

LOW PROFILE FILTER DEVICES SUITABLE FOR USE IN NEGATIVE PRESSURE WOUND THERAPY SYSTEMS

BACKGROUND

[0001] Fluid filters in various medical applications suffer from various limitations, some of which relate to resistance of fluid flow caused by the filter. For example, in fluid systems in which large volumes of fluid are passed through a filter, the rate at which the fluid passes through the filter is limited by several factors, such as, for example, the physical properties of the filter material, the physical properties of the fluid and the surface area of the filter that is available for passage of the fluid therethrough. These and other limitations can cause a build-up of pressure at the filter site and can cause unacceptable levels of fluid backup due to the flow rate characteristics of the filter.

[0002] In regards to a filter that is designed to for use in the filtering of a fluid flowing through a conduit, such as a catheter, a syringe, rubber tubing and the like, such a filter is conventionally provided in the form of a device that is fluidly connected to the conduit, also referred to herein as a “filter adaptor,” which situates a filter within the fluid flow path in an orientation perpendicular to the direction in which the fluid flows. A conventional way to improve flow of fluid through such a filter is to increase the surface area of the filter by increasing the diameter of the filter, thereby increasing the surface area of the filter that is operable to permit passage of the fluid being filtered. Increasing the diameter of a filter and/or a filter adaptor, however, creates problems in many applications of such filters. For example, when a filter adaptor is used in connection with fluid flow tubing of a fluid system that requires tubing to lie in contact with a patient’s skin or in which the adaptor is to be positioned on tubing between a wound dressing and a pump, as would occur in a negative pressure wound therapy system, the increased diameter of a filter adaptor is undesirable because the filter adaptor can become unwieldy, causing pressure damage to the patient’s skin or other tissues away from the wound site and/or become entangled with the patient’s clothing, which could cause damage to clothing and/or possibly disturb the wound. This can not only cause pain to the patient, but in the case of negative pressure wound therapy, can dislodge a dressing or otherwise cause a reduction in vacuum under the dressing.

[0003] In view of the above, there is a need for fluid filter systems that have a low profile and filter adaptors that are sufficiently compact to minimize impact to a patient while also filtering a

flow of fluid at an acceptable rate while minimizing pressure drop across the filter. The present disclosure addresses these needs.

SUMMARY

[0004] The present disclosure provides low profile filter devices suitable for use in negative pressure wound therapy systems and in other systems in which fluid filtering is desired. In one aspect of the disclosure, there is provided a filter adaptor that includes (i) a body that defines an internal passageway disposed between an inlet and an outlet, the passageway configured to permit passage of a fluid in a first direction defined by the inlet and the outlet; and (ii) a filter disposed within the passageway and oriented to define a volumetric direction that is different than the first direction. In some embodiments, the volumetric direction is perpendicular to the first direction. In some embodiments, the volumetric direction and the first direction are offset by an angle of at least 15°.

[0005] In some embodiments, the filter adaptor has a tubular shape and has an outside diameter, and the filter has a surface area that is independent of the outside diameter. In some embodiments, the outside diameter is from about 3 mm to about 15 mm.

[0006] In some embodiments, the filter is cylindrical. In some embodiments, the filter is planar. In some embodiments, the filter lies on a plane that is not perpendicular to the first direction. In some embodiments, the filter lies on a plane that forms an angle with the first direction, and wherein the angle is less than 45°. In some embodiments, the filter comprises gas permeable material. In some embodiments, the filter comprises liquid impermeable material. In some embodiments, the filter is gas permeable and liquid impermeable. In some embodiments, the filter is hydrophobic.

[0007] In some embodiments, the body includes a first connector at the inlet and a second connector at the outlet. In some embodiments, each of the first connector and the second connector comprises a barb, hose, or luer connector. In some embodiments, the filter adaptor further comprises an indicator positioned within the internal passageway. In some embodiments, the indicator detects blockage or detects a need for a dressing change. In some embodiments, the indicator sensor comprises symbols, letters, numbers, or a color change.

[0008] In another aspect of the disclosure, there is provided a filter adaptor that includes (i) a body that defines an internal passageway disposed between an inlet and an outlet, and (ii) a filter disposed within the passageway, wherein the filter comprises a gelling absorbent material that, when in a dry state, is permeable to gas and that, when contacted by an aqueous fluid, converts to a gel. In

some embodiments, the gelling absorbent material comprises a gel-forming fiber. In some embodiments, the gelling absorbent material comprises a compressed gel-forming fiber. In some embodiments, the compressed gel-forming fiber has a density of from about 10 to about 70kg/cm³. In some embodiments, the internal passageway comprises a spiral path.

[0009] Further features, characteristics and embodiments of the present disclosure will be apparent from the detailed description herein.

INCORPORATION BY REFERENCE

[0010] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0011] **Fig. 1** shows a side elevation view of one filter adaptor embodiment in accordance with the disclosure.
- [0012] **Fig. 2** is a cross-sectional view of the filter adaptor embodiment shown in **Fig. 1**.
- [0013] **Fig. 3** is a perspective view of the main body of the filter adaptor embodiment shown in **Fig. 1**.
- [0014] **Fig. 4** is a cross-sectional view of the main body of the filter adaptor embodiment shown in **Fig. 1**.
- [0015] **Fig. 5** is a perspective view of the main body and the filter of the filter adaptor embodiment shown in **Fig. 1**.
- [0016] **Fig. 6** is a cross-sectional view of the filter of the filter adaptor embodiment shown in **Fig. 1**.
- [0017] **Fig. 7** is a perspective view of the main body, the filter and the indicator of the filter adaptor embodiment shown in **Fig. 1**.
- [0018] **Fig. 8** is a cross-sectional view of the indicator of the filter adaptor embodiment shown in **Fig. 1**.
- [0019] **Fig. 9** is a cross-sectional view of the housing of the filter adaptor embodiment shown in **Fig. 1**.
- [0020] **Fig. 10** is a perspective view of the filter adaptor embodiment shown in **Fig. 1**.
- [0021] **Fig. 11** shows the filter adaptor embodiment of **Fig. 1** connected to a wound dressing.
- [0022] **Fig. 12** is a perspective view of another filter adaptor embodiment according to the present disclosure inside a tube.
- [0023] **Fig. 13** is a perspective view of the filter adaptor embodiment shown in **Fig. 12**.
- [0024] **Fig. 14** is a cross-sectional view of the filter adaptor embodiment shown in **Fig. 12** inside a tube.
- [0025] **Fig. 15** is a perspective view of another filter adaptor embodiment according to the present disclosure.
- [0026] **Fig. 16** is a cross-sectional view of the filter adaptor embodiment shown in **Fig. 15** with an exploded view of the filter.

