have a distance of at least 5 meter and/or maximally 15 meter, preferably of about 10 meter.

In a rather preferred embodiment the fibers, yarn, multitude of yarns, or fabric is/are conveyed over four, six, eight, or ten rotating drums while being conveyed from the ventilation station to the drying station, wherein the fibers, yarn, multitude of yarns, or fabric preferably travel/travels a distance of at least 30 meter and maximally 50 meter from the ventilation station to the drying station.

It has been found advantageous to supplemented the installation of the present invention by a pretreating station for pretreating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, with one of the aqueous solutions c1), c2), or c3), preferably by one of the pretreating steps d1), d2) or d3), before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through said drying station and said coloring station, more preferably before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a ventilation station, said drying station, and said coloring station.

Additionally or alternatively, it is preferred to supplement the installation for dyeing or coating a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers by a second installation as described in view of the fourth aspect of the present invention, wherein the coloring station of the first installation is a dyeing station, and wherein the coloring station of the second installation is a coating station, wherein the installations are arranged in such a way that the fabric is conveyed through said dyeing station before being conveyed through said coating station.

Additionally or alternatively, it is preferred to supplement the installation for dyeing or coating synthetic fibers, a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers by a second installation as described in view of the fourth aspect of the present invention, wherein the coloring

station of the first installation is a dyeing station, and wherein the coloring station of the second installation is a coating station, wherein the installations are arranged in such a way that the fibers, yarn, or multitude of yarns are conveyed through said dyeing station before being conveyed through said coating station. It has been found advantageous to supplement such an installation for dyeing said fibers, yarn, or multitude of yarns by a weaving machine for weaving said fibers, yarn, or multitude of yarns into a fabric after leaving the dyeing station and before entering the coating station.

According to a fifth aspect of the present invention an installation for dyeing, in particular for indigo-dyeing, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, is provided, said installation comprising:

X1) one dyeing station, wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said dyeing station, and

Y1) one drying station and/or one warm air ventilation station, wherein said fibers, yarn, multitude of yarns, or fabric applied with said dye formulation is/are dried, wherein said dyeing station comprises only one vat filled with said dye formulation, and wherein drums are arranged such that said fibers, yarn, multitude of yarns, or fabric merge/s once the dye formulation and leave the dye formulation for heading to said drying station and/or warm air ventilation station without again merging the dye formulation.

Preferably, before leaving said dyeing station, said fibers, yarn, multitude of yarns, or fabric is/are conveyed through at least two pressure drums opposing each other and building a slit through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed under pressure, said pressure preferably being at least 60 bar, more preferably at least 80 bar and/or preferably maximally 110 bar, more preferably maximally 90 bar. The amount of dye formulation applied to said fibers, yarn, multitude of yarns, or fabric after leaving the dyeing station preferably being at least 80

% and/or being preferably maximally 90 %, more preferably about 90 % of said fiber's, yarn's, multitude of yarn's, or fabric's mass before entering said dyeing station. The temperature of said dye formulation can be at least 20 °C, preferably at least 40 °C, more preferably at least 50 °C and/or maximally 90 °C, preferably maximally 70 °C, more preferably maximally 60 °C.

In a preferred embodiment said fibers, yarn, multitude of yarns, or fabric is/are conveyed for preferably more than 10 seconds, more preferably for more than 50 seconds and/or preferably for less than 90 seconds, more preferably for less than 70 seconds through said dyeing station.

Further, in some embodiments an installation of the present invention is complemented by a warm air ventilation station through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving said dyeing station. Within such a warm air ventilation station said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 60 °C, more preferably of at least 80 °C, most preferably of at least 100 °C, and/or preferably of maximally 140 °C, more preferably of maximally 120 °C, most preferably of maximally 110 °C, or of about 100 °C. Preferably said fibers, yarn, multitude of yarns, or fabric is/are conveyed for at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds through said warm air ventilation station.

It has also been found advantageous to complement an installation of the present invention with a drying station through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving said dyeing station, more preferably after leaving said dyeing station and after leaving a subsequent warm air ventilation station.

Said drying station may comprise at least one, preferably at least two, or four, or six heated drum/s and/or maximally fourteen, more preferably maximally twelve, or ten, or eight heated drums, the drums preferably conductively heat said fibers, yarn, multitude of yarns, or fabric being conveyed over said drum/s by a surface temperature, said surface temperature preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130°C and/or preferably maximally 140°C, more preferably maximally 130°C. It has been found advantageous to bring said fibers, yarn, multitude of yarns, or fabric in contact with the heated surface of said drum/s for

at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or preferably maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds.

While being conveyed over said heated drums, the fibers, yarn, multitude of yarns, or fabric is/are preferably conveyed over at least 150 degree, more preferably over at least 180 degree, most preferably over at least 210 degree and/or preferably over maximally 330 degree, more preferably over maximally 300 degree, most preferably over maximally 270 or 240 degree of the heated drum's circumference.

In a preferred embodiment said drying station comprises at least one stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or maximally 180 °C, preferably maximally 160 °C, more preferably maximally 145 °C, or about 140 °C. Preferably said fibers, yarn, multitude of yarns, or fabric is/are conveyed for at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or preferably maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds through said stenter.

Further it is preferred to supplement an installation of the present invention by a pretreating station for pretreating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers with one of the aqueous solutions c1), c2), or c3), preferably by one of the pretreating steps d1), d2) or d3), before the fibers, yarn, multitude of yarns, or fabric is/are conveyed through said dyeing station, preferably before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a drying station (11, 211, 311) and said dyeing station, more preferably before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a ventilation station, a drying station, and said dyeing station.

Additionally or alternatively, it is preferred to supplement the installation for dyeing or coating a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers by a second installation as described in view of the fourth

aspect of the present invention, wherein the coloring station of the second installation is a coating station, wherein the installations are arranged in such a way that the fabric is conveyed through said dyeing station before being conveyed through said coating station.

Additionally or alternatively, it is preferred to supplement an installation for dyeing or coating synthetic fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers by a second installation as described in view of the fourth aspect of the present invention, wherein the coloring station of the second installation is a coating station, wherein the installations are arranged in such a way that the fibers, yarn, multitude of yarns are conveyed through said dyeing station before being conveyed through said coating station. It has been found advantageous to complement such an installation for dyeing said fibers, yarn, or multitude of yarns by a weaving machine for weaving said fibers, yarn, or multitude of yarns into a fabric after leaving the dyeing station and before entering the coating station.

According to a sixth aspect of the present invention an installation for coating, in particular for indigo-coating, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, is provided, said installation comprising:

X2) a coating station, preferably a pre metering device such as a knife coater, wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric, in particular to said fabric, being conveyed through said coating station.

In a preferred embodiment said coating station comprises at least one post-metering device such as a knife coater, in particular in the arrangement of a floating knife, or of a knife over blanket, or of a knife over roll. In a less preferred embodiment said coating station comprises at least one, preferably at least three, more preferably at least six and/or preferably maximally twelve pre-metering devices such as roll coaters, in particular such as mayer rod coaters, or direct roll coaters, or gravure coaters.

Said coating station can also comprise a combination of said pre- and post-metering devices

It has also been found advantageous to complement an installation of the present invention by a drying station through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving said coating station.

Said drying station may comprise at least one, preferably at least two, or four, or six heated drum/s and/or preferably maximally fourteen, more preferably maximally twelve, or ten, or eight heated drums, the drums preferably conductively heat said fibers, yarn, multitude of yarns, or fabric being conveyed over said drum/s by a surface temperature, said surface temperature preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130°C and/or preferably maximally 140°C, more preferably maximally 130°C. It has been found advantageous to bring said fibers, yarn, multitude of yarns, or fabric in contact with the heated surface of said drum/s for at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or preferably maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds.

Further an installation of the present invention can be complemented by a softening station through which said fibers, yarn, multitude of yarns, or fabric can be conveyed after being coated and dried. A foulard can be used as softening station in which a softening agent, in particular a nano-silicone-based softening agent, can be applied to said fibers, yarn, multitude of yarns, or fabric for softening said fibers, yarn, multitude of yarns, or fabric.

While being conveyed over said heated drums, the fibers, yarn, multitude of yarns, or fabric is/are preferably conveyed over at least 150 degree, more preferably over at least 180 degree, most preferably over at least 210 degree and/or preferably over maximally 330 degree, more preferably over maximally 300 degree, most preferably over maximally 270 or 240 degree of the heated drum's circumference.

In a preferred embodiment said drying station comprises at least one stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or preferably maximally 180 °C, more preferably maximally 160 °C, most preferably maximally 145 °C, or about 140 °C. Preferably said fibers, yarn, multitude of

yarns, or fabric is/are conveyed for at least 10 seconds, or at least 20 seconds, or at least 40 seconds, or at least 60 seconds, or at least 80 seconds, or at least 100 seconds and/or preferably maximally for 200 seconds, or maximally 180 seconds, or maximally 160 seconds, or maximally 140 seconds, or maximally 120 seconds, most preferably for about 120 seconds through said stenter.

Further, it is preferred to supplement an installation of the present invention by a pretreating station for pretreating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers with one of the aqueous solutions c1), c2), or c3), preferably by one of the pretreating steps d1), d2) or d3), before said fibers, yarn, multitude of yarns, or fabric is/are conveyed through said coating station, preferably before said fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a drying station and said coating station, more preferably before said fibers, yarn, multitude of yarns, or fabric is/are conveyed in sequence through a ventilation station, a drying station, and said coating station.

Additionally or alternatively, it is preferred to supplement the installation for dyeing or coating a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers by a second installation as described in view of the fourth or fifth aspect of the present invention, wherein the coloring station of the second installation is a dyeing station, wherein the installations are arranged in such a way that the fabric is conveyed through said dyeing station before being conveyed through said coating station.

Additionally or alternatively, it is preferred to supplement the installation for dyeing or coating synthetic fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers by a second installation as described in view of the fourth or fifth aspect of the present invention, wherein the coloring station of the second installation is a dyeing station, wherein the installations are arranged in such a way that the fibers, yarn, or multitude of yarns are conveyed through said dyeing station before being conveyed through said coating station. It has been found advantageous to complement such an installation for dyeing fibers, yarn, or multitude of yarns by a weaving machine for weaving said fibers, yarn, or multitude yarns into a fabric after leaving the dyeing station and before entering the coating station.

According to a seventh aspect of the present invention an installation for dyeing or coating, in particular for indigo-dyeing or indigo-coating, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, is provided, said installation comprising:

x) a coloring station, in particular a coating station or a dyeing station, wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said coloring station, and

Z1) a thermal fixation station, through which said fibers, yarn, multitude of yarns, or fabric applied with said dye formulation is/are conveyed after leaving the coloring station, for fixing the applied dye formulation to said fibers, yarn, multitude of yarns, or fabric by heating said fibers, yarn, multitude of yarns, or fabric, and/or

Z2) at least one, preferably 3, chemical fixation station/s, through which said fibers, yarn, multitude of yarns, or fabric applied with said dye formulation is/are conveyed after leaving the coloring station, wherein an aqueous formulation containing at least one condensation product of an aliphatic polyamine and epihalohydrine, in particular epichlorohydrine, is applied to said fibers, yarn, multitude of yarns, or fabric, for fixing the applied dye formulation to said fibers, yarn, multitude of yarns, or fabric.

In a preferred embodiment said thermal fixation station comprises a stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 130 °C, more preferably of at least 150 °C, most preferably of at least 170 °C and/or preferably maximally 220 °C, more preferably maximally 200 °C, most preferably maximally 180 °C.

It has been found to be advantageous to convey said fibers, yarn, multitude of yarns, or fabric for preferably at least one minute, more preferably for at least three minutes, most preferably for at least five minutes and/or preferably for maximally fifteen

minutes, more preferably for maximally ten minutes, most preferably for maximally five minutes through said thermal fixation station, in particular through said stenter.

In a preferred embodiment the aqueous formulation in the at least one chemical fixation station has a temperature of at least 40 °C, preferably of at least 55 °C and/or of maximally 95 °C, preferably of maximally 85 °C. It has been found advantageous to convey said fibers, yarn, multitude of yarns, or fabric preferably for at least 10 seconds, more preferably for at least 30 seconds and/or preferably for maximally 60 seconds, more preferably maximally 45 seconds through said chemical fixation station. Preferably, the amount of said aqueous formulation picked up within the chemical fixation is between 2 and 4 %, preferably about 3 % of the fiber's, yarn's, multitude of yarn's, or fabric's mass before entering the chemical fixation station.

Complementing a coloring installation, in particular when dyeing polyester with an indigo dye formulation as described above, with a fixation station leads to an increased dyeing or coating efficiency. With an installations being designed according to the seventh aspect of the invention, dye stuff savings of about 20 % were achieved.

It has been found advantageous to supplement an installation according to the seventh aspect of the present invention by a warm air ventilation station or by a drying station, preferably in sequence by a warm air ventilation station and a drying station, through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the coloring station and before entering the fixation station. As warm air ventilation station and/or as drying station, the warm air ventilation station and the drying stations being described with respect to the fifth and eights aspect of the present invention can be used.

In particular in order to reduce or eliminate the shrinking properties of the dyed or coated fibers, yarn, multitude of yarns, or fabric an installation of the present invention can further comprise a sanforizing station, through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the thermal fixation station and/or after leaving the chemical fixation station.

Within an installation of the present invention fibers, yarn, multitude of yarns, or fabric is/are preferably conveyed with a conveying speed between 5 and 50 m/min, preferably between 5 and 15 m/min or between 15 and 30 m/min or between 30 and 50 m/min.

An exemplary pretreating station is a foulard, also known as padding machine, wherein at least one of the aqueous solutions c1), c2) or c3) is applied to said fibers, yarn,

multitude of yarns, or fabric by one of the pretreating steps d1), d2) or d3). Preferably before leaving said pretreating station, said fibers, yarn, multitude of yarns, or fabric is/are conveyed through at least two pressure drums opposing each other and building a slit through which the textile is conveyed under pressure, said pressure preferably being greater than 60 bar, more preferably greater than 80 bar and/or lower than 110 bar, preferably lower than 90 bar. The temperature of the aqueous solutions c1), c2) or c3) is preferably at least 20 °C, more preferably at least 30 °C and/or maximally 50 °C, preferably maximally 40 °C. It has been found that the aforementioned conditions, in particular the pressure conditions, lead to a preferred amount of aqueous solution, in particular c1), c2) or c3), being applied to the fibers, yarn, multitude of yarns, fabric. A preferred amount of aqueous solution applied to said fibers, yarn, multitude of yarns, or fabric after leaving the pretreating station is more than 70 %, more preferably more than 80 %, and/or less than 95 %, or less than 90 %, or less than 85%, most preferably about 90 % of said fiber's, yarn's, multitude of yarns', or fabric's mass before entering the pretreating station.

