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(54) Title: WATER FILTER ASSEMBLY AND FILTER ELEMENT

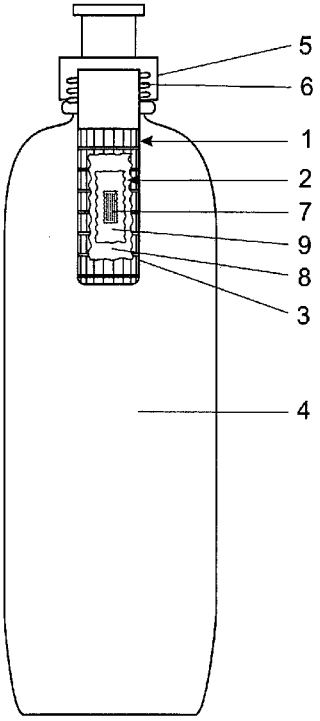

Figure 1

(57) Abstract: A water filter assembly and water filter element [1] are provided. The water filter element has water permeable barriers through which water is to be passed in use in order to purify same. The permeable barrier comprises a nanofibre layer [9] defining nanopores through which water is to permeate in use. The water filter element may be in the form of an enclosure [2] housing at least one of granular activated carbon, at least one appropriate ion exchange resin and at least one appropriate adsorbent [7]. Preferably, the water permeable barrier comprises a permeable support layer [8] and a nanofibre layer [9] carried thereby. The nanofibers preferably have antimicrobial properties that are either inherently a property of the nanofibres themselves or provided by a biocidal agent entrained or otherwise trapped within the nanofibres or a layer thereof, or both. The water filter assembly has a perforated holder [3, 23] that operatively snugly receives the water filter element in a flow path through the water filter assembly. Preferably, the perforated holder has a screw threaded socket [5, 26] for attaching it inside the mouth of a container [4].

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WATER FILTER ASSEMBLY AND FILTER ELEMENT

FIELD OF THE INVENTION

This invention relates to a water filter assembly and filter element therefor whereby water can be purified to an extent that it is generally potable. More particularly, the invention relates to water filter assemblies and replaceable water filter elements therefor that are especially, although not exclusively, suitable for small scale use, particularly domestic or personal scale of use, for the purpose of producing potable water.

BACKGROUND TO THE INVENTION

Various different forms of small-scale water filters, especially portable water filters, are available for use, in particular, by inhabitants of rural areas or visitors to rural areas as well as in disaster areas where potable water supplies have been disrupted or are simply not available. Not only are bacteria and other microorganisms [possibly including malaria protozoa] typically present in impure naturally occurring water, but, in many instances, pollution is also present in the form of man-made chemicals and waste as well as human and animal waste.

Most commonly used to purify small amounts of water are filter elements that include a filtration barrier and, commonly, a chlorine releasing compound and activated carbon contained in a filter bag or other container made of a filter material. Also commonly used are porous ceramic filters.

Some existing filter assemblies that are available, such as the so-called "LIFESAVER™" water bottle, are rather expensive and beyond the means of many would-be users of the system.

Another problem with many prior art filter assemblies is that microorganisms filtered out may propagate on the filter surface and cause the formation of a biofilm thereby blinding the filter surface at least to some extent.

As a result of difficulties and costs of filtration equipment, chemical treatment of water is often employed. One commercially available biocide that is used for this purpose is one sold under the trade name AquaQure, which is a solution containing the following elements in order of decreasing concentration, Cu, Zn, K, Ca, Na, Fe, Mg, B, Cr, Cd, Sr, Ni and Si. This product is available from AquaQure Global Water Solutions of Swellendam, Western Cape Province, South Africa.

OBJECT OF THE INVENTION

It is an object of this invention to provide a water filter assembly and filter elements for use therein that provide for effective water purification wherein at least one of the disadvantages mentioned above is obviated to some extent.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the invention there is provided a water filter element in the form of an enclosure having water permeable barriers through which water is to be passed in use in order to purify same with the interior of the enclosure housing at least one of granular activated carbon, at least one appropriate ion exchange resin and at least one appropriate adsorbent, the filter element being characterized in that the permeable barrier comprises a nanofibre layer defining nanopores through which water is to permeate in use.

