(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 November 2012 (29.11.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/159632 A1

(51) International Patent Classification:
C03C 4/00 (2006.01) *C03B 19/10* (2006.01)
C02F 1/68 (2006.01)

(21) International Application Number:
PCT/DK2011/050176

(22) International Filing Date:
26 May 2011 (26.05.2011)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **VESTERGAARD FRANDSEN SA** [CH/CH]; Chemin Messidor 5-7, CH-1006 Lausanne (CH).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MADIER DE CHAMPVERMEIL, Jean-Luc** [FR/FR]; 234 avenue de la grande champagne, Le Metna, F-01220 Divonne les Bains (FR). **FRAUCHIGER, Daniel** [CH/CH]; Route de Broye 45, CH-1008 Prilly (CH). **VESTERGAARD FRANDSEN, Mikkel** [DK/CH]; Rue de Mercerie 14, CH-1003 Lausanne (CH). **HEALY, David Michael** [IE/GB]; Midton House, By Alloway, Ayr, KA7 4EG, Scotland (GB).

(74) Agent: **PATRADE A/S**; Fredens Torv 3A, DK-8000 Aarhus C (DK).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

[Continued on next page]

(54) Title: SINTERED GLASS FOR RELEASE OF NUTRIENTS OR OTHER AGENTS

(57) Abstract: A sintered glass matrix containing nutrients or other agents in the pores is used for controlled release of the agent to water, for example as part of a water filtration device. The material in the pores has a lower solubility in the aqueous medium than the glass such that the dissolution of the glass determines the release of the material from the pores.

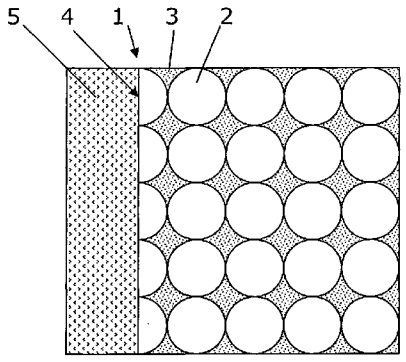

FIG. 1A

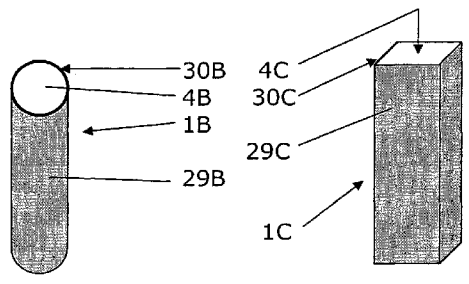

FIG. 1B

FIG. 1C

WO 2012/159632 A1

GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Sintered glass for release of nutrients or other agents

FIELD OF THE INVENTION

The present invention relates to a device and method for controlled release of a material into an aqueous medium. The device comprises a porous matrix of sintered, water-soluble glass particles having pores between the sintered glass particles, and comprising material partly or entirely filling the pores. The invention also relates to use of such a device, to a method for controlled release of material from the pores of a sintered, particulate, water-soluble glass, and to a method for production of the matrix.

BACKGROUND OF THE INVENTION

Soluble glass is well known as a medium for provision of nutrients to humans and animals. Kendall et al published in Animal Science 2001, 73, pp. 163-169, the article "The effect of a zinc, cobalt and selenium soluble glass bolus on the trace element status of extensively grazed sheep over winter" describes nutritional additives for sheep in sintered soluble glass. British patent application GB2030559 discloses soluble glass with Se and Zn for cattle and sheep. Slow release of Se over years is reported in US5049139. The company Telsol delivers soluble glass with Se and Zn for sheep and cattle, see http://www.telsol.co.uk/sel_def.html.

Glass is also used for release of antimicrobials. For example, US6555491 is concerned with water-soluble glasses, particularly glass fibres, containing small amounts of alkali metal compounds, with suggested uses being the sustained release of inorganic metals and anti-corrosion agents. US5792360 concerns water soluble glass with antimicrobial copper, silver and/or zinc submerged in a water tank in order to prevent fouling, corrosion and scaling, where zinc is primarily applied to prevent corrosion.

Slow-dissolving glasses, also known as controlled release glasses, include the range of products from Giltech Ltd (Ayr, UK; www.giltech.biz) under the trade name CORGLAES™. International patent application WO96/24364 by Giltech discloses a soluble glass matrix, preferably for combating infections, the glass matrix including metal ions like Zn and Se. Sintered glass is one of the options. Dissolution rates are given up to 25mg/cm2/hour at 38°C, preferably between 0.01 and 2 mg/cm2/hour. It is generally known that glasses can dissolve in water over years.

A different approach is disclosed in US4587267, where a sintered glass body contains a water soluble material in the pores of the sintered glass. The dissolution rate of the glass is significantly less than the dissolution rate of the material such that the material is dissolved before the glass. After dissolution of the material until a certain depth from the surface of the glass body, the dissolution is no any longer governed by convection but solely by diffusion, such that the dissolution of the material slows down with depth and at some point equals the dissolution rate of the glass.

Although, the approach as disclosed in US4587267 is theoretically appealing, it turns out that the ideal model is difficult to achieve in practice and the result not satisfactory. It is therefore desirable to find alternative and improved ways to release agents such as nutrients and biocides from glass matrices.

Addition of vitamins to filtered water in a personal drinking straw is discussed in international patent application WO2008/067816. Adding nutrients to filtered or otherwise purified water is discussed in International patent application WO03/011769 disclosing a water purifier for personal or domestic use and containing disinfectants and slow release nutrients, for example for use in rural areas of developing countries; the purifier includes a combination of (i) a primary coagulant, (ii) a microbicidal disinfectant, (iii) an oxidant, and optionally a food additive or nutrient source either as separate compositions in unit dosage form or incorporated directly into the water-purification composition itself.

Proportional addition of antimicrobials or other chemicals to filtered water by using a slip stream is also known in principle. US6855252 discloses a tubular filter inside which

a dispenser is centrally provided, the dispenser containing a solid or granular substance to be dissolved by liquid inside the dispenser. The dispenser has a fluid intake and a fluid outlet, and fluid flowing through the filter creates a differential pressure between the intake and the outlet, which draws saturated liquid out of the fluid dispenser and into the filtered water. Slipstream arrangements for dispensers in water filters are further disclosed in US4059522, US5897770, and US6485641.

DESCRIPTION / SUMMARY OF THE INVENTION

It is therefore the objective of the invention to provide a general improvement in the art. Especially, it is the purpose of the invention to provide an improved method and device with a water-soluble glass matrix for controlled release of agents, for example nutrients, into an aqueous medium. It is an even further objective to provide a system with a water-soluble glass matrix for adding agents to drinking water in portable water purification devices.

This objective is achieved with a device and a method for controlled release of a material into an aqueous medium according to the following. The objective is also achieved with a method for production according to the following.

The device comprises

- a porous matrix of sintered, water-soluble glass particles having pores between the sintered glass particles,
- a material located in the pores of the matrix,

wherein the material has a lower dissolution rate in the aqueous medium than the glass.

Optionally, the material is entirely filling the pores. Alternatively, the pores are partly filled by the material.

The dissolution rate is typically dependent on the temperature, and the ratio between the dissolution rate of the glass and the dissolution rate of the material can vary with temperature as well. The aspect of the dissolution rate of the material being lower than

that of the glass has to be understood as being determined at a temperature or in a temperature range, at which the device has its normal operation temperature. For example, the dissolution rate is determined at a fixed temperature of 20°C, 25°C, 30°C or 35°C, or for a range of temperature, for example between 1°C- 50°C or 20°C and 25°C degrees. If no specific temperature is emphasized, the dissolution rates are determined at 25°C.

In the simplest embodiment of the device, the device comprises only the glass matrix and the material that is provided in the pores of the glass matrix. However, as detailed below, the device can be provided according to various embodiments with additional features.

When an aqueous medium is provided in contact with the matrix, the matrix is dissolved into the aqueous medium, and the material released into the aqueous medium.

By providing a soluble glass matrix and a material in the pores of the sintered glass matrix, where the dissolution rate of the material is less that the dissolution rate of the glass, a high degree of control is achieved for the release of the material, because the dissolution rate of the glass determines how fast the material is released. The device is particularly advantageous when the dissolution rate of the material is substantially less than the dissolution rate of the glass. Such a device is much less sensitive with respect to the pore size than of the device described in US4587267, where the release of the material from the pores is determined by the diffusion rate of the material.