[0027] **Fig. 17** is a schematic view of another filter adaptor embodiment according to the present disclosure.

[0028] **Fig. 18** is a top plan view of another filter adaptor embodiment according to the present disclosure.

[0029] **Fig. 19** is an exploded view of the filter adaptor embodiment shown in **Fig. 18**

[0030] **Fig. 20** shows the filter adaptor embodiment of **Fig. 18** connected to a wound dressing.

[0031] It should be understood that the drawings are not necessarily to scale and that the disclosed embodiments are sometimes illustrated diagrammatically and in partial views. In certain instances, details which are not necessary for an understanding of the disclosed methods and devices or which render other details difficult to perceive may have been omitted. It should be further understood that this disclosure is not limited to the particular embodiments illustrated herein.

DESCRIPTION

[0032] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments described herein and illustrated in the Figures and specific language will be used to describe the same. The embodiments of the present application described below are not intended to be exhaustive or to limit the teachings of the present application to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may appreciate and understand the principles and practices of the present application. It will therefore be understood that no limitation of the scope of the invention is intended by the description of specific embodiments. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates.

[0033] Described herein are compact filter devices for use with medical equipment, including wound dressings and other negative pressure wound therapy equipment, which are capable of filtering large volumes of fluid. While the specific embodiments described herein are configured as filter adaptors that can be connected to, or positioned within, a fluid conduit, it is to be understood that this disclosure also contemplates that the filter devices alternatively can be constructed as a part of a fluid conduit or other device that defines a fluid flow path as a unitary construct. As a corollary, while various filter adaptor embodiments described herein include structures for engaging the filter adaptors to a conduit, such as luer connectors, barb fittings and connectors of various other types, it is to be understood that embodiments in which filter devices that are constructed as an integral part of a fluid conduit or other device that defines a fluid flow path would omit such connectors.

[0034] In various filter adaptor embodiments and method and process embodiments disclosed herein, filtering capacity of filter adaptors having generally tubular design under a given set of conditions, such as, for example, pressure, flow volume and the like, can be increased by increasing the tube length, which correspondingly increases the operational surface area of the filter, without changing the diameter of the filter adaptor. In other embodiments, adaptor filters having features as described herein can have other elongated shapes without departing from the principles of the disclosure, such as elongated shapes having outer cross-sectional shapes that are elliptical, square, triangular, circular or rectangular.

[0035] Throughout this disclosure, various quantities, such as amounts, sizes, dimensions, proportions and the like, are presented in a range format. It should be understood that the description of a quantity in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of any embodiments. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range unless the context clearly dictates otherwise. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6, from 1.2 to 5.2, from 1.25 to 5.25 etc., as well as individual values within that range, for example, 1.1, 2, 2.3, 2.33, 2.35, 5, and 5.9. This applies regardless of the breadth of the range. The upper and lower limits of these intervening ranges may independently be included in the smaller ranges, and are also encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the disclosure, unless the context clearly dictates otherwise.

[0036] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of any embodiment. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “includes,” “comprises,” “including” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0037] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section

discussed herein could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0038] As used herein, ranges and amounts can be expressed as “about” a particular value or range. About also includes the exact amount. For example, “about 5 μL ” means “about 5 μL ” and also “5 μL .” Generally, the term “about” includes an amount that would be expected to be within experimental error. The term “about” includes values that are within 10% less to 10% greater of the value provided. For example, “about 50%” means “between 45% and 55%.” Also, by way of example, “about 30” means “between 27 and 33.”

[0039] Described herein, in certain embodiments, are filter adaptors for filtering unwanted particulates during various uses including in conjunction with negative pressure wound therapy and syringes. In some embodiments, filter adaptors are provided that have generally tubular design. In some embodiments, filter adaptors are provided that are configured for in-line connection to two fluid conduits or two separated portions of a fluid conduit. In other embodiments, filter adaptors having generally tubular design are provided that are sized to be positioned inside a fluid conduit. Filter adaptors having generally tubular design according to various embodiments described herein are characterized by having a ratio of outside diameter to filter surface area that is lower than conventional filter adaptors, and which have designs that can be readily modified to provide filter adaptors having increased filter surface areas by increasing the length of a filter adaptor without increasing the overall diameter of the design. As will be understood by a person skilled in the art, increased filter surface area enables filtering of larger fluid volumes and/or filtering fluids at a greater volumetric rate and/or reduced pressure drop across the filter compared to a filter having a lower surface area.