In accordance with a second aspect of the invention there is provided a water filter element having a water permeable barrier through which water is to be

passed in use in order to purify same, the water filter element being characterized in that the water permeable barrier comprises a permeable support layer and a nanofibre layer carried thereby wherein the nanofibre layer defines nanopores through which the water is to permeate in use.

Further features of the invention provide for the nanofibers to have antimicrobial properties that are either inherently a property of the nanofibres themselves and / or provided by a biocidal agent entrained or otherwise trapped within the nanofibres or a layer thereof; for any enclosure to be either of a generally cylindrical shape or of a generally flat rectangular or square shaped bag rolled up to a cylindrical shape in each instance with the cylindrical shape being adapted to fit closely into a perforated holder; for at least one granular or bead-like ion exchange resin or adsorbent, especially a cation exchange resin, to be included within the enclosure typically in admixture with granular activated carbon; and for any permeable support layer to be a speciality filter type of paper of the general type widely used for producing teabags and the like.

It is to be noted that the type of speciality filter paper, when selected correctly, may exhibit a highly beneficial characteristic in that, when used as a supporting matrix for nano fibers, the fibers become interwoven into the pores of the speciality paper thereby eliminating the necessity for any additional adhesion or bond enhancing expedients. The speciality filter paper may be of a type that has a rougher and a smoother side, and in that instance, the nano fibers are carried by the rougher side.

The nanopores defined by the nanofibre layer generally have sizes that are selected to retain microorganisms and other particles having a size greater than about 1 micron.

The invention also provides a water filter assembly comprising a water filter element as defined above together with a perforated holder therefor wherein

the perforated holder snugly receives the water filter element in a flow path through the water filter assembly.

Further features of this aspect of the invention provide for the perforated holder to be configured to either operatively fit into a mouth of a water container such as a can or bottle, especially a plastic drinking water bottle in which instance the holder has formations whereby it fastens into an outlet thereof, especially a screw threaded outlet neck or the like, or for the perforated holder to be located in a housing adapted to fit onto a water supply outlet such as a tap; and, in the instance that the screw threaded socket is to be used for attaching the perforated holder inside the mouth of a bottle, for the screw threaded socket to be fitted with a closure for closing the flow path through the water filter assembly with the closure optionally being of a sports cap type.

In accordance with a third aspect of the invention there is provided a method of producing nano fibers exhibiting antimicrobial properties wherein the method comprises electro-spinning nano fibers from a solution of a suitable polymer material, the method being characterized in that a suitable biocidal agent is embodied in the solution prior to electro spinning such that it becomes incorporated in the nano fibers to provide them with, or enhance, their antimicrobial properties.

The nanofibres may themselves be antimicrobial in nature in which instance it is an optional addition to add a biocidal agent to become entrained within the nanofibre layer. Alternatively, the nano fibers themselves may not exhibit any antimicrobial properties in which instance it is regarded as generally essential to add the biocidal agent preparatory to electro-spinning.

The reason for providing the anti-microbial property is that microorganisms that are filtered out by the nanofibre layer are killed and therefore cannot multiply in a manner tending to promote biofilm formation. The nano fiber

layer therefore does not exhibit a propensity to become unnecessarily blinded. The life of the resultant filter element is thus considerably extended when compared to an instance in which biofilm can form.

The biocidal agent could be the AquaQure mentioned above or it could be one or more appropriate furanones, or any other compatible biocide.

In order that the invention may be more fully understood a more detailed discussion and various examples follow with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:-

Figure 1 a schematic sectional elevation of a water drinking bottle fitted with a water filter assembly according to the invention;

Figure 2 is a schematic sectional elevation of a tap fitted with a water filter assembly according to the invention

Figure 3 is an isometric view of a filter element in the form of a water permeable bag;

Figure 4 is an isometric view of the filter element in a rolled up format ready for insertion into a cylindrical perforated holder therefor;

Figure 5 is an exploded isometric view of a holder for the filter element illustrated in Figures 1 and 2; and,

Figure 6 is a sectional elevation of the holder assembly..

DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

In one embodiment of the invention a water filter element [1] is in the form of a water permeable bag [2] that defines an enclosure having water permeable barriers defining a pathway for water to pass through the filter element. The bag may be made from a speciality grade of paper of the type widely used for the production of teabags.

