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(54) **STORAGE OF CARBON DIOXIDE ON ADSORBENT**

SPEICHERUNG VON KOHLENDIOXIDE AUF EINEM ADSORBENT

STOCKAGE DE DIOXYDE DE CARBONE SUR ADSORBENT

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(56) References cited:
EP-A- 1 110 879 WO-A-95/17340
US-A- 5 308 821 US-A- 6 070 576
US-A- 6 083 298 US-A1- 2003 033 930
US-B1- 6 309 446 US-B1- 6 360 923

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Description

[0001] The present invention relates to the storage of carbon dioxide.

[0002] There exists a need to store a variety of compressed gases in conveniently sized containers for a wide range of applications. Such gases may include permanent gases of singular composition, such as oxygen, nitrogen, argon, carbon dioxide, methane and propane, or mixtures of gases of either synthetic or of natural origin (for example, air or natural gas).

[0003] Containers of gas are required for a large number of different applications, ranging from the need to store particular gases for identification and calibration purposes to paramedical uses. Gas containment may be needed for simple propellancy or pressure regulation requirements or to impart the unique property of the stored gas. For example, a container of compressed air may be used for dust removal from a computer keyboard or camera lens or it can be used as an emergency device to enable one to escape from a smoke-filled room, carriage or cabin. A container of compressed oxygen may be used so that the gas can be inhaled for therapeutic or other purposes. The application of oxygen is known to speed recovery following dental treatment. Other applications for containers of gas can be envisaged, such as flammable gases for welding, brazing or soldering in DIY or extinguishant gases, for example carbon dioxide, for extinguishing small fires.

[0004] A major drawback associated with the production of containers of gases is that, unless the gas can be easily liquefied, only a small quantity of gas can be stored within the container without the need to provide reinforced containment to withstand high pressures. Furthermore, the pressure in a container holding a compressed gas drops rapidly as the contents are depleted which hinders the delivery of the gas from the container. Additional drawbacks associated with storage of compressed gases are that generally the full container remains extremely light in weight. This results in the consumer purchasing what feels like an empty can and furthermore, the container is physically unstable due to the minimal weight of the contents of the container.

[0005] It is known to provide a pressurised container-dispenser device that contains an active ingredient (such as polish, hair lacquer or deodorant), together with a small amount of carbon dioxide adsorbed onto activated carbon (US 4,049,158). The adsorbed carbon dioxide acts as a propellant to disperse the active ingredient from the container. This device is concerned with the storage and delivery of the active ingredient, not the gas per se.

[0006] Further container-dispenser devices use compressed gases, such as hydrocarbons, that are charged to a can containing a bag of a fluid active ingredient whereby actuation of a valve provided in the can causes the gas to press on the bag and force the ingredient out from the can. However, discharge of the active ingredient tends to tail off as the pressure in the can falls resulting in non-uniform and inefficient dispensation of the ingredient. Furthermore, the use of hydrocarbons that are volatile organic compounds is environmentally unfriendly.

[0007] US 2003/033930 discloses a sorbent-based gas storage and delivery system that requires chemically aggressive, highly flammable or explosive materials with high molecular polarity.

[0008] WO95/17340 discloses the storage of carbon dioxide on activated charcoal.

[0009] It is an object of the present invention to provide an improved method for storing gases that, amongst other benefits and advantages, enables a greater volume of gas to be stored in a given volume.

[0010] Accordingly, the present invention provides a method of storing carbon dioxide, comprising:

- at least part filling a container with activated carbon;
- providing solid carbon dioxide for adsorption onto the activated carbon;
- sealing the container with a valve assembly; and
- charging the container with carbon dioxide

[0011] In the course of the present invention there is provided a storage container for a gas, the container comprising a sealed vessel containing an amount of activated carbon having the stored gas adsorbed thereon.

[0012] Preferably, the carbon dioxide is stored in the container at a pressure less than or equal to 2000000 Pascal (20 atmospheres or bars). More preferably, the pressure is 400000 1600000 Pascal (4-16 bar).

[0013] The container should be provided with a significant amount of activated carbon to increase the amount of gas that may be stored in the container and to increase the weight of the container. Preferably, the activated carbon fills at least 40% of the internal volume of the vessel, more preferably at least 50%, especially at least 75%.

[0014] It is to be appreciated that the container should be provided with a valve assembly to allow gas to be inserted into and dispensed from the container. Preferably, a filter is provided between the activated carbon in the container and the valve, such as a high efficiency particulate air filter.

[0015] The container may be adapted to receive a mask, mouthpiece and/or nose piece whereby the gas contained in the can may be breathed in through the mouth and/or nose. The mask, mouth or nose piece may be provided with a series of holes.

[0016] Preferably, a lower activity carbon is used, i.e. having less than 100% CTC, more preferably less than 60%,

especially less than 50%.

[0017] According to the invention, solid carbon dioxide is provided for adsorption on to the activated carbon. It has been found that this neutralizes any heat effect.

[0018] In the course of the present invention there is also provided the use of a container as herein described for the storage of carbon dioxide. In this respect, it is to be appreciated that the gas, i.e. carbon dioxide, is stored in as large a quantity as possible within the container for its later use in applications that the particular gas is suitable for. For example, applications include emergency escape devices (e.g. face masks) and traps for pests such as rodents wherein stored carbon dioxide is released inside a trap to cause death of the rodent without undue suffering or causing environmental damage.

[0019] Carbon dioxide may also be utilised as a storage atmosphere for bread or other perishable product (contained, for example, in a suitably designed box) since it is known that an atmosphere at least partially enriched in carbon dioxide helps to preserve bread enabling it to be stored for longer periods than when it is stored in air.