In some embodiments of the present invention, in particular for pretreating with c1), the installation is complemented with a standby station for keeping the pretreated fibers, yarn, multitude of yarns, or fabric for a defined time under defined conditions after leaving the pretreating station. It has been found advantageous to keep the pretreated fibers, yarn, multitude of yarns, or fabric for at least 14 hours, more preferably for at least 18 hours, most preferably for at least 21 hours, and/or maximally for 36 hours, more preferably for maximally 27 hours, most preferably for maximally 24 hours, at room temperature, or at a temperature of at least 20 °C, preferably at least 30 °C, and/or at maximally 60 °C, preferably maximally 50 °C, most preferably about 40 °C. The aforementioned conditions have been found by experiments and cause, in particular when pretreated with c1), an increased amount of pretreating elements, in particular lipase, being bound to the fibers, yarn, multitude of yarns, or fabric, and/or increased binding forces between the pretreating elements and the fibers, yarn, multitude of yarns, or fabric without causing too high manufacturing costs in view of process time, storage costs and energy costs.

It has been found advantageous in some embodiments of the present invention, in particular when pretreating with c3), to complement the installation with a steaming station. The steaming station is preferably located behind the pretreating station for subjecting fibers, yarn, multitude of yarns, or fabric with water steam, in particular with saturated steam, after leaving the pretreating station. Preferred conditions

regarding temperature of the water steam and the time of subjecting the fibers, yarn, multitude of yarns, or fabric with said steam have been discussed before.

In some embodiments of the present invention, in particular for pretreating with c1) or c3), the installation is complemented with a washing station. The washing station is preferably located behind the pretreating station, and/or behind the standby station, and/or behind the steaming station for washing the fibers, yarn, multitude of yarns, or fabric after they passed the pretreating station, and/or the standby station or the steaming station. The washing station preferably comprises a multi-vat-washing machine for washing the fibers, yarn, multitude of yarns, or fabric under different conditions, such as the washing solution, the temperature of the washing solution, and the time for which the fibers, yarn, multitude of yarns, or fabric is/are conducted with said washing solution. The multi-vat washing machine preferably comprises four, or six, or eight, or ten washing vats. Preferably, each washing vat comprises an arrangement of rotating drums conveying the fibers, yarn, multitude of yarns, or fabric such that they merge and leave the washing solution several times, preferably four times, or five times, or six times, or seven times, or eight times. Further to that the washing vats can comprise pressure drums opposing each other and building a slit through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed under pressure before merging and/or after leaving said washing solution. In case off an eight-vat washing machine, the preferred temperature off the washing solutions is between 30 and 40°C in the first and second washing vat, between 50 and 60°C in the third and fourth washing vat, between 90 and 95°C in the fifth and sixth washing vat, and/or between 55 and 70°C in the seventh and eight washing vat.

The aqueous dye formulation, in particular the alkaline aqueous leuko dye formulation in a coating station, preferably has a viscosity in the range from 10 to 70 Dpa·s, in particular in the range from 30 to 60 Dpa·s, determined at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C. This viscosity range is preferred since the viscosity is low enough such that the aqueous dye formulation can easily be applied to fibers, yarn, multitude of yarns, or fabric, in particular to fabric, but high enough to keep the dye formulation on said fibers, yarn, multitude of yarns, and/or fabric, and that said fibers, yarn, multitude of yarns, or fabric pick up enough dye formulation. Within a coating station, the dye formulation is preferably applied by at least one knife coater to said fibers, yarn, multitude of yarns, and/or fabric which is conveyed in warp direction through the coating station.

In a preferred embodiment of the present invention the installation is supplemented by a steaming station that is located behind the coloring station. In the steaming station the fibers, yarn, multitude of yarns, or fabric is/are subjected to water steam, particularly saturated steam. The water steam preferably has a temperature in the range from 95 to 110 °C, and in particular in the range from 98 to 102 °C. The fibers, yarn, multitude of yarns, or fabric is/are preferably subjected for one to ten minutes, more preferably for two to four minutes, with said water steam. In case, the coloring installation is supplemented with a steaming station, it is advantageous to supplement the installation with a washing station, in particular a multi-vat-washing machine, more particular an eight-vat-washing machine through which the fibers, yarn, multitude of yarns, or fabric can be conveyed after leaving the steaming machine. The temperatures of the washing solution used in the single vats of a multi-vat-washing machine is preferably in the range from 25 to 98°C, in particular in the range from 30 to 95 °C.

It is also possible to alternatively or additionally supplement the installation with a washing machine through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the coloring station.

According to a rather suitable embodiment of the present invention the installation can be supplemented by a drying station, such as an arrangement of heated drums or a stenter, through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed after they left the steaming station and/or the washing station. In such a drying station the temperature of the hot air or the surface temperature of the heated drums is preferably in the range from 98 to 130°C, in particular in the range from 100 to 120°C. The fibers, yarn, multitude of yarns, or fabric is/are preferably conveyed over a time period, in particular in the range from 30 seconds to 10 minutes, more in particular in the range from 1 to 3 minutes through said drying station.

The above described installations are particular advantageous for dyeing the synthetic fibers, yarns, and fabric, in particular polyester fibers, yarns, and fabric, as described above with an indigo or leuko-indigo dye as described above.

The above described installations are designed to conduct the above described process, and the above described process is developed to be used in the above described installations.

The fibers, yarn, plurality of yarns, and fabric obtained by dyeing or coating them with an installation of the present invention and/or with a process of the present invention, exhibit excellent crocking properties as well as a sufficient tensile strength and tear resistance. Particular good results can be achieved by conducting the process of the present invention with an installation of the present invention.

The eighth aspect of the invention present invention relates to dyed and/or coated synthetic fibers, in particular polyester fibers and/or polyamide fibers, or to a yarn comprising or consisting of synthetic fibers, or to a multitude of yarns comprising or consisting of synthetic fibers, or to a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers. Said fibers are dyed or coated with a dye formulation comprising at least one powdered indigo dye or a powdered precursor indigo dye, and/or with at least one aqueous indigo dye formulation or at least one aqueous precursor indigo dye formulation, in particular an alkaline aqueous leuko-indigo dye formulation. These fibers have a dry rubbing fastness in the range from 1,0 to 5,0, preferably in the range from 2,0 to 4,0, most preferably in the range from 2,5 to 3,5 and/or a wet rubbing fastness in the range from 0.5 to 3,0, preferably in the range from 1,0 to 2,5, more preferably in the range from 1,5 to 2,0. Such fibers, yarn, multitude of yarns, or fabric can for example be obtained by dyeing and/or coating said fibers, yarn, multitude of yarns, or fabric by the above described installations and/or by the above described process. The wet rubbing fastness is determined by ISO 105-X12:2001(E). The dry rubbing fastness is determined by ISO 105-X12:2001(E).

Particularly good results regarding the eighth aspect of the present invention are achieved when the fibers, yarn, multitude of yarns, and fabric is/are pretreated with at least one lipase enzyme as described above or with an aqueous system comprising nano-sized polyurethane particles as described above before being dyed and/or coated.

With the present invention has been surprisingly found how to arrive to dyed synthetic fibers, yarn, multitude of yarns, and fabric which essentially exhibit the same fading characteristics as dyed cotton fibers, yarn, plurality of yarns, and fabric as used for conventional denim fabrics. Thus, it is now possible to reliably prepare for example colored polyester fibers yarn, plurality of yarns, and fabric and/or polyamide fibers yarn, plurality of yarns, and fabric which can be used for the manufacture of denim-like fabrics.

Further properties, features and advantages of the present invention become apparent by the following description of preferred embodiments shown in the enclosed figures. These figures show in

Fig. 1 a conventional installation used for dyeing cotton fibers, yarn, multitude of yarns, or fabric with indigo;

Fig. 2 a schematic view of an installation for dyeing synthetic fibers, yarn, plurality of yarns, or fabric illustrating differences to a conventional installation in the arrangement of drying stations, coloring stations, and fixation stations;

Fig. 3 an installation for a coating synthetic fabric

Fig. 4 a pretreating station preferably used when pretreating with c1), c2) or c3);

Fig. 5 a standby stations, preferably used when pretreating with c1);

Fig. 6 a washing station and a drying station, preferably used when pretreating with c1);

Fig. 7 a pretreating station, and a drying station, preferably used when pretreating with c2);

Fig. 8 a pretreating station, a steaming station, a washing station, and a drying station preferably used when pretreating with c3), or when steaming, washing, and drying after the fibers, yarn, plurality of yarns, or fabric left the coloring station;

Fig. 9 a coating station, and a drying station, preferably used when coating;

Fig. 10 a thermal fixation station;

Fig. 11 a dyeing station, preferably used when conducting fibers, yarn, plurality of yarns, or fabric with an aqueous electrolyte solution after dyeing;

Fig. 12 a sanforizing station.

A schematic view of an installation for dyeing synthetic fibers, yarn, multitude of yarns, or fabric is shown in figure 2 illustrating schematically the fourth, fifth, and seventh

aspect of the present invention and differences as well as advantages compared to a conventional installation as schematically shown in figure 1. In the installation shown in figure 2 fibers, yarn, multitude of yarns, or fabric is/are conveyed through several stations by rotating drums starting with an accumulator station 1, followed in series by a calender 3, a pretreating station 15, a ventilation station 7, a drying station, a dyeing station 19, a warm air ventilation station 117, a drying station 11, fixation stations 17, in particular three chemical fixation stations 417, a drying station 11, and ending with a sizing station 13.

A drying station 11 being located before, in particular directly before the dyeing station 19 or the not shown coating station (39) illustrates the fourth aspect of the present invention. Contrary to the schematically shown conventional installation in figure 1, the upstream drying station 11 causes that dried fibers, yarn, multitude of yarns, or fabric enter/s the dyeing station 19. This leads to a higher amount of powdered dye and/or aqueous liquid dye formulation being picked up by the fibers, yarn, multitude of yarns, or fabric in the dyeing station 19. A higher amount of powdered dye and/or aqueous liquid dye formulation being picked up increases the amount of dye that can theoretically be fixed to the fibers and thereby the achievable colorfulness, in particular the chroma and/or saturation, of the colored fibers, yarn, multitude of yarns, or fabric.

In figure 2 a single dyeing station 19, followed by a warm air ventilation station 117 illustrates the fifth aspect of the present invention. Compared to a conventional installation as shown in figure 1, this leads to a reduced number of stations and thus to a reduced complexity of the installation which leads to lower manufacturing costs. Further to that, the use of a single dyeing station 19 surprisingly enables, in particular in combination with any of the first to the third, and/or of the fourth, and/or of the seventh aspect of the present invention, an increased reproducibility and precision in adjusting the amount of dye being picked up in the dyeing station 19, and/or in adjusting the color fastness, in particular the dry rubbing fastness, and/or the wet rubbing fastness, and/or the light fastness. Said advantages have been achieved when dyeing fibers, a yarn, a multitude of yarns, or a fabric.

As shown in figure 2, a single dyeing station 19 can be a dyeing vat 29 substantially filled with an aqueous dye formulation through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed. The fibers, yarn, multitude of yarns, or fabric is/are conveyed in series over five rotating drums 123 within the aqueous dye formulation, through two pressure drums 515 within the aqueous dye formulation, over five rotating drums 123 within the aqueous dye formulation, and through two pressure drums 415

outside of the dyeing vat 29 and outside of the aqueous dye formulation. The liquid level in the dyeing vat 29 is exemplary shown by the meandering line 25.

The seventh aspect of the present invention is illustrated by the dash lined box in figure 2 indicating a fixation station 17. One embodiment of such a fixation station 17 is illustrated within the dash lined box as a cascade of three chemical fixation stations 417, through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the dyeing station 19 or the not shown coating station 39. These chemical fixation stations comprise vats filled with an aqueous formulation containing at least one condensation product of an aliphatic polyamine and epihalohydrine, in particular epichlorohydrine, instead of a washing solution. In such a chemical fixation station, the fibers, yarn, multitude of yarns, or fabric is/are conveyed by five rotating through said aqueous solution, and through two pressure drums opposing each other and building a slit when leaving the chemical fixation stations.

However in another embodiment of the present invention, the fixation station can be a thermal fixation station 217, in particular a stenter for which an example is shown in Fig.10. Complementing a coloring installation with a fixation station 17 enables, in particular in combination with any of the first to the third, and/or of the fourth, and/or of the fifth or sixth aspect of the present invention, an increased reproducibility and precision in adjusting the color fastness, in particular the dry rubbing fastness, and/or the wet rubbing fastness, and/or the light fastness.

The sixth and seventh aspect of the present invention is illustrated in figure 3. The sixth aspect of the present invention relates to the use of a coating station 39 instead of the use of a cascade of dyeing stations 19 and ventilation stations 7 as shown in figure 1. In figure 3, a fabric is winded from a spool 21, conveyed over rotating drums 23 in sequence through a coating station 39, a drying station 11 in form of a stenter 311, and winded again on a spool 21. Compared to a conventional installation as shown in figure 1, the use of a coating station 39 instead of a cascade of dyeing stations 19 and ventilation stations leads to a reduced number of stations and thus to a reduced complexity of the installation which leads to lower manufacturing costs. Further to that, the use of a coating station 39 surprisingly enables, in particular in combination with any of the first to the third, and/or of the fourth, and/or of the seventh aspect of the present invention, an increased reproducibility and precision in adjusting the amount of dye being picked up in the coating station 39, and/or in adjusting the color fastness, in particular the dry rubbing fastness, and/or the wet rubbing fastness, and/or the light fastness. Said advantages have been achieved when coating a fabric.

As indicated by the upper arrow in figure 3, the coated and dried fabric is transported, in particular winded on a spool 21, to a thermal fixation station 311 (seventh aspect of the present invention) where the fabric is winded from said spool, conveyed through a thermal fixation station 311, and winded again on a spool 21. Alternatively or additionally to the thermal fixation station 311, the coated and dried fabric can also be conveyed through chemical fixation stations 417 as exemplary shown in figure 2. As indicated by the dash lined box in figure 3, the coated and dried fabric can be conveyed through a softening station 37 before being conveyed through the thermal fixation station 311 and/or the chemical fixation stations 417. As softening station 37 a foulard 43 can be used in which a softening agent, in particular a nano-silicone-based softening agent, can be applied to the fabric to soften said fabric.

As indicated by the lower arrow in figure 3, the coated, dried, optionally softened, and fixed fabric can be transported, in particular winded on a spool 21, to a sanforizing station 45 in which the fabric is again winded from a spool, conveyed through the sanforizing station 45 and winded again on a spool. The fabric is conveyed through the sanforizing station to reduce or eliminate the shrinking properties of the coated fabric. The coating station 39 and the drying station 11, 311 shown in figure 3 are described in more detail in figure 9. The softening station 37 can be similar or equal to the foulards described in detail as pretreating station 15 in figure 4 and figure 7. An exemplary thermal fixation station 311 is described in more detail in figure 10. An example for a sanforizing station is described in more detail in figure 12.