The filter element is made to be a close fit in a generally cylindrical perforated holder [3] that operatively fits into the mouth of a water container such as a can or bottle, especially a plastic drinking water bottle [4]. The holder thus has a screw threaded socket [5] for releasably fastening it onto a screw threaded outlet neck [6] of the bottle with the perforated walls of the holder projecting into the bottle so that the filter element forms the outlet passage from the bottle.

The bag houses granular activated carbon having a particle size of about 1 mm that is indicated by numeral [7] and that may be mixed with at least one granular or bead-like ion exchange resin also having a particle size of about 1 mm. In this instance a cation exchange resin was employed, although an anion exchange resin could be used in addition or alternatively, depending, at least to some extent, on the general characteristics of the water to be purified. Any other appropriate adsorbent may also be used by the in addition or instead of the granular activated carbon or ion exchange resin.

As provided by this invention, the filter element has a permeable barrier defined by the wall of the bag that comprises a permeable support layer defined by speciality paper [8] [teabag type of paper] and a nanofibre layer [9] carried thereby wherein the nanofiber layer defines nanopores through which water is to permeate in use.

The nanofiber layer is configured to provide nanopores that are dimensioned so as to prevent passage of microorganisms and other particles that render the water not potable.

In this embodiment of the invention the nanofibers are selected to have antimicrobial properties and, in particular, the nanofibers are electrospun from a PVA material that preferably has a biocidal agent entrained or otherwise trapped within the nanofibre layer.

Test 1

Nanofibers were made using polyvinyl alcohol (PVA) and the biocide AquaQure in order to provide required antimicrobial properties.

The nanofiber layer of PVA was prepared as follows:-

Hydrolyzed (87-89%) poly(vinyl alcohol) (8.5% w/v) was dissolved in distilled water. A cross-linking agent, glyoxal, (8% v/v) (40% aqueous solution) was stirred into the PVA solution until dissolved and a drop of concentrated HCl was added to lower the pH to 2. AquaQure (5% v/v) was added to the solution and stirred.

For electrospinning, a bubble spinner was used in an environment with a relative humidity of <40%. The anode was submerged in the polymer solution and the cathode was attached to the collector plate. The collector plate was positioned directly above the bubble-spinning widget at a distance of 25cm. The nano fibers formed were maintained at 60°C for a period of four days in order to allow cross-linking to take place.

Filter bags were formed of the resultant speciality paper carrying the nanofibre layer and were filled with 4 g activated carbon and ion exchanger mix. The bags were heat sealed with the electrospun nanofibre layer on the inside to form the final filter elements.

The nanopores defined by the nanofibre layer have sizes that are selected to retain microorganisms and other particles having a size greater than about one micron.

Tests were conducted on nanofiber PVA that did not incorporate the biocide AquaQure and PVA that did incorporate AquaQure. The results are given below and show that the latter totally removed the stated microorganisms whilst only a small proportion was removed using the PVA that did not incorporate the biocide AquaQure.

Strain	*Escherichia coli* (Xen 14)	*Staphylococcus aureus* (Xen 36)
Before filtering	1.41×10^9	1.72×10^{10}
After filtering with PVA only fibres	1.30×10^9	1.30×10^{10}
After filtering with PVA fibres incorporating AquaQure	CLEAN	CLEAN

It is therefore envisaged that the invention will provide an extremely simple yet highly effective and inexpensive water filter assembly and filter elements for use therein.

Of course, the water filter according to the invention can assume many different forms and it is envisaged that one other particularly useful form would be of the type illustrated in Figure 2. In this form the water filter, generally indicated by numeral [11] has a holder [12] fitting into a housing [13] adapted to fit onto a water supply outlet tap [14] using the usual screw

threaded socket [15]. In this form the water filter can be applied to a water tap by any user of the water as and when desired. Any sort of connector can be used to attach such a water filter to a tap, for example, depending on the configuration of the tap.

In another embodiment of the invention that is illustrated in Figures 3 to 6 of the accompanying drawings, a filter is produced as a generally flat rectangular or square bag [20] made of a speciality paper that is used for the production of tea bags and that is heat sealed, as indicated by numeral [21], around its periphery.

The speciality paper used in this instance is that sold under the trade name DYNAPORE tea filter paper by Glatfelter Gernsbach GmbH & Co. KG [Composite Fibers Business Unit] of Gernsbach, GERMANY, as their quality 117/S product. The paper had a weight of 16,50 ± 1,00 g/m^2; a thickness of 65,00 ± 5,00 micron; and a heat-sealable surface.

