

(21) Application No: 1120088.8

(22) Date of Filing: 21.11.2011

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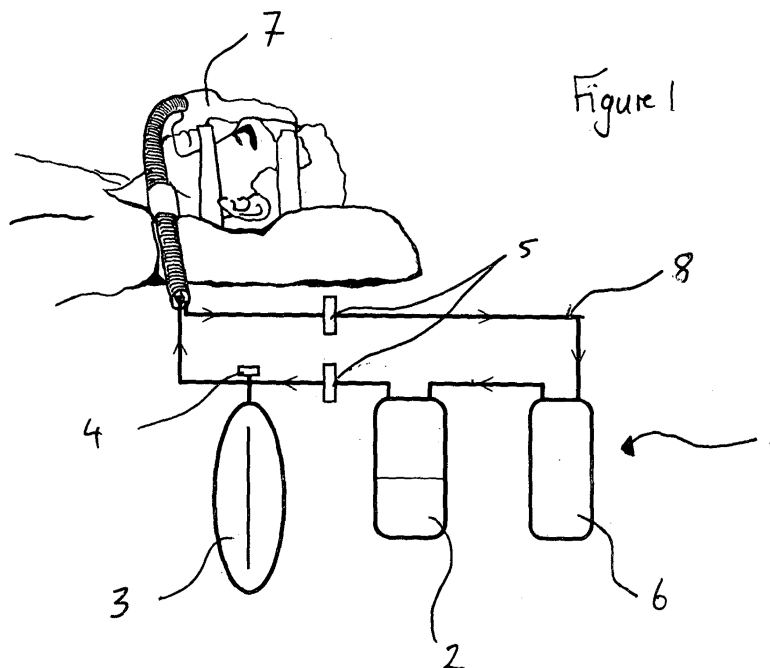
(51) INT CL:
B01J 7/02 (2006.01) **A62B 21/00** (2006.01)

(56) Documents Cited:
US 6443149 B **US 4817597 A**
US 20060090756 A1

(58) Field of Search:
INT CL **A62B, B01J**
Other: **WPI & EPODOC**

(54) Title of the Invention: **Device for the generation of a gas**
Abstract Title: **A gas generator system**

(57) A gas generator system 1 for the delivery of gas to an individual, said gas generator system comprises; a chemical gas generator 2 unit in combination with a recirculating gas delivery system. The chemical gas generator unit may include a solid gas generator reagent, which may be provided in the form of granules or pellets and which may be percarbonate. The reagents may be contained in a medium that allows their release over a period of time. The medium may be a wax or a resin. The gas generator unit may act as a container for the reagent, and may be divided into at least two chambers; one for holding reactants and the other being a reaction chamber. The gas generator may include a temperature control mechanism, which may take the form of either a cooling mechanism or a heat sink. The system may include one or more gas scrubbers.