[0040] In one aspect of the disclosure, a filter adaptor defines an internal fluid passageway, includes a first connector situated at a first end of the filter adaptor configured for connection to a first conduit for fluid delivery into the fluid passageway and a second connector situated at a second end of the filter adaptor configured for connection to a second conduit for fluid flow out of the fluid passageway, wherein the overall flow of fluid is generally in a first direction extending from the first connector to the second connector. In some examples in which the filter adaptor is a generally tubular filter adaptor, the first direction is generally parallel to a longitudinal axis of the filter adaptor. The filter adaptor also includes a filter disposed within the passageway such that all fluid

flowing through the passageway passes through the filter, and such that fluid passes through the filter in a volumetric direction that is different from the first direction. As used herein, the term “volumetric direction” is used to refer to a direction that a volume of fluid moves as it crosses a filter, and is generally perpendicular to the filter surface at a given point on the filter. In some embodiments, the volumetric direction is not parallel to the first direction. In other embodiments, the volumetric direction is perpendicular to the first direction. In yet other embodiments, the volumetric direction forms a non-zero angle relative to the first direction, which is referred to herein as an “offset angle.” In some embodiments, the offset angle is an angle of at least about 15°, an angle of at least 30°, an angle of at least 45°, an angle of at least 60° or an angle of at least 75°. Positioning a filter in such a way within a filter adaptor, which causes a fluid to pass through the filter in a direction different than the general direction of fluid flow through the adaptor, enables design modifications that increase filter surface area without increasing external dimensions, such as a diameter, of such filter adaptors.

[0041] A representative embodiment of a filter adaptor according to this aspect is depicted in **Figs. 1-11**. Filter adaptor **100** includes main body **110** configured for engagement with housing **150** to form a fluid flow path extending from inlet port **162** of housing **150**, positioned at a first end of filter adaptor **100** to outlet port **126** of main body **120**, positioned at a second end of filter adaptor **100**. In some embodiments, connector **120** is configured to connect to a pump unit (not shown) such as one used for negative pressure wound therapy or to a tube (not shown) that is, in turn, connected to a pump unit. In **Fig. 1**, connector **160** is shown connected to a tube **161**. Filter adaptor **100** further includes filter **190**, which, in this embodiment, has a cylindrical shape as more clearly seen in **Figs. 5 and 6** and indicator **195**. Indicator **195** is operable to indicate a state of filter adaptor **100**, such as, for example, an indicator for blockage or a dressing change indicator. In some embodiments, a one way valve (not shown) is located before or after the filter relative to the direction of fluid flow through filter adaptor **100**.

[0042] In some embodiments, the indicator is used as a dressing change indicator or a blockage indicator. In some embodiments, the indicator is a pH level indicator. In some embodiments, the filter adaptor comprises a plurality of indicators. In some embodiments, the filter adaptor comprises a first indicator for dressing change and a second indicator for blockage detection. In some embodiments, one or more stripes are used for the plurality of indicators.

[0043] The indicator for use with filter adaptors as described herein, in some embodiments, is a visual indicator. In some embodiments, the indicator demonstrates a change by a change in appearance of the indicator. For example, the change is a change in color. In some embodiments, the change in color is a color change of a line. In some embodiments, the line is horizontal, vertical, or circular. In some embodiments, the indicator comprises symbols, letters, or numbers for indicating a change.

[0044] In some embodiments, a one-way-valve is formed integrally into a filter adaptor, such as, for example, at a location indicated by box **103**. In other embodiments, a one-way valve is connected as a separate unit to filter adaptor **100**, either directly or by way of an intervening conduit such as a tube, either upstream or downstream of filter adaptor **100** relative to the direction of fluid flow therethrough. The filter adaptors as described herein comprise, in certain embodiments, a valve. In some embodiments, the valve is a one-way valve. In some embodiments, the valve is located before the filter. In some embodiments, the valve is located after the filter. The valve may comprise a check valve cartridge. In some embodiments, the check valve cartridge comprises a hydrocarbon polymer. Representative examples of hydrocarbon polymers include, but are not limited to, polyethylene, polypropylene, polystyrene, derivatives thereof, or combinations thereof. In some embodiments, the check valve cartridge comprises polystyrene. In some embodiments, the valve comprises a check valve disk. In some embodiments, the check valve disk comprises a polysiloxane, also referred to herein as silicone.

[0045] Tubular filter **190**, in some embodiments, comprises a gas permeable material. In some embodiments, the filter is hydrophobic. In some embodiments, the filter is liquid impermeable. In some embodiments, the filter is both gas permeable and liquid impermeable. In some embodiments, the filter comprises material that is gas permeable and liquid permeable. Representative examples of materials include, but are not limited to, polytetrafluoroethylene (PTFE), polypropylene, and polyethylene. In some embodiments, the material is microporous. In some embodiments, the material comprises a pore size of at least or about 0.01 μm , 0.02 μm , 0.03 μm , 0.04 μm , 0.05 μm , 0.1 μm , 0.2 μm , 0.3 μm , 0.4 μm , 0.5 μm , 0.6 μm , 0.7 μm , 0.8 μm , 0.9 μm , 1.0 μm , or more than 1.0 μm . In some embodiments, the material comprises a pore size in a range of about 0.01 μm to about 1.0 μm , about 0.02 μm to about 0.9 μm , about 0.03 μm to about 0.8 μm , about 0.04 μm to

about 0.7 μM , about 0.05 to about 0.6 μM , or about 0.1 μM to about 0.4 μM . In some embodiments, the material comprises a pore size of about 0.2 μM .

[0046] In various embodiments, each of connector **120** and connector **160** may comprise any one of a barb, hose, luer (e.g. male or female) connector or other type of connector as would occur to a person of ordinary skill in the art.

[0047] A cross section of filter adaptor **100** is shown in **Fig. 2**. As shown in **Fig. 2**, and with further reference to **Figs. 3 and 4**, main body **110** of filter adaptor **100** includes connector **120** and shaft **130**. Connector **120** is configured as a luer connector and includes center mounting bore **122**, which defines outlet port **126**, and hub **124** which, in this embodiment, is configured with threading on an inner surface thereof to engage a threaded collar of a male luer fitting, and ribbing on an outer surface thereof to assist a user with gripping connector **120**. Shaft **130** is configured for insertion into a chamber defined in housing **150**, as described further below. Shaft **130** defines passageway **131** that extends from end wall **132**, through shaft **130**, and extends through connector **120** to outlet port **126**. Shaft **130** extends distally beyond end wall **132** a short distance, thereby forming recess **138** to receive flanges **175** of housing **150**, as described further below. Shaft **130** has outer surface **134** that defines grooves **135** and includes holes **136** that provide fluid communication between grooves **135** and passageway **131**. While grooves **135** are shown in this embodiment as being oriented circumferentially around shaft **130**, this disclosure contemplates other orientations for grooves **135** such as, for example, spiral or helical grooves, longitudinal grooves and mesh-cut grooves.