Advantageously, the material has a dissolution rate in the aqueous medium, for example water, at least 5 times lower than the glass, for example at least 10 times lower, or at least 50 times lower, or even at least 100 times lower at a given temperature, for example 25°C or at one of the other temperatures or temperature ranges given above. Alternatively the material is insoluble in water at 25°C or at one of the other temperatures or temperature ranges given above.

For example, the matrix is provided in a bulk state which is then placed in an aqueous medium, for example water, in which the glass will slowly dissolve. As the material has a lower dissolution rate, the glass will dissolve more readily than the material, and will only free the material from the matrix once the glass around a pore is dissolved. Depending on the dissolution rate of the material itself, the material in a pore may be partly dissolved during the dissolution of the glass around that specific pore. However, the material from pores remote from the surface of the glass will be protected from dissolution. This way, the material is only released from the surface layer of the glass matrix, which gives a high degree of control for the release of the material. Typically such a surface layer has a thickness in the order of the size of the pores, because only the outermost pores release the material.

If the material comprises nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, biocides, and/or flavours, these are released to the aqueous medium upon dissolution of the glass.

Open pores in the glass mean that the volumes of neighbouring pores are in direct mutual contact and not closed by the glass. A glass matrix with open pores can be easily filled, for example by one of the following methods, where the volumes of the pores are filled or partially filled with the material.

For example, the porous matrix soaks up liquid material by capillary force. The material may be an oil but can also be a material that solidifies or semi-solidifies after having entered the pores, for example by solidification (hardening) of a molten material during cooling. If the solidification is accompanied by contraction of the material, at least some of the pores in the end product may only be partially filled. Alternatively, the material is dissolved in a solvent, and the material solidifies by evaporation of a solvent. Also in this case, at least some of the pores may end up not being entirely filled with the material due to the evaporation of solvent from the pores. It should be mentioned that evaporation of the solvent may take a substantial period of time, because the solvent from the innermost pores of a bulk matrix would have to diffuse through adjacent pores to the surface of the matrix. The process of diffusion may however be facilitated by the contraction process of the material during solidification, which leaves some open

spaces in at least some of the pores. As an alternative to hardening, also gel formation of the material in the pores is a possibility

In detail, production of a porous matrix of sintered, particulate, water-soluble glass containing a material can be achieved by the following methods.

The method comprises providing a porous matrix of sintered, water-soluble glass particles having empty pores between the glass particles, placing the matrix in contact with a liquid material and drawing the liquid material into the pores throughout the matrix. By "empty" pores, we mean that the pores contain only ambient air.

For example, the method comprises placing one part of the matrix, for example one end or side or edge of the matrix, in contact with a liquid material and an opposite part of the matrix outside the liquid material and drawing the liquid material into the pores throughout the matrix by capillary forces. By filling the empty matrix from one part, for example one end, trapped air bubbles in the matrix are avoided.

Alternatively, the method comprises placing the matrix with the empty pores in contact with a liquid material and applying a vacuum to the matrix to remove air from the pores and filling the pores with the liquid material as substitution for the air. Optionally, only a part of the matrix, for example a side or end or edge, is placed in the liquid material, and the vacuum is applied to another part of the matrix.

Another method comprises filling the pores of the matrix with a solvent, placing the matrix in a liquid material, causing the solvent to evaporate and drawing the liquid material into the pores by the evaporation of the solvent and substitution of the solvent by the liquid material. Optionally, only a part of the matrix, for example a side or end or edge, is placed in the liquid material, and another part of the matrix is outside the liquid material; evaporation of the solvent will draw the liquid material into the pores.

A further method of filling is achieved by the use of compression in which pressure is applied to the liquid to fill the sinter. For example, hydraulic pressure is applied to the

matrix for filing of the matrix with creams and pastes that are more viscous that typical oil.

An example of a material is oil containing an agent. Alternatively, the liquid material contains a solvent and an agent, whereby the agent is then trapped in the pores upon evaporation of the solvent. Examples of liquid material include the liquid material being a solution of solid material in a solvent or a dispersion of a solid material in a solvent.

The solvent for the liquid material need not be the same as a solvent that is used to fill the pores prior to drawing the liquid material into the pores. For example, the solvent provided in the pores as a prior step may evaporate easier and faster than the solvent of the liquid material.

As a further alternative, the liquid material is a molten material, which solidifies after its location into the pores.

The methods for filling the pores in the matrix can be applied successfully for producing a matrix according to the foregoing. However, the method for filling the matrix may be applied to porous, sintered, soluble-glass matrices in general, for example, also for filling a matrix according to US4587267. Thus, the methods for filling a matrix are independent of the feature of the material having a lower dissolution rate in the aqueous medium than the glass, although the use of the filling methods for especially such a matrix is highly useful.

References to the pores being "filled with the material" mean that the material extends across the pore from a glass particle on one side of a pore to a glass particle on an opposite side of the pore. This definition differentiates the invention from the example of having a very thin layer of material coating the surface of the pores but otherwise having empty pores that are not filled with the material. By filling the pores, even when the pores are only partly filled, the aqueous medium is prevented from flowing into pores deep inside the matrix and thus far from the surface of the matrix. If this is not achieved and the aqueous medium is able to penetrate the glass matrix it can lead to premature disintegration of the matrix due to the significant increase presented by the

internal surface area. For this reason, the pores are filled to a degree that prevents ingress of water into the pores.

For example, suitable glass particle sizes can be selected from the following ranges: 10 - 150μm, 150 - 300μm, 300 - 500μm, 500 - 710μm, 710 - 1.0mm, 1.0 - 1.4mm, 1.4 - 2.0mm, 2.0 - 3.15mm, and 3.15 - 4.0mm. Optionally, the glass particles of the matrix have a size of 0.05 to 0.5 mm. If the glass particles are not spherical or approximately spherical, the size is to be measured as an average dimension of the particle, that is, the diameter of a sphere having the same volume than the glass particle.

Optionally, 15% to 60% of the volume of the glass matrix are pores.

A useful example of a type of glass is phosphate glass, although silicon glass can be used as well, such as a glass using borosilicate as a glass former. For example, the glass can comprise phosphorous pentoxide as the principal glass former together with one or more glass modifying materials including at least one of the following oxides, sodium oxide, potassium oxide, magnesium oxide, zinc oxide, and calcium oxide. Production of the glass itself is explained in the prior art, for example in international patent application WO96/24364.

Optionally, the dissolution rate of the glass material may be strongly or weakly dependent on the pH of the aqueous medium. For determination of the dissolution rates, the pH should be at a value or in a range where the device is typically used. Typical pH values for determining the dissolution rates are 5, 6, 7, 8, or 9, especially at neutral pH=7, or at ranges of 5-9 or 6-8. Apart from this dependency, the dissolution rate may be dependent on other factors as well, for example the presence of material dissolved in the aqueous medium. As an example, hard water versus soft water may influence the dissolution rate.

The matrix can can be formed into any suitable shape, including, for example spherical, ellipsoidal, cubic, rectangular, elongate, tubular, or cylindrical. Advantageously the matrix may be in the form of a thin long slab. This shape has the advantage that the

surface area of the slab does not change significantly even with a substantial change of volume during dissolution.

Non-limiting examples of sizes suitable for the sintered matrix are: a length of 20-200 mm, a width of 5-100 mm, and a thickness of 1-20 mm. Alternative examples of sizes for the sintered matrix are: a length of 50-150 mm, a width of 10-50 mm, and a thickness of 2-10 mm. Advantageously, the thickness is at least 5 or 10 times smaller than the length. For example, the matrix is provided in the form of a slab having a thickness at least a factor of 10 less than a length of the slab. A non limiting example of slab dimensions are 30 mm x 120 mm x 5 mm.