Figure 4 illustrates an exemplary pretreating station 15 in form of a foulard, also known as padding machine. Fibers, yarn, multitude of yarns, or fabric become/s winded from a spool 21, conveyed over rotating drums through the pretreating station 15, and winded again on a spool 21. The pretreating station 21 comprises a vat 215 filled with an aqueous solution, in particular any of the aqueous solutions c1) to c3), through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed over four rotating drums 223 being located in the aqueous solution. Further to that the pretreating station comprises two pressure drums 414 opposing each other and forming a slit through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the vat 215 filled with the aqueous solution.

Figure 5 illustrates six exemplary standby stations 27 in the particular form of rotating stations. On said rotating stations fibers, yarn, multitude of yarns, or fabric that is/are winded on a spool 21 become rotated on a rotating table 227.

Figure 6 illustrates fibers, yarn, multitude of yarns, or fabric being winded from a spool 21, conveyed through an exemplary washing station 5 in form of a multi-vat washing machine 105, followed by an exemplary drying station 11 in the particular form of ten heated drums 211, and winded again on a spool 11 after having passed the last heated drum 211. The multi-vat washing machine 105 in figure 6 comprises six washing vats 205. Each washing vat 205 comprises rotating drums 25 and pressure drums 415 arranged in a cascade such that fibers, yarn, multitude of yarns, or fabric merge/s and leave the washing solution 305 five to six times in each washing vat. When leaving the first, the third, the fifth, and the sixth washing vat 205 the fibers, yarn, multitude of yarns, or fabric is/are conveyed through pressure drums 405 opposing each other and building a slit.

An installation comprising in serious the stations illustrated in figure 4, figure 5, and figure 6 followed by a coloring station 9 is preferably used when the fibers, yarn, multitude of yarns, or fabric is/are pretreated with the aqueous solution c1). A particular advantage regarding the reproducibility and precision in adjusting the color fastness results from the discontinuous process path allowing, contrary to the conventional continuous dyeing process shown in figure 1, to adjust process parameters of each station independently and to perform quality checks after each station. In addition, an advantage can be derived from the discontinuous process, namely that the production capacity of each station can be exploited independent from the others. This can become very relevant in view of long standby times between 14 and 36 hours in the standby station 27.

Figure 7 illustrates a fabric being folded in a movable container 121 from which the fabric is conveyed by rotating drums 23 in series through a pretreating station 15, a drying station in form of a stenter 311, and is winded again on a spool 21. For a better readability, machinery parts that has already been described before are designated with the same reference signs. The pretreating station 15 differs from the pretreating station illustrated in figure 4 by the number of rotating drums 223 in the pretreating vat 215, namely two. As can be seen in figure 7, instead of conveying the fabric from a movable container 121, the fabric can also be winded from a spool 21. The stenter 311 is separated in stenter sections 511 aligned in a row, wherein each stenter section 511 comprises an air blowing module 611 to provide a consistent flow of hot air in each stenter section 511. Four of these stenter sections 511 are illustrated in figure 7. However the cutting line C indicates that more than four stenter sections 511, for example five, six, eight, nine, ten, eleven, or twelve, can be used.

An installation comprising in serious a pretreating station 15, a drying station in form of a stenter 311, and a coloring station 9 is preferably used when fibers, a yarns, a multitude of yarns, or a fabric is/are pretreated with c2). One advantage of this installation, in particular in combination with pretreatment d2) is the short processing time, and the precision that can be achieved regarding the moisture content of the fibers, yarn, multitude of yarns, or fabric when leaving the stenter 311 since the temperature and the flow of heated air can be adjusted for each stenter section 411 separately.

Figure 8 shows an installation, wherein fibers, yarn, multitude of yarns, or fabric is/are winded from a spool 21 and conveyed in series through three pretreating stations 15, wherein the second pretreating station is equal to the pretreating station shown in figure 4, a steaming station 31, a washing vat 205 for prewashing before entering the subsequent multi-vat washing machine 105, a drying station 11 in form of ten heated drums 211, and winded again on a spool 21. For a better readability machinery parts that have already been described before are designated with the same reference signs. In the first and third pretreating station 15 shown in figure 8 only one rotating drum 223 is located in the pretreating vat 215. The fibers, yarn, multitude of yarns, or fabric is/are not conveyed through pressure drums when leaving the first pretreating station 15. The steaming station 31 consists of three steaming station sections 131 aligned in a row, wherein the fibers, yarn, multitude of yarns, or fabric is/are conveyed over eight rotating drums 23 in each steaming station section 131 while being subjected with water steam, in particular with saturated steam. In the washing vat 205 for prewashing between steaming station 31 and multi-vat washing station 105, the fibers, yarn, multitude of yarns, or fabric is/are conveyed over one drum within the washing solution 305 and through pressure drums 415 before heading to the multi-vat washing machine. The multi-vat washing machine 105 in figure 8 is similar to that shown in figure 6. One difference is the number of washing vats 205 through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed, namely four. However the multi-vat washing machine can also comprise more washing vats 205, such as five, six, seven, eight, nine or ten washing vats 205. Another difference is that in the multi-vat washing 105 shown in figure 8 the fibers, yarn, multitude of yarns, or fabric is/are conveyed through pressure drums 415 each time when leaving a washing vat 205.

An installation comprising in serious one to three pretreating stations 15, a steaming station 31, potentially a washing vat 205 for prewashing, a multi-vat washing machine 105, a drying station 11 in form of heated drums 211, and a coloring station 9 is

preferably used when the fibers, yarn, multitude of yarns, or fabric is/are pretreated with c3). The use of three independently adjustable steaming station sections 131 regarding steam temperature and/or steam saturation, allows to precisely and reproducibly softening the fibers, yarn, multitude of yarns, or fabric. The use of an independently adjustable pre washing vat 205 regarding the composition of the washing solution 305 and/or the temperature of the washing solution allows to precisely and reproducibly control the peeling process. Alternatively or in addition, the use of a multi-vat washing machine 105 comprising four to ten, preferably eight, independently adjustable washing vats 205 regarding washing solution 305 and temperature of the washing solutions allows to precisely and reproducibly control the peeling process. A properly controlled peeling process is of high importance since peeling increases on one hand the surface of fibers, yarn, multitude of yarns, or fabric, which increase/s the maximum amount of color that can be picked up by fibers, yarn, multitude of yarns, or fabric, and/or the amount of color that is picked up when fibers, yarn, multitude of yarns, or fabric is/are conveyed under certain process parameters through a coloring station 9. However on the other hand, peeling lowers the tensile strength of fibers, yarn, multitude of yarns, or fabric.

With an arrangement of stations as described and exemplary shown in figure 8, preferably in combination with the pretreating step d3) as described above, fibers, yarn, multitude of yarns, or fabric with a tensile strength can be obtained which is less than the tensile strength of said fibers prior to the pretreatment step, but not more than 20 % less the tensile strength of said fibers prior to the pretreatment step and more preferably not more than 10 % less the tensile strength of said fibers prior to the pretreatment step, measured in each case at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

The steaming station 31 shown in figure 8 can also be used to subject the fibers, yarn, multitude of yarns, or fabric after leaving the coloring station 9 with water steam, in particular with saturated water steam. In a preferred embodiment the steaming station 31 is followed by a multi-vat washing machine 105. Said multi-vat washing machine preferably comprises eight washing vats 405. Preferably used washing vats 405 and preferred arrangements of washing vats 405 are shown in figure 6 and figure 8. Features and advantages described with respect to the use a multi-vat washing machines before the fibers, yarn, multitude of yarns, or fabric is/are conveyed through the coloring station 9 also applies to the use of a multi-vat washing machine after leaving the coloring station 9 and a subsequent steaming station 31. Alternatively or

additionally a washing vat 415 can also be arranged directly behind the coloring station, such that colored fibers, yarns, or fabric can be subjected to a washing step after leaving the coloring station 9. Further a drying station 11, 211, 311 as exemplary shown and described in figure 6, figure 7, and figure 8 can be arranged behind the multi-vat washing machine 105 or behind a single washing vat, such that the fibers, yarn, multitude of yarns, or fabric can be subjected to a drying step after the washing step. Such a drying station 11 can for example be realized by heated drums 211, over which the fibers, yarn, multitude of yarns, or fabric is/are conveyed as shown in figure 6 and figure 8, or by a stenter 311 as exemplary shown in figure 7, figure 9, and figure 10.

Figure 9 shows an installation, wherein a fabric is winded from a spool 21, conveyed over rotating drums 23 in sequence through a coating station 39, a drying station 11 in form of a stenter 311, and winded again on a spool 21. For a better readability machinery parts that has already been described before are designated with the same reference signs. The coating station 39 comprises eight roll coaters 139 arranged adjacent to each other. The use of a coating station 39 consisting of several pre- and/or post-metering devices leads to a significant reduction of the required room capacity for an installation for dyeing or coating synthetic fabrics. Further to that, it has surprisingly been found that compared to a cascade of dyeing stations and ventilation stations as shown in figure 1, a coating station 39 consisting of several pre- and/or post-metering devices arranged adjacent to each other increases the reproducibility and precision in adjusting the amount of color being picked up by the fabric. The stenter 311 comprises three stenter sections 411, wherein each of the sections becomes heated separately. In the stenter 311 shown in figure 9, rotating drums are arranged in such a way that fibers, yarn, multitude of yarns, or fabric is/are conveyed three times through the three stenter sections 411. With such a stenter 311 the required room capacity for an installation for dyeing or coating fabrics can be reduced.

Using a coating station 39 as coloring station as shown in figure 9 illustrates the eight aspect of the present invention and is preferably used in combination with any of the first to the third, and/or with the fourth, and/or the seventh aspect of the present invention.

In figure 10 a thermal fixation station 217 in form of third stenter 311 is shown which comprises ten stenter sections 411, wherein the ten stenter sections 411 are separated in five groups each containing two stenter sections 411 that are arranged adjacent to each other, wherein each group of stenter sections 411 is followed by an air ventilation section 611. Hot air which is blown into the stenter sections 411 by the blowing modules

511 passes the fibers, yarn, multitude of yarns, or fabric that is/are conveyed through the thermal fixation station 217 and leaves the stenter 311 through the air ventilation sections 611.

Supplementing an installation for dyeing or coating synthetic fibers, yarn, multitude of yarns, or fabric with a thermal fixation station 217 as exemplary shown in figure 10 that is located behind a coloring station 9, in particular in sequence behind a coloring station 9 and a drying station 11, illustrates one embodiment of the seventh aspect of the present invention and is preferably used in combination with any of the first to the third, and/or with the fourth, and/or the fifth or sixth aspect of the present invention.

It has to be clear that each of the stenters 311 shown in figure 7, figure 9, and figure 10 can either be used as a drying station 11 or as thermal fixation station 217.

Figure 11 schematically shows a coloring installation that is preferably used, when the fibers, yarn, multitude of yarns, or fabric is/are subjected to an intermediate treatment with at least one aqueous electrolyte solution containing at least one cationic electrolyte, in particular at least one cationic polyelectrolyte, after the fibers, yarn, multitude of yarns, or fabric have/has been dyed and optionally subsequently washed. Such an installation preferably comprises in series a first dyeing station 19, optionally a ventilation station 7, a washing station 5, optionally a ventilation station 7, and an electrolyte treatment station 33. It has been found advantages to supplement such an installation with further dyeing stations 19, washing stations 5, and optionally ventilation stations 7. In a preferred embodiment as indicated in figure 11, the electrolyte treatment station 33 is followed downstream in serious optionally by a ventilation station 7, a washing station 5, optionally a ventilation station 7, and a cascade of four dyeing stations 19, each optionally followed by a ventilation station 7. The last dyeing station 19 can be followed downstream in serious by a cascade of five washing stations 5, wherein the first of these washing stations 5 is optionally followed by a ventilation station 7, and wherein the second of these washing stations 4 is optionally followed by a warm air ventilation station 117. In a rather preferred embodiment the cascade of five washing stations 5 is followed downstream in serious by a drying station 11 and/or a sizing station 15. Additionally or alternatively, the fibers, yarn, multitude of yarns, or fabric can be conveyed downstream in serious through an accumulator station 1, a calender 3, a washing station 5, a ventilation station 7, and/or three washing stations 5, before entering said first dyeing station 19.

As electrolyte treatment station 33 a vat comprising an aqueous electrolyte solution through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed as shown in figure 11 can be used. Thereby the fibers, yarn, multitude of yarns, or fabric is/are conveyed over three rotating drums 123 within the aqueous electrolyte solution.

As dyeing stations 19, vats comprising an aqueous dye formulation through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed as shown in figure 11 can be used. Thereby the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series over five rotating drums 123 within the aqueous dye formulation, through two pressure drums 515, over five rotating drums 123 within the aqueous dye formulation, and through two pressure drums 415 outside of the dyeing vat 29 and of the aqueous dye formulation.

As washing stations 5, vats comprising a washing solution through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed as shown in figure 11 can be used. Thereby the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series over rotating drums 123 in the washing solution, optionally through pressure drums 515 followed again by rotating drums 123 in the washing solution, and through two pressure drums 415 outside of the washing vat 29. It is also possible to conduct the washing steps with washing stations 5 as shown and described with respect to figure 6 and figure 8.

In particular in order to reduce or eliminate the shrinking properties of the colored fibers, yarn, multitude of yarns, or fabric, an installation of the present invention can further comprise a sanforizing station through which, preferably after the fixation step, colored fibers, yarn, multitude of yarns, or fabric is/are conveyed. In the sanforizing station shown in figure 12, fibers, yarn, multitude of yarns, or fabric is/are winded from a spool 21 or unloaded from a movable container 121, conveyed over rotating drums in serious through a wetting station 35, a drying station 11 consisting of fourteen heated drums 211, a shrinking unit 47, a dryer 55, an accumulator station 41, and winded again on a spool 21 or loaded into a movable container 121. The wetting station 35 comprises a wetting vat 135, through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed when entering the wetting station 35 and pressure drums 415 through which the fibers, yarn, multitude of yarns, or fabric is/are conveyed when leaving the wetting station 35. The sanforizing unit 47 comprises a pressure roll 51 and a rubber sleeve 49 that is clamped by three rubber sleeve cylinders 53. The pressure roll 51 and the rubber sleeve cylinders 53 squeeze the rubber sleeve 49 in a pressure zone such that the rubber sleeve becomes elastically stretched. The wetted, heated and thereby partially dried

fibers, yarn, multitude of yarns, or fabric is/are fed into this pressure zone and conveyed with the rubber sleeve out of the pressure zone. When leaving the pressure zone the rubber sleeve returns to its original length thereby compressing the fibers, yarn, multitude of yarns, or fabric such that the fibers, yarn, multitude of yarns, or fabric shrink/s. When the shrunk fibers, yarn, multitude of yarns, or fabric is/are conveyed through the dryer 55, in this case over a heated drum, they become dried such that they remain in the shrunk state. After leaving the dryer 55 and before entering the accumulator section 41, the fibers, yarn, multitude of yarns, or fabric can be stretched between two rotating drums 23.