[0048] As shown in **Fig. 1**, and with further reference to **Figs. 5 and 6**, filter adaptor **100** further includes filter **190** configured for placement over, and in contact with outer surface **134** of shaft **130**. In the embodiment shown, filter **190** is cylindrical.

[0049] As shown in **Fig. 2**, and with further reference to **Figs. 9 and 10**, filter adaptor **100** also includes housing **150** that is configured to connect with main body **110** to defined a fluid pathway from inlet port **162** to outlet port **126** of filter adaptor **100**. Housing **150** includes connector **160** defining inlet port **162** and configured to connect with tube **161**. Housing **150** also includes intermediate side wall **170** that defines an intermediate chamber within housing **150** for receiving shaft **130** of main body **110** when housing **150** and main body **110** are connected with one another.

Intermediate side wall **170** is sized such that its inner surface is spaced apart from filter **190** when shaft **130** and filter **190** are positioned therein.

[0050] Housing **150** also includes flanges **175** configured to seat within recess **138** formed in shaft **130** when housing **150** and main body **110** are connected to one another, thereby maintaining shaft **130** centered within the intermediate chamber, which in turn maintains proper spacing to maintain a fluid flow path within filter adaptor **100** as described further below. Aperture **176** is defined between connector **160** and the intermediate chamber between flanges **175**.

[0051] Housing **150** also includes outer side wall **180** that is configured to engage main body **110** and also to provide a fluid collection space **181** between outer side wall **180** and shaft **130** of main body **110**. In the embodiment shown, housing also includes a circumferential collar **185** extending into the fluid collection space and defining a slot for retaining indicator **195** within the fluid collection space, as most clearly seen in **Figs. 1 and 2**. In other embodiments, not shown, collar **185** and indicator **195** are absent.

[0052] With reference again to **Fig. 2**, arrows **199** show the fluid flow path into inlet port **162**, through filter adaptor **100** and out through outlet port **126**. More specifically, arrows **199** show directions of fluid flow in various areas of filter adaptor **100** from inlet port through connector **160**, and through the aperture between connector **160** and the intermediate chamber, where it is redirected in a lateral direction through flanges **175** toward outer surface **134** of shaft **130**. The fluid flow path is then again redirected by intermediate side wall **170** of housing **150** to flow toward the fluid collection space and indicator **195** of this embodiment. Within the intermediate cavity and the fluid collection space, the fluid flow path is again redirected toward passageway **131**, and travels into passageway **131** by passing through filter **190** into grooves **135**, then through holes **136** into passageway **131**, where it is again redirected toward outlet port **126**.

[0053] In the embodiment shown, fluid flow is achieved in the direction of arrows **199** by application of a pressure gradient across filter adaptor **100** that is sufficient to pass the fluid through filter **190**. Pressure may be applied by exerting a positive pressure on the inlet port side of filter adaptor **100** or by applying a negative pressure (i.e., suction) on the outlet port side of filter adaptor **100**. Moreover, due to the construction of filter adaptor **100**, it can be operated equally well with a fluid flow in the opposite direction of that described above, in which case outlet port **126** operates as an inlet port and inlet port **162** operates as an outlet port. When filter adaptor **100** or a variant

thereof is used in this opposite direction, indicator **195** and collar **185** can be omitted. Of course, in an embodiment that omits indicator 195, a user may employ a separate indicator unit by positioning an indicator upstream of the filter adaptor (i.e., between the filter adaptor and the wound dressing, or “pre-filter”).

[0054] As will be appreciated by a person of ordinary skill, an adaptor having features similar to adaptor 100 can be constructed to significantly increase the surface area of filter 190 without increasing the outside diameter of the adaptor by simply increasing the length of adaptor 100 and increasing the length of filter 190. Elongating filter 190 increases the surface area of filter 190 that is available for passage of the fluid without increasing the outer profile of the filter adaptor.

[0055] Another representative embodiment of a filter adaptor according to this aspect of the disclosure is depicted in **Figs. 12-14**. Filter adaptor **200** differs from filter adaptor **100** in that filter adaptor **200** does not include a housing, does not include connectors and is not configured for attachment to conduits as is filter adaptor **100**. Rather filter adaptor **200** is configured to be positioned within a lumen of a conduit to filter a fluid that flows through the conduit. Filter adaptor **200** includes main body **210** configured for frictional engagement with a lumen wall of a conduit in which filter adaptor **200** is inserted.

[0056] Main body **210** of filter adaptor **200** includes seal **220** and shaft **230**. Seal **220** has an outer dimension approximating the lumen dimension of a conduit in which filter adaptor **200** is to be positioned for use and defines outlet port **226**. If desired, seal **220** may include circumferential ribbing on an outer surface thereof (not shown) to assist with frictional engagement of seal **220** to the lumen. Shaft **230** of main body **210** has an outer dimension less than the lumen dimension of a conduit in which filter adaptor **200** is to be positioned for use. Shaft **230** defines passageway **231** that extends from end wall **232**, through shaft **230**, and extends through seal **220** to outlet port **226**. Shaft **230** has outer surface **234** that defines grooves **235** similar to grooves **135** in filter adaptor **100** and includes holes **236** that provide fluid communication between grooves **235** and passageway **231**.

