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COMPOSITION FOR PURIFICATION OF AIR
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This invention relates to air purifying compositions and to their manufacture, and, more particularly, to a composition, and its manufacture, which is adaptable for use at relatively low or subnormal temperatures by being reactive at such temperatures to purify contaminated air, as an example, reacting with respired or exhaled air to render air suitable for breathing.

An important circumstance to which this invention is directed is to provide a composition which is suitable for use in a breathing apparatus which is in itself self-contained, that is, it is operative in supplying oxygen sufficient for respiration. This is accomplished for the most part by including a compressed supply of oxygen as a part of the apparatus, but since it is necessary to keep the extent of the apparatus at a minimum, advantage is taken of the oxygen available in exhaled air by providing a completely closed breathing circuit within the apparatus to constrain exhaled air to move along a defined path and to be subjected to a composition reactive with the air to remove or absorb carbon dioxide and thus free or purify the oxygen for re-breathing.

For a composition to be suitable for the type of breathing apparatus as considered above, the composition must have the property of being highly reactive with respired air in absorbing carbon dioxide and at substantially the instant the exhaled air contacts the composition. Any delay in reaction would allow the exhaled air to pass through the composition and into that portion of the breathing circuit reserved for respirable air and inhalation purposes. The circuit, due to practical necessities is of a relatively small volume, and any such initial delay in reaction would result in the volume of the circuit being filled with carbon dioxide, and if this delay continues for even a short duration, the carbon dioxide would build up in the circuit to the extent that physiological hazards of serious consequence would be created.

The alkali metal peroxides, such as sodium or potassium peroxide, have been used heretofore in self-contained breathing apparatus for reacting with respired air to absorb carbon dioxide and thereby purify the unused oxygen and also to evolve additional amounts of oxygen, but it has been found that these materials, although satisfactory at the normal atmospheric temperatures, that is, at temperatures comparable to ordinary room temperatures (at or about 15 degrees centigrade), are unreactive at low or subnormal temperatures with respired air (that is, temperatures

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being at or below the freezing temperature of water). They continue to be unreactive, or, at least, insufficiently so when contacted by respired air until large amounts of the air have passed through the material to raise its temperature sufficiently that it becomes reactive. Because of the requirements of a composition, it is obvious that this delay in reaction, which is ordinarily referred to as the induction period, renders these materials unsuitable as a purifying composition when the apparatus is to be used at these relatively low temperatures.

It has been proposed to supply heat to these metallic peroxides from some outside source as by incorporating in the apparatus an electrical resistance unit, but one of the principal difficulties encountered with such an arrangement is that it limits the use of the apparatus to locations where an ample source of energy is available, and it further complicates the apparatus and its operation.

Since it is intended by this invention to provide a composition which renders self-contained breathing apparatus adaptable for use at low temperatures, a further problem is encountered due to the condensation of moisture which occurs at these low temperatures. Respired air at body temperature is almost completely saturated with moisture, and it is evident that reduction in temperature of almost saturated air produces condensation. Under ordinary circumstances condensation in the apparatus does not occur and even if it does it is inconsequential. At low temperatures, condensation does occur and is hazardous because it will freeze and render the valve means of the circulatory breathing system and the means controlling the admission of oxygen from an auxiliary source inoperable and result in failure of the apparatus. It is, therefore, important and, in fact, an indispensable property that for a composition to render breathing apparatus usable at low temperatures, it must be adaptable in removing moisture from respired air, and it must do so in such a manner that moisture is removed almost instantly whereby substantially all air discharged from the composition and into the inhalation side of the breathing system contains a moisture content which is not more than the amount necessary to saturate the air at these low temperatures.

It is a major object of this invention to provide a composition reactive in the prescribed manner at low or subnormal temperatures in removing carbon dioxide and moisture from respired air

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and which is reactive at temperatures as low as 25 to 30 degrees centigrade below zero.