An even better control of the dissolution of the glass can be achieved if one or more of the surfaces, or part of the one or more surfaces, are covered with a sealant for protecting the covered surfaces from contact with the aqueous medium. A possible candidate for such a sealing is wax, for example bees wax, but also other sealants may be used, for example thermoplastic polymers or other water-insoluble polymers. In some embodiments, the matrix is a block with a constant or approximately constant cross section along a length of the block and with a plane surface at one end of the block or with two plane surfaces at opposite ends of the block. The one or two plane surfaces have a shape of the cross section, and the block is covered with the sealant apart from the one or two plane surfaces leaving only the plane surface(s) in contact with the aqueous media. For example, for a cubic or otherwise rectangular matrix, 4 or 5 sides are covered with a sealant for prevention of dissolution of the glass from these sides. As only one plane side is exposed to the aqueous medium or two plane sides are exposed, long-term control is achieved, because the entire surface area from which the glass is dissolved is kept constant. Alternatively, the matrix is elongate and rod-shaped with only one or two ends of the rod being exposed to water, as the remaining part is covered with the sealant.

An option for the material is a hydrophobic material, although also amphiphilic materials may be used. For example, the material can comprises lipid. Non limiting examples are various viscosities of oils, greases, fats or waxes.

For example, the material comprises an agent distributed in the material. Examples of such an agent are nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, biocides, and flavours or mixtures of at least two thereof. Optionally, the agent has a higher dissolution rate in oil than in water, for example a dissolution rate in oil that is at least 10 times higher than its dissolution rate in water. An example of an oil soluble agents is carotene, for example the vitamin A precursor beta carotene.

Other options for the material includes lipid vesicles containing an agent or microcapsules containing an agent. Such microcapsules can be based on starch or other materials that have a slow dissolution rate in water. This way, the agent, for example a nutrient, may be supplied to the consumer in a protected form. In case of consumption of the enriched water by drinking, such microcapsules should be digestible.

The agent may be encapsulated by using amphiphilic materials, which contributes to a controlled release. For example, lipid and a surfactant are mixed to obtain a dispersion, for example homogenous size dispersion, of globules containing water-soluble agents, for example vitamins from the B complex group or vitamin C. The concentration of the surfactant would then allow a control of the average hydrophobic globule size, yielding an additional control for the release rate of the hydrophilic active agent, which contributes to a controlled release.

The material comprises the agent as outlined above; it is also possible that the glass itself comprises some agent in addition. For example, the material may comprise one agent and the glass comprises another agent. A non limiting example is the material comprising an agent that is more lipophilic than hydrophilic, for example at least 5 or 10 times more lipophilic than hydrophilic, whereas the glass contains an agent that is more hydrophilic than lipophilic, for example at least 5 or 10 times more hydrophilic than lipophilic.

One option is the device for use as a water purification unit, where material with the agent inside the porous matrix is released to the water; alternatively or in addition, the agent is contained in the material and released directly to the water, for example by seeping out or diffusing out of the material.

For example, the material or agent in the material is released into the water in small amounts, optionally as small portions, in order to obtain a long-lasting enrichment device. A possibility in this respect is the enclosure of agent in lipid vesicles or microcapsules.

As options, the agent for enriching the water may comprise nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, flavours, biocides or a combination thereof. For example, the matrix is useful for enriching drinking water with nutrients and/or flavours. Other examples are water purification devices for medical or cosmetic use, where the water is enriched by pharmaceuticals, nutraceuticals, and/or nutricosmetics.

Non limiting examples of nutrients are iodine, zinc, selenium, iron, magnesium, calcium, vitamins and folic acid, which can also be used in combination. Examples of vitamins are vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin B12, niacin, pantothenate, biotin, vitamin C, vitamin D, and vitamin K.

For example, the material in the device comprises a carotinoid or a suspension of carotinoid as disclosed in international patent application WO2010/112406 assigned to BASF.

For example, the material in the pores of the matrix is a hydrophobic material comprising a pro-retinol, especially beta-carotene. The beta-carotene itself is an antioxidant, which counteracts destructive oxidisation, resulting in a longer preservation in the matrix as well as outside the matrix when released into the water. This way, a self preserving system is provided. Furthermore, DL-alpha-tocopherol(vitamin E active) can be added to the material in the pores acting as an anti-oxidant

Optionally, Zn ion release is combined with the release of other agents, for example pro-retinol. For example, a source of Zn ions is incorporated in the material in the pores, but may alternatively be incorporated in the sintered glass itself. During storage, minute amounts of Zn ions would be released from the glass and into the material, thereby acting antimicrobially during storage before the sintered material is used for

release of the agent, for example pro-retinol. In addition, the Zn ions would also act as an antimicrobial during use of the matrix in the aqueous medium.

Further,when added to a potable water stream, for example from a purification unit, the dissolved Zn ions released from the device would act as a nutrient for the consumer.

It should be emphasized that Zn ions are important in connection with the conversion of the pro-retinol beta carotene into vitamin A. Thus, a combination of especially pro-retinol and Zn works synergistically in different directions, including antimicrobial action and nutritional action, especially in connection with enhancement of the nutritional action of Vitamin A.

A combination of pro-retinol, for example beta-carotene, in the material and a source of Zn ions in the water soluble glass composition is not only beneficial for a matrix as described above but also for sintered matrices an general, thus, also for the matrix as disclosed in US4587267. For example, a device is provided for controlled release of a material into an aqueous medium, wherein the device comprises a porous matrix of sintered water-soluble glass particles having pores between the particles in the sintered matrix, the pores containing the material, wherein the material contains a pro-retinol, for example beta-carotene, and wherein the water-soluble glass contains a source of Zn ions. Optionally, the material has a lower dissolution rate in the aqueous medium than the glass. Whilst this independent device is particularly advantageous even when considered alone, the device can be combined with any of the features as described above for any of the other objectives.

Non limiting pharmaceuticals include orally administrable pharmaceuticals in general; generic drugs, non-generic drugs, for example analgesics, as well as pharmaceuticals that are not regarded as drugs, such as caffeine.

Specific non-limiting examples of pharmaceuticals include:

Antipyretics: reducing fever (pyrexia/pyresis), for example Quinine

Analgesics: reducing pain (painkillers)

Antimalarial drugs: treating malaria, for example Quinine

Antibiotics: inhibiting germ growth

Antiseptics: prevention of germ growth near burns, cuts and wounds

For the gastrointestinal tract (digestive system), useful pharmaceuticals include the following non limiting examples:

Upper digestive tract: antacids, reflux suppressants, antiflatulents, antidopaminergics, proton pump inhibitors (PPIs), H2-receptor antagonistss, cytoprotectants, prostaglandin analogues

Lower digestive tract: laxatives, antispasmodics, antidiarrhoeals, bile acid sequestrants, opioid

For the cardiovascular system), useful pharmaceuticals include the following non limiting examples:

General: β-receptor blockers ("beta blockers"), calcium channel blockers, diuretics, cardiac glycosides, antiarrhythmics, nitrate, antianginals, vasoconstrictors, vasodilators, peripheral activators

Affecting blood pressure (antihypertensive drugs): ACE inhibitors, angiotensin receptor blockers, α blockers, calcium channel blockers

Coagulation: anticoagulants, heparin, antiplatelet drugs, fibrinolytics, anti-hemophilic factors, haemostatic drugs

Atherosclerosis/cholesterol inhibitors: hypolipidaemic agents, statins.

For the central nervous system, useful pharmaceuticals include the following non limiting examples:

hypnotics, anaesthetics, antipsychotics, antidepressants (including tricyclic antidepressants, monoamine oxidase inhibitors, lithium salts, and selective serotonin reuptake inhibitors (SSRIs)), antiemetics, anticonvulsants/antiepileptics, anxiolytics, barbiturates, movement disorder (e.g., Parkinson's disease) drugs, stimulants (including amphetamines), benzodiazepines, cyclopyrrolones, dopamine antagonists, antihistamines, cholinergics, anticholinergics, emetics, cannabinoids, and 5-HT (serotonin) antagonists.

For pain & consciousness (analgesic drugs), useful pharmaceuticals include the following non limiting examples: NSAIDs, opioids, and various orphans such as paracetamol, tricyclic antidepressants, and anticonvulsants.

For musculo-skeletal disorders, useful pharmaceuticals include the following non limiting examples: NSAIDs (including COX-2 selective inhibitors), muscle relaxants, neuromuscular drugs, and anticholinesterases.