The nano fiber layer is applied directly to the rougher of the two surfaces of the speciality paper by an electrospinning procedure the details of which are as follows. This method has the highly beneficial characteristic in that the nano fibers become interwoven into the pores of the speciality paper thereby eliminating the necessity for any additional adhesion or bond enhancing expedients.

Test 2

Poly(vinyl alcohol) (PVA, Mr 146 000 – 186 000 Dalton, 87 – 89% hydrolysis) (8.5% w/v) was dissolved in distilled water and heated at 90°C for 30 min while stirred. A cross-linking agent in the form of glyoxal, (8% v/v) (40% aqueous solution) was stirred into the PVA solution until dissolved and a drop of concentrated HCl was added to lower the pH to 2. It should be noted that the glyoxal concentration can be lowered and cured at a higher temperature for a shorter period of time. It should also be noted that PVA was used again

simply for the reason that the PVA used is approved for use in relation to food and drugs.

This polymer solution was left to cool down and AquaQure (5% v/v) was added to the solution and stirred until it was dissolved.

The heat sealable speciality paper was cut into squares of 64 x 64 mm. The paper, with the rough side facing upwards, was attached to a tinfoil collector plate.

The polymer solution was injected into a Pasteur pipette and a copper wire, attached to the positive electrode of a high voltage power supply was inserted into the polymer solution. The negative electrode was attached to the tinfoil collector plate at a distance of 200 mm from the pipette. A high voltage was applied at a current of 15 kV and nanofibres were ejected towards the tinfoil collector plate and thus onto the speciality paper.

The paper was then removed and baked in an oven for 4 days at 60°C. The dry weight of the nanofibres was 600 g/m^2. The diameter of the nanofibres was between 200 and 350 nm, depending on the concentration of AquaQure and the voltage used. An applied voltage of 15 kV with a 5% PVA/AquaQure concentration gave rise to nanofibres having a diameter of about 250 nm. The sizes of the pores formed is between the nanofibres was from 7 and 13 nm^2

Bags were then prepared by heat sealing the edges of the electrospun paper on top of each other whilst leaving one side open. Each bag was filled with 3 g granular activated carbon (AquaSorb® 1000, Jacobi Carbons AG, Rheinweg 5, 8200 Schaffhausen, Switzerland) and heat sealed in order to close it.

The filter bags, are dimensioned to be accommodated in a perforated cylindrical holder [23] that has an integral fitting [24] at one end and a removable cap [25] at the opposite end, as shown clearly in Figure 3. The dimensions of the cylindrical holder are selected so that, when tightly rolled up, as illustrated in Figure 4, a filter bag can be inserted into the cylindrical holder in which it becomes a snug fit. The removable cap is then replaced on the open end of the holder through which the rolled up filter bag was introduced.

The fitting has a screw threaded socket [26] for releasably fastening it onto a screw threaded outlet neck of a bottle with the perforated cylindrical holder [23] projecting into the bottle so that the filter element forms the outlet passage from the bottle.

The fitting preferably has what is known as a sports cap outlet that embodies a valve comprising a closure teat [27] having an external skirt [28] that slides axially between a closed position and an open position. In the closed position an aperture [29] in an end wall [30] of the closure teat is occupied by a plug member [31] held centrally in the outlet passage by integral webs [32] of material attaching it to the inner wall of the fitting [24]. In the open position, the closure teat is axially displaced outwards [as illustrated in Figure 6] so that water can flow through the outlet passage past the plug and through the aperture [29].

It will be understood that whilst the cylindrical holder and fitting are described above as being integral with each other, tools and dies for manufacturing such an integral plastics injection molding may not be practical and, in that instance, the cylindrical holder can be made as a separate unit that attaches to the fitting, preferably in a generally irreversible manner in order to substantially avoid use of the fitting without the holder in its operative position.