At the altitudes now reached in aviation, the atmospheric pressure is reduced in some instances to a pressure equal to an amount about one-half that of normal atmospheric pressure, and this relatively low pressure is accompanied by low temperatures. It is a specific purpose of this invention to provide a composition sufficiently reactive at these extreme pressure and temperature conditions with respired air to remove carbon dioxide and moisture in a closed breathing circuit in order to render exhaled air suitable for respiration and without resulting in material amounts of condensation.

It is a more specific object of this invention to provide a composition which, in addition to reacting with respired air to remove moisture and carbon dioxide, evolves oxygen when reacting with respired air and thereby reduces to some extent the amount of oxygen needed from an auxiliary supply.

A composition, even though adaptable to purify respired air at the contemplated temperatures, must be relatively inexpensive because of the limited reactive capacity of materials and the alternative of using other types of apparatus. It is an object of this invention to provide a suitable composition which can be made, at least for the most part, of readily available and cheap materials and by a method which does not require special or additional apparatus other than as used ordinarily in the manufacture of this general type of composition.

In breathing apparatus of the type considered, it is the practice to use reactive material in a granulated state in order to provide as large a contactable surface area of material as possible, but on the other hand the particles of material making up the granulated mass must be large enough and be of sufficient hardness so that breathing resistance through a substantial layer of the material is less than the maximum allowed for such purpose. Also, the material must be of a character which does not change materially in physical state by reaction with air in order that the limited breathing resistance through the layer is maintained during the useful life of the composition. It is among the objects of this invention to provide a composition of this character and which is reactive in the manner as heretofore described with respired air and at the low temperatures contemplated.

Still another feature of this invention is to provide a composition which, when placed in a layer of substantial thickness, is reactive substantially progressively throughout the entire layer of the material as the material becomes used. The advantage of this condition is that in the event respiration should be discontinued before the material is completely used, the remaining unused composition is reactive satisfactorily at low temperatures by a later resumption of respiration through the layer.

Other objects and advantages of this invention will become apparent from the following description of a method of manufacture of a composition adaptable for use in a breathing apparatus to be disposed in and used in an atmosphere at a relatively low temperature since it is recognized that advantage may be taken of the principle of my invention in treating a material in a similar fashion to lower its reactive temperatures in removing an undesirable constituent from contaminated air.

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To illustrate this principle, a quantity of a suitable metallic peroxide normally unreactive at the low temperatures contemplated can be treated with a relatively small quantity of lithium hydroxide to render the peroxide reactive at low temperatures and thus enlarge its scope of use in purifying air for respiration.

In preparing a composition of these materials for breathing apparatus purposes, sodium peroxide is preferred as the metallic peroxide because of its cheapness and relatively light weight, although potassium peroxide, aside from these advantages, can just as well be used. Lithium hydroxide is selected as the initiating compound because of its commercial availability and also because of its reaction at low temperatures with carbon dioxide to form a carbonate, and since purification of respired air requires absorption of carbon dioxide, this reactive property augments the purification capacity of the composition. The compound itself is not suitable alone as a composition because its moisture absorption capacity is negligible, and furthermore, the compound is relatively expensive. However, it is a feature of this invention to provide a method of treatment of the metal peroxide to supply a composition containing a substantial proportion of the metal peroxide and reactive at temperatures far below those at which the peroxide is normally reactive. For example, one proportion used and found to be satisfactory was the use of nine pounds of lithium hydroxide to forty pounds of sodium peroxide and the resulting composition was reactive at temperatures below zero degree centigrade. With this as the composition, the lithium hydroxide reacts with the air to absorb carbon dioxide and to evolve heat, and it has been found that with such a proportion of constituents, the heat evolved by the reaction is sufficient to initiate reaction of the peroxide at these low temperatures provided the lithium hydroxide is properly disposed in relation to the peroxide.

To provide an operative disposition of the constituents, the amounts of each are pulverized or granulated sufficiently so that the individual particles making up the mass of each are relatively minute and can be intimately mixed with the other. The granulated mass of lithium hydroxide is then added to the sodium peroxide and the total mass is then mixed thoroughly.

