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(54) Bulletproof woven fabric.

(57) The invention relates to bulletproof woven fabrics composed of filaments or yarns having high strengths and high moduli and consisting of polymers having ultrahigh molecular weights, the warp filaments or yarns consisting of other polymers than the weft filaments or yarns. By virtue of this arrangement the mutual friction of the warp and weft filaments is increased, so that impacting projectiles are no longer capable of moving these filaments aside as is the case, for example, with existing bulletproof fabrics made of polyolefin warp and weft filaments.

EP 0 310 199 A1

Bulletproof Woven Fabric

Bulletproof woven fabrics composed of filaments and yarns which are made of polymers of ultrahigh molecular weights and which have high strengths and moduli are known.

For instance, US Patent 4,181,768 describes bulletproof woven fabrics whose warp and weft filaments consist of polyaramid filaments or yarns. The disadvantage of these fabrics is that they are relatively heavy, owing to the high specific weight of the polyaramids, and that in addition the antiballistic properties are substantially reduced by the action of moisture.

EP 89,537 discloses bulletproof woven fabrics where the warp and weft filaments consist of polyolefin fibers having ultrahigh molecular weights of more than 500,000 g/mol. These fabrics have the disadvantage that, owing to the very smooth surface of the polyolefin filaments, these filaments are easily moved aside in the fabric on penetration of a bullet, so that more layers are required to arrest impacting bullets.

It is an object of the present invention to remove the prior art disadvantages by providing bulletproof woven fabrics of the above-described generic category which, on the one hand, are lightweight and whose filaments or yarns, on the other hand, are only difficultly movable by impacting projectiles, so that said fabrics can be produced in lower layer thicknesses than the structures disclosed in EP 89,537.

This object is achieved by means of the bulletproof woven fabrics according to the invention, which are composed of filaments or yarns having high strengths and high moduli and consisting of polymers of ultrahigh molecular weights, wherein the warp filaments or yarns consist of other polymers than the weft filaments or yarns.

The invention is based on the surprising finding that, if the warp filaments or yarns of bulletproof woven fabrics are made of other polymers than the weft filaments or yarns, the mutual gliding action of the filaments or yarns is substantially reduced, so that an impacting projectile is no longer capable, as in the case of existing woven fabrics whose warp and weft filaments or yarns consist of the same polymers, of moving apart these filaments or yarns. Accordingly, the woven fabrics according to the invention can be produced in lower thicknesses than those disclosed in EP 89,537.

Preferably, the weft filaments or yarns of the woven fabrics according to the invention consist of polyethylenes, in particular linear polyethylenes, of ultrahigh molecular weight of in particular more than 600,000 g/mol (weight average of the molecular weight). These polyethylenes may contain minor amounts, preferably not more than 5 mol %, of one or more other alkenes copolymerizable therewith, such as propylenes, butylenes, pentene, hexene, 4-methylpentene, octene etc. In addition they can preferably contain 1 to 10, in particular 2 to 6, methyl or ethyl groups per 1,000 carbon atoms. However, it is also possible to use other polyolefins, for example, polypropylene homopolymers and copolymers, which polyolefins may also contain minor amounts of one or more other polymers, in particular alkene-1, polymers.

However, the weft filaments can consist of still other polymers, for example polyvinyl alcohols having such high molecular weights that the filaments or yarns produced therefrom have high strengths and moduli as conventionally required for producing bulletproof fabrics. Also suitable are, for example, copolymers of polyvinyl alcohol and ethylene which have a low ethylene content.

The ultrahigh molecular weight filaments used in each case are preferably produced by the gel process, which comprises essentially dissolving the particular polymer in a solvent, then molding the solution into a filament at a temperature above the dissolving temperature of the polymer, cooling the filament, to effect gelling, down to a temperature below the dissolving temperature and then drawing the gel filament with solvent removal, preferably to high draw ratios of more than 20, in particular more than 30. Such a process is described for example in GB-A-2,042,414 and -2,051,667 and also in DE Offenlegungsschrift 3,724,434.

The weft filaments preferably have a low linear density, in particular less than 700 d, particularly preferably less than 500 d.

It has also proved highly advantageous to use in the production of the bulletproof woven fabrics according to the invention weft yarns which are produced from very thin highly oriented monofilaments and preferably have deniers of less than 4, in particular less than 2, made preferably of polyethylenes having ultrahigh molecular weights of more than 600,000 g/mol (weight average of the molecular weight).

Preferably, the bulletproof woven fabrics according to the invention consist of warp filaments and/or yarns having lower moduli and higher elongations than the weft filaments and/or yarns. This embodiment is particularly advantageous insofar as it is easier to produce a woven fabric which has elastic warp filaments. Furthermore, it is advantageous for ballistic purposes if the stiffness of bulletproof fabrics is the same not only in the warp but also in the weft direction. Normally, however, the

stiffness in the warp direction is higher. By using warp filaments and/or yarns which have a lower modulus and a higher elongation than the weft filaments and/or yarns it is possible to keep the stiffness substantially the same both in the warp and in the weft direction.

The warp and weft filaments or yarns of which the bulletproof fabrics according to the invention are made can be subjected for improved antigliding properties to a gentle surface treatment which does not affect the strength and modulus values, for example to a plasma treatment as described in European patent application filed with the European Patent Office under file reference 5410 on the same date as the present application. Other possibilities for this pretreatment include corona treatment or any of the existing mechanical and/or chemical methods for improving the antigliding properties, provided the strength and modulus values are not reduced thereby. Even coating the filaments with known antigliding agents is possible. Furthermore, the antigliding properties of the warp and weft filaments or yarns can be improved by core spinning these filaments and yarns with filaments and/or yarns having high coefficients of friction and hence a rough surface.

Claims

1. A bulletproof woven fabric composed of filaments or yarns having high strengths and high moduli and consisting of polymers having ultrahigh molecular weights, wherein the warp filaments or yarns consist of other polymers than the weft filaments or yarns.

2. A bulletproof woven fabric as claimed in claim 1, wherein the weft filaments or yarns consist of polyethylene, in particular linear polyethylene.

3. A bulletproof woven fabric as claimed in either of claims 1 and 2, wherein the weft filaments have a low linear density, in particular less than 700 d.

4. A bulletproof woven fabric as claimed in any of claims 1 to 3, wherein the warp filaments or yarns consist of polyamides, in particular aramids.

5. A bulletproof woven fabric as claimed in either of claims 1 and 4, wherein the warp filaments or yarns have lower moduli and higher elongations than the weft filaments and yarns.

6. A bulletproof woven fabric as claimed in any of claims 1 to 5, which has weft yarns which are produced from very thin, highly oriented monofilaments and have in particular deniers of less than 4 and have been produced in particular from polyethylenes of ultrahigh molecular weights of more than 600,000 g/mol (weight average of molecular weight).

European Patent Office

EUROPEAN SEARCH REPORT

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 88202159.5

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A,D	US - A - 4 181 768 (SEVERIN) * Totality * --	1	D 03 D 15/00 F 41 H 1/02
A,D	EP - A1 - 0 089 537 (ALLIED CORP.) * Totality * --	1	
A	EP - A2 - 0 082 495 (INTERGLAS) * Totality * --	1	
A	EP - A1 - 0 048 332 (PETER-BTR GUMMI-WERKE AG) * Lines 4,5; abstract * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

D 03 D 1/00
D 03 D 15/00
D 03 D 25/00
F 41 H 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	22-11-1988	BAUMANN

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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