[0057] Filter adaptor **200** further includes filter **290** configured for placement over, and in contact with outer surface **234** of shaft **230**. In the embodiment shown, filter **290** is cylindrical. In one embodiment (not shown), main body **210** also includes flanges **275** extending laterally from distal end **237** of shaft **230**, which operate to hold filter **290** in position relative to shaft **230** and also

to maintain end **237** of shaft **230** centered within the lumen into which filter adaptor is inserted, which in turn maintains proper spacing to maintain a fluid flow path between filter **290** and the wall of the lumen.

[0058] Fluid flow in the lumen is in the direction indicated by arrow **299**. As fluid reaches filter adaptor **200**, it passes between filter **290** and the wall of the lumen toward seal **220**. Within the space between the filter and the lumen wall, the fluid flow path is redirected toward passageway **231**, and travels into passageway **231** by passing through filter **290** into grooves **235**, then through holes **236** into passageway **231**, where it is again redirected toward outlet port **226**.

[0059] In the embodiment shown, fluid flow is achieved in the direction of arrow **299** by application of a pressure gradient across filter adaptor **200** that is sufficient to pass the fluid through filter **290**. Pressure may be applied by exerting a positive pressure on the upstream side of filter adaptor **200** or by applying a negative pressure (i.e., suction) on the downstream side of filter adaptor **200**. Moreover, due to the construction of filter adaptor **200**, it can be operated equally well with a fluid flow in the opposite direction of that described above, in which case outlet port **226** operates as an inlet port, fluid flows into inlet port **226**, through passageway **231**, through holes **236**, into grooves **235**, then through filter **290** before continuing through the lumen in the direction opposite that of arrow **299**.

[0060] As will be appreciated by a person of ordinary skill, an adaptor having features similar to adaptor **200** can be constructed to significantly increase the surface area of filter **190** without increasing the outside diameter of the adaptor by simply increasing the length of shaft **230** and increasing the length of filter **290**. Elongating filter **290** and shaft **230** increases the surface area of filter **290** that is available for passage of the fluid without increasing the outer profile of the filter adaptor.

[0061] Another representative embodiment of a filter adaptor according to this aspect of the disclosure is depicted in **Figs. 15 and 16**. Filter adaptor **300** differs from filter adapter **100** in that filter adaptor **300** does not include a cylindrical filter as used in filter adaptor **100**. Rather filter adaptor **300** includes a generally planar filter block **390**. Filter adaptor **300** includes main body **310** that includes connector **320** defining outlet port **326**, connector **360** defining inlet port **362** and filter retaining brackets **330**, **331** operable to retain planar filter block **390** in a longitudinal position

separating first lateral passageway **332** from second lateral passageway **333**. First lateral passageway **332** opens directly to inlet port **362**. Second lateral passageway **331** opens directly to outlet port **326**.

[0062] Connector **320** is configured as a luer connector and includes center mounting bore **322**, which defines outlet port **326**. Connector **360** defines inlet port **362** and is configured to connect with a tube. With reference to **Fig. 16**, arrows **399** show the fluid flow path into inlet port **362**, through filter adaptor **300** and out through outlet port **326**. More specifically, arrows **399** show directions of fluid flow in various areas of filter adaptor **300** from inlet port **362** through connector **360**, and into first lateral passageway **332**, where it is redirected through filter **390** into second lateral passageway **333**, where it is again redirected toward outlet port **326**.

[0063] In the embodiment shown, fluid flow is achieved in the direction of arrows **399** by application of a pressure gradient across filter adaptor **300** that is sufficient to pass the fluid through filter **390**. Pressure may be applied by exerting a positive pressure on the inlet port side of filter adaptor **300** or by applying a negative pressure (i.e., suction) on the outlet port side of filter adaptor **300**. Moreover, due to the construction of filter adaptor **300**, it can be operated equally well with a fluid flow in the opposite direction of that described above, in which case outlet port **326** operates as an inlet port and inlet port **362** operates as an outlet port.

[0064] As will be appreciated by a person of ordinary skill, an adaptor having features similar to adaptor **300** can be constructed to significantly increase the surface area of filter **390** without increasing the outside diameter of the adaptor by simply increasing the length of adaptor **300** and increasing the length of filter **390**. Elongating filter **390** increases the surface area of filter **390** that is available for passage of the fluid without increasing the outer profile of the filter adaptor.

[0065] In some embodiments, the main body and housing components of filter adaptors **100**, **200** and **300** comprise polymeric material. Representative examples of polymers include, but are not limited to, polyurethanes, ionomers, polycarbonates, polysulphone, acrylic, polyamide, acrylonitrile-butadiene-styrene terpolymer, polyethylene terephthalate, polyoxymethylene, acrylonitrile, styrene acrylonitrile, styrene butadiene rubber, polyetheretherketone, or polyaryletherketone. In some embodiments, the filter adaptors comprise an acrylic polymer. In some embodiments, the filter adaptors comprise acrylonitrile-butadiene-styrene. In some embodiments, the filter adaptors

comprise glass, fused silica, silicone, plastics (for example polytetrafluoroethylene, polypropylene, polystyrene, polycarbonate, polymethylmethacrylate, and blends thereof), or metal. In some embodiments, the filter connector comprises polypropylene, polycarbonate, nylon, or PVDF material.