For the eye, useful pharmaceuticals include the following non limiting examples:
General: adrenergic neurone blocker, astringent, ocular lubricant
Diagnostic: topical anesthetics, sympathomimetics, parasympatholytics, mydriatics, cycloplegics
Anti-bacterial: antibiotics, topical antibiotics, sulfa drugs, aminoglycosides, fluoroquinolones
Antiviral drugs
Anti-fungal: imidazoles, polyenes
Anti-inflammatory: NSAIDs, corticosteroids
Anti-allergy: mast cell inhibitors
Anti-glaucoma: adrenergic agonists, beta-blockers, carbonic anhydrase inhibitors/hyperosmotics, cholinergics, miotics, parasympathomimetics, prostaglandin agonists/prostaglandin inhibitors. nitroglycerin

For the ear, nose and oropharynx, useful pharmaceuticals include the following non limiting examples: sympathomimetics, antihistamines, anticholinergics, NSAIDs, steroids, antiseptics, local anesthetics, antifungals, cerumenolyti.

For the respiratory system, useful pharmaceuticals include the following non limiting examples:
bronchodilators, NSAIDs, anti-allergics, antitussives, mucolytics, decongestants
corticosteroids, Beta2-adrenergic agonists, anticholinergics, steroids.

For endocrine problems, useful pharmaceuticals include the following non limiting examples:

androgens, antiandrogens, gonadotropin, corticosteroids, human growth hormone, insulin, antidiabetics (sulfonylureas, biguanides/metformin, thiazolidinediones, insulin), thyroid hormones, antithyroid drugs, calcitonin, diphosponate, vasopressin analogues.

For the reproductive system or urinary system, useful pharmaceuticals include the following non limiting examples:
antifungal, alkalising agents, quinolones, antibiotics, cholinergics, anticholinergics, anticholinesterases, antispasmodics, 5-alpha reductase inhibitor, selective alpha-1 blockers, sildenafils, fertility medications.

For contraception, useful pharmaceuticals include the following non limiting examples: Hormonal contraception, Ormeloxifene

For obstetrics and gynecology, useful pharmaceuticals include the following non limiting examples:
NSAIDs, anticholinergics, haemostatic drugs, antifibrinolytics, Hormone Replacement Therapy (HRT), bone regulators, beta-receptor agonists, follicle stimulating hormone, luteinising hormone, LHRH, gamolenic acid, gonadotropin release inhibitor, progestogen, dopamine agonists, oestrogen, prostaglandins, gonadorelin, clomiphene, tamoxifen, Diethylstilbestrol.

For the skin, useful pharmaceuticals include the following non limiting examples:
emollients, anti-pruritics, antifungals, disinfectants, scabicides, pediculicides, tar products, vitamin A derivatives, vitamin D analogues, keratolytics, abrasives, systemic antibiotics, topical antibiotics, hormones, desloughing agents, exudate absorbents, fibrinolytics, proteolytics, sunscreens, antiperspirants, corticosteroids.

Against infections and infestations, useful pharmaceuticals include the following non limiting examples: antibiotics, antifungals, antileprotics, antituberculous drugs, antimalarials, anthelmintics, amoebicides, antivirals, antiprotozoals.

For the immune system, useful pharmaceuticals include the following non limiting examples: vaccines, immunoglobulins, immunosuppressants, interferons, monoclonal antibodies

For allergic disorders, useful pharmaceuticals include the following non limiting examples: anti-allergics, antihistamines, NSAIDs

Hormones; for example insulin or progesterone.

For nutrition, useful pharmaceuticals include the following non limiting examples: tonics, iron preparations, electrolytes, parenteral nutritional supplements, vitamins, anti-obesity drugs, anabolic drugs, haematopoietic drugs, food product drugs

For neoplastic disorders, useful pharmaceuticals include the following non limiting examples: cytotoxic drugs, therapeutic antibodies, sex hormones, aromatase inhibitors, somatostatin inhibitors, recombinant interleukins, G-CSF, erythropoietin

Preferable nutraceuticals include (but are not limited to):
products isolated or purified from foods, and generally sold in medicinal forms not usually associated with food and demonstrated to have a physiological benefit or provide protection against chronic disease. Examples: beta-carotene, lycopene, etc.
food stuff (as a fortified food or a dietary supplement) that provides health benefits

Examples of nutraceutical chemicals include probiotics, antioxidants, and phytochemicals:
Antioxidants: resveratrol from red grape products; flavonoids inside citrus, tea, wine, and dark chocolate foods; anthocyanins found in berries
Reducing hypercholesterolemia: soluble dietary fiber products, such as psyllium seed husk
Cancer prevention: broccoli (sulforaphane)
Improved arterial health: soy or clover (isoflavonoids)
Lowered risk of cardiovascular disease: alpha-linolenic acid from flax or Chia seeds
Amino acids

Enzymes

Botanical, herbal and spices extracts such as ginseng, garlic oil, etc.

Neutraceutical are products which typically claim to prevent chronic diseases, improve health, delay the aging process, and increase life expectancy.

Preferable nutricosmetics include (but are not limited to):

Antioxydants: Vitamin C, Omega-3 fatty acids, Carotenes, Flavonoids

The term "nutricosmetics" refers to nutritional supplements which can support the function and the structure of the skin. Many micronutrients have this effect. Vitamin C, for example, has a well established anti-oxidant effect that reduces the impact of free radicals in the skin. It also has a vital function in the production of collagen in the dermis. Other micronutrients, for example, some omega-3 fatty acids, carotenes, and flavonoids protect the skin from the damaging effects of Ultraviolet (UV) light exposure, which may lead to accelerated skin ageing and wrinkle formation.

A practical embodiment includes a device comprising a water purification unit with a purification medium for providing a stream of purified water. Optionally, the device comprises a supply chamber containing the matrix. For example, the supply chamber is in fluid flow connection to a water purification unit for guiding the stream or part of the stream along the matrix. With this combination, water is purified by the water purification unit after which the water contacts the matrix resulting in dissolution, for example slow dissolution, of the material contained within the pores

In some embodiments, a stream of purified water from the purification medium is divided into a main stream and a side stream, and only the side stream is guided along a surface of the matrix before the side stream is combined again with the main stream. This way, small amounts of the material can be provided to a relatively large volume of water in a controlled manner.

For example, the device comprises a supply chamber containing the matrix. Optionally, the supply chamber is separate or even remote from the water purification unit. In specific embodiments, the supply chamber is separate or remote from the water purifica-

tion unit and has a first fluid flow connection to the water purification unit for receiving part of the stream and a second fluid flow connection to the water purification unit for delivering treated water back to the water purification unit.

Differential pressure may be provided between the first and the second fluid flow connection if the spacing between the first and the second fluid flow connection is along the direction of the main stream. In this case the side stream is received through the first fluid flow connection and guided along the matrix before returning the enriched side stream back to the main stream through the second fluid flow connection.

Such a device can optionally be provided with the following features. For example, the water purification unit can comprise a downstream side of the purification medium, for example a membrane filter or chemical purification medium or a combination thereof. The downstream side can comprise a water outlet for consumption of purified water from the downstream side. In use, the downstream side comprises a stream of purified water from the purification medium to the water outlet. The first and the second connections from the supply chamber are to the downstream side and are dimensioned to guide only part of the stream into and through the supply chamber, thereby dividing the stream of purified water into a main stream in the downstream side and a smaller side stream through the supply chamber. By configuring the device so that the first and the second connections a mutual distance along a line following the flow direction of the main stream in the downstream side, a differential pressure is provided between the first and the second connection which draws the side stream through the supply chamber.

In one example, the purifying medium is a membrane filter, for example a ceramic filter or a polymer membrane. Such polymer membranes are well known in the art and made from various polymers, including polyethersulfone (PES) and polyvinylporrylidone (PVP). Optionally the membrane is a bundle of hollow fibre membranes. Examples are described in international patent applications WO98/15342.

In one example the device is a portable device. The term “portable device” means that the device can easily be carried by an adult human. Optionally, the device has a largest

dimension of less than 1 meter. Preferably, the device also has a weight of less than 30 kg, more preferably less than 20 kg, or less than 10 kg when containing no water, or even less than 2 kg for a small model. For example, the device is a portable device with dimensions less than 60 cm in all three orthogonal directions. Another example is a portable device being less than 50 cm in one dimension and less than 20 cm in the other two orthogonal dimensions.

