does not show the disadvantages of the prior art filter elements. It is an aim of the present invention to provide a filter element which tolerates without any problems the upward viscous drag from the non-filtered liquid onto its membrane layers.

[0023] In addition, it is an aim to provide such filter elements which are easy to manufacture and economical. It is therefore also an aim of the invention to provide a method of producing such filter elements.

[0024] According to the present invention, there is therefore provided a filtration element of the flat or planar type as set out in the appended claims. Planar filtration elements according to the ~~invention~~ disclosure comprise a planar support structure and at least one filtration layer made of an advantageously polymeric membrane material. The planar support structure comprises first and second opposite outer surface layers, which are spaced apart and secured to each other by spacing members extending between the first and second outer surface layers. The spacing members are arranged at a multitude of points distributed throughout the support structure. Between said first and second outer surface layers is thus defined a drainage compartment, which is configured to drain filtrate.

[0025] At least one of said first and second outer surface layers comprises through-openings distributed throughout the outer surface layers. The through-openings are in fluid connection with the drainage compartment. However, as an advantage, the through-openings do not have internal connections between one another within the outer surface layer. As an advantage, the at least one outer surface layer, when one disregards the through-openings, is formed of a material extending continuously throughout the outer surface layer.

[0026] The at least one filtration layer covers the at least one outer surface layer, including the through-openings. According to an ~~aspect of the invention~~embodiment, the membrane material of the filtration layer penetrates the through-openings, thus forming protuberances towards the drainage compartment. As an advantage, the protuberances have sizes larger than sizes of the through-openings, thus forming undercut-type anchors. Such anchors provide strong anchoring of the filtration layer to the support structure.

[0027] According to another ~~aspect of the present invention~~embodiment, there is provided a method of producing filtration elements of the above type as set out in the appended claims. Disclosed ~~M~~methods ~~of the invention~~ comprise providing a planar support structure comprising first and second opposite outer surface layers. The first and second opposite outer surface layers are spaced apart and secured to each other by spacing members extending between the first and second outer surface layers. The spacing members are arranged at a multitude of points distributed throughout the support structure. Between said first and second outer surface layers is thus defined a drainage compartment. As an advantage, the outer surface layers are formed of a material extending continuously throughout the outer surface layers.

[0028] In disclosed methods ~~according to the invention~~, at least one of said first and second outer surface layers, and possibly both, is provided with through-openings disposed at a multitude of points distributed throughout the layer. The through-openings are in fluid connection with the drainage compartment. However, as an advantage, the through-openings do not have internal connections between one another within the outer surface layer.

[0029] In a next step of methods disclosed herein ~~according to the invention~~, said at least one outer surface layer is coated with a membrane forming liquid solution to obtain a coated support structure. The solution is coated/applied on top of the at least one outer surface layer and penetrates the through-openings. At least one membrane forming step is subsequently applied to the coated support structure to obtain a filtration layer from the coated solution. The filtration layer is composed of an advantageously polymeric membrane material and covers the at least one outer surface layer. In addition, the membrane forming step also affects the solution which penetrated the through-openings, which forms protuberances of membrane material projecting from the filtration layer towards the drainage compartment, through the through-openings. The protuberances have sizes larger than sizes of the through-openings thus forming undercut-type anchors, which anchor the filtration layer to the support structure.

[0030] Additional advantageous aspects are set out in the dependent claims.

In one aspect, there is provided a planar filtration element, comprising a rigid planar support structure and at least one filtration layer made of a membrane material, wherein the planar support structure comprises first and second opposite outer surface layers spaced apart and secured to each other at a multitude of points distributed throughout the support structure by spacing members extending between the first and second outer surface layers, thus defining a drainage compartment between said first and second outer surface layers, which is configured to drain filtrate, wherein at least one of said first and second outer surface layers comprises through-openings in fluid connection with the drainage compartment, wherein the through-openings are distributed throughout the outer surface layers and do not have internal connections between one another within the outer surface layer, wherein said at least one outer surface layer, when one disregards the through-openings, is formed of a material extending continuously throughout the outer surface layer, and wherein the at least one filtration layer covers the at least one outer surface layer including the through-openings, characterised in that the membrane material of the filtration layer penetrates the through-openings, thus forming protuberances towards the drainage compartment, the protuberances having sizes larger than sizes of the through-openings, thus forming undercut-type anchors for anchoring the filtration layer to the support structure.