[0066] In some embodiments, the filter has a surface area of at least or about 10 square millimeters (mm^2), 40 mm^2 , 90 mm^2 , 150 mm^2 , 245 mm^2 , 350 mm^2 , 480 mm^2 , 625 mm^2 , 790 mm^2 , 980 mm^2 or 1960 mm^2 . In some embodiments, the surface area of the filter is in a range of about 10 mm^2 to about 1960 mm^2 , about 40 mm^2 to about 980 mm^2 , or about 90 mm^2 to about 625 mm^2 . In some embodiments, a filter adaptor has a length of at least or about 10 mm, 15 mm, 20 mm, 25 mm, 30 mm, 35 mm, 40 mm, 45 mm or 50 mm. In some embodiments, the length of the filter adaptor is in a range of about 10 mm to about 50 mm, about 15 mm to about 40 mm, or about 20 mm to about 30 mm. In some embodiments, the outer diameter of the filter adaptor is at least or about 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, or 10 mm. In some embodiments the outer diameter of the filter adaptor is in a range of about 3 mm to about 10 mm, about 4 mm to about 9 mm, or about 4 mm to about 8 mm. In some embodiments, an outer diameter of a filter is about 25 mm. In some embodiments, the filter adaptor has a ratio of filter surface area (in mm^2) to outer diameter (in mm) of at least or about 2:1, 5:1, 10:1, 15:1, 20:1, or 25:1. In some embodiments the ratio of surface area (in mm^2) to outer diameter (in mm) is in a range of about 2:1 to about 50:1, about 5:1 to about 25:1, or about 5:1 to about 20:1.

[0067] In another aspect of the disclosure, filter adaptors are provided that include a main body that define an internal fluid passageway, and a filter material comprising a gelling absorbent material contained within the passageway. The gelling absorbent material is capable, when in a dry state, of permitting passage of air, vapor and other gases therethrough upon application of a pressure gradient across the filter adaptor, and of absorbing aqueous fluid, such as exudate from a wound, when contacted thereby. Upon contact with the aqueous fluid, the gelling absorbent material converts to a gel and thereafter blocks passage of air, vapor and other gases through the main body of the filter adaptor. In various embodiments, the gelling absorbent material may be nonwoven, knitted or formed of a tight weave. The gelling absorbent material can expand upon absorption of aqueous fluid such as wound exudate or other fluid produced from a wound site. When the gelling absorbent

material blocks passage of air, vapor and other gases through the main body of the filter adaptor, the blockage causes a pressure drop in the pump, which indicates that a dressing change is needed (i.e., wound exudate has reached the filter adaptor). In some embodiments, the gelling absorbent material also includes an indicator that functions as a blockage indicator or a dressing change indicator. In some embodiments, the indicator comprises symbols, letters, numbers, or color for indicating a change.

[0068] In some embodiments, the gelling absorbent material comprises a gel-forming fiber, filament, or agent. In some embodiments, the gel-forming fiber or filament is chemically-modified cellulose, alginate, or carboxymethyl cellulose, or a combination thereof. In some embodiments, the gel-forming fiber is carboxymethyl cellulose. The gelling absorbent material also can include other absorbent materials such as, for example, polyacrylate, polyacrylate fibers, bi-component superabsorbent fibers, air laid nonwovens, needlefelt nonwovens, thermobonded nonwovens and foams.

[0069] Some formulations of the gelling absorbent material contain an alginate to increase absorption capabilities. The active surface of the absorbent layer can be coated with a cross-linked adhesive mass containing a dispersion of gelatin, pectin and/or carboxymethyl cellulose together with other polymers. The polysaccharides and other polymers, when contacted with an aqueous fluid, absorb water and swell, forming a gel. The gel which is formed as a result of the absorption of water is held in place within the main body of the filter adaptor.

[0070] The gelling absorbent material preferably comprises gel forming fibres. The gel forming fibres can be of the type which retain their structural integrity on absorption of exudate or can be of the type which lose their fibrous form and become a structureless gel. The gel forming fibres are preferably spun sodium carboxymethylcellulose fibres, chemically modified cellulosic fibres, pectin fibres, alginate fibres, chitosan fibres, hyaluronic acid fibres, or other polysaccharide fibres or fibres derived from gums. The gel forming fibres are preferably sodium carboxymethylcellulose fibres, chemically modified cellulosic fibres, alkyl sulphonate modified cellulosic fibres such as those described in WO2012/061225, pectin fibres, alginate fibres, chitosan fibres, hyaluronic acid fibres, or other polysaccharide fibres or fibres derived from gums. The gel forming fibres are preferably chemically modified cellulosic fibres in the form of a fabric and in particular carboxymethylated cellulose fibres as described in PCT WO00/01425 to Azko Nobel UK Ltd. The cellulosic fibres

preferably have a degree of substitution of at least 0.05 carboxymethyl groups per glucose unit. In another embodiment, the cellulosic fibres have a degree of substitution of from about 0.12 to about 0.35 as measured by IR spectroscopy (as defined in WO 00/01425). In another embodiment, the cellulosic fibres have a degree of substitution of from about 0.20 to about 0.30 and are made by carboxymethylating a woven or non-woven cellulosic fabric such that the absorbency is increased. The gel forming fibres preferably have an absorbency of at least 2 grams 0.9% saline solution per gram of fibre (as measured by the free swell method). Preferably the gel forming fibres have an absorbency of at least 10 g/g as measured in the free swell absorbency method, more preferably, between 15 g/g and 25 g/g.

[0071] The gelling absorbent material can be made in accordance with the disclosure of WO 93/12275, which describes the production of various absorbent carboxymethylated cellulosic products that are capable of absorbing many times their own weight of water.

[0072] Carboxymethylation can be achieved, for example, by sequential or simultaneous treatment of the cellulosic material with a strong alkali, such as aqueous sodium hydroxide, and monochloroacetic acid or a salt thereof. The appropriate reaction conditions will depend upon the composition of the fabric and the degree of carboxymethylation required and will be readily apparent to the person skilled in the art. They may be identical or similar to those described in WO 93/12275, WO 94/16746 or WO 00/01425. Desirably the carboxymethylation is carried out in the presence of industrial methylated spirits (IMS), and IMS is preferably also used in a subsequent washing step, suitably along with water, as a cleaner and steriliser.

[0073] In some embodiments, the gelling absorbent material comprises carboxymethylated cellulose fibres formed into a fabric. In other embodiments, the gelling absorbent material comprises two or more layers of fabric comprising carboxymethylated cellulose fibres. In some embodiments, the gelling absorbent material comprises compressed carboxymethylated cellulose. In some embodiments, the compressed carboxymethylated cellulose has a density of from about 10 to about 70kg/cm³. Various degrees of compression, and thus, various densities are envisioned and can be determined based upon the dimensions of a given filter adaptor and the fluid flow rate that is desired for the filter adaptor.