[0020] However, in another embodiment, the method and container may be adapted for the storage and dispensation of a fluid that is discharged by means of the gas stored therein. To this end, in the course of the present invention, there is provided a method of filling a container for the storage and dispensation of a fluid, the method comprising the steps of:

partially filling a container with activated carbon introducing a fluid into a malleable enclosure:

inserting the enclosure into the container;

sealing the container with a valve assembly; and

charging a gas to the container for adsorption on the activated carbon.

[0021] A fourth aspect adopted in the course of the present invention provides a fluid container-dispenser device comprising an outer relatively rigid container, an inner relatively malleable enclosure containing a fluid, a gas adsorbed on activated carbon occupying a space between the container and the enclosure and a valve assembly.

[0022] It is to be appreciated that the malleable enclosure is plastically open to the forces of the gas released from the activated carbon whereas the outer container is rigid with respect to these forces.

[0023] Preferably, the gas is carbon dioxide adsorbed on activated carbon. Solid carbon dioxide or dry ice is preferably used to provide the adsorbed gas. A grommet may be provided in the base of the container and the valve assembly may include a dip leg that extends into the enclosure.

[0024] The third and fourth aspect are particularly suitable for storing and dispensing carbonated beverages.

[0025] The invention will now be further illustrated by means of the following examples in which Example 1 (not in accordance with the invention) investigates the adsorption of oxygen by activated carbon, Example 2 investigates the adsorption of carbon dioxide by activated carbon, Example 3 (not in accordance with the invention) illustrates the use of carbon dioxide adsorbed on activated carbon for dispensing fluids from a container and Example 4 (not in accordance with the invention) investigates the adsorption of nitrogen by activated carbon, and with reference to the accompanying drawings in which:

Figure 1 is a schematic drawing of a gas container;

Figure 2 is a plot of the uptake of carbon dioxide versus pressure where the uptake of carbon dioxide is measured in terms of weight per unit volume, together with a plot of the weight of compressed carbon dioxide as a function of pressure for comparison;

Figure 3 is a plot of the uptake of carbon dioxide versus pressure for 111% carbon tetrachloride (CTC) and 57% CTC;

Figure 4 is a plot of carbon dioxide adsorption versus bulk density;

Figure 5 is a schematic drawing of a fluid dispensing system; and

Figure 6 is a plot of the uptake of nitrogen versus pressure an activated carbon compared with the uptake of carbon dioxide versus pressure an activated carbon.

[0026] There are further provided a method and container for the enhanced storage of a gas, such as oxygen. This is achieved by incorporating activated carbon within a container as a filling adsorbent. The activated carbon can advantageously adsorb gases of various types to increase the storage and working capacity of the gas within a given volume. Hence, at lower system pressures, adsorbed gas volumes are possible which are far greater than would be achieved by equivalent pressure compressed gas only.

[0027] Figure 1 of the accompanying drawings illustrates the components of the container according to one embodiment. A cylindrical container 2 is part-filled (generally being at least 50% full) with activated carbon. A valve assembly 4 is then crimped to the top of the container and the gas to be stored therein is charged to the container. The valve is also provided with a filter 6 to prevent any dust from the carbon from exiting the container upon dispensing the gas.

[0028] Activated carbons consist of a range of carbonaceous materials that have been specifically treated to develop

an extensive capacity for the adsorption of a wide variety of gases and liquids. Such carbons may be derived from a host of sources and any type of activated carbon may be utilised in the present invention. However, for practical and commercial reasons the raw materials tend to be confined to, for example, peat, wood, coal, nutshell (such as coconut), petroleum coke and bone. Synthetic sources, such as poly(acrylonitrile) or phenol-formaldehyde, are also used for the production of activated carbon. Other sources include bamboo shoot, drupe stones and seeds.

[0029] Numerous methods for activation of carbon exist in the art and may be used for providing activated carbon for the present invention. Most commonly, gaseous activation using steam, carbon dioxide or other gases at elevated temperatures is used, or chemical activation using, for example, zinc chloride or phosphoric acid. The activation process is used to develop an intricate network of pores of various sizes ranging from macroporous (>50 nm) to sub-microporous dimensions of molecular-sized entities. The larger pores are known as transport pores and these serve to provide access to the smaller pores in which most of the adsorption of gaseous species takes place. This unique pore structure, and the large surface area developed as a result, provides the extensive physical adsorption property and the highest volume of adsorbing porosity of any substance known.

[0030] The activated product can be supplied in a variety of forms, most commonly as powdered, granular or pelleted products. Any of these forms may be used in the present invention. In addition, these forms come in a variety of sizes, which can affect the adsorption kinetics of the activated carbon. The type of base, the activation process and the activated carbon's final form and size can all influence the material's adsorption performance.

[0031] Activated carbons have an enormous range of commercial applications. They have been used, amongst others, for odour control, VOC abatement, propellants, flue gas treatment, protection of nuclear installations, gold recovery, solvent recovery, decolourisation, catalysis, water treatment and as the adsorbent for respirators used in civil and military filters for the removal of noxious gases. However, activated carbons have not previously been used in relation to the production of gas storage containers as described herein.

[0032] The concept according to the present invention is suitable for the storage of any gas that may be adsorbed on to activated carbon. Table 1 below illustrates the total volume of gas stored by a 1 litre container filled with activated carbon of high volumetric capacity at room temperature for seven different gases over various pressures. The corresponding volume contained by the compressed gas, in the absence of the activated carbon, is provided for comparison.