The weights and dimensions given above also apply for the device having a water purification unit as explained above. Examples of small size and portable water purification devices are published in International patent applications WO2008/067816, WO2008/067817, WO2008/110165 or WO2008/110172. Products on the market include personal water filter straws with the registered trademark LifeStraw® or gravity feeded filters of the trademark LifeStraw Family® marketed by the company Vestergaard-Frandsen with the internet site www.vestergaard-frandsen.com.

For a long-term purification device, suitable for personal use or use in a family in rural areas, a target value for production of purified water is 10,000 litres of drinking water over two years. This corresponds largely to a water purification device in the form of the above-mentioned LifeStraw Family®. Therefore in a further embodiment, the device is configured for water purification of 10,000 litres before exhaustion. As further options, the device may contain between 100 mg and 1000 mg of Retinol Equivalent (RE) to pure Vitamin A, for example between 350 mg and 1000 mg. With such a device, it is possible to fulfil a target of delivery of 350 mg per annum of Retinol Equivalent (RE) to pure Vitamin A. Optionally, in addition, the device contains between 1g and 10 g of zinc, for example between 3.5g and 10g. The zinc can be in the form of metallic zinc or zinc ions. Advantageously, the Zn is contained in the glass as part of the molecular structure of the glass and will be released as zinc ions upon dissolution of the glass by aqueous media, although it could have been incorporated in the material as well. With such a device, a target can be reached of delivering 3.5 grams per annum of Zinc ions through the 10,000 litres of drinking water. This equates to 35µg RE/l and 0.35mg/l zinc ions for a 12 month period.

In one embodiment, an RE Vitamin A is formulated and incorporated into the material in the pores of the water-soluble sintered glass. The glass itself contains a source of zinc (Zn) ions to form a composite material that will slowly release the required levels of Vitamin A and zinc ions for a year or longer.

The reference to Zn or to a source of Zn ions includes various zinc compositions that are able to release zinc in a proper form, for example in a biologically suitable form when used for nutrition and in a biocidally active form when used as a biocide. Such forms include salts of Zn

It should be pointed out that Retinol and Vitamin A are harmful if the appropriate dose is exceeded, although this is dependent on age and sex. For example, Vitamin A is not used in its pure form, but a natural or synthetic dietary pro-retinol is used, such as beat-carotene, because it is not possible to overdose this precursor form. In order to achieve a 350mg RE, it would require approximately 3.5 – 4.0 g beta-carotene. For this reason, in a further embodiment, the matrix contains 1 to 12 g of beta carotene, for example 3.5 to 12 g of beta-carotene. The amount of pro-retinol can be further reduced, possibly to 1 g or even less, if delivered in an oil base, because lipids have the potential to improve dietary bioavailability and its subsequent conversion to retinol.

In general for the matrix, a lipid formulation for the material in the pores can be based on various materials, for example taken from the following non-limiting list comprising cottonseed oil, sunflower seed oil, rape seed oil, other vegetable oil, coconut oil, cocoa butter, shea butter, vegetable fats, Carnauba wax, beeswax.

In case that the lipid formulation and the material/active agent is meant for consumption by eating, the lipid material should be an edible material, where the term “edible” means that the material can be ingested by a human or animal without harm.

SHORT DESCRIPTION OF THE DRAWINGS

The invention will be explained in more detail with reference to the drawings, where

FIG. 1 is a schematic sketch of a glass matrix, with 1A) showed a detailed sketch, 1B) showing a cylindrical matrix, and 1C) showing an elongate rectangular matrix;

FIG. 2 illustrates a device with in the form of a water purification unit and a supply chamber.

DETAILED DESCRIPTION / PREFERRED EMBODIMENT

FIG. 1A is a sketch of a device with a glass matrix 1 comprising glass particles 2 that are sintered together into a solid, porous matrix. The particles 2 are illustrated as spheres, which is normally not the case after sintering but which is used here for simple illustration. In the pores between the particles 2, there is provided a material 3 containing an agent, for example nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, flavours, biocides, or combinations thereof. Such agents can be part of a composition that is included in the material 3 before filling into the pores.

When a surface 4 is exposed to water 5, the glass of the outermost particles is dissolved, freeing the material from the pores. Although the material itself may dissolve slowly, it is finally released into small portions, because the dissolution rate of the glass is higher than the dissolution rate of the material. For example, the material is released as vesicles or microcapsules. Alternatively, the content of an entire pore or even the content of several pores can be released to the water as a lump of material. The nature of the material and convection at the surface 4 determines the type of release.

FIG. 1B shows a cylindrical matrix 1B and FIG. 1C an elongate rectangular matrix 1C. The matrices 1B, 1C have a constant or approximately constant cross section along a length of the matrix and a plane surface 4B, 4C at one end of the matrix. The wall 29B, 29C of the matrix, apart from the plane surface 4B, 4C, is covered with a sealant 30B, 30C, leaving only the plane surface 4B, 4C in contact with the aqueous medium. The opposite ends of the matrices 1B, 1C may optionally be covered in order only to expose one end 4B, 4C to the aqueous medium, or may be free of sealant in order to double the exposed surface.

FIG. 2 illustrates the principle of a device 6 for purifying and enriching water. The device 6 contains a water-soluble matrix 1 containing releasable material, for example as illustrated in FIG. 1. The device comprises a fluid inlet side 7, a fluid inlet 8 into the fluid inlet side 7, and a filter 9, for example comprising a plurality of microporous hollow fibre membranes. The device further comprises a fluid outlet side 10 and a first fluid outlet 11 from the fluid outlet side 10. In addition, it comprises a side-stream outlet 12 from the fluid outlet side 10, the side-stream outlet 12 being in tubular connection to an inlet 13 of a supply chamber 14 in order to provide water from the outlet side 10 to the supply chamber 14. An outlet 15 of the supply chamber 14 is in tubular connection to a side stream return 16 for returning water from the supply chamber 14 to the fluid outlet side 10. As illustrated, the device 6 comprises a separate filtering unit 17 and a remote supply chamber 14, which are mutually connected by tubing 18 from side stream outlet 12 to chamber inlet 13 and by tubing 19 from chamber outlet 15 to side stream return 16.

The device 6 has a first and a second fluid flow paths between the fluid inlet 8 and the first fluid outlet 11. The first fluid flow path is from the fluid inlet 8 into the fluid inlet side 7, through the filter 9 to the fluid outlet side 10 and to the first fluid outlet 11. The second fluid flow path is from the fluid inlet 8 to the fluid inlet side 7, through the filter 9 to the fluid outlet side 10, to the side-stream outlet 12, through the chamber inlet 13, into the inner volume 20 of the supply chamber 14 and along the matrix 1, which is illustrated by arrows 28, then, through the chamber outlet 15 through the side-stream return 16, into the fluid outlet side 10 and through first fluid outlet 11.

The second fluid flow is a side stream relative to the first fluid flow, which is the main steam. The side stream is typically of much smaller volume than the main stream and has the purpose to transport minor amounts of agent, for example nutrients, from the supply chamber 14 into the main stream in the fluid outlet side 10. Such agents are supplied from a soluble matrix 1 inside the inner volume 20 of chamber 14 providing the side stream with the agent upon slow dissolution of the matrix 1. The driving force for the side stream is the differential pressure in the fluid outlet side 10 between the side-stream outlet 12 and the side-stream return 16.

For example, the soluble matrix 1 is provided as a slab, although it can have various shapes, including rods or tubes.

The device 6 further comprises a second fluid outlet 24 out of the fluid inlet side 2 defining a third fluid flow path between the fluid inlet 3 and the second fluid outlet 24. The third flow path is from the fluid inlet 8 into the fluid inlet side 7 to the second fluid outlet 24.

The first fluid outlet 11 and the second fluid outlet 21 have valves 22, 23, respectively, for controlling the flow of fluid therethrough. The valves 22, 23 each have valve fluid outlets 24, 25 for dispensing fluid therefrom.

There is provided a passageway on the fluid inlet side 7 from the fluid inlet 8 to the fluid outlet 21, the passageway being defined by the filter 9. The filter 9 is typically cylindrical in shape. Typically, the filter 9 is a ceramic membrane or a polymer membrane, for example a porous PES/PVP ultra-filtration or micro-filtration membrane. In this embodiment there is an annular passageway on the fluid outlet side 12 defined on its inside by the filter 9 and defined on its outside by a wall 26 of the purifier housing 27. The wall 26 is typically cylindrical in shape but could have many other tubular shapes, if convenient. The filter 9 is provided such that fluid cannot pass from the fluid inlet side 7 to the fluid outlet side 10 without passing through the filter 9, thereby ensuring that all water dispensed from the valve fluid outlet 25 has been filtered.