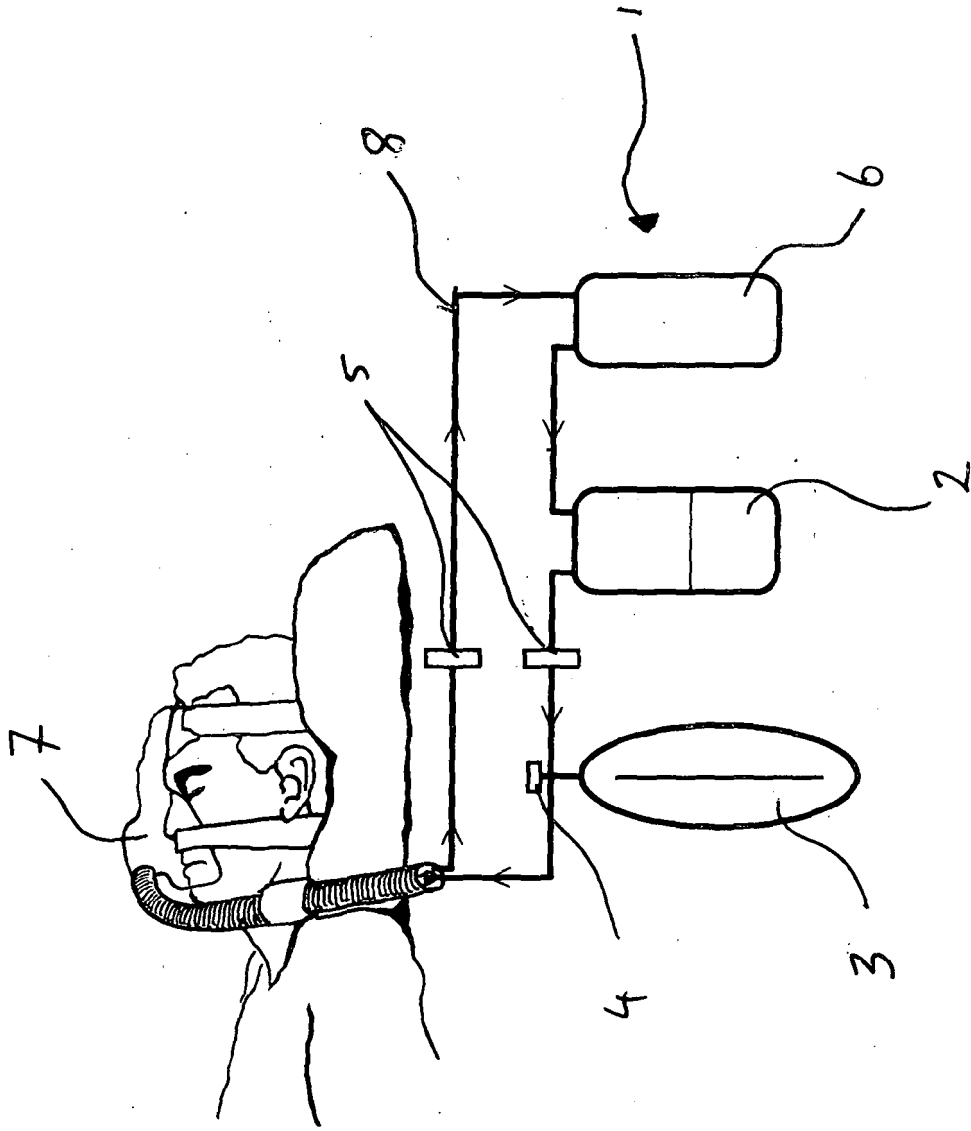


Figure 1

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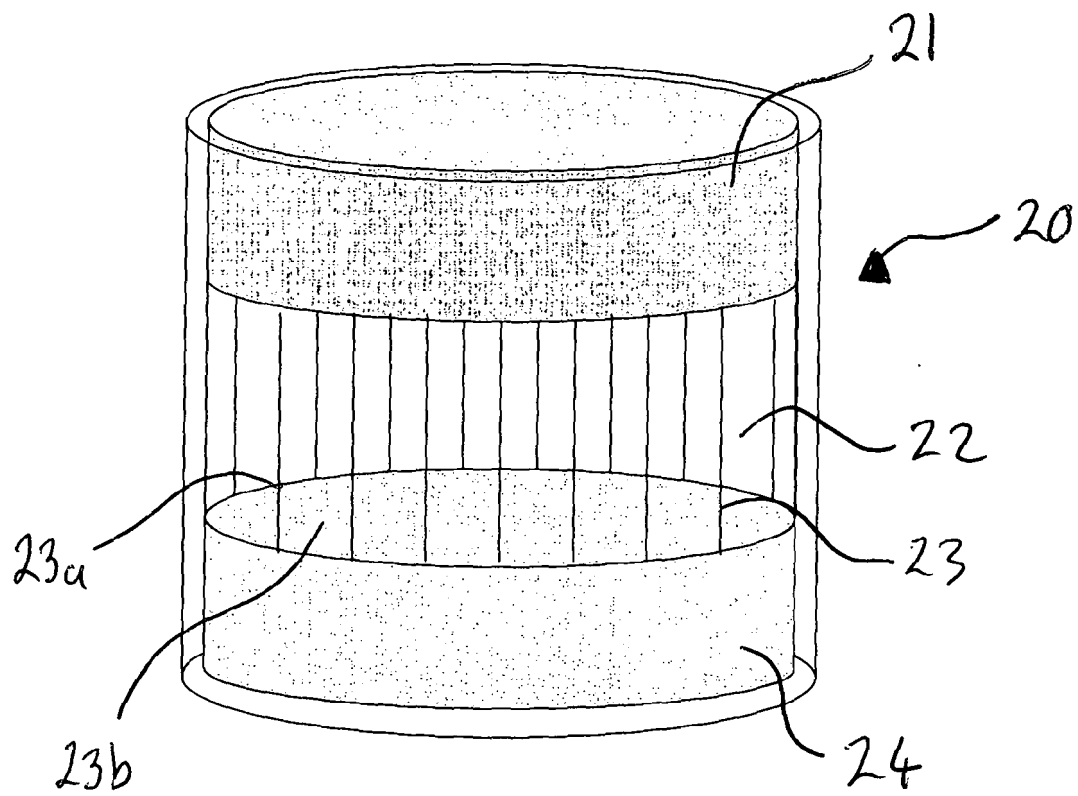
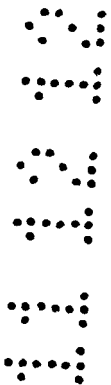


Figure 2



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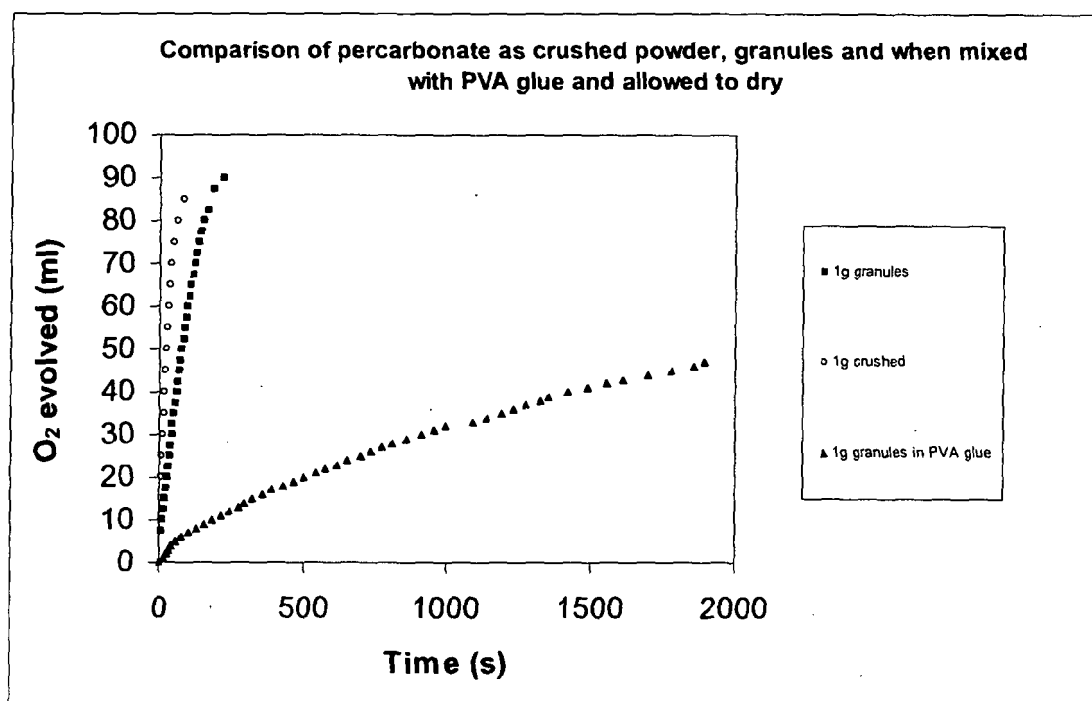


Figure 3.

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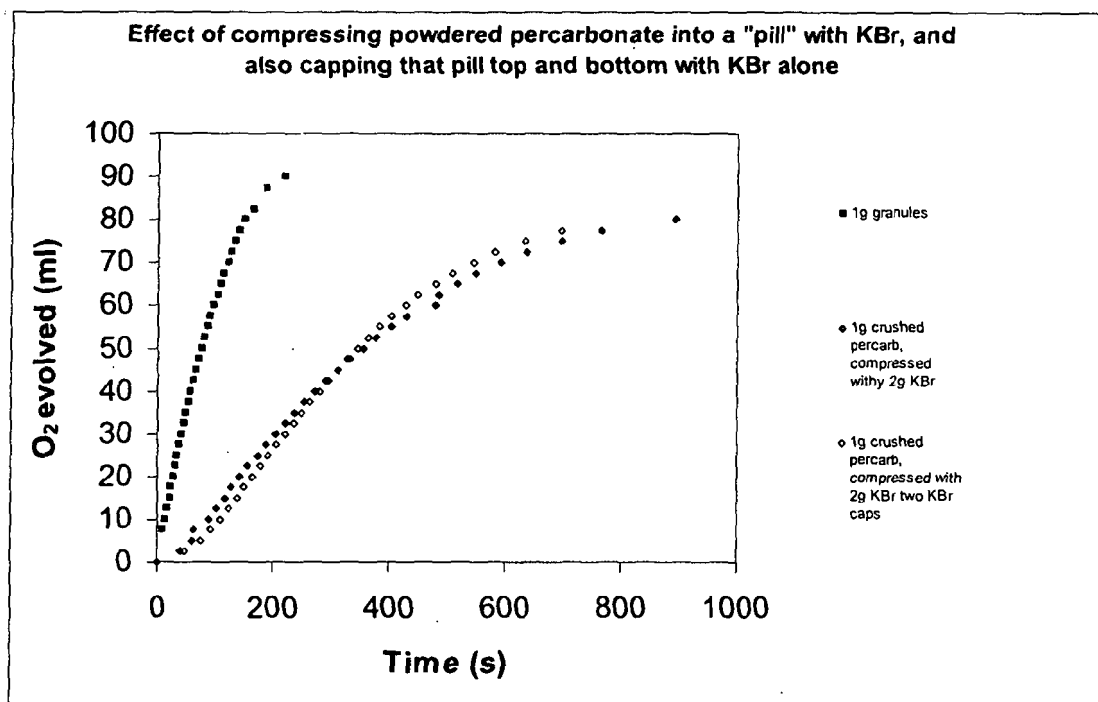