Table 1

Gas	Pressure/atmospheres			
	5	10	15	20
Hydrogen	18.7	22.7	26.8	30.8
Nitrogen	33.8	37.9	42.0	46.2
Oxygen	30.2	34.7	38.9	43.1
Carbon Dioxide	115.2	119.3	123.3	127.4
Argon	33.5	37.6	41.8	45.9
Propane	92.8	97.6	102.4	107.2
Butane	39.9	44.7	49.5	54.3
Compressed Gas Volume	5	10	15	20

[0033] As illustrated from Table 1, the incorporation of activated carbon within the gas enables far greater adsorbed gas volumes to be achieved at lower system pressures than would be possible by equivalent pressure compressed gas only.

Example 1: Storage of Oxygen (not in accordance with the invention)

[0034] Activated carbons of various types, origins, densities, activities and mesh sizes were used for the study. In a typical run, an empty aerosol-type can (400 cm³) was part filled with a particular type of activated carbon. A valve was crimped to the can and oxygen, at a pre-set pressure (12 bar, 1200000 Pascal), was charged to the can via the valve to constant weight. When the filling was complete it was noted that the uptake of oxygen was typically more than double the quantity that would have occupied the same can at that pressure. The ratio of the weight of oxygen contained in the carbon-filled can to the weight of oxygen in the same volume of can, without any added activated carbon, is given as the Benefit Factor in Table 2 below.

Table 2

Sample No.	Can+valve	Can+valve+ Carbon	Can+valve+ Carbon+ Oxygen	Wt Carbon	Wt Oxygen	Wt. Oxygen/ 100 g Carbon	Benefit. Factor
1	49.9	232.7	248.6	182.8	15.9	8.70	2.61
2	50.1	231.7	247.5	181.6	15.8	8.70	2.59
3	50.1	230.4	246.2	180.3	15.8	8.76	2.59
6	50.3	243.9	259.7	193.6	15.8	8.16	2.59
7	50.4	236.6	252.2	136.2	15.6	8.38	2.56
8	50.1	220.1	232.9	170	12.8	7.53	2.10
9	50	212.2	224.9	162.2	12.7	7.83	2.08
10	50	204.2	219.6	154.2	15.4	9.99	2.52
11	49.3	199.1	214.4	149.8	15.3	10.21	2.51
13	50.1	136.7	147.5	86.6	10.8	12.47	1.77
14	49.3	233.7	247.1	184.4	13.4	7.27	2.20
15	49.7	247.1	261.5	197.4	14.4	7.29	2.36
16	50	213.2	226.3	163.2	13.1	8.03	2.15
17	50.3	197.9	210.1	147.6	12.2	8.27	2.00
18	50.2	190.3	202.4	140.1	12.1	2.61	1.98
19	50.3	50.3	56.4	0	6.1		1.00

[0035] Subsequent tests have shown that the uptake of oxygen is very much dependent upon the grade of activated carbon and the characterization of a typical, highly activated carbon for this application is shown in Table 3. Without prejudice, it would appear that most of the adsorption occurs in the narrow micropores which in the example is over a half of the total pore volume.

[0036] One of the problems that arise with the oxygen-adsorbed activated carbon is that a small quantity of dust is emitted with the gas. This problem has been obviated by the use of a so-called HEPA filter (high efficiency particulate air-filter), as illustrated in Figure 1. This commercially available device, fabricated into a hollow tube, closed at one end, can be snugly fitted over the dip leg of the valve to trap all traces of dust from the carbon that would otherwise be emitted through the valve. However, it is to be appreciated that other methods may be employed to filter dust from the gas stream.

Table 3

Designation	SRD/347/1
Carbon size/mm	2 mm pellets
Bulk Density/g cm ⁻³	0.40
CTC Sorption/%	109
OXYGEN capacity (at 12 barg)	8.64g/100g 34.5 g/litre
BET Surface Area/m ² g ⁻¹	1342
Total Pore Volume/cm ³ g ⁻¹	0.850
Micropore Volume/cm ³ g ⁻¹	0.777
Narrow Micropore Vol/cm ³ g ⁻¹	0.367
Broad Micropore Vol/cm ³ g ⁻¹	0.410

(continued)

Designation	SRD/347/1
MERCURY POROSIMETRY Total Pore Volume/cm ³ g ⁻¹	0.881
Mesopore Volume/cm ³ g ⁻¹	0.413
Macropore Volume/cm ³ g ⁻¹	0.468
NOTE : Nitrogen Total Pore Volume ... 0 - 200 $\text{\AA}$ width	Mercury Total Pore Volume .. 20 - 10 ⁵ $\text{\AA}$ width
Micropore Volume ... 0 - 20 $\text{\AA}$ width	Mesopore " 20 - 500 $\text{\AA}$ width
Narrow Micro. Vol. ... 0 - 6 $\text{\AA}$ width	Macropore " 500 - 10 ⁵ $\text{\AA}$ width
Broad Micro. Vol. ... 6 - 20 $\text{\AA}$ width	

[0037] The inhalation of pure oxygen from conveniently sized containers is practiced for athletic enhancement, therapeutic, medical, cosmetic and other reasons. It is purported to alleviate stress and anxiety, cure headaches, hangovers and jetlag, improve memory and to give a feeling of general well being. Mountaineers use oxygen canisters to boost their intake at high altitude and drivers use them to combat drowsiness. Sportsmen and sportswomen use oxygen canisters legitimately to improve their performance and to aid recovery from physical exertion. Medical uses include the use in dentistry to speed recovery after surgery. Application of oxygen to local areas of the skin can aid adsorption of creams and lotions into subcutaneous layers.