In another aspect, there is provided a filtration device comprising a plurality of vertically arranged filtration elements as disclosed herein.

In still another aspect, there is provided a method of producing a planar filtration element, comprising: providing a rigid planar support structure comprising first and second opposite outer surface layers formed of a material extending continuously throughout the outer surface layers, the outer surface layers being spaced apart and secured to each other at a multitude of points distributed throughout the support structure by spacing members to define a drainage compartment interposed between the first and second outer surface layers, providing at least one of said first and second outer surface layers at a multitude of points distributed throughout the layer with through-openings in fluid

connection with the drainage compartment and not having internal connections between one another within the outer surface layer, coating said at least one outer surface layer with a membrane forming liquid solution to obtain a coated support structure and such that the solution penetrates the through-openings, and applying at least one membrane forming step to the coated support structure to obtain, from the coated solution, a filtration layer composed of a membrane material, covering the at least one outer surface layer, and protuberances of membrane material projecting from the filtration layer through the through-openings and having sizes larger than sizes of the through-openings thus forming undercut-type anchors for anchoring the filtration layer to the support structure.

In still another aspect, there is provided the use of a planar filtration element as disclosed herein in a filtration device wherein the planar filtration element is subjected to a backwash cycle at a pressure of at least 1.4 bar, preferably at least 5 bar.

CLAIMS

1. Planar filtration element (10, 60), comprising a rigid planar support structure (11, 61) and at least one filtration layer (12, 13, 52, 62) made of a membrane material,

wherein the planar support structure comprises first and second opposite outer surface layers (111, 112) spaced apart and secured to each other at a multitude of points distributed throughout the support structure by spacing members (113) extending between the first and second outer surface layers, thus defining a drainage compartment (14) between said first and second outer surface layers (111, 112), which is configured to drain filtrate, wherein at least one of said first and second outer surface layers comprises through-openings (115) in fluid connection with the drainage compartment (114), wherein the through-openings are distributed throughout the outer surface layers and do not have internal connections between one another within the outer surface layer,

wherein said at least one outer surface layer (111, 112), when one disregards the through-openings (115, 515, 615), is formed of a material extending continuously throughout the outer surface layer,

and wherein the at least one filtration layer (12, 13, 52, 62) covers the at least one outer surface layer (111, 112) including the through-openings (115, 515, 615),

characterised in that the membrane material of the filtration layer (12, 13, 52, 62) penetrates the through-openings, thus forming protuberances (122, 521, 622) towards the drainage compartment, the protuberances having sizes larger than sizes of the through-openings (115, 515, 615), thus forming undercut-type anchors for anchoring the filtration layer to the support structure.

2. Filtration element (10, 60) of claim 1, wherein both the first and the second outer surface layers (111, 112) comprise through-openings (115, 515, 615) and both are covered with filtration layers (12, 13, 52, 62) with the membrane material penetrating the through-openings thus forming the protuberances with undercut-type anchors.

3. Filtration element (10, 60) of claim 1 or 2, wherein the at least one outer surface layer and the filtration layer exhibit a substantially flat interface extending between the through-openings.

4. Filtration element (10, 60) of claim 1 or 2, wherein the support structure (11, 61) has a flexural modulus of at least 150 MPa, preferably at least 250 MPa.

5. Filtration element (10, 60) of any one preceding claim, wherein the through-openings (115, 615) are perforations.

6. Filtration element (10, 60) of any one preceding claim, wherein the area of the through-openings (115, 515, 615) per unit total surface area of the at least one outer surface layer falls in the range between 2% and 70%, preferably between 2% and 50%.