Other antimicrobial nanofibers that have been prepared are as follows:-

i. The biocide copper and the polymer PVA

Poly(vinyl alcohol)/Copper (PVA/Cu) fibre mats were fabricated by mixing 10% w/v PVA and $CuSO_4.5H_2O$ (5-15% w/v) in water at room temperature with continuous stirring until the salt was completely dissolved. Glyoxal (8%) was added as cross-linking agent and the nanofibres were cross linked by curing at 60°C for 4 days.

ii. The biocide furanones and the polymer PVA

Poly(vinyl alcohol)/furanones fibre mats were fabricated by mixing 8% w/v PVA and furanones (2-10% w/v) in water at room temperature with continuous stirring until the salt was completely dissolved. Glyoxal (8%) was added as cross-linking agent and cross linked by curing at 60°C for 4 days.

iii. The biocide silver and the polymer PVA

A polymer solution of 8wt% PVA was prepared by dissolving PVA powder in water with gentle stirring at 90°C. The polymer solution was left to cool down and 8%v/v glyoxal was added as cross-linking agent and the pH was adjusted to 5 with concentrated HCl to aid the cross-linking process. Finally, 5 % (wt/v) $AgNO_3$ was added to the polymer solution, and was thoroughly mixed. PVA nanofibers containing $AgNO_3$ were collected on the plate, and were cross linked by curing at 60°C for 4 days. Subsequent to cross-linking, the nanofibers were exposed to UV irradiation for 1hour to reduce silver ions in the nanofibers to silver nanoparticles.

iv. The biocide silver and the polymer PAN (polyacrylonitrile)

A polymer solution of 6% (wt/v) PAN in dimethyl formamide (DMF) (Sigma Aldrich) was prepared. DMF was heated up to 90°C and stirred while PAN was added gradually. The mixture was stirred at 90°C for 5 hours until a clear, dark yellow solution was obtained. Silicone surfactant, JSYK L580

(0.95 g/l) was added to stabilize bubble formation during bubble-electrospinning. Finally, 5% (wt/v) $AgNO_3$ was added to the polymer solution and was mixed thoroughly. PAN nanofibers containing $AgNO_3$ and already reduced silver nanoparticles, were collected on the plate. Subsequently, the nanofibers were exposed to UV irradiation for 1 h to reduce any remaining silver ions in the nanofibers to silver nanoparticles.

Numerous variations may be made to the two different forms of the invention described above without departing from the scope hereof. In particular, the nature of the nano fiber layer can be varied widely and the permeable support can also be varied, as may be desired and appropriate. Also, the granular activated carbon or the ion exchange resin could be replaced completely, or in part, by any other appropriate absorbent such as zeolite or betonite.

CLAIMS:

1. A water filter element [1] in the form of an enclosure [2] having water permeable barriers through which water is to be passed in use in order to purify same with the interior of the enclosure housing at least one of granular activated carbon, at least one appropriate ion exchange resin and at least one appropriate adsorbent [7], the filter element being characterized in that the permeable barrier comprises a nanofibre layer [9] defining nanopores through which water is to permeate in use.

2. A water filter element [1] having a water permeable barrier through which water is to be passed in use in order to purify same, the water filter element being characterized in that the water permeable barrier comprises a permeable support layer [8] and a nanofibre layer [9] carried thereby wherein the nanofibre layer defines nanopores through which water is to permeate in use.

3. A water filter element as claimed in either one of claims 1 or 2 in which the nanofibers have antimicrobial properties that are either inherently a property of the nanofibres themselves or provided by a biocidal agent entrained or otherwise trapped within the nanofibres or a layer thereof, or both.

4. A water filter element as claimed in any one of claims 1 to 3 in which any enclosure is of a generally cylindrical shape with the cylindrical shape being adapted to fit closely into a perforated holder [3].

5. A water filter element as claimed in any one of claims 1 to 3 in which any enclosure is a generally flat rectangular or square shaped bag [20] suitable for being rolled up to a cylindrical shape with the cylindrical shape being fitting closely into a perforated holder [23].

6. A water filter element as claimed in any one of the preceding claims in which at least one granular or bead-like ion exchange resin or adsorbent is included within any enclosure.

7. A water filter element as claimed in claim 6 in which any permeable support layer is a speciality filter type of paper of the general type widely used for producing teabags and the like.

8. A water filter element as claimed in claim 7 in which the speciality filter paper is of a type that has a rougher and a smoother side and the nano fibers are carried by the rougher side.

10. A water filter element as claimed in any one of the preceding claims in which the nanopores have sizes that are selected to retain microorganisms and other particles having a size greater than about 1 micron.