[0038] The ability to produce containers of compressed oxygen or other gas adsorbed on activated carbon provides a number of clear benefits, including: -

(1) The capacity of oxygen or other gas in the can is increased by a factor of two or more (see Table 2). This enables the can to be provided in a smaller, more portable size.

(2) The increased weight of the can gives the consumer a strong perception of extra product and hence more value.

(3) Any extraneous smells associated with the processing of the product is retained by the activated carbon.

(4) The activated carbon imparts an improved static (physical) equilibrium to the can.

(5) The activated carbon assists in retaining the pressure within the can thereby maintaining efficient and uniform delivery of the gas from the can as the contents are depleted.

(6) The storage capacity of compressed gas from air and gas storage compressors is enhanced by the use of activated carbon. Typically, a vessel fitted with activated carbon can store 3 times more compressed air than, for example, a classical air vessel. As a consequence, the load on the compressor is itself reduced.

[0039] It is to be appreciated that the can may be provided with an adapter piece, for example in the form of a mask or mouth and/or nose piece for fitting over the mouth and/or nose of the user. Such an arrangement would enable the gas, such as oxygen or air, to be breathed in by the user. This is particularly suitable for use in, for example, a fire or terrorist situation where inhalation of smoke or other chemicals is to be avoided. The adapter may be provided with a series of holes to enable the piece to be flushed with the stored gas prior to the user then breathing in the gas. This type of face or nose mask is preferable to prior art gas masks which only filter out particular chemicals. In contrast, this allows the user to breathe in pure oxygen or air from the can thereby removing the need to breathe in air from the atmosphere which may not have the harmful chemical filtered out sufficiently to render the air safe.

Example 2: Storage of Carbon Dioxide

[0040] Carbon dioxide is another example of a gas whose storage in a container may be enhanced by the presence of activated carbon. Carbon dioxide can have an extraordinarily high uptake on activated carbon. Values as high as about 250 g litre⁻¹ of carbon have been recorded at 16 bar gauge pressure (1600000 Pascal) where the corresponding compressed gas weight would be only 29 g in a 1 litre volume. Such high-density gas storage may be employed for all manner of applications, particularly for an innocuous, non-flammable, low toxicity and environmentally neutral material. Examples of such applications include aerosol propellants, working fluids and pressure regulating devices.

[0041] The degree of CO₂ uptake on activated carbon is normally regarded as a function of the level of activity to which the carbon has been subjected; the more highly activated carbons showing an increased propensity to adsorb

more carbon dioxide as the microporosity and surface area increases. The percentage activity of the activated carbon is measured in terms of its ability to adsorb carbon tetrachloride (% w/w) by saturating the carbon's pores with CTC. Surprisingly, we have found that at the pressures compatible with the common aerosol-type containment devices (4 - 16 bar, 40000 - 1600000 Pascal), this correlation is not necessarily true and that the lower activity carbons can show higher carbon dioxide uptake than their higher activity counterparts. This dramatic changeover is illustrated in Figure 2 of the accompanying drawings where the uptake of CO₂ is measured in terms of weight per unit volume (this measurement is important when the application is for fixed volume containment such as is the case in an aerosol-type can). A plot of the weight of compressed CO₂ as a function of pressure is also illustrated on the Figure for comparison. Coconut shell carbons were used for these investigations.

[0042] The most important feature for carbon dioxide uptake in the range of pressures indicated is the adsorbent material's bulk density. This finding is exemplified in Figure 3 where increased CO₂ uptake of the lower activity/higher density carbon is indicated only at pressures below about 10 bar absolute (1000000 Pascal).

[0043] Figure 4 is a generalisation of the above finding and illustrates that CO₂ adsorption increases approximately linearly with increase in the carbon's bulk density in the range of interest for carbons of the same generic type.

[0044] The present invention enables a sufficient amount of carbon dioxide to be stored in a suitable container to take advantage of the properties of the carbon dioxide other than its propellant properties, such as its ability to carbonate beverages or to conveniently extinguish small fires.

[0045] Surprisingly, low activity carbons should be used for adsorption of the carbon dioxide for storage of gas in these lower pressure containers, rather than high activity carbon that would normally be considered to provide maximum adsorption of the gas.

Example 3: Use of Carbon Dioxide adsorbed on Activated Carbon in Dispensing fluid from a container (not in accordance with the invention)

[0046] Conventionally, a pressure regulating device for dispensing a variety of active ingredients (such as shaving gel and hair treatment products) from a container uses a so-called "bag-in-can" or "bag-on-valve" system wherein a pressurized gas surrounds the bag containing the active ingredient to force the ingredient from the bag upon actuation of a valve. Originally, chlorofluorocarbons (CFCs) were employed as the gas but, following their prohibition, products are generally dispensed by a mixture of hydrocarbons, for example, isopentane, isobutane and propane mixtures. Such mixtures, in certain proportions, provide a convenient pressure regulating fluid with a room temperature vapour pressure that is suitable for the steady and complete discharge of the active ingredient.

[0047] However, these hydrocarbons do have a number of drawbacks, such as being toxic, highly flammable, greenhouse gases, volatile organic compounds and geopolitically sensitive. Additionally, cans containing these hydrocarbons are difficult to recycle owing to the flammable residues.

[0048] The present concept employs carbon dioxide adsorbed on activated carbon as the pressurized gas. Carbon dioxide is non-toxic, non-flammable and does not fall within the definition of a volatile organic compound. Carbon dioxide is derived from natural sources or as a by-product of a large combustion plant. Thus, at worst it has minimal contribution to global warming and may actually sequester carbon dioxide from the environment. It is ubiquitously available and is not politically or territorially sensitive.