Figure 4

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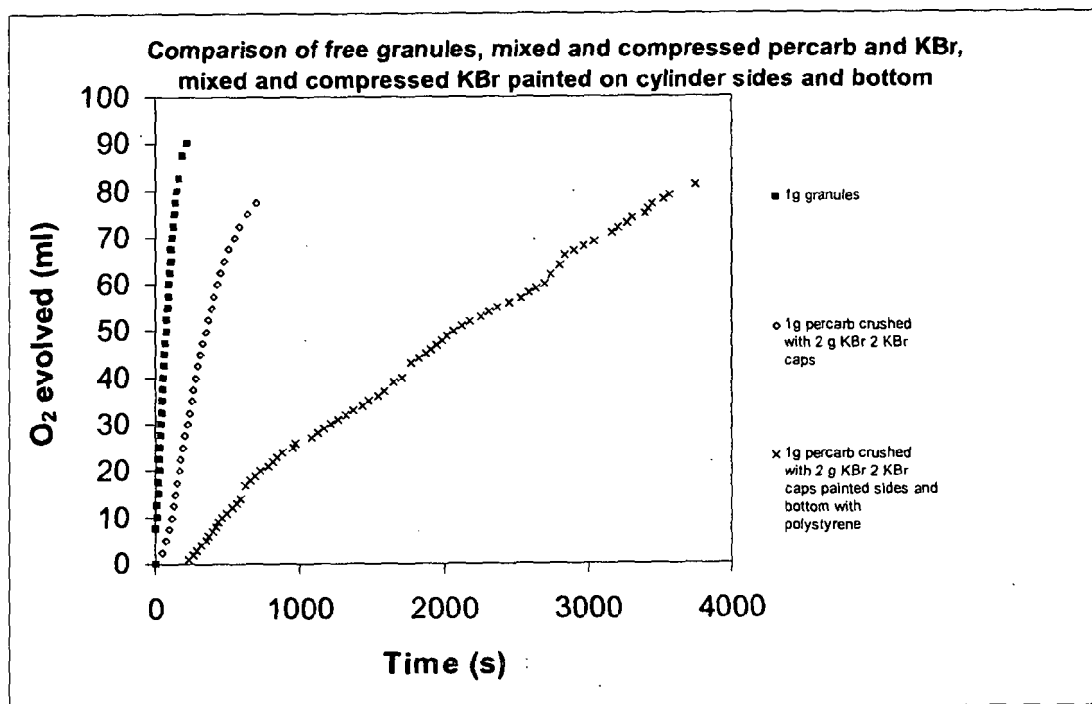
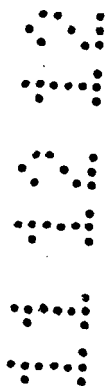


Figure 5



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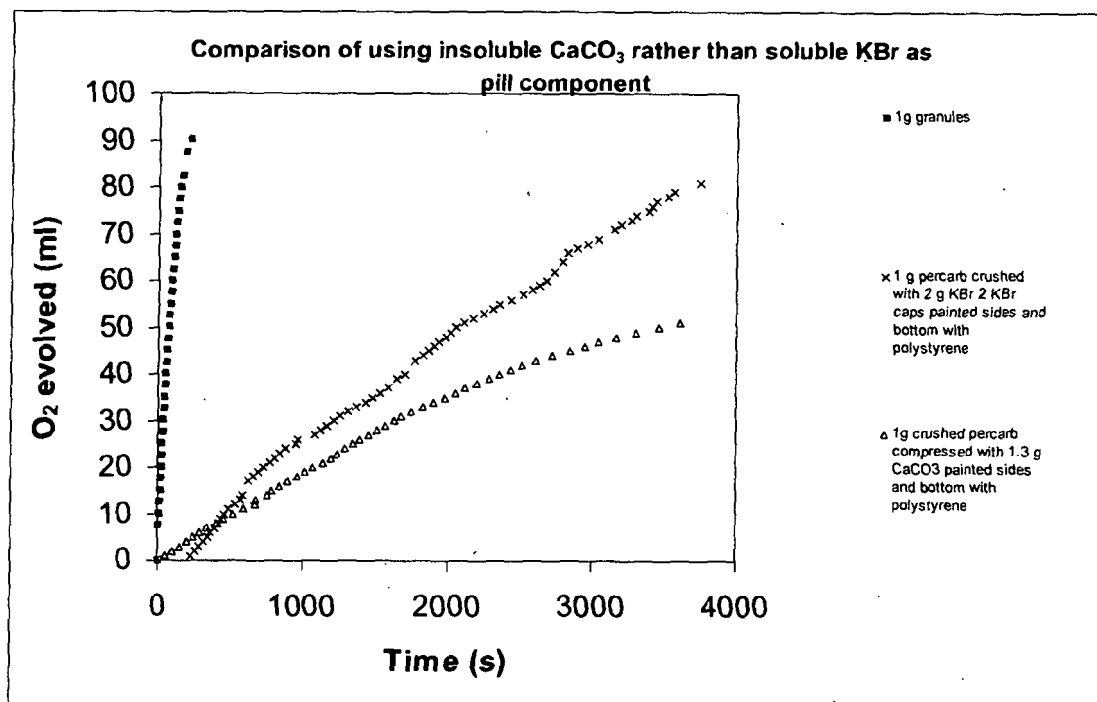


Figure 6.

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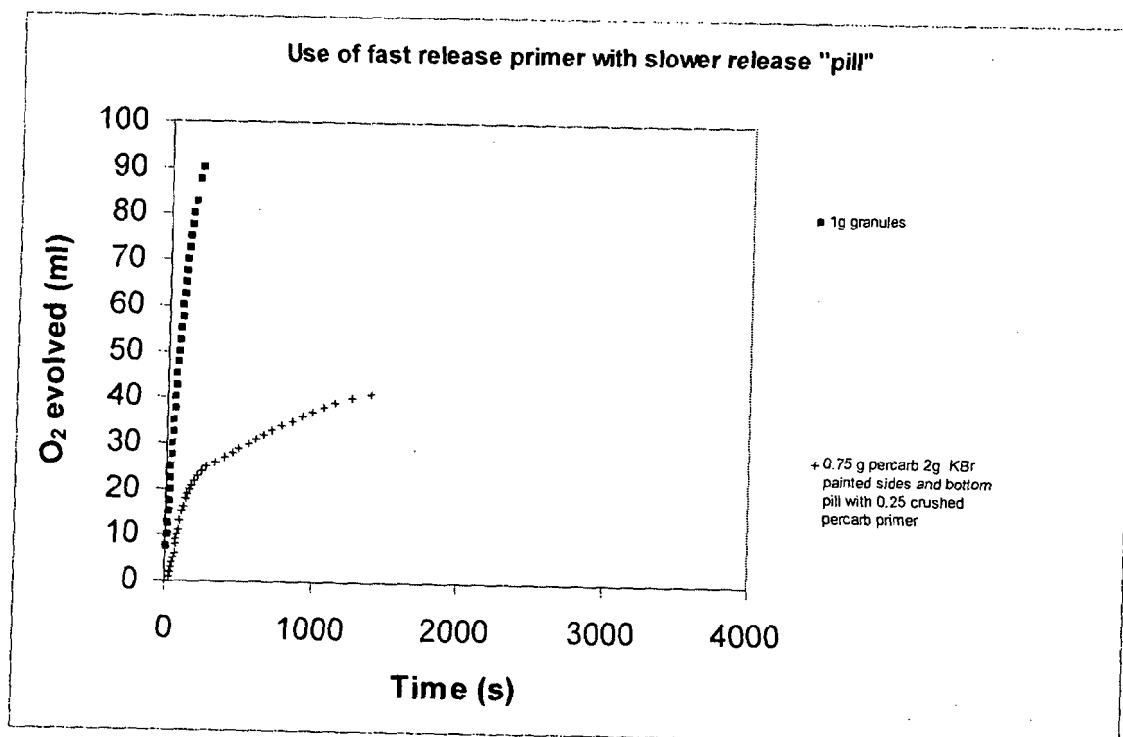