[0074] With reference to the filter adaptor embodiment depicted in **Fig. 17**, filter adaptor **400** includes main body **410** that includes connector **420** defining inlet port **426**, connector **460** defining

outlet port **462** and defines a chamber **411** operable to retain filter **490** comprising gelling absorbent material. Main body **410** also defines apertures **412**, **413** that fluidly connect chamber **411** to inlet port **426** and outlet port **462**, respectively. Arrows **499** show the fluid flow path into inlet port **426**, through filter adaptor **400** and out through outlet port **362**. More specifically, arrows **499** show directions of fluid flow from inlet port **426** through connector **420**, through aperture **412** and into chamber **411**, where it passes through filter **490**, then through aperture **413** into connector **460**, and toward outlet port **462**. In the embodiment shown, fluid flow is achieved in the direction of arrows **499** by application of a pressure gradient across filter adaptor **400** that is sufficient to pass the fluid through filter **490**. Pressure may be applied by exerting a positive pressure on the inlet port side of filter adaptor **400** or by applying a negative pressure (i.e., suction) on the outlet port side of filter adaptor **400**. Moreover, due to the construction of filter adaptor **400**, it can be operated equally well with a fluid flow in the opposite direction of that described above, in which case outlet port **462** operates as an inlet port and inlet port **426** operates as an outlet port. As with other embodiments described herein, first connector **420** is configured for connection to a first conduit for fluid delivery into filter adaptor **400** and second connector **460** is configured for connection to a second conduit for fluid flow out of filter adaptor **400**.

[0075] As will be appreciated by a person of ordinary skill, an adaptor having features similar to adaptor **400** can be constructed to significantly increase the volume of filter **490** without increasing the outside diameter of the adaptor by simply increasing the length of adaptor **400** and increasing the length of filter **490**. Elongating filter **490** increases the volume of filter **490** that is available for passage of the fluid without increasing the outer profile of the filter adaptor.

[0076] In some embodiments, an outer dimension of filter adaptor **100**, which is generally defined by the outer dimensions of hub **124** and outer side wall **180**, filter adaptor **200**, which is generally defined by the outer dimensions of seal **220**, filter adaptor **300**, which is generally defined by the outer dimensions of main body **310**, and/or filter adaptor **400**, which is generally defined by the outer dimensions of main body **410**, is no more than 25 mm. In some embodiments, an outer dimension of the filter adaptor is at least or about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm, 20 mm, 25 mm, or more than 25 mm. In some embodiments, an outer dimension of the filter adaptor is about 11 mm. In some embodiments, a length of the filter adaptor is no more than 30 mm. In some embodiments, a length of the filter

adaptor is at least or about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm, 20 mm, 25 mm, 30 mm, 35 mm, 40 mm, 45 mm, 50 mm, or more than 50 mm. In some embodiments, a length of the filter adaptor is about 25 mm.

[0077] Another filter adaptor embodiment that includes a filter composed of a gelling absorbent material is depicted in **Figs. 18-20**. In filter adaptor **500**, also referred to as spiral filter **500**, chamber **511** that retains gelling absorbent material filter **590** is in the form of a spiral tube defining a spiral flow path. In alternate embodiments, chamber **511** can alternatively be formed into different shapes.

[0078] Filter adaptor **500** can be made, for example, by assembling four components as shown schematically in **Fig. 19**. Bottom layer **520** defines central aperture **522** and includes weld trace **524** to form chamber **511**. Top layer **530** includes weld trace **534** having a shape and position that corresponds to weld trace **524** on bottom layer **520**. Filter material **590** is shaped such that, when bottom layer **520**, filter material **590** and top layer **530** are pressed together, first end **591** of filter material **590** lies adjacent central aperture **522** and filter material **590** extends in an outward spiral pattern between weld traces **524**, **534** to a point where second end **592** of filter material **590** lies adjacent first end **541** of conduit **540**. Filter material **590** can be formed into a desired shape, for example, by die punching the desired shape from a layer of the gelling absorbent material. When bottom layer **520**, fiber material **590**, conduit **540** and top layer **530** are positioned as described, weld traces **524**, **534** are fused to one another by heat sealing or welding, such as, for example, radiofrequency welding or laser welding, to achieve filter adaptor **500** defining chamber **511** formed into spiral path with filter **590** contained therein. In one embodiment, filter adaptor **500** also includes indicator **550** situated adjacent central aperture **522** in the center of the spiral path. In some embodiments, the indicator is a blockage indicator or a dressing change indicator. In some embodiments, the indicator comprises symbols, letters, numbers, or color for indicating a change.

[0079] In some embodiments, filter adaptor **500** is mounted directly on a foam dressing or other negative pressure wound therapy dressing, such as that shown in **Fig. 20**. In this embodiment central aperture **522** is connected to an aperture or port in the cover layer of the dressing (not shown) that opens to the dressing/wound environment such that, upon connecting second end **542** of conduit **540** to a source of negative pressure, such as, for example, a vacuum pump (not shown), the negative

pressure is transmitted through, conduit **540**, through chamber **511** and central aperture **522** to the dressing/wound environment.

[0080] As will be appreciated by a person of ordinary skill, an adaptor having features similar to adaptor **500** can be constructed to significantly increase the volume of filter **590** without increasing the outside diameter of the adaptor by simply increasing the length of filter **590** and, if desired, increasing the number of spirals in filter adaptor **500**. Elongating filter **590** increases the volume of filter **590** that is available for passage of the fluid without increasing the outer profile of the filter adaptor.