Although modifications and changes maybe suggested by those skilled in the art, it is the intention of the applicant to embody within the patent warranted hereon all changes and modifications as reasonably and probably come within the scope of this contribution to the art. The features of the present invention which are believed to be novel are set forth in detail in the appended claims. The features disclosed in the description, as well as the features disclosed in the figures can individually or in any combination be of relevance for the present invention in the different embodiments.

References

1	accumulator
3	calender
5, 105, 305	washing station
7,	ventilation station
9, 19, 39	coloring station
11, 211, 311	drying station
13	sizing station
15	pretreating station
17, 217, 417	fixation station
19	dying station
21, 121	spool
23, 123, 223	rotating drums
25	liquid level
27	standby station
29	dyeing vat
31	steaming station
33	electrolyte treatment station
35	wetting station
37	softening station
39	coating station
41	accumulator station
43	foulard
45	sanforizing station
47	shrinking unit
49	rubber sleeve
51	pressure roll
53	rubber sleeve cylinders
55	dryer
105	multi-vat washing machine
117	warm air ventilation station
121	movable container
123	rotating drums in the aqueous dye formulation

131	steaming station section
135	wetting vat
139	roll coater
205	washing vat
211	heated drums
215	pretreating vat
217, 311	thermal fixation station
223	rotating drums in pretreating vat
227	rotating table
305	washing solution
311	stenter
411	stenter section
415	pressure drums
417	chemical fixation station
511	air blowing module
515	pressure drums in the aqueous dye formulation
611	air ventilation section
C	cutting line

Claims

1. A process for dyeing, in particular vat dyeing, or coating synthetic fibers, in particular polyester fibers and/or polyamide fibers, or yarns comprising or consisting of synthetic fibers or fabrics comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, said process comprising the steps of:

   a) providing a multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or
   providing at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or
   providing at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, or of at least one yarn, in particular a multitude of yarns, comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers; and

   b1) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or
   providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation,

   c1) providing an aqueous system comprising at least one lipase enzyme, in particular lipase from Candida sp., and

   d1) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric with the aqueous system comprising the at least one lipase enzyme, in particular lipase from Candida sp., and

   e1) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation;

or

b2) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or
providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation,

c2) providing an aqueous system comprising nano-sized polyurethane particles, at least one cross-linking agent and at least one wetting agent and

d2) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric, in particular said fabric, with said aqueous system comprising said nano-sized polyurethane particles, at least one cross-linking agent and at least one wetting agent and

e2) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular with said powdered leuko dye, or with said at least one aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation;

or

b3) providing at least one powdered dye or a powdered precursor dye, in particular powdered leuko dye, or
providing at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation,

c3) providing an aqueous system comprising at least one base, in particular an alkali hydroxide, more in particular potassium hydroxide, and optionally at least one wetting agent, and

d3) pretreating said multitude of fibers or said yarn or said multitude of yarns or said fabric, in particular said multitude of fibers, yarn or multitude of yarns, with said aqueous system comprising the at least one base and optionally the at least one wetting agent, and

e3) coating or dyeing said pretreated multitude of fibers or said pretreated yarn or multitude of yarns or said pretreated fabric with said at least one powdered dye or with said powdered precursor dye, in particular said powdered leuko dye, or with said at least one aqueous dye formulation or

with said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation.

2. The process according to claim 1, wherein
the dye is a vat dye, in particular selected from the group consisting of indigo, indigoid dyes, in particular isoindigo, indirubin and/or 6,6′-dibromoindigo, e.g. Tyrian purple, indanthren dyes, anthrachinon dyes, anthraquinone dyes, naphthalene dyes and mixtures thereof; or wherein the precursor dye is the leuko dye, in particular selected from the group consisting of leuko-indigo, leuko-indigoid dyes, in particular leuko-isoindigo, leuko-indirubin and/or leuko-6,6′-dibromoindigo, e.g. leuko-Tyrian purple, leuko-indanthren dyes, leuko-anthrachinon dyes, leuko-anthraquinone dyes, leuko-naphthalene dyes and mixtures thereof.

3. The process according to claim 1 or 2, wherein
the leuko dye is obtained from a corresponding vat dye by treatment in an aqueous alkaline system with a reducing agent, in particular selected from the group consisting of thiourea dioxide, sodium dithionite, sodium hydrogen sulphite, hydroxyacetone, sodium hydroxymethylsulfinate, borohydride and mixtures thereof.

4. The process according to claim 3, wherein
the aqueous alkaline system containing the leuko dye is the least one aqueous precursor dye formulation.

5. The process according to any of the preceding claims, further comprising
treating the coated or dyed multitude of fibers, yarn, multitude of yarns or fabric of step e1), e2) or e3), resp., with at least one oxidizing agent, in particular selected from the group consisting of oxygen, air, in particular heated air, inorganic peroxo compounds, hydrogen peroxide, potassium dichromate, sodium hypochlorite, peracetic acid and mixtures thereof.

6. The process according to any of the preceding claims, wherein
the fiber is a multicomponent fiber, in particular a bicomponent fiber.

7. The process according claim 6, wherein
the multicomponent fiber, in particular bicomponent fiber, is a solid or hollow side-by-side fiber, a sheath-core fiber, an islands-in-the-sea fiber (matrix-fibril) or a segmented-pie-structure fiber.

8. The process according claim 6 or 7, wherein
the bicomponent fibers are made of poly(ethylene)terephthalate and polyethylene naphthalate, nylon-6,6 and polycyclohexylenedimethylene terephthalate (PCT), polypropylene and poly(butylene)terephthalate, nylon-6 and copolyamides, polylactic acid and polystyrene, polyacetal, in particular polyoxymethylene, and polyurethane, copolyesters and HD-polyethylene or copolyesters and LLD-polyethylene, polyolefins, in particular polypropylene, and polyamides.

9. The process according claim 7 or 8, wherein
the core-sheath bicomponent fibers are comprising a polyester core, in particular a poly(ethylene)terephthalate core, and a copolyester sheath, or of a polyester core, in particular a poly(ethylene)terephthalate core, and a polyethylene sheath or of a polypropylene core and a polyethylene sheath or of a polyamide core, in particular nylon-6,6, and a polyolefin sheath, in particular a polypropylene sheath, or wherein
the islands-in-the-sea bicomponent fibers are comprising a polyolefins matrix, in particular polypropylene matrix, and polyamide, in particular polyamide fibrils, embedded in the matrix.

10. The process according to any of the preceding claims, wherein
the yarn is a textured and/or an oriented yarn selected from the group consisting of a Low Oriented Yarn (LOY), Medium Oriented Yarn (MOY), Partially Oriented Yarn (POY), High Oriented Yarn (HOY) and Fully Oriented Yarn (FOY).

11. The process according to any of the preceding claims, wherein
the yarn or the multitude of yarns represents or comprises yarns which are textured and partially oriented yarns.

12. The process according to any of the preceding claims, wherein dyeing of said pretreated fibers, yarn, multitude of yarns or fabric with said aqueous dye formulation or with said at least one aqueous precursor dye formulation, in particular with the alkaline aqueous leuko dye formulation, is conducted according to the pad-batch method.

13. The process according to any of the preceding claims, wherein in step d1) the pretreatment with the at least one lipase enzyme, in particular lipase from Candida sp., is conducted according to the pad-batch method, in particular at a temperature in the range from 25 to 60°C, more in particular in the range from 30 to 50°C, and also in particular at a pH in the range from 4.5 to 9, and more particular in the range from 5 to 8.

14. The process according to any of the preceding claims, wherein after the pretreatment step d1), d2) or d3) the fibers, yarn, multitude of yarns or the fabric are kept at room temperature for about 14 to 36 hours, in particular for about 18 to about 24 hours, and subsequently washed, in particular in a multi-vat-, more in particular in an 8 vat-, washing machine, using a temperature in the range from 30 to 95°C, in particular in the range from 40 to 90 °C.

15. The process according to any of the preceding claims, wherein said multitude of fibers, said yarn, said multitude of yarns or said fabric are subjected to the pretreatment step d1), d2) or d3) while being wrapped on a roll.

16. The process according to any of the preceding claims, wherein said aqueous dye formulation or said at least one aqueous precursor dye formulation, in particular the alkaline aqueous leuko dye formulation, used for coating in step e1), e2) or e3) has a viscosity in the range from 10 to 70 Dpa·s, in particular in the range from 30 to 60 Dpa·s, determined at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

17. The process according to any of the preceding claims, further comprising after the coating or dyeing step subjecting said fibers, said yarn, said multitude of yarns or said fabric to water steam, in particular at a temperature in the range from 95 to 110°C, more in particular in the range from 98 to 102°C, over a

period of time, in particular in the range from 1 to 10 minutes, more in particular in the range from 2 to 4 minutes.

18. The process according to claim 17, further comprising after the treatment with water steam subjecting the steamed fibers, yarn, multitude of yarns or fabric to a washing step, in particular in a multi-vat-, more particular in an 8 vat-, washing machine using a temperature in the range from 25 to 98°C, in particular in the range from 30 to 95 °C.

19. The process according to any of the preceding claims, wherein after dyeing the fibers, yarn, multitude of yarns or fabric are subjected to at least one washing step.

20. The process according to any of the preceding claims, wherein the washed fibers, or the washed yarn or multitude of yarns or the washed fabric are subjected to a drying step, in particular at a temperature in the range from 98 to 130°C, more in particular in the range from 100 to 120°C.

21. The process according to any of the preceding claims, wherein the washed fibers, the washed yarn, the washed multitude of yarns or the washed fabric are subjected to a drying step over a period of time in the range from 30 seconds to 10 minutes, in particular in the range from 1 to 3 minutes.

22. The process according to any of the preceding claims, wherein in step e1), e2) or e3) the dye used for dyeing or coating is a powdered leuko dye or an alkaline aqueous leuko dye formulation, in particular an alkaline aqueous leuko-indigo dye formulation.

23. The process according to any of the preceding claims, wherein after the dyeing step e1), e2) or e3) (first dyeing step), and optionally after the at least one washing step, the fibers, the yarn, the multitude of yarns or the fabric are treated with at least one aqueous electrolyte solution containing at least one cationic electrolyte, in particular at least one cationic polyelectrolyte, and optionally subsequently subjected to at least one washing step, and are subsequently subjected to another dyeing step (second dyeing step) with at least one powdered dye or with at least one powdered precursor dye, in particular

with a powdered leuko dye, or with at least one aqueous dye formulation or with at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko dye formulation, in particular according to the pad-batch method, which is optionally followed by at least one washing step.

24. The process according to claim 23, wherein
the at least one cationic electrolyte is poly(diallyldimethylammonium chloride).

25. The process according to claim 23 or 24, wherein
the dye in the first dyeing step and/or in the second dyeing step is a powdered leuko dye, in particular powdered leuko-indigo dye, or an aqueous leuko dye formulation, in particular an alkaline aqueous leuko-indigo dye formulation.

26. The process according to any of the preceding claims, further comprising
after the dyeing or coating step at least one drying step, in particular comprising subjecting the dyed or coated fibers, yarn, multitude or yarns or fabric to a temperature in the range from 100 to 175 °C, in particular in the range from 120 and 160 °C, over a period of time, in particular in the range from 5 seconds to 5 minutes.

27. The process according to any of the preceding claims, further comprising
after the dyeing or coating step, in particular after the treatment step with the oxidizing agent, at least one fixation step, in particular comprising subjecting the dyed or coated and optionally dried fibers or fabric to a temperature in the range from 160 to 220°C, more in particular in the range from 170 to 200°C, for a period of time, in particular in the range from 30 seconds to 5 minutes, more in particular the range from 1 to 3 minutes, in particular by use of a heated gas, more preferably by use of heated air.

28. The process according to any of the preceding claims, wherein
the at least one aqueous dye formulation, in particular the aqueous indigo dye formulation, used for coating, in particular following step d2), said fibers, yarn, multitude of yarns or fabric, in particular said fabric, comprises at least one dye, in particular the vat dye, in particular said (unreduced) indigo dye, or the precursor dye, in particular said leuko-indigo dye, and more in particular the vat dye, in particular said (unreduced) indigo dye, at least one binder, in particular

a cross-linkable acrylic binder, at least one thickener and optionally at least one softening agent, in particular a nano-silicone-based softening agent.

29. The process according to any of the preceding claims, wherein the coating step is conducted by way of knife coating or by way of rotary printing, in particular by way of knife coating.

30. The process according to any of the preceding claims, wherein the aqueous dye formulation, in particular the aqueous dye formulation used for dyeing, comprises at least one organic coloring substance as a dye, preferably a non-ionic dye, more preferably an (unreduced) indigo dye, and at least one dispersing agent.

31. The process according to claim 30, wherein the dispersing agent is selected from the group consisting of alkyl sulphates, alkylaryl sulphonates, fatty alcohols, condensation products of amines and ethylene oxide, condensation products of naphthalene sulphonic acid and formaldehyde, lignin sulphonate and mixtures thereof.

32. The process according to any of the preceding claims, wherein the at least one aqueous dye formulation, in particular the aqueous leuko dye formulation and more in particular the aqueous leuko-indigo dye formulation, has a pH in the range from 10 to 13, in particular in the range from 10,5 to 12,5.

33. The process according to any of the preceding claims, wherein the at least one aqueous dye formulation, in particular the aqueous leuko dye formulation and more in particular the aqueous leuko-indigo dye formulation, has a density at 25 °C in the range from 0,6 to 1,5 g/ml, in particular in the range from 0,8 to 1,2 g/ml.

34. The process according to any of the preceding claims, wherein the at least one aqueous dye formulation, in particular the aqueous (unreduced) indigo dye formulation, to be used for dyeing comprises at least one dye, in particular (unreduced) indigo dye, at least one silicone, in particular nano-silicone, at least one binder, in particular a crosslinkable acrylic binder, at least one thickener, at least one defoamer, at least one amine, in particular ammonia, and water.

35. The process according to any of the preceding claims, wherein said coating or dyeing of said pretreated multitude of fibers, yarn, multitude of yarns or fabric with the at least one powdered dye, in particular the powdered vat dye, and more in particular said (unreduced) indigo dye, or the precursor dye, in particular said leuko-indigo dye, and more in particular the vat dye, in particular said (unreduced) indigo dye, or with the at least one aqueous dye formulation, in particular the alkaline aqueous leuko dye formulation, is warp or rope coating or warp or rope dyeing.