[0049] In the present example, the conventional hydrocarbon fluid contained in a standard bag-in-can system (for example of the type used for dispensing shaving gel) was removed by disengaging the grommet located at the base of the can and allowing the vapour to escape to atmosphere. The can was then charged with activated carbon which had previously been saturated with carbon dioxide gas. An additional amount of carbon dioxide gas was then charged to the can such as to give a total pressure of 5 bar gauge after equilibrium between the adsorbed and gaseous phases. The grommet was replaced immediately after charging the carbon dioxide.

[0050] Solid carbon dioxide or dry ice was used to provide the adsorbed carbon dioxide since this has been found to counteract any exothermic reaction. This is particularly important if large quantities of cans are being filled as otherwise repeated cooling and charging of the can would be required.

[0051] The valve of the can was then actuated and the dispensing characteristics of this device containing carbon dioxide was compared with an originally manufactured device containing the traditional hydrocarbon mix. The mode and rate of dispensation of the active ingredient from the modified device was noted to be indistinguishable from that of an original can. Discharging of the active ingredient was continued until cessation. On subsequent examination of the device, it was confirmed that the gas still contained excess gas pressure and that the inner bag had been completely emptied.

[0052] The use of adsorbed carbon dioxide gas in this manner instead of compressed gas has a number of benefits. Compressed gases require excessive pressures to be used to accommodate the volume of gas required to discharge the contents of the bag. Additionally, there is a rapid and unsatisfactory fall in pressure when compressed gas is employed. This means that too much of the active ingredient is ejaculated at initial actuation and too little discharged towards the

end. In contrast, adsorbed carbon dioxide gives only a small, almost indiscernible, pressure decrease at the end of the discharge resulting in a steadier flow of product. Hence, although the total volume of gas required for dispensation of the product is the same both for compressed gas and adsorbed gas, the delivery profile is very different. The important parameter is the volume of gas delivered per unit of pressure drop.

[0053] The principle described in the example above could be employed from the dispensing of carbonated beverages from a bag-in-can system, as illustrated in Figure 5 of the accompanying drawings. The system would employ a large volume of can, for example, 5 litres, for home consumption. The device would comprise a 5 litre can 10 within which is a plastic enclosure 12 containing beer or other carbonated beverage 14, the device having a grommet 16 at the base thereof. A dip-leg 18 attached to an actuating valve 20 serves to ensure that only beverage is dispensed from the device via a dispensing tube 22. A space 24 surrounding the plastic enclosure is filled with carbon dioxide adsorbed on activated carbon.

[0054] The activated carbon, optionally pre-saturated with carbon dioxide, and additional carbon dioxide, is charged to the vessel in a manner hereinbefore described. This device ensures a smooth flow of beverage is dispensed until its discharge is complete. The beverage also remains in a fresh and carbonated condition because the volume of the bag enclosure tracks the volume of the remaining liquid and no gas headspace can be effectively generated.

Example 4: Storage of Nitrogen not in accordance with the invention)

[0055] It is to be appreciated that any gas that can be adsorbed by activated carbon may be stored in a low pressure container according to the present concept. Adsorbed nitrogen has similar advantages to carbon dioxide for use as an aerosol propellant or pressure regulating device but, more activated carbon is required to adsorb a similar quantity of nitrogen relative to carbon dioxide at a given pressure. A typical comparison, using carbon of a moderately high activity, is illustrated in Figure 6 of the accompanying drawings. However, in certain situations, it may be preferable to use nitrogen, for example it may be seen to be more environmentally friendly or it may be less permeable to the plastic enclosure.

Claims

1. A method of storing carbon dioxide, comprising:

at least part filling a container (2) with activated carbon;
providing solid carbon dioxide for adsorption onto the activated carbon;
sealing the container with a valve assembly (4); and
charging the container with carbon dioxide.

2. The method as claimed in claim 1 wherein the carbon dioxide is stored at a pressure less than or equal to 2000000 Pascal (20 atmospheres or bars).

3. The method as claimed in claim 2 wherein the pressure is 400000-1600000 Pascal (4-16 atmospheres or bar).

4. The method as claimed in any one of claims 1 to 3 wherein the container is filled to at least 40% of its internal volume with activated carbon.

5. The method as claimed in claim 4 wherein the container is filled to at least 50% of its internal volume with activated carbon.

6. The method as claimed in claim 5 wherein the container is filled to at least 75% of its internal volume with activated carbon.

7. The method as claimed in any one of claims 1 to 6 wherein carbon dioxide is adsorbed on a low activity carbon having less than 60% CTC.

8. The method as claimed in claims 7 wherein carbon dioxide is adsorbed on a low activity carbon having less than 50% CTC.

Patentansprüche

1. Verfahren zum Lagern von Kohlendioxid, umfassend:

mindestens teilweise Füllen eines Behälters (2) mit Aktivkohle,
das Bereitstellen von festem Kohlendioxid zur Adsorption auf der Aktivkohle,
Verschließen des Behälters mit einer Ventileinheit (4) und
Beschicken des Behälters mit Kohlendioxid.

2. Verfahren, wie in Anspruch 1 beansprucht, wobei das Kohlendioxid bei einem Druck von weniger als oder gleich 2000000 Pascal (20 Atmosphären oder Bar) gelagert wird.

3. Verfahren, wie in Anspruch 2 beansprucht, wobei der Druck 400000-1600000 Pascal (4-16 Atmosphären oder Bar) ist.

4. Verfahren, wie in einem der Ansprüche 1 bis 3 beansprucht, wobei der Behälter zu mindestens 40% von dessen innerem Volumen mit Aktivkohle befüllt wird.