Figure 7



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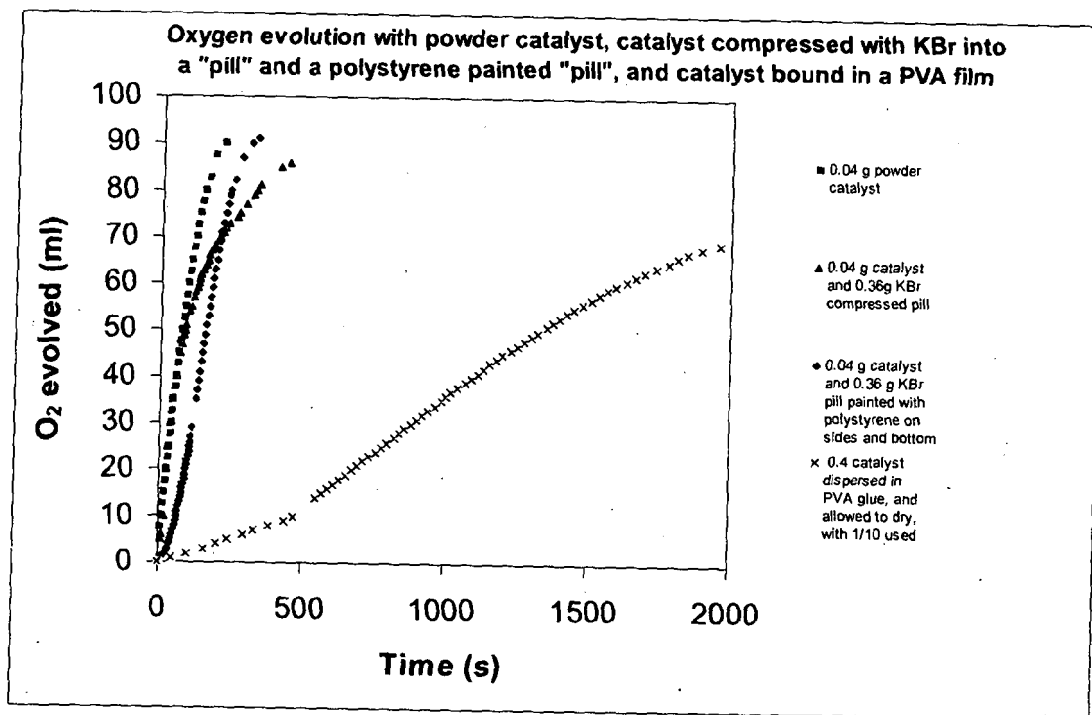


Figure 8

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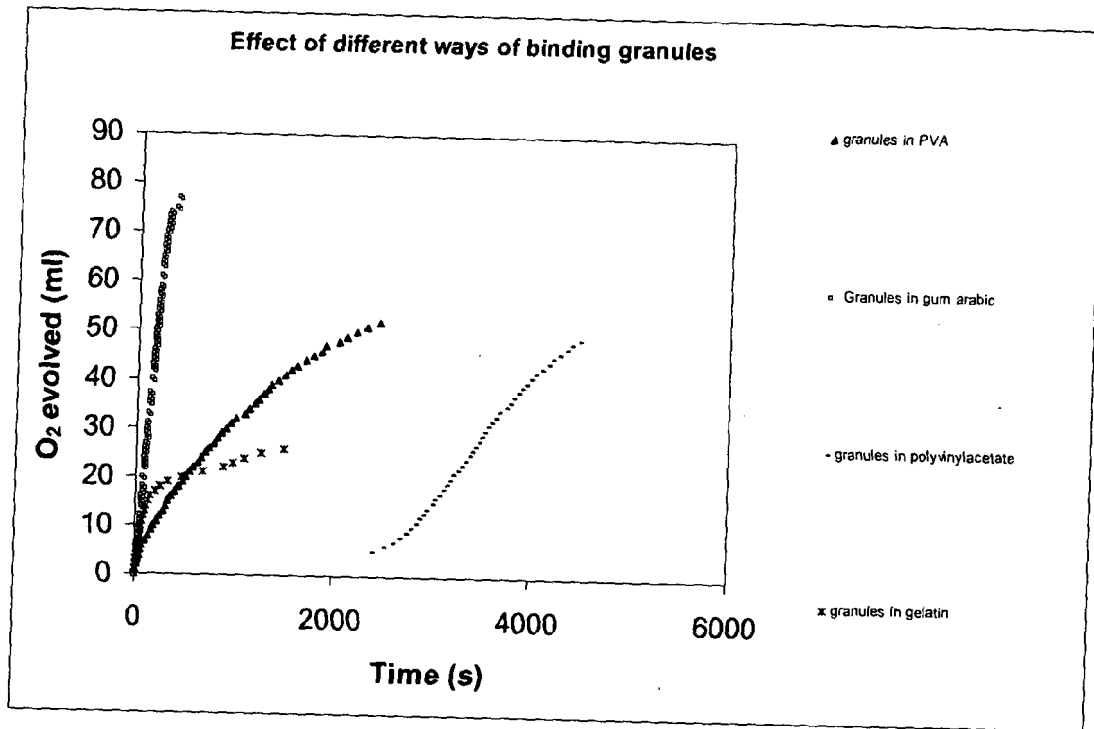


Figure 9

Device for the Generation of a Gas

Field of the Invention

The present invention relates to a device for the generation of a gas and in particular but not exclusively to a device and method for the generation of oxygen.

Background of the Invention

Gas generators are needed in a range of situations but in particular such generators are required in the medical field to generate gases such as oxygen to a patient in a medical emergency. Typically medical gases are supplied by way of gas cylinders but these have the problem that they are not generally readily portable as they are heavy. Also gas cylinders must be carefully stored because they contain gas stored at high pressure (typically around 200 times atmospheric pressure). If such cylinders are damaged (e.g. by impact or corrosion), or the cylinder pressure increases beyond its working limit (e.g. due to increased environmental temperature) there is the risk that an explosion may occur. Oxygen strongly supports combustion. Therefore if the contents of the cylinder leak in storage, and combine with a source of fuel and ignition, violent combustion will occur.