36. The process according to any of the preceding claims, wherein step b1), b2) or b3) comprises providing at least one powdered leuko dye, in particular powdered leuko-indigo dye, or at least one aqueous leuko dye formulation, in particular alkaline aqueous leuko-indigo dye formulation, and also at least one migration inhibitor, at least one dispersing agent, at least one wetting agent and at least one cationic polymer, in particular based on polyamide-epichlorohydrin resin, and wherein said multitude of fibers, yarn, multitude of yarns or fabric is dyed with said powdered leuko dye or said aqueous leuko dye formulation according to b1), b2) or b3).

37. The process according to any of claims 1 to 36, wherein step b1), b2) or b3) comprises providing at least one powdered leuko dye, in particular powdered leuko-indigo dye, or at least one aqueous leuko dye formulation, in particular alkaline aqueous leuko-indigo dye formulation, and also at least one migration inhibitor, at least one dispersing agent, at least one wetting agent and at least one cationic polymer, in particular based on polyamide-epichlorohydrin resin, and and wherein said multitude of fibers, yarn, multitude of yarns or fabric is coated with said powdered leuko dye or said aqueous leuko dye formulation according to b1), b2) or b3).

38. The process according to any of the preceding claims, wherein the aqueous dye formulation comprises the indigo dye, at least one base, at least one wetting agent and optionally at least one carrier agent.

39. The process according to any of the preceding claims, wherein in pretreatment step d3) the aqueous system has a pH in the range from 10 to 13, in particular in the range from 10,5 to 12,0, and/or a temperature in the range from 20 to 70°C, in particular from 30 to 60°C, and/or wherein pretreatment step d3) is conducted in such a manner that surface material of said pretreated synthetic fibers is at least partially peeled off whereby said synthetic fibers exhibit a weight reduction, in particular in the range from 5% to 35%, more in particular in the range from 10 to 30%.

40. The process according to any of the preceding claims, wherein the pretreatment step d3) further comprises subjecting the multitude of fibers, yarn, yarns or fabric to steam, in particular to saturated steam, for a period of time, in particular for 15 to 100 seconds, preferably for 30 to 60 seconds.

41. The process according to any of the preceding claims, wherein the multitude of fibers, yarn, yarns or fabric in the pretreatment d1), d2) or d3) are subjected to the aqueous system for no more than 30 seconds, in particular for no more than 15 seconds.

42. The process according to any one of claims 27 to 41, further comprising after the fixation step at least one sanforizing step of the at least one dyed fabric.

43. The process according to any of the preceding claims, wherein after the pre-treatment step and prior to the coating or dyeing step, in particular prior to the fixation step, the fibers, yarn, yarns and/or the fabrics are subjected to a cationization step.

44. The process according to any one of claims 27 to 43, wherein in the fixation step the coated or dyed fibers, yarn, yarns or fabric, in particular the dyed fibers, yarn, yarns or fabric, are treated with at least one aqueous formulation containing at least one condensation product of an aliphatic polyamine and epihalohydrine, in particular epichlorohydrine, and in particular simultaneously with heated water steam.

45. The process according to claim 44, wherein
the aqueous formulation has a pH value in the range from 3 to 6, particular in the range from 3,5 to 5, and/or a temperature in the range from 40 to 95°C, in particular in the range from 55 to 85°C.

46. The process according to claim 44 or 45, wherein
the condensation product of an aliphatic polyamine and epihalohydrine comprises a cationic reaction product of a homopolymer of diallylamine, a homopolymer of N-methyl-diallylamine or a copolymer of diallylamine and N-methyl-diallylamine with epihalohydrine, in particular with epichlorohydrine.

47. The process according to any of claims 23 to 46, wherein
the treatment with the at least one aqueous electrolyte solution containing at least one cationic electrolyte is conducted at a pressure in the range from 60 to 120 bar, particular in the range from 70 to 100 bar.

48. The process according to any of the preceding claims, wherein
the aqueous system comprising nano-sized polyurethane particles is a nano-dispersion of self-cross-linking amphoteric or anionic polyether polyurethanes, in particular having an average particle size of less than 100 nm.

49. The process according to any of the preceding claims, wherein
the wetting agent comprises at least one anionic phosphoric acid ester.

50. The process according to any of the preceding claims, wherein
in step a) a mixture of the multitude of synthetic fibers, in particular polyester fibers and/or polyamide fibers, and cotton fibers and/or at least one yarn, multitude of yarns or at least one fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, and cotton fibers is provided.

51. The process according to any of the preceding claims, wherein
the particle size of the powdered dye, in particular the particle size of the powdered indigo dye, as provided in step b1), b2) or b3) is below 10 μm, and in particular in the range from 1 to 5 μm.

52. The process according to any of the preceding claims, wherein the multitude of fibers comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, e.g. multi- or bicomponent fibers, or the fabric comprising or consisting of synthetic fibers, in particular polyester fibers and/or polyamide fibers, e.g. multi- or bicomponent fibers, pretreated according to step d3) exhibit after said pretreatment step a tensile strength which is less than the tensile strength of said fibers prior to the pretreatment step, in particular not more than 20 % less the tensile strength of said fibers prior to the pretreatment step and more in particular not more than 10 % less the tensile strength of said fibers prior to the pretreatment step, measured in each case at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

53. The process according to any of the preceding claims, wherein
- a fabric prepared from synthetic fibers or from a yarn or a multitude of yarns comprising or consisting of synthetic fibers is subjected to pretreatment step d1), d2) or d3), in particular d2), and pretreated fabric is coated according to step e1), e2) or e3), respectively; or wherein
- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are formed into a fabric, and said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively; or wherein
- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are dyed according to step e1), e2) or e3), resp.; or wherein
- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are dyed according to step e1), e2) or e3), resp., said fibers, yarn or yarns are formed into a fabric, and said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively; or wherein
- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are formed into a fabric, said fabric is subjected to

pretreatment step d1), d2) or d3), in particular d2), and in the following said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively; or wherein
- synthetic fibers or a yarn or a multitude of yarns comprising or consisting of synthetic fibers are subjected to pretreatment step d1), d2) or d3), in particular d2), said fibers, yarn or yarns are dyed according to step e1), e2) or e3), resp., and are in the following formed into a fabric, said fabric is subjected to pretreatment step d1), d2) or d3), in particular d2), and in the following said fabric is coated or dyed, in particular coated, according to step e1), e2) or e3), respectively.

54. Dyed synthetic fibers, in particular dyed polyester fibers and/or dyed polyamide fibers, or a dyed yarn, or a dyed multitude of yarns, or a dyed fabric obtained or obtainable according to the process according to any one of the preceding claims.

55. The dyed synthetic fibers, the dyed yarn, the dyed multitude of yarns, or the dyed fabric according to claim 54, wherein
the polyester fibers are selected from the group consisting of polyethylene terephthalate (PET) fibers and poly-1,4-cyclohexylene-dimethylene terephthalate (PCDT) fibers.

56. Coated synthetic fibers, in particular coated polyester fibers and/or coated polyamide fibers, or a coated yarn, or a coated multitude of yarns, or a coated fabric obtained or obtainable according to the process according to any one of claims 1 to 53.

57. The coated synthetic fibers, the coated yarn, the coated multitude of yarns, or the coated fabric according to claim 56, wherein
the polyester fibers are selected from the group consisting of polyethylene terephthalate (PET) fibers and poly-1,4-cyclohexylene-dimethylene terephthalate (PCDT) fibers.

58. An installation for dyeing or coating, preferably according to one of the claims 1 to 53, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns

comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, preferably according to one of the claims 54 to 57, comprising:

x) a coloring station (9), in particular a coating station (39) or a dyeing station (19), wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko-dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko-dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said coloring station (9), and

w) a drying station (11, 211, 311), wherein before, in particular directly before, said fibers, yarn, multitude of yarns, or fabric enter the coloring station (9), said fibers, yarn, multitude of yarns, or fabric is/are conveyed through said drying station (11, 211, 311) such that said dye formulation is applied to dried fibers, a dried yarn, a dried multitude of yarns, or a dried fabric within the coloring station (9).

59. The installation according to claim 58, wherein
after leaving the drying station (11, 211, 311), the dried fibers, yarn, multitude of yarns, or fabric has/have a moisture content less than 1 wt.-%, preferably less than 0,5 wt.-%, more preferably less than 0,25 wt.-% of the fiber's, yarn's, multitude of yarn's, or fabric's dry mass, and/or the amount of dye formulation being picked up in the subsequent coloring station is preferably at least 80 %, more preferably at least 70 %, most preferably at least 60 % and/or preferably maximally 90 %, more preferably maximally 80 %, most preferably maximally 70 % of the fiber's, yarn's, multitude of yarn's, or fabric's dry mass.

60. The installation according to claim 58 or 59, wherein
said drying station (11) comprises at least one, preferably at least two, or four, or six heated drum/s and/or preferably maximally fourteen, more preferably maximally twelve, or ten, or eight heated drum/s (211), the drum/s (211) preferably conductively heat said fibers, yarn, multitude of yarns, or fabrics being conveyed over said drum/s by a surface temperature, said surface temperature preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130 °C and/or preferably maximally 140 °C, more preferably maximally 130 °C.

61. The installation according to one of the claims 58 to 60, wherein said drying station (11) comprises at least one stenter (311), wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or preferably maximally 180 °C, more preferably maximally 160 °C, most preferably maximally 145 °C, or about 140 °C.

62. The installation according to one of the claims 58 to 61, further comprising a ventilation station (7) through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed before entering the drying station (11), in which said fibers, yarn, multitude of yarns, or fabric is/are air dried, wherein said air preferably has a temperature of at least 20 °C and/or of maximally 40 °C, more preferably of about 25 °C.

63. The installation according to one of the claims 58 to 62, further comprising a pretreating station (15) for pretreating said fibers, yarn, multitude of yarns, or fabric, with one of the aqueous solutions c1), c2), or c3), preferably by one of the pretreating steps d1), d2) or d3), before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through said drying station (11, 211, 311) and said coloring station (9), more preferably before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a ventilation station (7), said drying station (11, 211, 311), and said coloring station (9).

64. The installation according to one of the claims 58 to 63 for dyeing or coating a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, wherein said installation is supplemented by a second installation according to one of the claims 58 to 63, wherein the coloring station of the first installation is a dyeing station (19), and wherein the coloring station of the second installation is a coating station (39), wherein the installations are arranged in such a way that the fabric is conveyed through said dyeing station (19) before being conveyed through said coating station (39).

65. The installation according to one of the claims 58 to 63 for dyeing or coating synthetic fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, wherein said installation is supplemented by

a second installation according to one of the claims 57 to 62, wherein the coloring station of the first installation is a dyeing station (19), and wherein the coloring station of the second installation is a coating station (39), wherein the installations are arranged in such a way that said fibers, yarn, or multitude of yarns is/are conveyed through said dyeing station (19) before being conveyed through said coating station (39).

66. The installation according to claim 65 for dyeing or coating said fibers, yarn, or multitude of yarns further comprising a weaving machine for weaving said fibers, yarn, or multitude of yarns into a fabric after leaving the dyeing station (19) and before entering the coating station (39).

67. An installation, preferably according to one of the claims 58 to 66, for dyeing, preferably according to one of the claims 1 to 53, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, preferably according to one of the claims 54 to 55, comprising:

X1) one dyeing station (19), wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko-dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko-dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said dyeing station (19), and

Y1) one drying station (11, 211, 311) and/or one warm air ventilation station (117), wherein said fibers, yarn, multitude of yarns, or fabric applied with said dye formulation are dried, wherein said dyeing station (19) comprises only one vat (29) filled with said dye formulation, and wherein drums are arranged such that said fibers, yarn, multitude of yarns, or fabric merge/merges once the dye formulation and leave the dye formulation for heading to said drying station (11, 211, 311) and/or warm air ventilation station (7) without again merging the dye formulation.

68. The installation according to claim 67, wherein
said dyeing station (19) comprises at least two pressure drums (415) opposing each other and building a slit through which, after leaving the dye formulation, said fibers, yarn, multitude of yarns, or fabric is/are conveyed under pressure, said pressure preferably being at least 60 bar, more preferably at least 80 bar and/or preferably maximally 110 bar, more preferably maximally 90 bar.

69. The installation according to claim 67 or 68, wherein
the dye formulation has a temperature being at least 20 °C, preferably at least 40 °C, more preferably at least 50 °C and/or maximally 90 °C, preferably maximally 70 °C, more preferably maximally 60 °C.

70. The installation according to one of the claims 60 to 69, wherein
the amount of dye formulation applied to said fibers, yarn, multitude of yarns, or fabric after leaving the dyeing station preferably being at least 80 % and/or preferably maximally 90 %, more preferably about 90 % of said fiber's, yarn's, multitude of yarn's, or fabric's mass directly before entering said dyeing station (19).

71. The installation according to one of the claims 58 to 70, further comprising
a warm air ventilation station (117) through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the dyeing station (19), in which said fibers, yarn, multitude of yarns, or fabric is/are dried by warm air, wherein said warm air preferably has a temperature of at least 60 °C, more preferably of at least 80 °C, most preferably of at least 100 °C, and/or preferably of maximally 140 °C, more preferably of maximally 120 °C, most preferably of maximally 110 °C, or of preferably about 100 °C.

72. The installation according to one of the claims 58 to 71, further comprising
a drying station (11, 211, 311) through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving said dyeing station (19), preferably after leaving said dyeing station and after leaving a subsequent warm air ventilation station (117), wherein the drying station preferably comprises at least one, preferably at least two, or four, or six heated drum/s and/or preferably maximally fourteen, more preferably maximally twelve, or ten, or eight heated drums, the drums preferably conductively heat said fibers, yarn, multitude of

yarns, or fabric being conveyed over said drum/s by a surface temperature, said surface temperature preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130 °C and/or preferably maximally 140 °C, more preferably maximally 130 °C, and/or wherein the drying station preferably comprises at least one stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or preferably maximally 180 °C, more preferably maximally 160 °C, most preferably maximally 145 °C, or about 140 °C.

73. The installation according to one of the claims 67 to 72, further comprising a pretreating station (15) for pretreating said fibers, yarn, multitude of yarns, or a fabric with one of the aqueous solutions c1), c2), or c3), preferably by one of the pretreating steps d1), d2) or d3), before the fibers, yarn, multitude of yarns, or fabric is/are conveyed through said dyeing station (19), preferably before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a drying station (11, 211, 311) and said dyeing station (19), more preferably before the fibers, yarn, multitude of yarns, or fabric is/are conveyed in series through a ventilation station (7), a drying station (11, 211, 311), and said dyeing station (19).

74. The installation according to one of the claims 67 to 73 for dyeing or coating a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, wherein said installation is supplemented by a second installation according to one of the claims 58 to 63, wherein the coloring station of the second installation is a coating station (39), wherein the installations are arranged in such a way that the fabric is conveyed through said dyeing station (19) before being conveyed through said coating (39) station.