In order to provide more complete and uniform mixing and further pulverization of the particles, a putty chaser or muller can be used until a rather finely divided and uniform mass is produced. Then the mixture is compressed, and since the particles are relatively soft, they lend themselves to compression, and the mass can be consolidated to such an extent that they are placed in intimate contact with each other. It is to be remembered that the disposition of the constituents relative to each other renders the mass more instantly reactive because of the fact that the heat evolved by the reaction of the lithium hydroxide is rendered more effective by intimate contact in initiating the reaction of the peroxide.

Some moisture is added to the mixture in this preferred method and for purposes to be hereinafter explained. Due to the fact that it is not feasible to add moisture directly to the mixture, since to do so would result in premature reaction of the peroxide, it is added in the form of water of crystallization or hydration. This may be done by using one of the constituents in a hydrated form, but it is difficult to use a hydrated peroxide

as a means of supplying moisture at room temperatures as it is unstable in that the peroxide reacts with the moisture to form a hydroxide. It has been found that sufficient moisture is provided in the mixture by using lithium hydroxide in the monohydrate form, this being a commercially available product, when used in the proportion of nine pounds of lithium hydroxide monohydrate to forty pounds of sodium peroxide.

A separate or additional hydrated compound may be used in supplying the necessary moisture such as by the addition of a quantity of hydrated sodium sulfate. Sodium sulfate does not interfere or react with the other constituents nor does it interfere with their reaction with respired air and when included in the mixture and subjected to heat for the purpose of dehydration, the sulfate remains stable. Likewise, any other hydrated compound may be used which remains stable or does not interfere with the reactive constituents when subjected to heat necessary for dehydration and which does not unnecessarily interfere with their reaction in purifying respired air.

After the mixture has been sufficiently compressed and an adequate amount of water has been included, heat is then added to the mixture and in a sufficient amount so that the hydrated compound is dehydrated, or at least substantially so, and sodium hydroxide is formed and oxygen evolved. Generally, the heat is continued until the reaction occurring in the mixture occurs throughout the entire mass and until a hard and porous mass results from the reaction. Obviously, the reaction should be kept at a minimum in order to conserve as much as possible the oxygen evolving capacity of the composition. At room temperatures, it may be necessary only to start the reaction since the heat evolved by the reaction will cause reaction to progress through the entire mass. However, for manufacturing it may be desirable to add heat during the entire reaction in order to conserve time and cost of production.

It has been discovered that this reaction of the peroxide with moisture in preparing the composition serves an important function of forming a uniform and intimate association throughout the mass of the lithium hydroxide with the remaining unreactive peroxide. This disposition is in such a manner that the final composition, although containing a large percentage of the peroxide, is reactive at temperatures much lower than its normal reactive temperatures. As a matter of explanation, it is thought that the effect of the reaction of sodium peroxide and moisture, forming sodium hydroxide and in liberating oxygen, is that the sodium hydroxide formed effectively binds the previously distributed lithium hydroxide to the small particles of sodium peroxide in the mixture. The evolution of oxygen also assists to some degree in providing this intimate association and it forms also a porous resulting composition.

After the reaction is completed and the mass becomes hard and cool, it may be granulated depending upon its subsequent use. If the composition is to be used for individual breathing apparatus, it is granulated sufficiently to provide adequate reaction while remaining within the limits of breathing resistance allowed. The minute particles formed by granulation have sufficient hardness to maintain their structure during storage and when disposed and used in substantial layers.

If the composition is to be made under ordinary atmospheric conditions, it may be necessary to

protect the mixture as by wetting with carbon tetrachloride, but this step is not necessary if the composition is manufactured in a comparatively dry atmosphere and at relatively low temperatures.

The proportion of lithium hydroxide to the other constituent which forms the bulk of the composition to be used will depend upon the reactive property desired of the final composition. However, sufficient lithium hydroxide should be supplied so that a very limited amount is bound to small portions of the metal peroxide. It is understood that this invention when directed to providing an air purifying composition is not to be limited to any specific proportions of constituents because in any event the proportion used will depend upon the temperatures at which the composition is to be reactive and also the instantaneousness of the reaction desired when contacted by the contaminated air.