It is known to produce oxygen by a number of methods, one being by electrolysis where an electric current is passed through a conductive salt solution in order to release oxygen gas from water. Also oxygen concentrators are known where ambient air is pumped over a zeolite catalyst which acts as a molecular sieve to separate the components of the air, such as nitrogen and oxygen. The nitrogen is usually discarded and oxygen is collected ready for use. However, both of these methods have the disadvantage that a low flow rate of oxygen is produced and also the generation of the oxygen requires significant power input to generate the oxygen.

Another method to produce a gas is by way of a chemical reaction where two or more reagents are reacted together to produce the required gas. For the generation of oxygen typically reagents are used to produce hydrogen peroxide which is then decomposed in the presence of a catalyst to generate oxygen and water. However, this technique has the disadvantage that a large amount of oxygen is produced in a short length of time and there is sustained release of oxygen over a period of time. Also being a catalytic reaction there is the generation of heat, which may not be required in some environments. Furthermore, catalytic reactions can also be dependent on the ambient air temperature

and if the temperature is too high or low then this may affect the reaction and the amount of oxygen produced.

It is therefore preferable to have a means of supplying gases which avoids the inconvenience and risk associated with pressurised cylinders; and avoids the risk of leakage of flammable or toxic gases during storage. These problems may be overcome by generation of the gases at the point of use.

The present invention seeks to overcome the problems associated with the prior art by providing a way of generating oxygen over a sustained period of time, using safe and readily portable equipment.

Summary of the Invention

According to a first aspect of the invention there is provided a gas generator system for the delivery of gas to an individual, said gas generator system including a chemical gas generator unit in combination with a recirculating gas delivery system.

In a preferred arrangement the chemical gas generator unit includes a solid gas generator reagent.

It is envisaged that the solid gas generator reagent is provided in the form of granules or pellets.

Preferably the granules or pellets include percarbonate as the gas generator.

In a preferred arrangement the reagents of the chemical gas generator are contained in a medium that allows release of the reagents over a period of time. It is preferred that the medium is a wax or resin.

It is envisaged that the solid gas generator reagent generates oxygen. The gas generated may be pure oxygen or oxygen mixed with other gases such as nitrogen and/or argon to give a gas composition that is very similar to air.

Preferably the chemical gas generator unit is provided as a container into which the solid gas generator reagent is introduced either as a single dose or the container may have an opening into which the reagent can be fed either as a dose or on a continual basis.

Preferably the container is formed of at least two chambers, one for holding reactants and the other being a reaction chamber where the reaction occurs to generate a gas and the container has a feed control so that reagents can be fed to the reaction chamber so that gas is generated in a controlled manner.

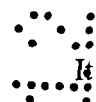
Preferably the chemical gas generator unit can be removed from the gas generator system and replaced with another unit if required.

In a preferred arrangement the gas generator system may also deliver other materials such as gases having pain killing effects or gases which can anaesthetise an individual. The use of such additional gases is of particular advantage where the gas generator system is being used in an emergency situation, for example if an individual is injured and needs pain relief or sedation.

Preferably the gas generator system includes a gas scrubber, for example a carbon dioxide scrubber to remove gases that may be harmful to the individual.

It is envisaged that the gas generator system includes one or more filters to filter gas that is being delivered to the individual.

It is preferred that the gas generator system includes gas monitors, for example to monitor the levels of carbon dioxide and/or oxygen in the system. This is to ensure that the appropriate levels of gases are being delivered to the individual and to make sure that the levels do not become harmful, for example if there is a build-up of carbon dioxide.



It is envisaged that the monitor may be an electronic or and optico-chemical monitor that can give a visual or an audible warning or a combination of the two if gas level are not at a safe level.



Preferably the gas generator system includes a temperature control to control the reaction rate of gas generator reagent in the chemical gas generator unit. The temperature control can act to bring the chemical gas generator unit to an optimal temperature to generate a gas generation reaction and once the reaction is started the temperature control can be regulated to control the gas delivery over a period of time.

It is envisaged that the gas generator system includes a gas release control whereby gas generated by the chemical gas generator unit is released at a controlled rate.

Preferably the gas generator system includes tubing for the transport of gas that is coaxial tubing.

According to a second aspect of the invention there is provided chemical gas generator unit adapted to be used with a gas generating system for the generation of gas to be delivered to a recirculating gas delivery system, said chemical gas generator unit including solid gas generator reagent to generate the gas to be delivered.

According to a third aspect of the invention there is granules of gas generating material to be used with a gas generating system for the generation of gas to be delivered to a recirculating gas delivery system.

It is envisaged that the device is used in the medical field in general but due to the transportability of the device it has particular applications in situations where there are medical emergencies. It would be a particularly useful device for paramedics where a patient has to be stabilised before moving the hospital and it has a particular application in military situations where first aid is given before the patient is evacuated to a base where they can receive full medical care.

Brief Description of the Drawings

••••• An embodiment of the invention will now be described, by way of example only and not in any
•••••imitative sense, with reference to the accompanying drawings in which:

••••• Figure 1: shows a gas generator system in conjunction with a recirculating system;
•••••

••••• Figure 2: shows a gas generator reagent in the form of a granule for chemical gas generation in the
••••• gas generator system as shown in Figure 1;

Figure 3: shows a comparison between different types of chemical gas generation vehicles;

Figure 4: shows the effect of having a cap of potassium bromide (KBr) on the top and bottom of a gas generator granule;

Figure 5: shows the effect of having KBr on the base and sides of a gas generator granule;

Figure 6: shows the use of calcium carbonate rather than potassium bromide as a gas generator reagent;

Figure 7: shows the effect of using a primer for the reaction to create a gas using a gas generator reagent;

Figure 8: shows the use of a catalyst with granules and their effect of gas generation; and; and

Figure 9: shows the use of different binders to form a gas generator reagent according to an embodiment of the invention.

Detailed Description of the Invention

A gas generator system according to an embodiment of the invention is shown generally as 1 in **Figure 1**. The system includes a chemical gas generator 2 which once activated generates gas and leading from this a ventilation bag 3, which is self-inflating and which can be squeezed by medical personnel to deliver gas generated to an individual. The ventilation bag is connected to the system by way of a pressure relief valve 4 to ensure the correct level of ventilation is being given. The gas is delivered to an individual by way of a face mask 7. Returning from the individual there is optionally a gas scrubber 6, which is typically arranged to remove carbon dioxide that has built up in the system. The carbon dioxide scrubber may include strong bases such as lithium, potassium, barium hydroxide or soda lime and optionally also regenerative metal oxide materials to capture unwanted gases. There may also be molecular sieves to remove any additional gases that have built up. In the gas delivery circuit and in the return circuit there are ideally filters. The filter in the gas delivery circuit prevents caustic dust or solution from the gas scrubber from entering the breathing system and lungs of the individual. The return circuit has a filter to prevent water from the breath of the individual from entering the scrubber to avoid explosion of the scrubber reagents should they contact

moisture. The gas delivery circuit includes one or more one-way valves (not shown) to ensure that the gas only flows in the desired direction around the circuit: from generator to patient to scrubber.