Valve 23 can be opened for allowing water to flow from the fluid inlet 8 along the inner surface of the filter 9 and out of the valve fluid outlet 24. This acts to flush out the filter 9 and remove any residue trapped in or on the filter 9 which then leaves device 6 through valve fluid outlet 21.

The device 6 is preferably oriented in use such that the second fluid outlet 21 is disposed below the fluid inlet 8, for example vertically, approximately vertically or inclined to not more than 45 degrees. This allows a good flow-rate of water from the fluid inlet 8 to the valve fluid outlet 24 when flushing out the device. In the same orien-

tation, the side stream return 16 is disposed above the side stream outlet 12, allowing improved circulation of water through the supply chamber 14.

Initially, valves 22, 23 are closed to prevent water from leaving the device 6 unintentially. Fluid inlet 8 is connected to a supply of untreated water (not shown), for example a container suitable for storing untreated water and positioned higher than the fluid inlet 8, such that untreated water can flow to the fluid inlet 8 by gravity. This saves a user from the need to pump water through the device 6. In other embodiments (not shown) the device is arranged to be driven by a pump. The container may contain a coarse filter for filtration of larger particles. The outlet of the container is in fluid flow communication with the fluid inlet 8 of the device 6. Valve 22 is to be opened in order to dispense water. Once, air has cleared from the device 6, treated water flows from the valve fluid outlet 25.

FIG. 2 has arrows indicating the direction of fluid flow through the device 6. It shows the agent dispensed by supply chamber 14 as zinc ions (Zn2+), but the invention is not limited thereto. Although not strictly limited thereto, the term “agent” covers nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, or flavours, but the principle could as well serve for adding other chemicals, for example biocides.

As illustrated, the supply chamber 14 is provided outside and remote from the purifier housing 27. However, the supply chamber 14 could also be provided outside the purifier housing 27 but abutting the purifier housing 27. As further alternative, the supply chamber 14 could share a common housing with the purification medium, for example a filter 9, although, a separating wall between the fluid outlet side 10 and inner volume 20 of the supply chamber 14 would be needed in order to use the principle.

CLAIMS

1. A device for controlled release of a material into an aqueous medium, the device comprising a porous matrix of sintered, water-soluble glass particles having pores between the sintered glass particles, and comprising material partly or entirely filling the pores, characterised in that the material has a lower dissolution rate in the aqueous medium than the glass.

2. A device according to claim 1, wherein the material has a dissolution rate in the aqueous medium at least 5 times lower than the glass.

3. A device according to claim 1, wherein the material has a lower dissolution rate in water than the glass.

4. A device according to claim 3, wherein the material has a dissolution rate in water at least 5 times lower than the glass.

5. A device according to any preceding claim, wherein the material is insoluble in water.

6. A device according to any preceding claim, wherein the pores have a volume and at least 50% of the volume is filled with the material.

7. A device according to claim 6, where the pores are completely filled with the material.

8. A device according to claim 6 or 7, wherein the pores are filled to a degree that prevents ingress of water into the pores.

9. A device according to any preceding claim, wherein the material or part of the material is hydrophobic.

10. A device according to any preceding claim, wherein the material comprises a lipid.

11. A device according to any preceding claim, wherein the material comprises fat.

12. A device according to any preceding claim, wherein the material comprises wax.

13. A device according to any preceding claim, wherein the material comprises a blend of oil and wax.

14. A device according to any preceding claim, wherein the material comprises an agent that is at least one of the group consisting of nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, biocides, and flavours.

15. A device according to claim 14, wherein the material comprises particles suspended in a lipid, the particles comprising the agent.

16. A device according to claim 14, wherein the material comprises microcapsules containing an agent inside the microcapsules.

17. A device according to claim 14, wherein the material comprises lipid vesicles containing an agent inside the vesicles.

18. A device according to claim 14, wherein the agent has a higher dissolution rate in oil than in water.

19. A device according to claim 18, wherein the agent has a dissolution rate in oil that is at least 10 times higher than its dissolution rate in water.

20. A device according to any one of claim 14-19, wherein an agent of a first type is provided in the material and an agent of a second, different type is provided in the glass, wherein the first type of agent and the second type are is at least one of the group consisting of nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, biocides, and flavours.

21. A device according to any preceding claim, wherein the matrix has a shape of a thin, long slab having a thickness at least a factor of 10 less than a length of the slab.

22. A device according to any preceding claim, wherein part (29B, 29C) of the matrix (1B, 1C) is covered with a sealant (30B, 30C) that protects the matrix against dissolution by the aqueous medium.

23. A device according to claim 22, wherein the matrix (1A, 1B) is a block with a constant or approximately constant cross section along a length of the block and with a plane surface (4B, 4C) at one end of the block, the plane surface (4B, 4C) having a shape of the cross section, wherein the block is covered with the sealant apart from the plane surface at one end leaving only the plane surface in contact with the aqueous media; or wherein the matrix is a block with a constant or approximately constant cross section along a length of the block and with plane surfaces at opposite ends of the block, the plane surfaces having shapes of the cross section, wherein the block is covered with the sealant apart from the plane surfaces leaving only the plane surfaces at opposite ends in contact with the aqueous media.

24. A device according to any preceding claim, wherein the material comprises nutrients.

25. A device according to any preceding claim, wherein the material comprises a pharmaceutical.

26. A device according to any preceding claim, wherein the material comprises a a nutraceutical or nutricosmetic.

27. A device according to any preceding claim, wherein the material comprises a flavour.

28. A device according to any preceding claim, wherein the material comprises a biocide.

29. A device according to any preceding claim, wherein the material contains Zn and a pro-retinol.

30. A device according to claim 29, wherein a source of Zn ions is provided in the glass and a pro-retinol in the material.

31. A device according to any preceding claim, wherein the device comprises a water purification unit with a purification medium for providing purified water, the device further comprising means for guiding at least part of the purified water along the matrix for dissolution of the matrix.

32. A device according to claim 31, wherein the means comprises a supply chamber containing the porous matrix, wherein the supply chamber is fluid flow connected to the water purification unit for guiding said at least part of the purified water along the matrix.

33. A device according to claim 31 or 32, wherein the purifying medium is a membrane filter.

34. A device according to any one of claims 31-33 wherein the device is a portable device with the largest dimensions being less than 1 meter.

35. A device according to any one of the claims 31-34, wherein the device without aqueous medium has a weight of less than 20 kg.

36. A method for controlled release of a material into an aqueous medium, the method comprising providing a device comprising a porous matrix of sintered, water-

soluble glass particles with pores between the particles, and filling the pores partly or entirely with a material, characterised in providing the material with a dissolution rate lower than the dissolution rate of the glass in the aqueous medium.

37. A method according to claim 36, wherein the pores have a volume and at least 50% of the volume is filled with the material.

38. A method according to claim 36 or 37, wherein the method comprises providing an aqueous medium in contact with the matrix and dissolving the glass by the aqueous medium at a higher rate than the material.

39. A method according to any one of claims 36-38, wherein the material has a dissolution rate in water at least 5 times lower than the glass.

40. A method according to claim 38, wherein the material comprises wax or oil or both.

41. A method according to claim 39, wherein the material comprises a blend of oil and wax.

42. A method according to any one of claim 36-40, wherein the method comprises predetermining a suitable viscosity range for the material in relation to a size of the pores and in relation to filling the material into the pores and adjusting the viscosity of the material.

43. A method according to claim 40, wherein the method comprises blending oil and wax into the material at a ratio where the viscosity of the material is within the predetermined viscosity range.

44. A method according to any one of claims 36-42, wherein the method comprises providing the material with an agent in the material, wherein the agent comprises at least one of the group consisting of nutrients, pharmaceuticals, nutraceuticals, nutricosmetics, biocides, and flavours.

45. A method according to claim 43, wherein the agent comprises nutrients.

46. A method according to any one of claims 36-44, wherein the method comprises providing the device with a water purification unit, purifying water with the purification unit, and contacting the matrix with the purified water.