For the purpose of illustration, other proportions of sodium peroxide and lithium peroxide which have been found suitable in making a breathing apparatus composition which is reactive at temperatures as low as thirty degrees below zero degree centigrade are the following:

	Pounds
A. Na_2O_2	40
$\text{LiOH}\cdot\text{H}_2\text{O}$	9
Copper oxychloride	0.5
B. Na_2O_2	30
$\text{LiOH}\cdot\text{H}_2\text{O}$	4
LiOH (dry)	2
Slaked lime	0.5
Copper oxide	0.4
C. Na_2O_2	60
$\text{LiOH}\cdot\text{H}_2\text{O}$	6.5
Slaked lime	1
MnO_2	0.7
D. Na_2O_2	65
$\text{LiOH}\cdot\text{H}_2\text{O}$	6.5
$\text{Na}_2\text{SO}_4\cdot 10\text{H}_2\text{O}$	3.2
Copper oxychloride	0.7
E. Na_2O_2	65
$\text{LiOH}\cdot\text{H}_2\text{O}$	9.5
Slaked lime	1
NiO	0.7

The inclusion of oxides or oxychlorides of copper, manganese, nickel or any other similar metallic oxide or oxychloride of a metal having an atomic weight between 50 and 65 serves as a catalyst to accelerate the liberation of oxygen from the composition. However, these catalysts are not indispensable to the composition for removing moisture and absorbing carbon dioxide. They, also, are not necessary in evolving oxygen, but it has been found that the addition of such a catalyst to material such as the metallic peroxides serves as a margin of safety in the use of my composition, and accordingly, its use is preferred. The catalyst should be added to the mixture before the mass is compressed.

As previously stated, it has been found that sufficient moisture is added to the mixture to provide a suitable composition by using the monohydrate of lithium hydroxide, but it is to be understood that the amount of moisture included will depend upon the desired physical character of the composition and the extent of intimate association of the exothermic and highly reactive substance at low temperatures with the normally unreactive substance at these temperatures. It

is the moisture that is added that reacts with peroxide to evolve oxygen and form a hydroxide which, it is thought, binds the unreacted peroxide with the lithium compound and which reaction forms a hard and porous mass. The proportion of the principal constituents of the composition will depend upon the temperature conditions at which the composition is to be reactive. It is intended that this invention extend and include all such compositions that incorporate the principles as heretofore set forth.

Other compounds of lithium can be substituted for lithium hydroxide, such as any available oxide of lithium, which may be lithium peroxide, or any other compounds may be used which have the property of being intimately disposable with a peroxide, and which are reactive when subjected to contaminated air in producing heat and, preferably, in supplying a breathing apparatus composition to react with respired air to absorb carbon dioxide or any other undesirable constituent. The compound must have the property, if to be physically bonded to a peroxide, of not being being affected by the application of heat and the consequent reaction in preparing the composition, or if reactive, its resulting state is reactive with respired air to produce the desired exothermic reaction. In the case of providing respirable air, a limitation of the compounds, which may be used, is that such compounds must not give off any toxic or undesirable gases in reacting with the respired air, nor should they react in such a manner with the normally unreactive substance to produce like undesirable results.

Other methods can be used in providing exchange masses or compositions reactive at low temperatures which contain a substantial proportion of an inexpensive and commercial material, or a mixture of such materials, normally unreactive at the temperatures contemplated, and it is intended that the invention as described and defined be limited only by the scope of the appended claims. Also, while the invention has been described in connection with providing a composition suitable for breathing apparatus, it is recognized that other uses can be made of the composition and these other uses may require a modification of the method used in combining the constituents, but, nevertheless, are within the scope of this invention. It is intended that no inference be drawn from the detail of description given in disclosing a composition and a preferred method of manufacture which might tend to narrow the scope of the invention beyond that as defined by the claims.