5. Verfahren, wie in Anspruch 4 beansprucht, wobei der Behälter zu mindestens 50% von dessen inneren Volumen mit Aktivkohle befüllt wird.

6. Verfahren, wie in Anspruch 5 beansprucht, wobei der Behälter zu mindestens 75% von dessen inneren Volumen mit Aktivkohle befüllt wird.

7. Verfahren, wie in einem der Ansprüche 1 bis 6 beansprucht, wobei Kohlendioxid auf einem Kohlenstoff mit niedriger Aktivität mit weniger als 60% CTC adsorbiert wird.

8. Verfahren, wie in Anspruch 7 beansprucht, wobei Kohlendioxid auf einem Kohlenstoff mit niedriger Aktivität mit weniger als 50% CTC adsorbiert wird.

Revendications

1. Procédé de stockage de dioxyde de carbone, comprenant :

le remplissage au moins partiel d'un conteneur (2) en carbone actif ;
l'introduction de dioxyde de carbone solide destiné à être adsorbé par le carbone actif ;
l'obturation du conteneur avec un ensemble de vanne (4) ; et
le chargement du conteneur avec du dioxyde de carbone.

2. Procédé selon la revendication 1, dans lequel le dioxyde de carbone est stocké à une pression inférieure ou égale à 2 000 000 Pascals (20 atmosphères ou bars),

3. Procédé selon la revendication 2, dans lequel la pression est comprise entre 400 000 et 1 600 000 Pascals (4 à 16 atmosphères ou bars).

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel le conteneur est rempli à au moins 40% de son volume interne avec du carbone actif.

5. Procédé selon la revendication 4, dans lequel le conteneur est rempli à au moins 50% de son volume interne avec du carbone actif.

6. Procédé selon la revendication 5, dans lequel le conteneur est rempli à au moins 75% de son volume interne avec du carbone actif.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel le dioxyde de carbone est adsorbé sur un carbone à faible activité présentant un indice CTC (tétrachlorure de carbone) inférieur à 60%.

8. Procédé selon la revendication 7, dans lequel le dioxyde de carbone est adsorbé sur un carbone à faible activité présentant un indice CTC inférieur à 50%.