Preferably the scrubber contains lithium hydroxide as it can absorb the greatest amount of carbon dioxide per unit mass of the scrubber. A patient takes up around 300ml/min of oxygen (VO_2) and metabolizes this to produce around 250ml/min of carbon dioxide (VCO_2). To achieve this, an average adult has a minute ventilation (MV) of approximately 5000 ml/min (Tidal volume V_T of 500ml per breath x respiratory rate of 10 breaths per minute) at rest. A given mass of LiOH can absorb 1.6 x the mass of carbon dioxide that an equivalent mass of soda lime will absorb. 1kg LiOH will absorb 0.93kg carbon dioxide at a MV of 12l/min i.e. for a hyperventilating shocked patient 90kg LiOH will last 2.7 hrs.

Oxylithe which is a sodium peroxide (Na_2O_2 or NaO_2) or potassium superoxide KO_2 may also be used as carbon dioxide scrubbers as it also has the added benefit of producing oxygen as carbon dioxide is absorbed.

Typically the oxygen and carbon dioxide levels are monitored in the breathing system. Also the carbon dioxide status in the gas scrubber is monitored to indicate whether it still has capacity to absorb gases or whether it needs replacing. The monitoring may be electronic or optico-chemical means (not shown). Preferably an optico-chemical system is used so that a monitor can be seen to change colour as the level of carbon dioxide and or oxygen changes. The use of an optico-chemical system avoids the use of chemical or moving parts and so provides a more failsafe system. The colour change may be any change in colour but preferably not from red to green or vice versa as a

proportion of the population is colour blind and so operators with this condition would not be able to see if the gas level had changed.

In a preferred arrangement the tubing in the system that is used for the movement of gases around the system is coaxial tubing. This is so the bulk and weight of the gas generator system can be kept to a minimum. This is especially important as the gas generator system is optimally used in emergency situations of where there is a potentially hazardous environment, for example in avalanche rescues, high altitude situations (mountaineering, aviation or space) mine rescue, underwater situations (diving or submarine escape) or in anaesthesia delivery.

Figure 2 shows a solid gas generator 20 that is typically used in the invention. The solid gas generator is typically in the form of a capsule. As shown in this embodiment the capsule is cylindrical with a cap 21 at a first end. The cap may be a soluble material such as potassium bromide (KBr), or insoluble for example calcium carbonate (CaCO_3). Other materials may be used such as organic or inorganic membranes, or a mix of materials which dissolve or break up at a required rate, including such materials as a PVA polymer. This cap may also contain percarbonate. The cap can be a single layer of material or there may be multiple layers.

Further along the cylindrical granule, there is a reactive section 22 that includes a reactive substrate and typically such a substrate as percarbonate, with or without mix of other components. These may be soluble, e.g. KBr or insoluble e.g. CaCO_3 , or a mix of materials which dissolve or break up at a required rate, including such materials as a PVA polymer.

Around the reactive section there may also be an outer coating 23. The outer coating typically is formed of areas of soluble 23a and insoluble material 23b applied in areas to allow a controlled exposure of reactive materials such as percarbonate. The outer coating is typically soluble, e.g. KBr or insoluble e.g. CaCO_3 , or an insoluble paint or polymer e.g. polystyrene, or a metal sheath, or organic or inorganic membrane or a soluble polymer such as PVA. It may also contain percarbonate. The outer coating may be applied over whatever area is required to give the required rate, (in this example the outer component is applied over whole of the three inner components except the top cap).

In addition to the first cap 21 as shown in this embodiment, there is also a second cap 24 at the other end of the cylindrical granule. Again capping component may be soluble, e.g. KBr or insoluble e.g. CaCO_3 , or organic or inorganic membrane, or a mix of materials which dissolve or break up at a required rate, including such materials as a PVA polymer. The bottom cap may also contain percarbonate. Top and bottom caps may be of the same or different materials. Furthermore the coating and/or the caps may be of different shapes and cover different areas of the reactive part of the granule in order to give different reaction rates so the gas can be generated as required. The granules in the chemical gas generating unit may be coated in the same way for all of the granules or there may be different coatings for different amounts of granules so the reaction rate can be controlled according to how gas can be released due to the areas coated.

The rate of delivery of gas to an individual is important as is the time period over which the gas is delivered. If there is a large amount of gas delivered in a short time period then in a rescue or emergency situation, this may not sustain the individual long enough for them to be kept alive as the gas will be exhausted before the individual is rescued. If the gas is not delivered at an adequate rate, again this will have a detrimental effect of the individual. Therefore the nature of the solid gas generator material is important for adequate and sustained gas delivery.

The figures show the effect of conditions on the granules used as a gas generator reagent according to an embodiment of the invention.

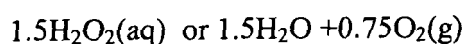
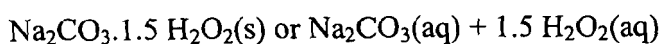
Rate studies

Unless specified otherwise these were generally carried out at room temperature, using nominally 1 g percarbonate; 0.04 g MnO_2 powder, and 80 mL of distilled water. The reaction vessel was connected to a graduated gas syringe so that the volume of oxygen evolved could be measured at any time after the start of the reaction.

For a reaction to occur using solid percarbonate, three components need to be present: 1) sodium percarbonate; 2) catalyst, and 3) water. Each reaction was started by adding one of these three components to the other two in the reaction vessel. The reaction vessel was contained in a water bath at room temperature. [Note: The heat of reaction of decomposition of hydrogen peroxide is 98 kJ mol^{-1} , and the molecular weight of sodium percarbonate is 157 g mol^{-1} so decomposition of H_2O_2 from 1 g of percarbonate generates $1/157 \times 98 \times 1.5 = 936 \text{ J}$; enough to raise the temp of 80 mL of water by 2.8 K.]

••••• The compression of material to obtain the reactant granules, which are also referred to as "pills" was achieved using a KBr disc die (as used in Infra-red spectroscopy) and applying a pressure of 2 ton for 1 minute from a hydraulic press. The resultant "pills" are small cylindrical objects of approximately 1 cm diameter and about 0.2 -3 cm in length thereby providing a small cylindrical granule. The amount of KBr used as the "capping" layers was approximately 0.1-0.2 g. The pills themselves could, using other compression devices, be made to any size and with any thickness of the various layers making up the structure. Compression of the percarbonate is not necessarily a requirement, and it may be simpler to use bags of percarbonate held in soluble or insoluble polymer or inorganic membranes.

Also a solution of polystyrene in toluene was used to make a paint to apply to the "pills" to control the surface area available for dissolution. Typically the reactions are as follows:



1 mole (157.01 g) generates 0.75 moles of oxygen i.e. $.75 \times 0.082 \times 293 = 18.02$ L of oxygen at 20 °C

(and 27 mL of water)

For 1 L oxygen per minute for one hour the following is used - 522.8 g percarbonate gives 60 L (or 10% extra: 575.08 g i.e. 3.66 moles).