75. The installation according to one of the claims 67 to 73 for dyeing or coating synthetic fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, wherein said installation is supplemented by a second installation according to one of the claims 58 to 63, wherein the coloring station of the second installation is a coating station (39), wherein the installations are arranged in such a way that

the fibers, yarn, or multitude of yarns is/are conveyed through said dyeing station (19) before being conveyed through said coating station (39).

76. The installation according to claim 75 for dyeing or coating said fibers, yarn, or multitude of yarns, further comprising a weaving machine for weaving said fibers, yarn, or multitude of yarns into a fabric after leaving the dyeing station (19) and before entering the coating station (39).

77. An installation, preferably according to one of the claims 58 to 66, for coating, preferably according to one of the claims 1 to 53, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, preferably according to one of the claims 56 to 57, comprising:

X2) a coating station (39), wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko-dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko-dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric, in particular to said fabric, being conveyed through said coating station (39).

78. The installation according to claim 77, wherein
the coating station comprises at least one post-metering device as a knife coater, in particular in the arrangement of a floating knife, or of a knife over blanket, or of a knife over roll.

79. The installation according to claim 77 or 78, being supplemented by
a drying station (11, 211, 311) through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving said coating station (39), wherein the drying station preferably comprises at least one, preferably at least two, or four, or six heated drum/s and/or preferably maximally fourteen, more preferably maximally twelve, or ten, or eight heated drum/s, the drums preferably conductively heat said fibers, yarn, multitude of yarns, or fabric being conveyed over said drum/s by a surface temperature, said surface temperature

preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130 °C and/or preferably maximally 140 °C, more preferably maximally 130 °C, and/or wherein the drying station preferably comprises at least one stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or preferably maximally 180 °C, more preferably maximally 160 °C, most preferably maximally 145 °C, or about 140 °C.

80. The installation according to one of the claims 77 to 79, further comprising a pretreating station (15) for pretreating said fibers, yarn, multitude of yarns, or fabric with one of the aqueous solutions c1), c2), or c3), preferably by one of the pretreating steps d1), d2) or d3), before said, fibers, yarn, multitude of yarns, or fabric is/are conveyed through said coating station (39), preferably before being conveyed in series through a drying station (11, 211, 311) and the coating station (39), more preferably before being conveyed in series through a ventilation station (7), a drying station (11, 211, 311), and said coating station (39).

81. The installation according to one of the claims 77 to 80 for dyeing or coating a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, wherein said installation is supplemented by a second installation according to one of the claims 58 to 76, wherein the coloring station of the second installation is a dyeing station (19), wherein the installations are arranged in such a way that the fabric is conveyed through said dyeing station (19) before being conveyed through said coating (39) station.

82. The installation according to one of the claims 77 to 80 for dyeing or coating synthetic fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, wherein said installation is supplemented by a second installation according to one of the claims 58 to 76, wherein the coloring station of the second installation is a dyeing station (19), wherein the installations are arranged in such a way that the fibers, yarn, multitude of yarns is/are conveyed through said dyeing station (19) before being conveyed through said coating station (39).

83. The installation according to claim 82 for dyeing or coating said synthetic fibers, yarn, or multitude of yarns further comprising
a weaving machine for weaving said fibers, yarn, or multitude of yarns into a fabric after leaving the dyeing station (19) and before entering the coating station (39).

84. An installation, preferably according to one of the claims 58 to 83, for dyeing or coating, preferably according to one of the claims 1 to 53, synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, preferably according to one of the claims 54 to 57, comprising:

x) a coloring station (9), in particular a coating station (39) or a dyeing station (19), wherein a dye formulation comprising at least one powdered dye or a powdered precursor dye, in particular powdered leuko-dye, and/or at least one aqueous dye formulation or at least one aqueous precursor dye formulation, in particular an alkaline aqueous leuko-dye formulation, is applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said coloring station (9), and

Z1) a thermal fixation station (217, 311), through which said fibers, yarn, multitude of yarns, or fabric applied with said dye formulation is/are conveyed after leaving the coloring station (9), for fixing the applied dye formulation to said fibers, yarn, multitude of yarns, or fabric by heating said fibers, yarn, multitude of yarns, or fabric, or

Z2) at least one, preferably three, chemical fixation station/s (417), through which said fibers, yarn, multitude of yarns, or fabric applied with said dye formulation is/are conveyed after leaving the coloring station, wherein an aqueous formulation containing at least one condensation product of an aliphatic polyamine and epihalohydrine, in particular epichlorohydrine, is applied to said fibers, yarn, multitude of yarns, or fabric, for fixing the applied dye formulation to said fibers, yarn, multitude of yarns, or fabric.

85. The installation according to claim 84, wherein
said thermal fixation station comprises a stenter (311), wherein said fibers, yarn, multitude of yarns, or fabric is/are convection heated by air, preferably by air having a temperature of at least 130 °C, more preferably of at least 150 °C, most preferably of at least 170 °C, and/or preferably of maximally 220 °C, more preferably of maximally 200 °C, most preferably of maximally 180 °C.

86. The installation according to claim 84 or 85, wherein
the aqueous formulation in the at least one chemical fixation station has a temperature of at least 40 °C, preferably of at least 55 °C and/or of maximally 95 °C, preferably of maximally 85 °C.

87. The installation according to one of the claims 84 to 86, comprising
a warm air ventilation station (117) through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the coloring station (9) and before entering the fixation station (17), in which said fibers, yarn, multitude of yarns, or fabric is/are dried by warm air, wherein said warm air preferably has a temperature of at least 60 °C, more preferably of at least 80 °C, most preferably of at least 100 °C, and/or preferably of maximally 140 °C, more preferably of maximally 120 °C, most preferably of maximally 110 °C, or of preferably about 100 °C.

88. The installation according to one of the claims 84 to 87, further comprising
a drying station (11, 211, 311) through which said fibers, yarn, multitude of yarns, or fabric is/are conveyed after leaving the coloring station (9), preferably after leaving the coloring station and after leaving the subsequent warm air ventilation station (117), and before entering said fixation station (17), wherein the drying station preferably comprises at least one, preferably at least two, or four, or six heated drum/s and/or preferably maximally fourteen, more preferably maximally twelve, or ten, or eight heated drums, wherein the drums preferably conductively heat said fibers, yarn, multitude of yarns, or fabric being conveyed over said drum/s by a surface temperature, said surface temperature preferably being at least 100 °C, more preferably at least 120 °C, most preferably at least 130 °C and/or preferably maximally 140 °C, more preferably maximally 130 °C, and/or wherein the drying station preferably comprises at least one stenter, wherein said fibers, yarn, multitude of yarns, or fabric is/are convection

heated by air, preferably by air having a temperature of at least 120 °C, more preferably of at least 140 °C, and/or preferably of maximally 180 °C, more preferably of maximally 160 °C, most preferably of maximally 145 °C, or about 140 °C.

89. The installation according to one of the claims 58 to 66 or 74 to 88, wherein the aqueous dye formulation has a viscosity in the range from 10 to 70 Dpa·s, in particular in the range from 30 to 60 Dpa·s, determined in each case at 23 ± 5 °C, preferably at 23 ± 2.5 °C, more preferably at 23 ± 1.5 °C, most preferably at 23 ± 0.5 °C.

90. The installation according to one of the claims 58 to 89, wherein the dye formulation applied to said fibers, yarn, multitude of yarns, or fabric being conveyed through said coloring station (9) is a vat dye, in particular selected from the group consisting of indigo, indigoid dyes, in particular isoindigo, indirubin and/or 6,6′-dibromoindigo, e.g. Tyrian purple, indanthren dyes, anthrachinon dyes, anthraquinone dyes, naphthalene dyes and mixtures thereof; or wherein the precursor dye is the leuko dye, in particular selected from the group consisting of leuko-indigo, leuko-indigoid dyes, in particular leuko-isoindigo, leuko-indirubin and/or leuko-6,6′-dibromoindigo, e.g. leuko-Tyrian purple, leuko-indanthren dyes, leuko-anthrachinon dyes, leuko-anthraquinone dyes, leuko-naphthalene dyes and mixtures thereof.

91. Synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, wherein said fibers are dyed and/or coated by an installation according to one of the claims 58 to 90 and/or by a process according to one of the claims 1 to 53.

92. The synthetic fibers, or the yarn, or the multitude of yarns, or the fabric according to claim 91, wherein the polyester fibers are selected from the group consisting of polyethylene terephthalate (PET) fibers and poly-1,4-cyclohexylene-dimethylene terephthalate (PCDT) fibers.

93. Synthetic fibers, in particular polyester fibers and/or polyamide fibers, or a yarn comprising or consisting of synthetic fibers, or a multitude of yarns comprising or consisting of synthetic fibers, or a fabric comprising or consisting of synthetic fibers or of yarns comprising or consisting of synthetic fibers, wherein
said fibers are dyed or coated with a dye formulation comprising at least one powdered indigo dye or a powdered precursor indigo dye, and/or wherein
said fibers are dyed or coated with at least one aqueous indigo dye formulation or at least one aqueous precursor indigo dye formulation, in particular an alkaline aqueous leuko-indigo dye formulation, wherein
said dyed and/or coated fibers have a dry rubbing fastness in the range from 1,0 to 5,0, preferably in the range from 2,0 to 4,0, more preferably in the range from 2,5 to 3,5, wherein the dry rubbing fastness is determined by ISO 105-X12:2001(E), and/or wherein
said dyed and/or coated fibers have a wet rubbing fastness in the range from 0.5 to 3,0, preferably in the range from 1,5 to 2,5, more preferably in the range from 1,0 to 2,0, wherein the wet rubbing fastness is determined by ISO 105-X12:2001(E).

94. The synthetic fibers, or the yarn, or the multitude of yarns, or the fabric according to claim 91, wherein
said fibers are dyed and/or coated by an installation according to one of the claims 58 to 90 and/or by a process according to one of the claims 1 to 53.

95. The synthetic fibers, or the yarn, or the multitude of yarns, or the fabric according to claim 93 or 94, wherein said fibers have been pretreated with an aqueous system comprising at least one lipase enzyme, in particular lipase from Candida sp. or with an aqueous system comprising nano-sized polyurethane particles, at least one cross-linking agent and at least one wetting agent.

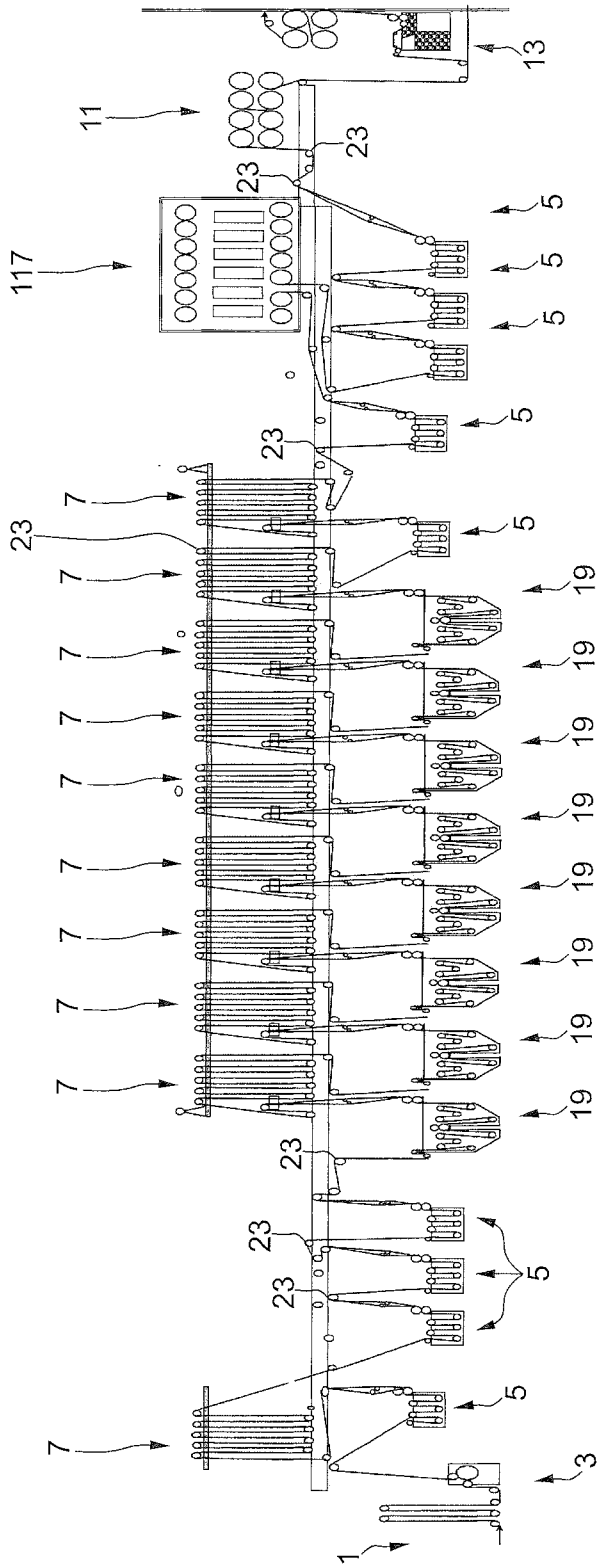

Fig. 1 (Prior Art)

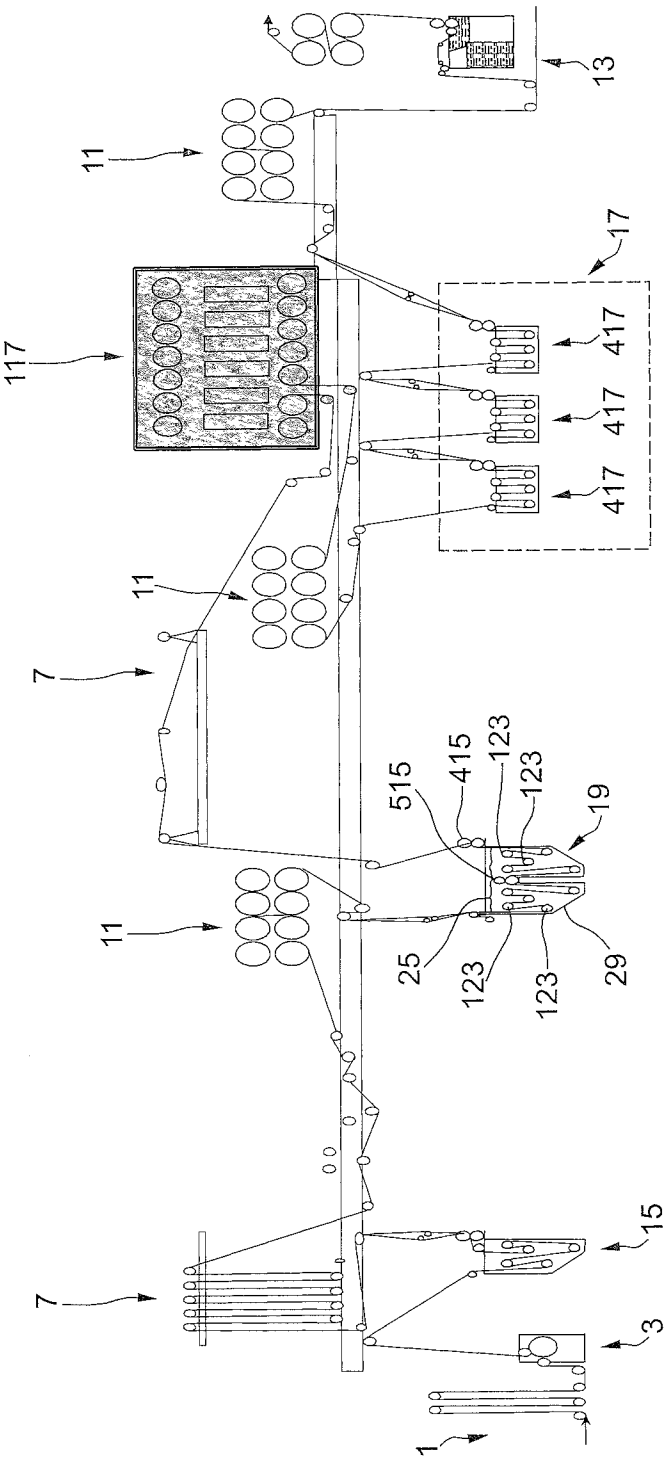
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Fig. 2