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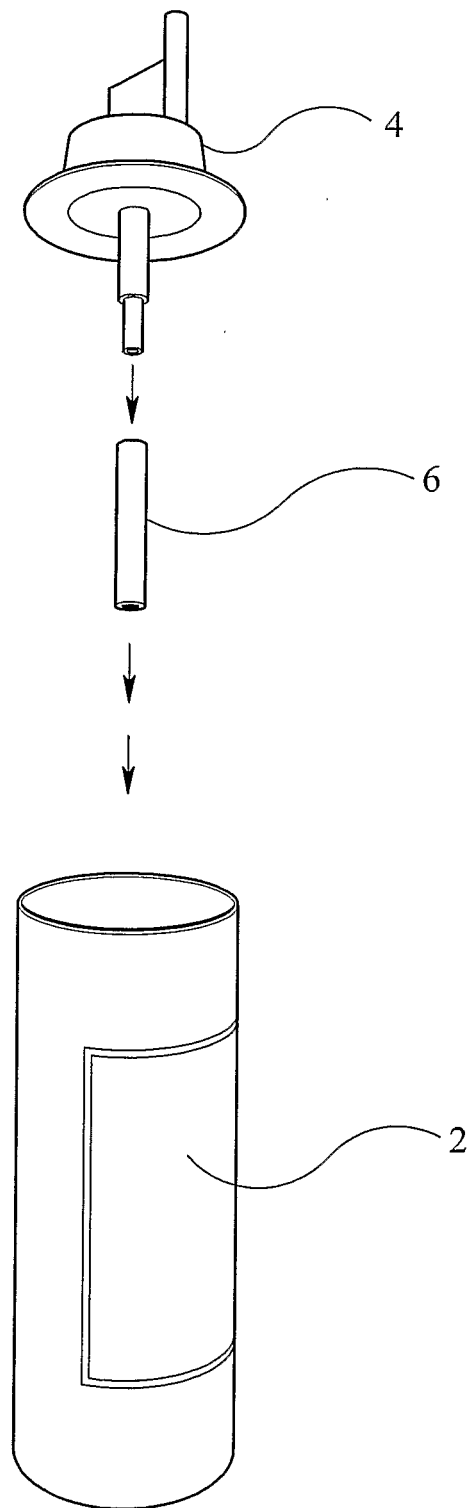
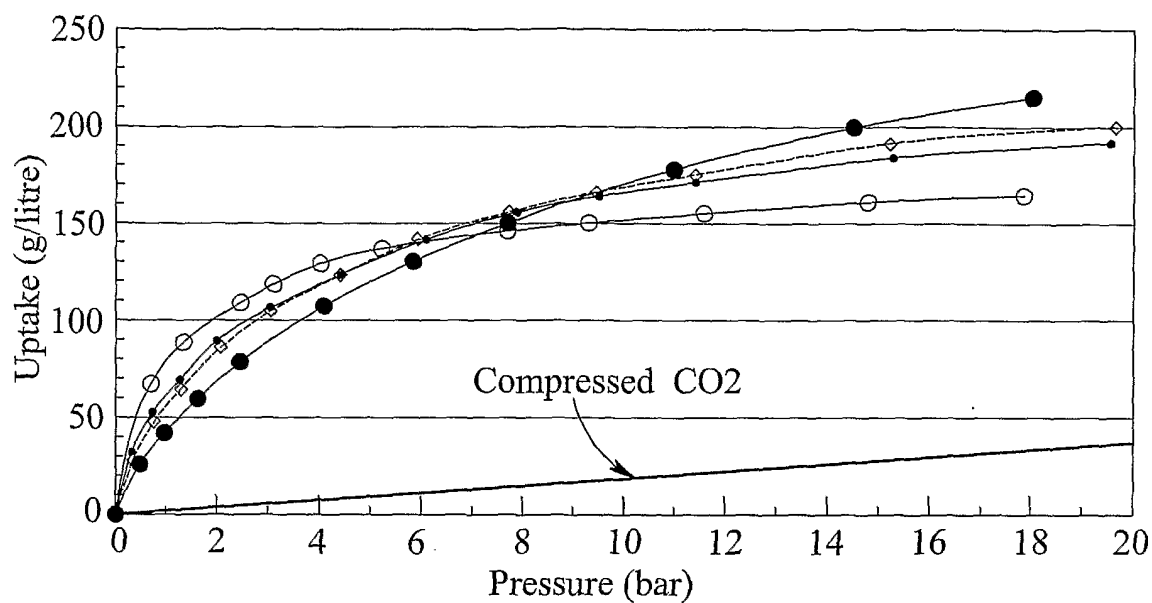
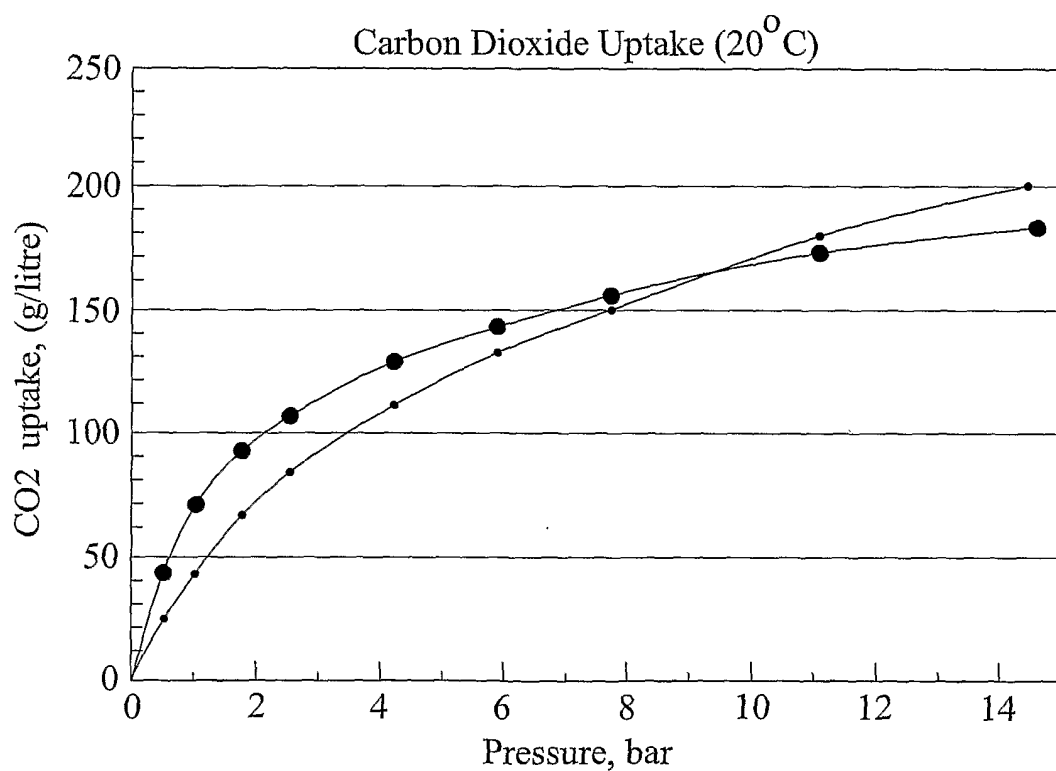