11. A water filter assembly comprising a water filter element as claimed in any one of the preceding claims and having a perforated holder [3, 23] that operatively snugly receives the water filter element in a flow path through the water filter assembly.

12. A water filter assembly as claimed in claim 11 in which the perforated holder is provided with a screw threaded socket [5, 26] for attaching the perforated holder either inside the mouth of a container [4] or to a screw threaded water tap [14].

13. A water filter assembly as claimed in claim 12 in which the screw threaded socket is fitted with a closure for closing the flow path through the water filter assembly with the closure.

14. A water container fitted with a water filter assembly as claimed in either one of claims 12 or 13.

15. A method of producing nano fibers exhibiting antimicrobial properties wherein the method comprises electro-spinning nano fibers from a solution of a suitable polymer material, the method being characterized in that a suitable biocidal agent is embodied in the solution prior to electro spinning such that it becomes incorporated in the nano fibers to provide them with, or enhance, their antimicrobial properties.

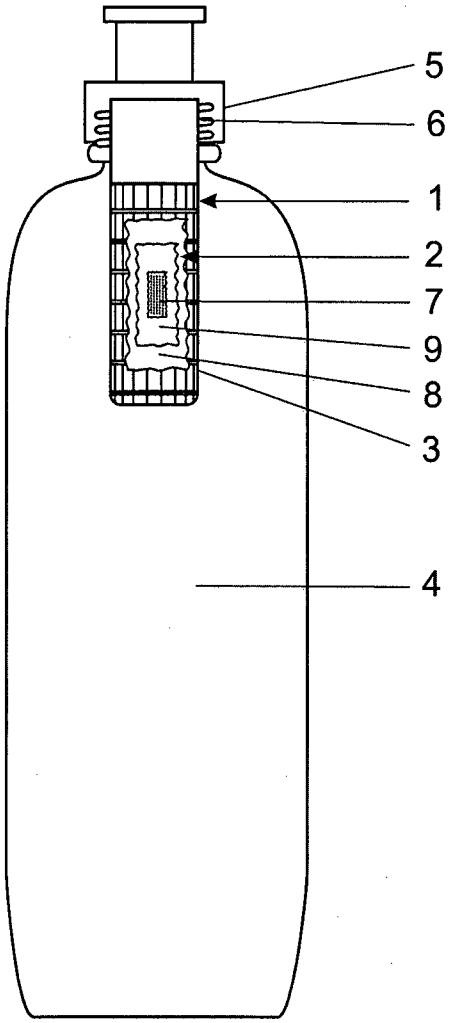

Figure 1

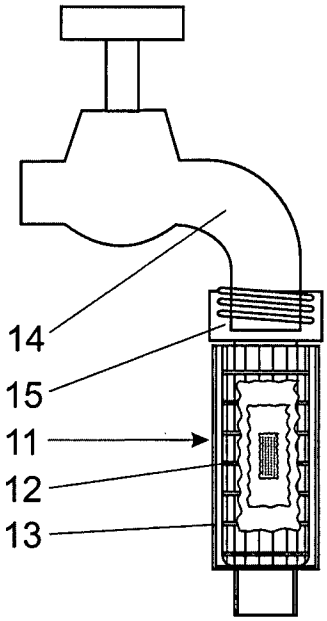

Figure 2

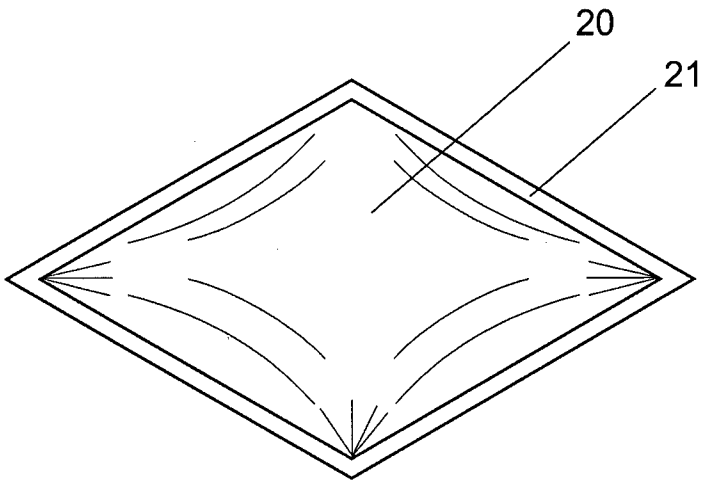

Figure 3

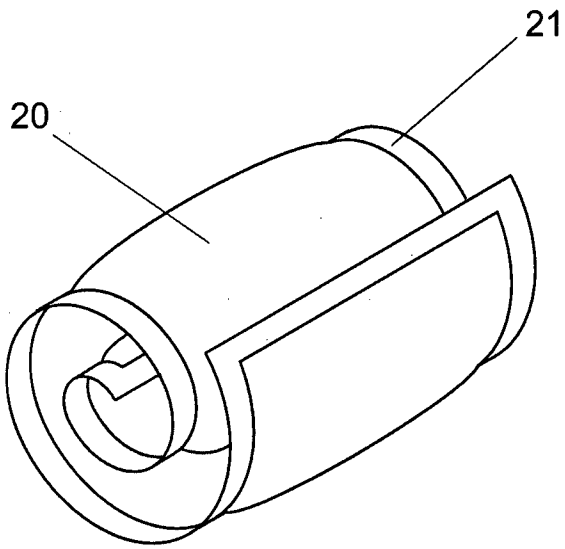

Figure 4

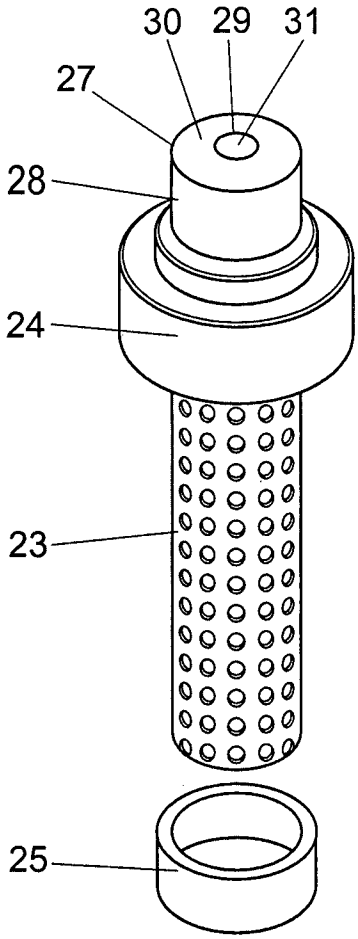

Figure 5

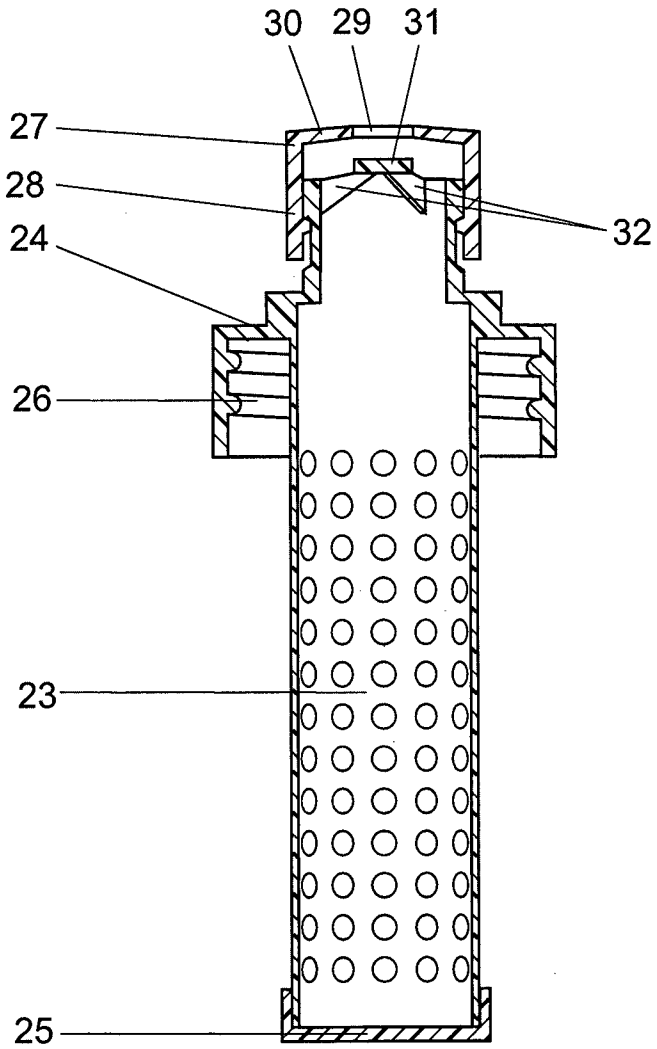

Figure 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2011/000346

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

B01D 24/10 (2006.01) ***C02F 1/00*** (2006.01)