7. Filtration element (10, 60) of any one preceding claim, wherein the through-openings (115, 515, 615) have a size between 0.1 mm and 2 mm, preferably between 0.2 mm and 1.5 mm.

8. Filtration element (10, 60) of any one preceding claim, wherein the protuberances comprise stems (121) through the through-openings (115, 615) and projecting heads (122, 622) extending beyond the through-openings towards the drainage compartment, the heads engaging with the support structure.

9. Filtration element (10, 60) of claim 8, wherein the size of the projecting heads (122, 622) is larger than the size of corresponding through-openings (115, 615).

10. Filtration element (60) of any one preceding claim, wherein the at least one outer surface layer is formed of a superposition of an outer foil (618) and an inner layer (611), wherein the outer foil (618) is bonded to the inner layer (611) and both the foil and the inner layer comprise corresponding through-openings (615), the through-openings of the outer foil (618) being smaller than corresponding ones of the inner layer (611), and wherein the protuberances (622) are at least anchored to the outer foil (618).

11. Filtration element (10, 60) of any one preceding claim, wherein the drainage compartment comprises liquid passageways (114) at least partially void of membrane material.

12. Filtration element (10, 60) of any one preceding claim, wherein the first and/or second outer surface layer is void of through-openings (115) along a peripheral border (151-154), and wherein the filtration layer (12) is additionally

bonded to the corresponding outer surface layer at said border to provide sealing between non-filtered and filtered liquids.

13. Filtration element (10, 60) of any one preceding claim, wherein the filtration layer (12, 13, 52, 62) has a thickness falling in the range between 25 µm and 500 µm.

14. Filtration element (10, 60) of any one preceding claim, wherein the support structure has a thickness falling in the range between 2 mm and 50 mm.

15. Filtration element (10, 60) of any one preceding claim, wherein a size of the through-openings (115, 515, 615), an area of the through-openings per unit area of the at least one outer surface layer, a membrane material, and a size of the protuberances are selected to obtain an anchorage between outer surface layer and filtration layer resisting a back pressure of at least 1.4 bar, preferably at least 5 bar.

16. Filtration device comprising a plurality of vertically arranged filtration elements according to any one preceding claim.

17. Method of producing a planar filtration element (10, 60), comprising:

- providing a rigid planar support structure (11, 61) comprising first and second opposite outer surface layers (111, 112, 511, 611, 618) formed of a material extending continuously throughout the outer surface layers, the outer surface layers being spaced apart and secured to each other at a multitude of points distributed throughout the support structure by spacing members (113) to define a drainage compartment (114) interposed between the first and second outer surface layers (111, 112),
- providing at least one of said first and second outer surface layers at a multitude of points distributed throughout the layer with through-openings in fluid connection with the drainage compartment (114) and not having internal connections (115, 515, 615) between one another within the outer surface layer,
- coating said at least one outer surface layer with a membrane forming liquid solution to obtain a coated support structure and such that the solution penetrates the through-openings (115, 515, 615), and
- applying at least one membrane forming step to the coated support structure to obtain, from the coated solution, a filtration layer (12, 13, 52, 62) composed of a membrane material, covering the at least one outer surface layer, and protuberances (122, 521, 622) of membrane material projecting from the filtration layer

through the through-openings and having sizes larger than sizes of the through-openings thus forming undercut-type anchors for anchoring the filtration layer to the support structure.

18. Method of claim 17, wherein the protuberances extend beyond the through-openings towards the drainage compartment.

19. Method of claim 17 or 18, wherein the through-openings are selected such that their size falls in the range between 0.1 mm and 2 mm and such that the area of the through-openings per unit total surface area of the at least one outer surface layer falls in the range between 2% and 70%

20. Use of a planar filtration element of any one claim 1 to 15 in a filtration device wherein the planar filtration element is subjected to a backwash cycle at a pressure of at least 1.4 bar, preferably at least 5 bar.