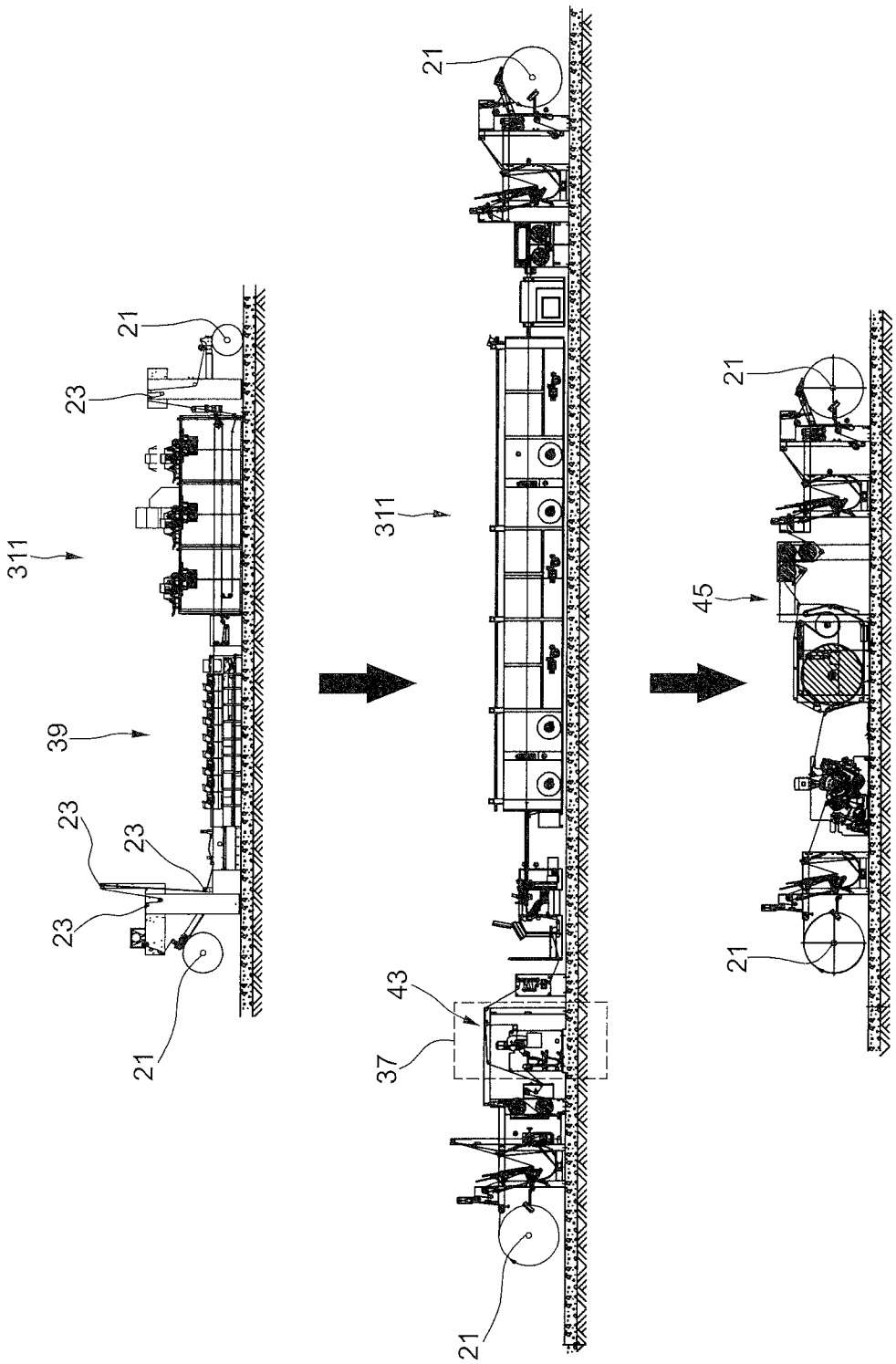

Fig. 3

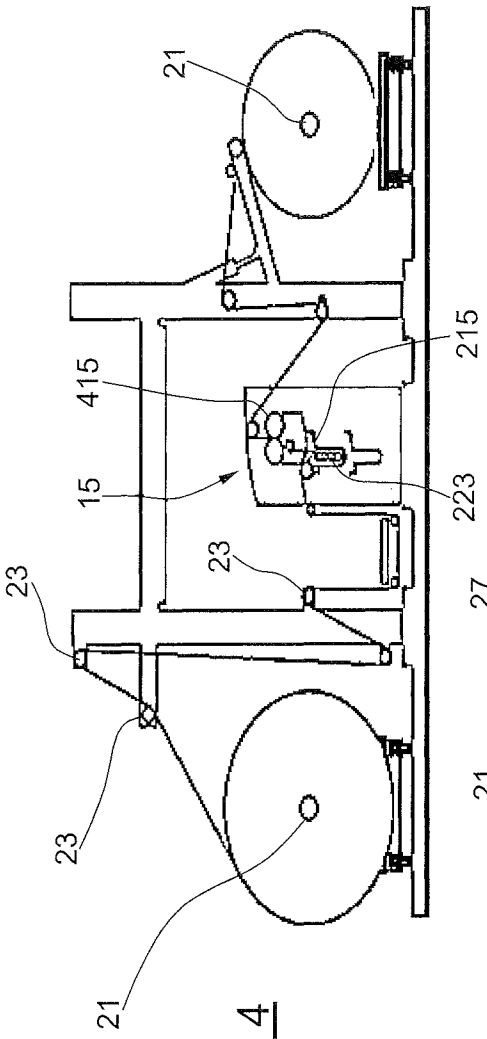

Fig. 4

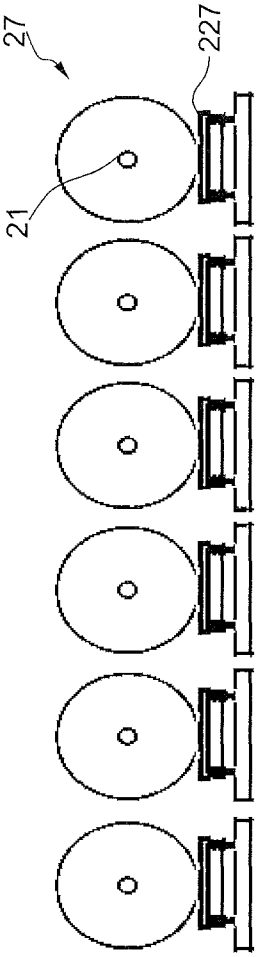

Fig. 5

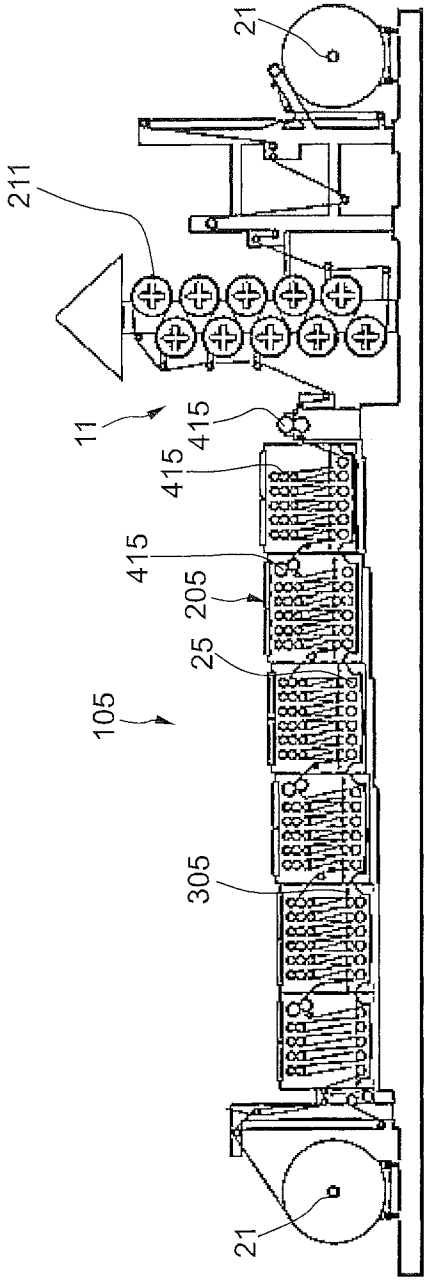

Fig. 6

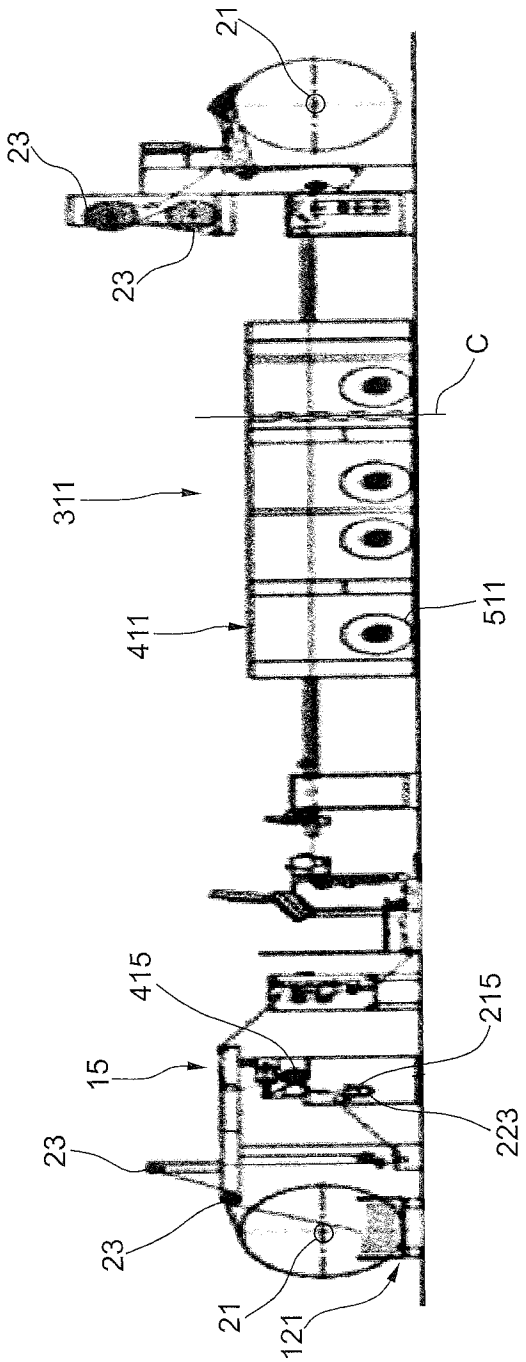

Fig. 7

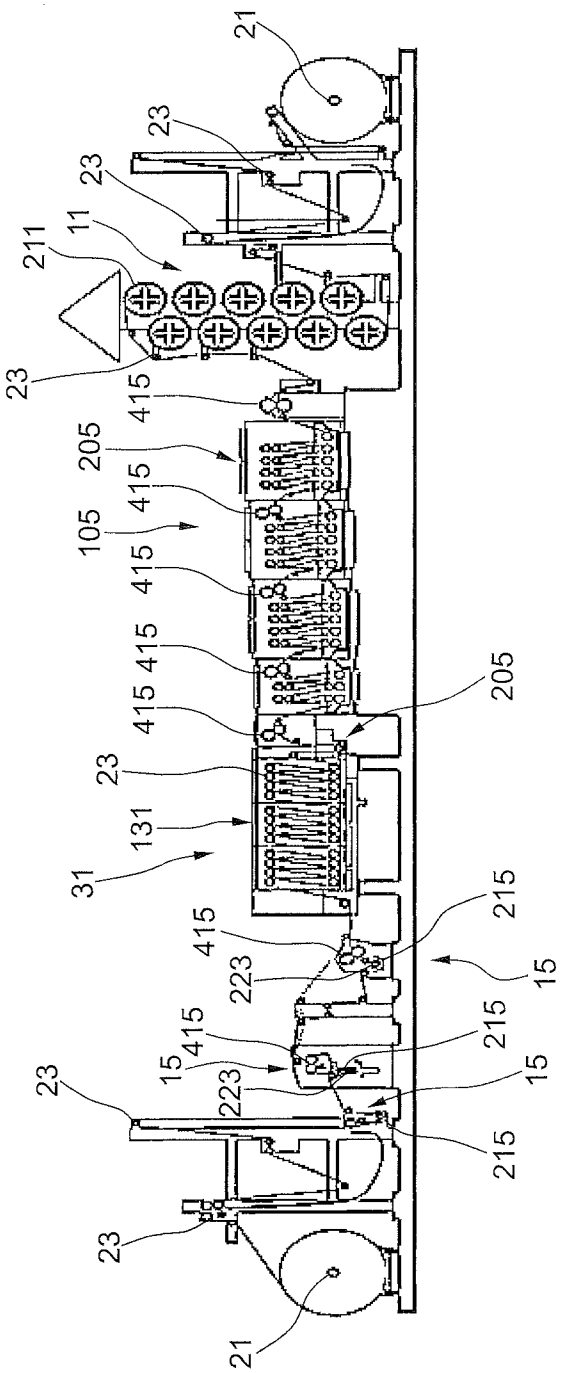
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Fig. 8