I claim:

1. In a process of making from an alkali metal peroxide a composition for removing carbon dioxide from a gas containing it, the method of rendering said peroxide reactive at subnormal temperatures which comprises intimately mixing with the peroxide an alkaline compound of lithium that is reactive to carbon dioxide at subnormal temperatures.

2. That method of making an air purifying composition comprising the steps of intimately mixing a major proportion by weight of powdered alkali metal peroxide with a minor proportion by weight of powdered alkaline compound of lithium that is reactive to carbon dioxide at subnormal temperatures, supplying water to the mixture and heating it and thereby producing a bonded porous body comprising said peroxide having said lithium compound distributed there-

through and reactive to carbon dioxide at subnormal temperatures.

3. That method of making an air purifying composition comprising the steps of intimately mixing a major proportion by weight of powdered alkali metal peroxide with a minor proportion by weight of powdered alkaline compound of lithium that is reactive to carbon dioxide at subnormal temperatures, supplying water to the mixture, compressing the mixture to consolidate it, and heating the compressed body and thereby producing a bonded porous body comprising said peroxide having said lithium compound distributed therethrough and reactive to carbon dioxide at subnormal temperatures.

4. A method according to claim 3, said peroxide being sodium peroxide, and said lithium compound being lithium hydroxide.

5. A method according to claim 3 in which said water and said lithium compound are supplied by lithium hydroxide monohydrate.

6. That method of removing carbon dioxide from a gas containing it which comprises passing the gas into contact with an intimate mixture of an alkali metal peroxide and an alkaline lithium compound reactive to carbon dioxide at subnormal temperatures and thereby removing carbon dioxide from the gas, and recovering the thus treated gas.

7. A method according to claim 6, said peroxide being sodium peroxide and said lithium compound being lithium hydroxide.

8. A composition for removing carbon dioxide from a gas containing it comprising a body of an alkali metal peroxide having intimately distributed therethrough an alkaline lithium compound reactive to carbon dioxide at subnormal temperatures, said composition reacting promptly at subnormal temperatures with carbon dioxide contained in gas passed into contact with it.

9. A composition for removing carbon dioxide from air comprising granules of an intimate admixture of a major proportion by weight of alkali metal peroxide and a minor proportion by weight of lithium hydroxide bonded by hydroxide of said alkali metal, said granules reacting promptly with exhaled air at subnormal temperatures to remove carbon dioxide and water and to liberate oxygen.

10. A composition according to claim 9, said peroxide being sodium peroxide.

11. The process of preparing an air purifying composition, the steps comprising mixing intimately a comminuted alkali metal peroxide and a comminuted hydroxide of lithium, including water in the mixture, applying pressure to the mixture sufficient to consolidate the components, applying heat to the consolidated mass sufficient to cause a reaction to form a porous and hard mass and granulating the mass to the extent suitable for respiratory purposes.

12. The process of preparing an air purifying composition, the steps comprising pulverizing a quantity of alkali metal peroxide, pulverizing a quantity of hydroxide of lithium, combining the pulverized masses to form a mixture, including water in the mixture, applying pressure and heat to the mixture sufficient to form a consolidated mass and to initiate a reaction in the mass, and continuing the reaction until a porous hard and uniformly reactive aggregate is formed.

13. The process of preparing a carbon dioxide and moisture absorbing and an oxygen liberating composition reactive at subnormal temperatures with the air to be treated, the steps comprising comminuting a quantity of an alkali

metal peroxide, comminuting a quantity of hydrated lithium hydroxide, combining to form a mixture of a major portion of the peroxide with an amount of the lithium hydroxide depending upon the temperature at which reaction is desired, forming a compact mass, applying heat to the mass sufficient to initiate a reaction, continuing the reaction to form a hard porous aggregate, and granulating and screening the aggregate to the size suitable for respiration purposes.

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14. As a new article of manufacture, an air purifying composition formed of alkali peroxide, and a heavy metal catalyst, the composition being characterized by the addition thereto in a predetermined manner of lithium hydroxide whereby the composition is capable in an atmosphere at a relatively low temperature to react substantially instantly with respired air to absorb carbon dioxide, to remove moisture and to evolve oxygen.

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