Thermal Calculations for containers used in the reactions

522.8 g percarbonate gives 60 L. (Using 10% extra: 575.08 g, i.e. 3.66 moles). The amount of water needed is approximate but on average 1 L water is required.

Products:

66 L oxygen

352.89 g sodium carbonate (of which 142.02 g solid; and 210.9 g in solution.

98.82 mL water

Final mix:

1098.82 ml water

heat capacity = 4593 J K^{-1}

142.02 g solid sodium carbonate (guesstimate 50 J K^{-1} per mole) = 67 J K^{-1}

210.9 g in solution (I've ignored this)

Heat generated by reaction

$3.66 \times 1.5 \times 98 \text{ kJ} = 538 \text{ kJ}$. The potential temperature rise (for water remaining as liquid) $\sim 113 \text{ C}$. Heat generated for 1 L min^{-1} about 9 kJ min^{-1} or 0.15 kJ s^{-1} . (Over an hour in an insulated vessel this would be about a 2 °C rise per minute). A 4 inch (10 cm) diameter cylinder; would be filled (assuming ca 1.5 L solid/liquid charge) to:

$$\text{Vol} = ht \times \pi r^2$$

$$1500/(5 \times 5 \times 3.14) = 19.1 \text{ cm}$$

And this would have a contact area of:

$$2\pi rh + \pi r^2 = 2 \times 3.14 \times 5 \times 19.1 + 3.14 \times 5 \times 5 = 599.74 + 78.5 = 678.24 \text{ cm}^2$$

A plate of 1 mm stainless steel with typical thermal conductivity of $20 \text{ W m}^{-1} \text{ K}^{-1}$ of this area $[(678)/(100 \times 100) = 0.0678 \text{ m}^2]$ transfers $0.0678 \times 20/0.001 = 1.36 \text{ kJ}$ per degree temp difference per second. This suggests that thermal conductivity of the vessel would be enough to keep the temperature near ambient if it was not insulated. Assuming uniform temp in the reaction mix then thermal equilibrium will be reached when rate of production of heat: 0.15 kJ s^{-1} is equal to loss = $1.36 \times \Delta T$; and for stainless steel $\Delta = 0.11 \text{ C}$ and the content will remain 0.11 C above ambient.

The thermal conductivity of the PET plastic used in pop bottles is $0.15 \text{ W m}^{-1} \text{ K}^{-1}$ so a cylinder made out of this would transfer: $0.0678 \times 0.15/0.001 = 0.01 \text{ kJ}$ per degree temp difference per second. For a 1 mm (which is thick for a PET bottle) PET container the contents would remain 15 C above ambient. (7.5 C if the container is composed of 0.5 mm PET).

Aluminium alloys have very high thermal conductivity of about $120 \text{ W m}^{-1} \text{ K}^{-1}$ and so would be a good choice for container. Given the thermal conductivity of metals, it would be desirable to use a thermally conducting bottle and a catalyst charge chosen to give a rate of 1 L per minute at that temp.

It is possible to use a catalyst with a coloured thermochromic indicator and/or a mechanical indicator

such as a bimetallic block so an operator is aware of the right temperature reaction. In the case of a bimetallic block, this can be included with a valving system to control the release of material into the reaction.

Furthermore the container, which may be in the form of a bottle, could contain a mesh of loose thin metal wire to enhance thermal uniformity inside. Another possibility to enhance thermal control would be to have the catalyst deposited on the inside surface of the metal cylinder itself. If the active part of the cylinder surface was only the base or top then it would be possible to arrange a push fit or screw fit top half which pushed/screwed over a different area depending on the ambient temperature. It would need a few dimples or ridges to lock in place and a rubber ring seal to prevent leakage but

might be possible. Furthermore it is possible to have a powder catalyst charge for all ambient temps but with a "peel-off" insulation or "twist to insulate" device on the outside of an aluminium cylinder with thin metal wire wool (with catalyst stuck on even) thermal equaliser inside.

Turning to the reactions themselves, **Figure 3** shows the influence of dissolution rate on oxygen evolution where there are granules of 1-2 mm diameter; crushed percarbonate where granules are ground using a pestle and mortar to give a powder and granules of percarbonate mixed with PVA glue. As can be seen the use of a mixing agent such as PVA glue inhibits dissolution of percarbonate and slows down the oxygen evolution rate considerably. The oxygen evolution from the crushed sample is much faster than that from the granular material and hence may not sustain gas generation over a period of time.

As shown in **Figure 4**, the influence of dissolution rate on oxygen evolution can be altered by capping the granule. Percarbonate is compressed with KBr, in a ratio of 1:2 to give percarbonate:KBr. This is done in a press, typically a 2 ton press to give a "pill" and this "pill" is then capped top and bottom with KBr also using a 2 ton press to give a three layer "pill". Results using percarbonate granules included for comparison. KBr was chosen because it is readily soluble and gives good crystalline discs when compressed under pressures of a few ton. There is an induction period in oxygen evolution for the experiments using these compressed pills, and this is most clearly marked when using the capped pill. Considering the capped pill, initial dissolution can only occur from the sides of the pill and is therefore relatively slow but when the KBr caps dissolve there is a greater surface area of percarbonate/KBr exposed and the rate of oxygen evolution increases.

As can be seen in **Figure 5**, the influence of dissolution rate on oxygen evolution can be altered by in effect of painting the "pill" with an insoluble polymer layer. The pill was the same type as used in **Figure 4** but this time the pill was coated with polystyrene in toluene to give an insoluble polystyrene layer around all but the top of the pill. Results using percarbonate granules, 2, are included for comparison. The effect of the polystyrene is to limit dissolution to the top of the pill only, and the delay time arises because the KBr cap must dissolve before any of the percarbonate/KBr mix is exposed to the solution.

Figure 6 shows the influence of dissolution rate on oxygen evolution using soluble or insoluble material as a mix with percarbonate. The graph shows the uses of insoluble CaCO_3 instead of soluble KBr, 7, the results include the results using percarbonate granules for comparison. The effect of

using an insoluble matrix component is to slow down dissolution and also there is lack of an induction period for the uncapped CaCO_3 pill, 7.

The influence of dissolution rate on oxygen evolution using a fast release primer and slower release "pill" is shown in **Figure 7**. Oxygen evolution from a mix of a 25% fast release primer of crushed percarbonate with a slower acting pill (0.75 g percarbonate : 2 g Ker, with the sides and one end of the granule being covered with polystyrene. Results using percarbonate granules are included for comparison. The use of fast release primer may be useful to give a pulse of oxygen to remove residual air in the delivery device, but once cleared only the slow release from the "pill" is necessary to maintain the oxygen concentration.

Figure 8 shows the use of a catalyst with the gas generator reagent. The plots show oxygen evolution using 1 g of granular percarbonate and either:

- a) powdered catalyst (as supplied by manufacturer);
- b) 0.04 g of catalyst ground up with 0.36 g KBr then compressed in a 2 ton press to give a pill,
- c) 0.04 g of catalyst ground up with 0.36 g KBr compressed in a 2 ton press to give a pill which was then painted with polystyrene on sides and bottom;
- d) 0.4 g catalyst mixed with PVA glue, dried to a thin sheet and then $1/10^{\text{th}}$ used.