47. A method according to claim 45, wherein the method comprises providing a stream of purified water from the purification unit, dividing the stream of purified water into a main stream and a side stream, guiding only the side stream along a surface of the matrix, dissolving glass from the matrix with the side stream, and thereafter combining the side stream again with the main stream.

48. A method according to claim 46, wherein the method comprises providing the device with a supply chamber separate from the purification unit and with spaced first and second fluid flow connections between the supply chamber and the purification unit, providing differential pressure between the first and the second fluid flow connection due to a spacing between the first and the second fluid flow connection along the direction of the main stream, receiving the side stream in the supply chamber through the first fluid flow connection and guiding the side stream along the matrix before returning the side stream back to the main stream through the second fluid flow connection.

49. A method for production of a device, the method comprises providing a porous matrix of sintered, water-soluble glass particles with pores between the sintered glass particles, placing the matrix in contact with a liquid material and drawing the liquid material into the pores throughout the matrix.

50. A method according to claim 49, wherein the method comprises placing one part of the matrix in contact with a liquid material and an opposite part of the matrix outside the liquid material and drawing the liquid material into the pores throughout the matrix by capillary forces.

51. A method according to claim 49, wherein the method comprises placing the matrix with the empty pores in contact with a liquid material and applying vacuum to matrix, removing air from the pores by the vacuum, and filling the pores with the liquid material by vacuum-induced flow of the liquid material into the pores.

52. A method according to claim 49, wherein the method comprises filling the pores of the matrix with a solvent, placing the matrix in a liquid material, causing the solvent to evaporate and drawing the liquid material into the pores by the evaporation of the solvent.

53. A method for controlled release of a material into an aqueous medium, the method comprising providing a device according to any one of claims 1-35, providing an aqueous medium in contact with the matrix and dissolving the glass by the aqueous medium.

54. Use of a device according to any one of the claims 1-35 for enriching drinking water with the material or with an agent contained in the material.

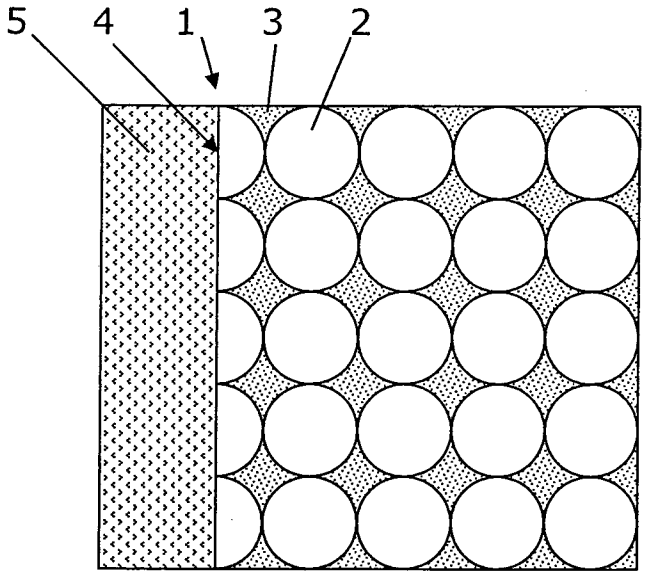

FIG. 1A

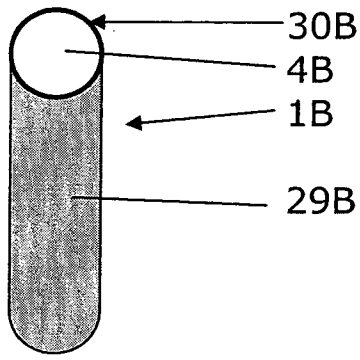

FIG. 1B

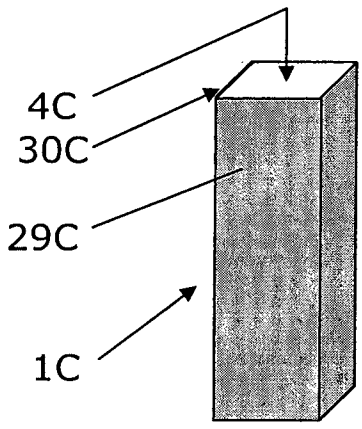

FIG. 1C

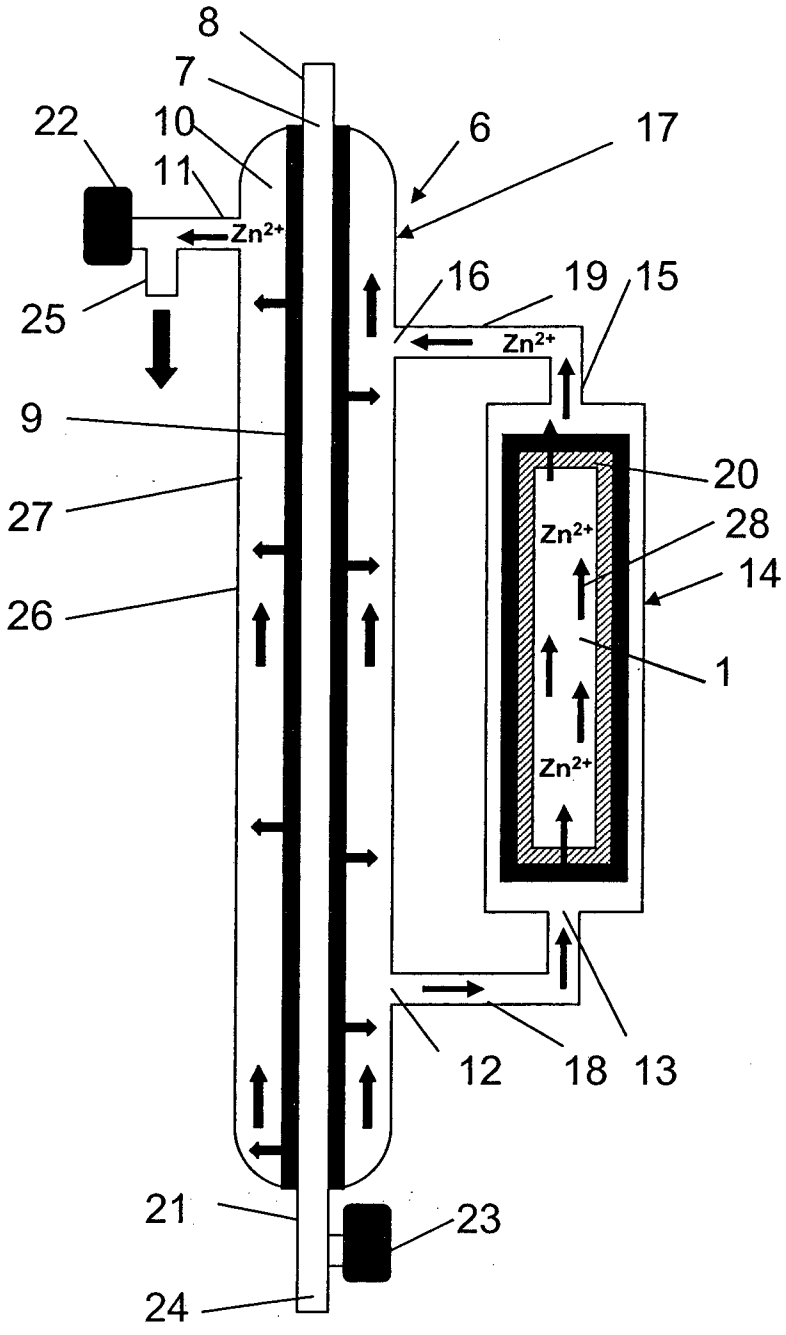
8
7
22
10
11
6
17
Zn^{2+}
25
16
19
15
Zn^{2+}
9
20
27
Zn^{2+}
28
14
26
1
Zn^{2+}
12
18
13
21
23
24

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2011/050176

A. CLASSIFICATION OF SUBJECT MATTER
C03C 4/00 (2006.01), C02F 1/68 (2006.01), C03B 19/10 (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)