[0081] Filter Adaptor Uses

[0082] Filter adaptors as described herein may be used for various applications including negative pressure wound therapy, wound dressing, and syringe filters. In some embodiments, the filter adaptors are used for negative pressure wound therapy. For example, the filter adaptor is connected to a source of negative pressure, such as, for example, a vacuum pump for use in negative pressure wound therapy. In some embodiments, the filter adaptor comprises a tube connected to a dressing or, in some cases, such as, for example, a filter adaptor of the type shown in **Figs. 18-20**, the filter adaptor can be connected directly to a dressing.

[0083] While a number of discrete embodiments have been described, aspects of each embodiment may not be specific to only that embodiment and it is specifically contemplated that features of embodiments may be combined with features of other embodiments. As will be appreciated from the descriptions herein and the associated Figures, a wide variety of aspects and embodiments are contemplated by the present disclosure, examples of which include, without limitation, the aspects and embodiments listed below: A filter adaptor that includes (i) a body that defines an internal passageway disposed between an inlet and an outlet, the passageway configured to permit passage of a fluid in a first direction defined by the inlet and the outlet; and (ii) a filter disposed within the passageway and oriented to define a volumetric direction that is different than the first direction.

[0084] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the volumetric direction is perpendicular to the first direction.

- [0085] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the volumetric direction and the first direction are offset by an angle of at least 15°.
- [0086] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter adaptor has a tubular shape and has an outside diameter, and wherein the filter has a surface area that is independent of the outside diameter.
- [0087] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the outside diameter is from about 3 mm to about 15 mm.
- [0088] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter is cylindrical.
- [0089] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter is planar.
- [0090] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter lies on a plane that is not perpendicular to the first direction.
- [0091] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter lies on a plane that forms an angle with the first direction, and wherein the angle is less than 45°.
- [0092] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the body includes a first connector at the inlet and a second connector at the outlet.
- [0093] A filter adaptor in accordance with any other embodiment disclosed herein, wherein each of the first connector and the second connector comprises a barb, hose, or luer connector.
- [0094] A filter adaptor in accordance with any other embodiment disclosed herein, further comprising an indicator positioned within the internal passageway.
- [0095] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the indicator detects blockage or detects a need for a dressing change.
- [0096] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the indicator sensor comprises symbols, letters, numbers, or a color change.
- [0097] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter comprises gas permeable material.
- [0098] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter comprises liquid impermeable material.

[0099] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter is gas permeable and liquid impermeable.

[00100] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the filter is hydrophobic.

[00101] A filter adaptor that includes (i) a body that defines an internal passageway disposed between an inlet and an outlet, and (ii) a filter disposed within the passageway, wherein the filter comprises a gelling absorbent material that, when in a dry state, is permeable to gas and that, when contacted by an aqueous fluid, converts to a gel.

[00102] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the gelling absorbent material comprises a gel-forming fiber.

[00103] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the gelling absorbent material comprises a compressed gel-forming fiber.

[00104] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the compressed gel-forming fiber has a density of from about 10 to about 70kg/cm³.

[00105] A filter adaptor in accordance with any other embodiment disclosed herein, wherein the internal passageway comprises a spiral path.

[00106] While embodiments of the present disclosure have been shown and described herein, it is to be understood by those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the disclosure. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

CLAIMS

What is claimed is:

1. A filter adaptor, comprising:
a body that defines an internal passageway disposed between an inlet and an outlet, the passageway configured to permit passage of a fluid in a first direction defined by the inlet and the outlet; and
a filter disposed within the passageway and oriented to define a volumetric direction that is different than the first direction.
2. The filter adaptor of claim 1, wherein the volumetric direction is perpendicular to the first direction.
3. The filter adaptor of claim 1, wherein the volumetric direction and the first direction are offset by an angle of at least 15°.
4. The filter adaptor of claim 1, wherein the filter adaptor has a tubular shape and has an outside diameter, and wherein the filter has a surface area that is independent of the outside diameter.
5. The filter adaptor of claim 4, wherein the outside diameter is from about 3 mm to about 15 mm.
6. The filter adaptor of claim 1, wherein the filter is cylindrical.
7. The filter adaptor of claim 1, wherein the body includes a first connector at the inlet and a second connector at the outlet.
8. The filter adaptor of claim 1, wherein each of the first connector and the second connector comprises a barb, hose, or luer connector.

9. The filter adaptor of claim 1, further comprising an indicator positioned within the internal passageway.
10. The filter adaptor of claim 9, wherein the indicator detects blockage or detects a need for a dressing change.
11. The filter adaptor of claim 9, wherein the indicator sensor comprises symbols, letters, numbers, or a color change.
12. The filter adaptor of claim 1, wherein the filter comprises gas permeable material.
13. The filter adaptor of claim 1, wherein the filter comprises liquid impermeable material.
14. The filter adaptor of claim 1, wherein the filter is gas permeable and liquid impermeable.
15. The filter adaptor of claim 1, wherein the filter is hydrophobic.
16. A filter adaptor, comprising:
a body that defines an internal passageway disposed between an inlet and an outlet, and
a filter disposed within the passageway,
wherein the filter comprises a gelling absorbent material that, when in a dry state, is permeable to gas and that, when contacted by an aqueous fluid, converts to a gel.
17. The filter adaptor of claim 16, wherein the gelling absorbent material comprises a gel-forming fiber.

18. The filter adaptor of claim 16, wherein the gelling absorbent material comprises a compressed gel-forming fiber.
19. The filter adaptor of claim 18, wherein the compressed gel-forming fiber has a density of from about 10 to about 70kg/cm³.
20. The filter adaptor of claim 16, wherein the internal passageway comprises a spiral path.
21. The filter adaptor of claim 1, wherein the filter is planar.
22. The filter adaptor of claim 21, wherein the filter lies on a plane that is not perpendicular to the first direction.
23. The filter adaptor of claim 21, wherein the filter lies on a plane that forms an angle with the first direction, and wherein the angle is less than 45°.