All of these runs have nominally the same amount of catalyst, but availability of catalyst to hydrogen peroxide varies according to preparation, and with time, and the different curves show the range of reaction control available using these various catalyst preparations. The slow rate of oxygen evolution for the PVA bound sample suggests only a small fraction of catalyst is available for reaction. The variation in rate seen with the painted pill shows the effect of the increasing amount of catalyst released into solution as the pill dissolves. The use of a binder with the catalyst may also be used to slow down the reaction by minimising the amount of free catalyst at any time during the reaction.

Solid sodium percarbonate has H_2O_2 held in the crystal lattice as "peroxide of crystallisation" in the same way that other crystal structures have "water of crystallisation". H_2O_2 will decompose to oxygen and water in the presence of a number of both heterogeneous and homogeneous catalysts. Perhaps the most widely known catalyst for peroxide decomposition is solid MnO_2 .

Evolution of oxygen from percarbonate is therefore a 3 stage process:

- 1) Dissolution of crystalline percarbonate to give free H_2O_2 in solution.
- 2) Mass transport of H_2O_2 and/or catalyst to bring these two reactants together.
- 3) Decomposition of H_2O_2 by reaction with the catalyst.

Control of the rate of evolution of oxygen can be achieved by control of the rate of any one, or any combination, of these three steps. Further control of the reaction may be by controlling the following:

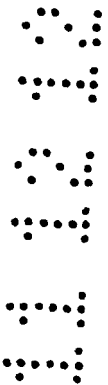
- i) release of inhibitors into the reaction mix;
- ii) release of viscosity altering agents into the reaction mix to inhibit mass transport;
- iii) control of temperature; introduction of endothermic and exothermic processes into the reaction at various times and/or at various temperatures.

Finally, **Figure 9** shows the effect of different binders on oxygen evolution. The plots show oxygen evolution as a function of time using a nominally 1 g sample of granules of percarbonate mixed with various organic binders to give a pellet of material. The data indicate the range of control of oxygen evolution available by using binders of different solubilities and swelling rates. Typical binders that can be used are polymers; gum Arabic, PVA, gelatin or adhesives. Such binders may also be used with the catalysts as discussed in relation to Figure 8. It is envisaged that the device includes reaction inhibitors that are used to decelerate chemical production of the gas.

The device of the invention is lightweight, portable and can withstand damage and this makes it a particularly safe device in emergency situations. The benefit of having no electronics or major moving parts means that the risk of failure of the device is minimised which again makes the device particularly useful in outside emergencies where there may be no access to power. Further by not using pressurised gas containers the risk of explosion, for example if emergency crews are working in a situation where there is a fire risk or a risk of impact damage to the cylinder makes the device of the invention a very safe option to use.

The device has particular applications in the areas of avalanche rescue, mountaineering, aviation or space travel, mine rescue or in general anaesthesia


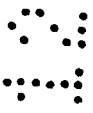


It should be noted that the above mentioned embodiment illustrates rather than limits the invention and that alterations or modifications are possible without departing from the scope of the invention as described. It is to be noted that the invention covers not only individual embodiments described but also combinations of those embodiments.



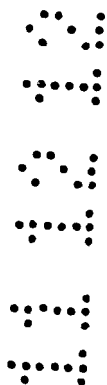
Claims

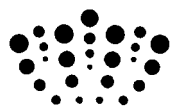
1. A gas generator system for the delivery of gas to an individual, said gas generator system including a chemical gas generator unit in combination with a recirculating gas delivery system.
2. A gas generator system according to claim 1, wherein the chemical gas generator unit includes a solid gas generator reagent.
3. A gas generator system according to claim 2, wherein that the solid gas generator reagent is provided in the form of granules or pellets.
4. A gas generator system according to claim 4, wherein the granules or pellets include percarbonate as the gas generator.
5. A gas generator system according to any preceding claim wherein the reagents of the chemical gas generator are contained in a medium that allows release of the reagents over a period of time.
6. A gas generator system according to claim 5 wherein the medium is a wax or resin.
7. A gas generator system according to any preceding claim wherein the gas generated is oxygen, or an oxygen containing gas mixture.
8. A gas generator system according to any preceding claim wherein the chemical gas generator unit is provided as a container for the gas generator reagent.
9. A gas generator system according to claim 8, wherein the container includes an opening into which the gas generator reagent can be introduced as a single dose or on a continual basis.
10. A gas generator system according to claim 9, wherein the container includes a valve to control the supply of gas generator reagent.
11. A gas generator system according to any of claim 8 to 10 wherein the container is formed of at least two chambers, one for holding reactants and the other being a reaction chamber where

the reaction occurs to generate a gas and the container has a feed control so that reagents can be fed to the reaction chamber so that gas is generated in a controlled manner.

12. A gas generator system according to any preceding claim including an indicator to show the reaction conditions during gas generation.
13. A gas generator system according to claim 12, wherein the indicator is a visual or a mechanical indicator or a combination of the two.
14. A gas generator system according to claim 13, wherein when the indicator is a visual indicator the indicator is a change in colour.
15. A gas generator system according to any preceding claim including a temperature control mechanism to slow down gas generation if required.
16. A gas generator system according to claim 15, wherein the reaction is controlled by a cooling mechanism.
17. A gas generator system according to claim 16, wherein the cooling mechanism is a heat sink on a container holding gas generator reagents.
18. A gas generator system according to any preceding claim arranged to additional gases which can act as analgesics or anaesthetics.
-  19. A gas generator system according to any preceding claim including one or more gas scrubbers.
-  20. A gas generator system according to any preceding claim including one or more filters.
-  21. A gas generator system according to any preceding claim including monitors which active an alarm if required gas levels are outside a desired range.
-  22. A gas generator system according to any preceding claim wherein gas delivery is by way of coaxial tubing.

23. A chemical gas generator unit adapted to be used with a gas generating system for the generation of gas to be delivered to a recirculating gas delivery system according to any preceding claim
24. A chemical gas generator unit that is releasably connected to the gas generator system according to any of claims 1 to 22.
25. A solid gas generator reagent to be used in a gas generator system according to any of claims 1 to 22.





Application No: GB1120088.8

Examiner: Dr Matthew Hall

Claims searched: 1-25

Date of search: 27 February 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-5, 7-9, 19-20, 23 & 25	US2006/090756 A1 (MAWHIRT) See whole document.
X	1-5, 7-9, 19-20, 22-23 & 25	US6443149 B (WISE) See whole document.
X	1-5, 7-9, 19-20, 23 & 25	US4817597 A (JAPAN PIONICS) See whole document.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X:

Worldwide search of patent documents classified in the following areas of the IPC

A62B; B01J

The following online and other databases have been used in the preparation of this search report

WPI & EPODOC

International Classification:

Subclass	Subgroup	Valid From
B01J	0007/02	01/01/2006
A62B	0021/00	01/01/2006