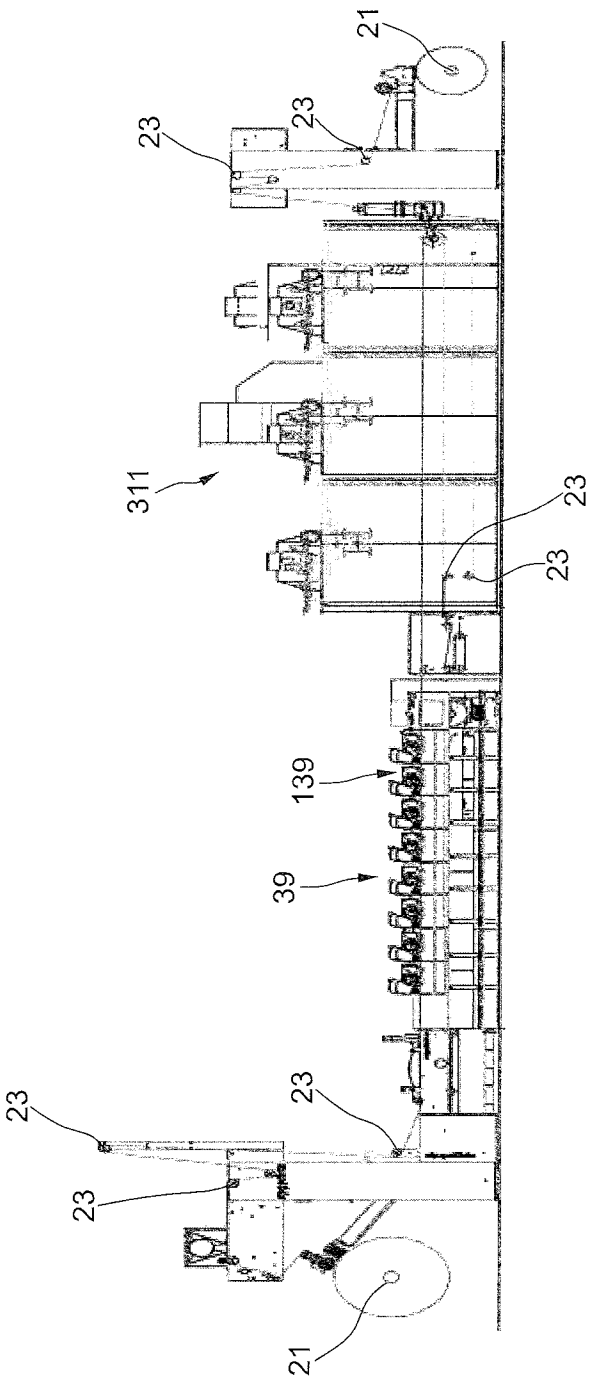

Fig. 9

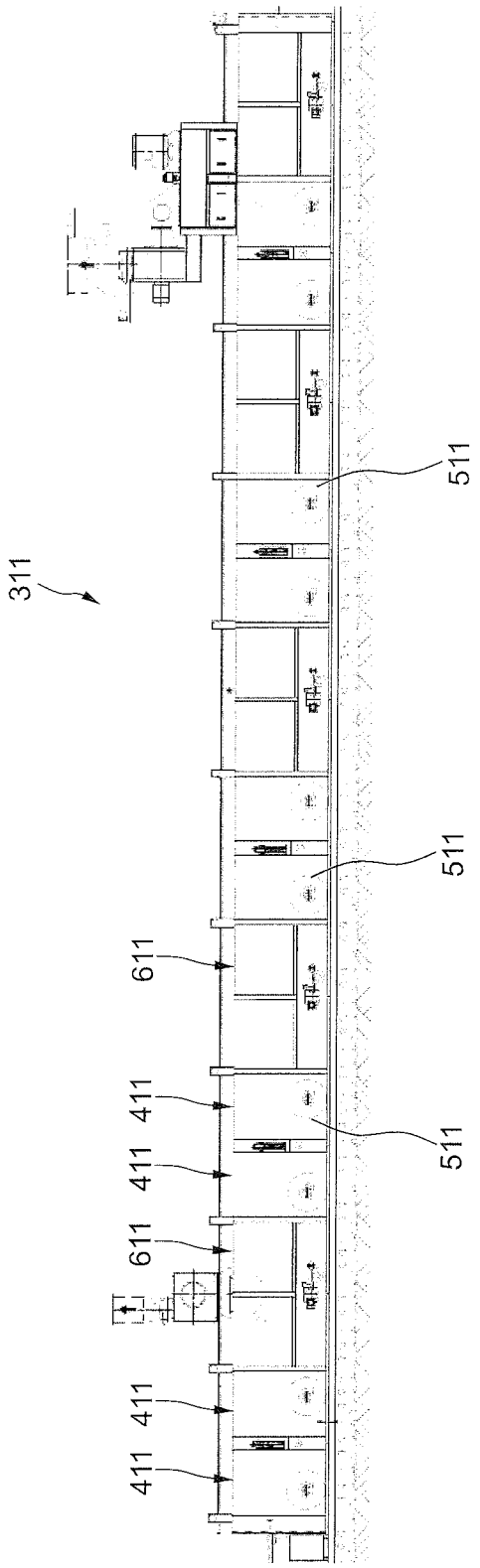

Fig. 10

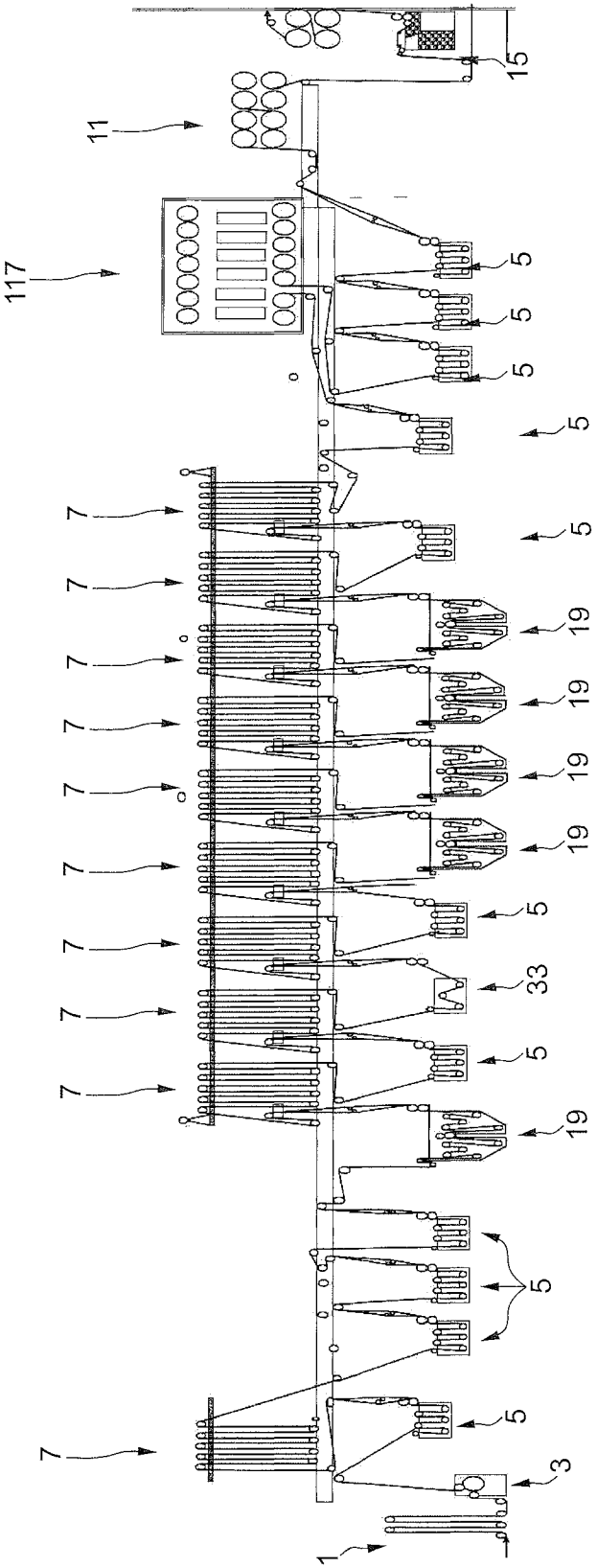

Fig. 11

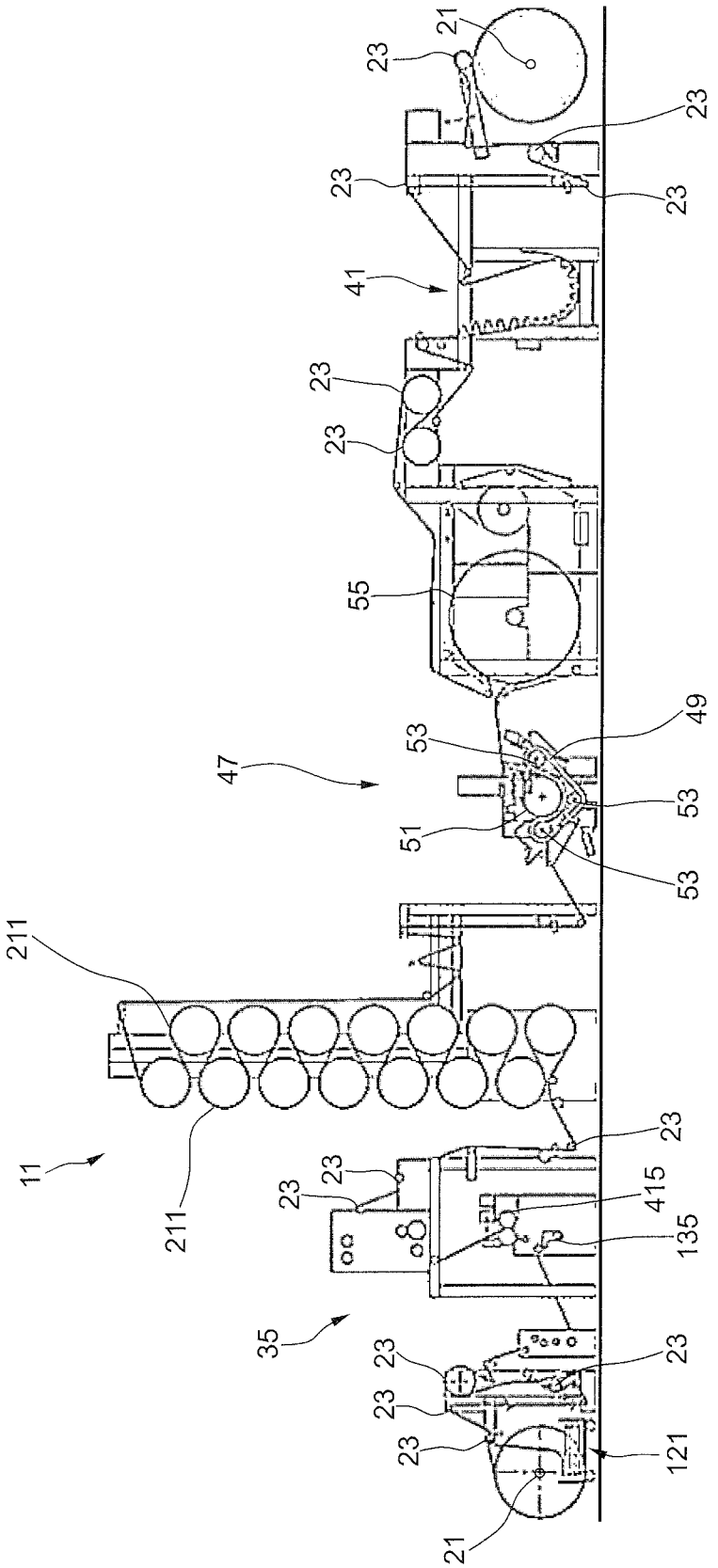
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Fig. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/051594

A. CLASSIFICATION OF SUBJECT MATTER
INV. D06P1/00 D06P1/22 D06P1/52 D06P1/673 D06P1/54
D06P3/52 D06P3/04 D06P3/82 D06P5/13 D06P5/22
D06P5/20 D06M16/00 D06N3/00 D06N3/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D06P D06N D06M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 815 190 B1 (ABO MASANOBU [JP] ET AL) 9 November 2004 (2004-11-09)	1,6-11, 14-18, 21, 30-33, 35, 41-47, 49-51, 53-57, 59,91, 92,94
Y	column 1, lines 24-31; examples 7,13	12,13, 28,29, 34,56
A		2-5,22, 36-38,95

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 November 2018	29/11/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Menard, Claire

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Week 201675 Thomson Scientific, London, GB; AN 2016-43493S XP002784988, & CN 105 735 014 A (TAICANG JINDA PRINTING & DYEING CO LTD) 6 July 2016 (2016-07-06)	1,6-11, 15-19, 21,27, 35, 41-47, 49-51, 53-57, 59,91, 92,94
Y	abstract	12,13, 23-25, 28,34,56
A		2-5,22, 36-38,95

X	US 2002/007518 A1 (KELLIS JAMES T [US] ET AL) 24 January 2002 (2002-01-24)	1,6-11, 14-21, 26,35, 41-47, 49-51, 53-57, 59,91, 92,94
Y	paragraphs [0003], [0106]; example 2; table 1	12,13, 28,34,56
A		2-5,22, 36-38,95

X	US 2004/064898 A1 (BARTL HEIKE [DE] ET AL) 8 April 2004 (2004-04-08)	67-72, 74-91,94
Y	paragraphs [0002], [0008] - [0012]; example 3	12,13, 29,56

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Y	abstract	28,34,56

A	DATABASE WPI Week 201708 Thomson Scientific, London, GB; AN 2016-63683J XP002784990, & CN 105 962 499 A (ANHUI YAYUAN PRINTING & DYEING CO LTD) 28 September 2016 (2016-09-28) abstract	1

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Y	column 1, lines 5-15; example 1	12,13

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/009021 A1 (SCHOOTS HARRIE P [US] ET AL) 13 January 2011 (2011-01-13) paragraphs [0009] - [0010], [0012], [0063] - [0064], [0074] - [0215] -----	1,3-11, 22,25, 27,28, 30-39, 50,54, 55,57, 59,69, 84,89-95

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2018/051594

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 13, 58-90(completely); 1-12, 14-38, 41-47, 49-51, 53-57, 91-95(partially)

   concept of pretreating the synthetic fibers with an aqueous system comprising a lipase

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2. claims: 48(completely); 1-12, 14-38, 41-47, 49-51, 53-57, 91-95(partially)

   concept of pretreating the synthetic fibers with an aqueous system comprising nano-sized polyurethane particles, at least one crosslinking agent and at least one wetting agent.

   ---

3. claims: 39, 40, 52(completely); 1-12, 14-38, 41-47, 49-51, 53-57, 91-95(partially)

   concept of pretreating the synthetic fibers with an aqueous system comprising at least one base

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/051594

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