IPC/ECLA: C03C, C02F, A61K, A61M, C03B

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

DK, FI, NO, SE: Classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI, English full-text (TXTAU1, TXTCA1, TXTEP1, TXTGB1, TXTUS0, TXTUS1, TXTUS2, TXTUS3, TXTUS4, TXTWO1)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4587267 A (DRAKE et al.), 1986.05.06, see whole document.	1-14, 21-30, 36-45,49-54
Y		31-35, 46-48
X	WO 9011756 A1 (ABERDEEN UNIVERSITY), 1990.10.18, page 2, line 21 - page 3, line 20 and claims.	1-8, 14, 24-28, 36-39, 53-54
Y		31-35, 46-48
X	US 4866097 A (DRAKE et al.), 1989.09.12, see whole document.	1-8, 14, 24-28, 36-39, 53-54
Y		31-35, 46-48
X	US 4517006 A (DRAKE et al.), 1985.05.14, see claims.	1-9, 14, 24-28, 36-39, 53-54
Y		31-35, 46-48
X	WO 2005087274 A1 (XL SCI-TECH, INC), 2005.09.22, see paragraphs [0007]-[0010] and claims.	1-8, 14, 25, 36-39,44,53-54

☒ Further documents are listed in the continuation of Box C. ☒ 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
24/10/2011	04/11/2011
Name and mailing address of the ISA/ Nordic Patent Institute Helgeshøj Allé 81, DK-2630 Taastrup Facsimile No. +45 43 50 80 08	Authorized officer Bergenholtz, Frank G. Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2011/050176

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0220928 A1 (STC PLC), 1987.05.06, see examples.	1-8, 36-39, 53
X	WO 9626364 A2 (GILTECH LTD), 1996.08.15, see page 4, line 27 - page 6, line 14, examples and claims.	1-8, 14, 25, 28, 36-39, 44, 53
X	US 20070104949 A1 (BUNGE), 2007.05.10, see claims.	1-8, 36-39, 53-54 31-35, 46-48
Y	US 5897770 A1 (HATCH et al.), 1999.04.27, see whole document.	31-35, 46-48
Y	US 6267886 B1 (BRENDRETH,III), 2001.07.31, see whole document.	31-35, 46-48
Y	US 6325926 B1 (HANSEN), 2001.12.04, see whole document.	31-35, 46-48
A	WO 2007011612 A2 (TYCO HEALTHCARE), 2007.01.25, see example 1.	1-48, 53-54
A	WO 0118174 A2 (GILTECH LTD), 2001.03.15, see claims.	1-48, 53-54
A	EP 0955084 A1 (CORNING INC), 1999.11.10, see [0011]-[0013]	49-52
A	WO99/55461 A1 (CORNING INC), 1999.11.04, see page 6, line 6 - page 12, line 29	49-52

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2011/050176

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

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

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

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

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

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

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

See 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.:

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.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2011/050176

Continuation of Box III:

This application is deemed to comprise multiple groups of inventions, therefore it does not meet the requirements for unity of invention, as set forth in Rule 13.1 PCT. The separate groups of inventions are considered to be:

A: Claims 1-48 and 53-54 defining a device for controlled release of a material into an aqueous medium, the device containing a water-soluble glass matrix containing a material and a method for using such a device, wherein the material has a lower dissolution rate than the glass in the aqueous medium.
B: Claims 49-52 defining different methods of fabricating a water-soluble glass matrix including material in its pores.

Prior art describes a porous matrix of water-soluble glass particles sintered or fused together, leaving pores in between the particles, which are filled wholly or partially with a material. The matrix is slowly dissolved in water or an aqueous medium to controllably release the material into the aqueous medium. The material may be a pharmaceutical, nutrient, biocide, flavour or food additive, which can have a lower dissolution rate in water than the glass.

The features of the first group addresses the objective technical problem of providing a water-soluble glass matrix for controlled release of a material contained in the glass matrix.

The second group addresses the objective technical problem of producing a water-soluble glass matrix including material in its pores.

The only technical feature common to the two groups is the glass matrix containing a material. Such a glass matrix, however, is known from the prior art, e.g. US 4587267 A.

The requirement of unity is not fulfilled, according to Rule 13.2 PCT, because there are no common special technical features binding the two inventions together.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/DK2011/050176

Patent document Cited in search report	Publication date	Patent family member(s)	Publication date
US4587267 A	1986-05-06	JP60155110 A	1985-08-15
		CA1239545 A1	1988-07-26
		BR8404607 A	1985-08-06
		ZA8407208 A	1985-04-24
		AU3278584 A	1985-03-21
		AU567968B B2	1987-12-10
		NZ209435 A	1988-02-12
		EP0140538 A2	1985-05-08
		AT51146T T	1990-04-15
		GB2146531 A	1985-04-24
WO9011756 A1	1990-10-18	AU5414990 A	1990-11-05
US4866097 A	1989-09-12	JP60097040 A	1985-05-30
		BR8404608 A	1985-08-06
		ZA8407209 A	1985-04-24
		CA1241551 A1	1988-09-06
		AU3278484 A	1985-03-21
		AU560546B B2	1987-04-09
		NZ209436 A	1988-02-12
		EP0138361 A2	1985-04-24
		AT48941T T	1990-01-15
		GB2146524 A	1985-04-24
US4517006 A	1985-05-14	ES8601756 A1	1986-03-01
		EP0080330 A2	1983-06-01
		BR8206675 A	1983-10-04
		NZ202518 A	1986-10-08
		AU9047282 A	1983-05-26
		AU558046B B2	1987-01-15
		GB2109237 A	1983-06-02
		GB2111388 A	1983-07-06
US2007104949 A1	2007-05-10	NO20060284 A	2006-01-31
		JP2007506535 A	2007-03-22
		EP1651580 A1	2006-05-03
		WO2004113245 A1	2004-12-29
		CA2529871 A1	2004-12-29
		BRPI0411416 A	2006-07-25
WO2005087274 A1	2005-09-22	US2011206603 A1	2011-08-25
		US2007053830 A1	2007-03-08
		EP1729822 A1	2006-12-13
		CN1946432 A	2007-04-11
EP0220928 A1	1987-05-06	US4849001 A	1989-07-18
		WO8702657 A1	1987-05-07
		AU6479186 A	1987-05-19
		GB2182034 A	1987-05-07
WO9626364 A2 1996-08-29		AU4985696 A	1996-09-11
		US5552657 A	1996-09-03

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/DK2011/050176

Patent document Cited in search report	Publication date	Patent family member(s)	Publication date
US5897770 A	1999-04-27	US6117332 A	2000-09-12
		EP0919269 A2	1999-06-02
US6267886 B1	2001-07-31	None	
US6325926 B1	2001-12-04	US2001001511 A1	2001-05-24
		US6241884 B1	2001-06-05
		US6325925 B1	2001-12-04
WO2007011612 A2	2007-01-25	MX2008000582 A	2008-03-14
		US2007020320 A1	2007-01-25
		JP2009501065 A	2009-01-15
		EP1904014 A2	2008-04-02
		CN101252905 A	2008-08-27
		CA2615368 A1	2007-01-25
		BRPI0613046 A2	2010-12-14
		AU2006270308 A1	2007-01-25
WO0118174 A2	2001-03-15	JP2003509021 A	2003-03-11
		EP1210409 A2	2002-06-05
		CA2380767 A1	2001-03-15
		AU7022700 A	2001-04-10
		AT346911T T	2006-12-15
EP0955084 A1 1999-11-10		US6884626 B1	2005-04-26
		WO9955461 A1	1999-11-04
		US6350618 B1	2002-02-26
		AU3760499 A	1999-11-16
		US6596237 B1	2003-07-22
		WO9955460 A1	1999-11-04
		JP2002513136 A	2002-05-08
		EP1075327 A1	2001-02-14
		CN1311717 A	2001-09-05
		CA2327664 A1	1999-11-04
		AU3552499 A	1999-11-16
		DE69835342T T2	2007-08-23
WO9955461 A1 1999-11-04		US6884626 B1	2005-04-26
		US6762061 B1	2004-07-13
		US6350618 B1	2002-02-26
		AU3760499 A	1999-11-16
		US6596237 B1	2003-07-22
		WO9955460 A1	1999-11-04
		JP2002513136 A	2002-05-08
		EP1075327 A1	2001-02-14
		CN1311717 A	2001-09-05
		CA2327664 A1	1999-11-04
		AU3552499 A	1999-11-16
		EP0955084 A1	1999-11-10
		DE69835342T T2	2007-08-23