FIG 1

FIG 2

27% CTC 61% CTC 78% CTC 111% CTC

—○— —●— —◇— —●—

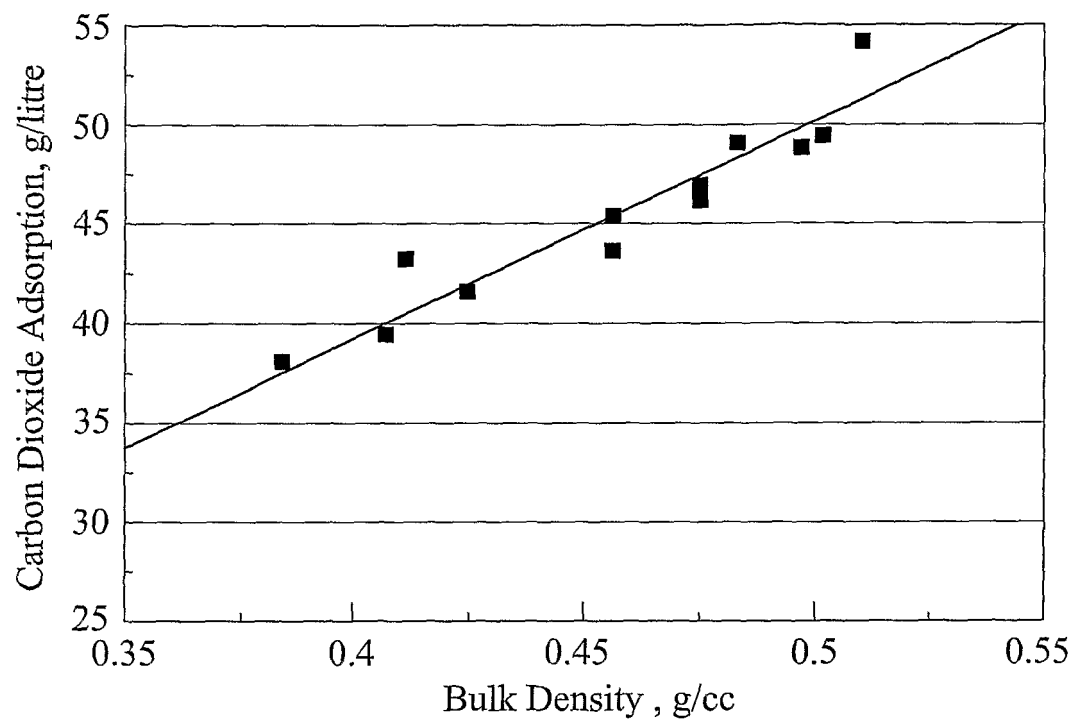


111% CTC 57% CTC

0.39 g/cc 0.52 g/cc

—●— —●—

FIG 3

FIG 4

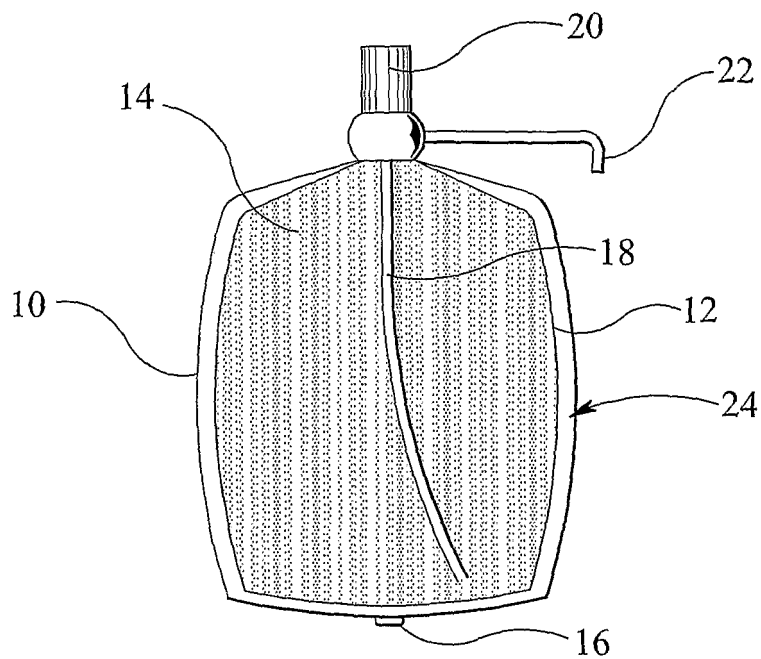


FIG 5

Nitrogen & CO₂ v Pressure
(g of gas uptake per litre carbon)

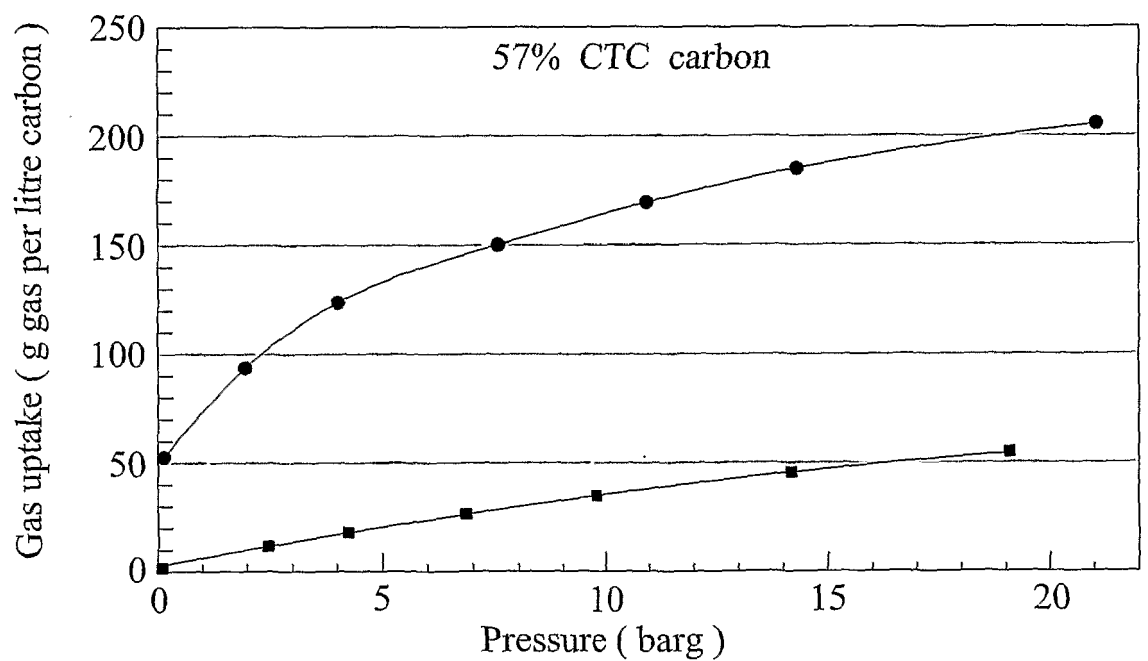


FIG 6

- Carbon dioxide
- Nitrogen

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4049158 A [0005]
- US 2003033930 A [0007]
- WO 9517340 A [0008]