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)

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)
WPI & EPODOC: IPC/EC: C02F 1/28, C02F 1/00, C02F 1/42, C02F 1/44D, C02F 1/00, B01D 24/10, B01D 25/--, B01D 63/00, B01D 65/-- & keywords (charcoal, activated carbon, coal, absorbent, adsorbent, ion exchange resin, nanofibre, layer, barrier, film and similar keywords); Google Patents: keywords (water filter, nanofibre, barrier, layer, activated carbon)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 2008/0302713 A1 (PATRICK) 11 December 2008	
X	Abstract; para 0002; para 0008-0009; para 0016-0024; figs. 1-5	1-6, 10-11
Y		7-8
	CN 201372218 Y (MINGMENG MA) 30 December 2009. English abstract retrieved from EPODOC	
X	Abstract; fig.	1-2, 4-5, 11-14
Y		7-8
	CN 201037116 Y (JIANZHONG XIE [CN]) 19 March 2008. English abstract retrieved from EPODOC	
X	abstract; fig.	1-3, 6, 11
Y		7-8

[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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 June 2011	21 JUN 2011
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **HATINDER SHARMA** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6225 6151

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2011/000346

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6251960 B1 (ISHIZAKI et al.) 26 June 2001 Abstract; col 23, line 13 to col 24, line 24; figs. 1-2	7-8
A	US 6197193 B1 (ARCHER) 6 March 2001 Abstract; col 3, line 10 to col 4, line 40	
	For Y combinations: • For claims 7-8 US 2008/0302713 or CN 201372218 or CN 201037116 is combined with US 6197193.	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2011/000346

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:

As reasoned on the extra 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 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.: 1-8, 10-14

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.

Supplemental Box
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No III:

The specification does not comply with Section 40(4) because the claims do not relate to one invention only. I have found different inventions based on the following features that distinguish the claims from each other:

- Claims 1-8, 10-14 are directed to a water filter element in the form of an enclosure having water permeable barriers through which water is to be passed in use in order to purify same with the interior of the enclosure housing at least one of granular activated carbon, at least one appropriate ion exchange resin and at least one appropriate adsorbent, the filter element being characterized in that the permeable barrier comprises a nanofibre layer defining nanopores through which water is to permeate in use. It is considered that a water filter element having water permeable barriers, enclosure housing having granular activated carbon, an ion exchange resin and an appropriate adsorbent and permeable barrier further comprising a nanofibre layer defining nanopores comprises a first distinguishing feature.

- Claim 15 is directed to a method of producing nano fibres exhibiting antimicrobial properties wherein the method comprises electro-spinning nano fibres from a solution of a suitable polymer material, the method being characterized in that a suitable biocidal agent is embodied in the solution prior to electro spinning such that it becomes incorporated in the nano fibres to provide them with, or enhance, their antimicrobial properties. It is considered that a method of producing nano fibres exhibiting antimicrobial properties comprises a second distinguishing feature.

Unity of invention is only fulfilled when there is at least one "special technical feature" present in the claims. This is a feature that both:

- provides a technical relationship among all the claims; and,
- makes a contribution over the prior art.

In the above groups of claims, the identified distinguishing features may have the potential to make a contribution over the prior art but are not common to all the claims and therefore cannot provide the required technical relationship. The nanofibre layer of claims 1-8, 10-14 does not relate to the method of production of nanofibre layer with antimicrobial properties defined in claim 15. Therefore there is no shared special technical feature present in the two set of claims (i.e. claims 1-8, 10-14 and claim 15) and consequently the requirements for unity of invention are not satisfied, *a priori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/IB2011/000346

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2008302713	NONE					
CN	201372218	NONE					
CN	201037116	NONE					
US	6251960	CN	1140458	EP	0744435	EP	1364985
		JP	2007314794	US	5985944	WO	9617884
US	6197193	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX