MATERIALS FOR STORING AND RELEASING REACTIVE GASES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/557,146, filed Mar. 26, 2004. The application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

The field of this invention is generally related to the generation and containment of solutions incorporating reactive gases and their precursors.

Reactive and inert gases have significant utility in modern society. Therefore, significant effort has been expended in the development of methods to isolate, concentrate, store, and transport highly purified single compositions as well as mixtures of gases with specific component ratios. The beneficial characteristics of gases such as chlorine dioxide, oxygen, sulfur dioxide, carbon dioxide, chlorine, and nitrogen containing gases are known in many fields. These gases modify solution properties by interacting with both chemical and biological components contained therein.

Methods have been extensively described for generating and packaging many reactive gases for transportation and for storage on-site when continual use is required. However, a particular distinction must be made concerning chlorine dioxide gas generation, storage, and transport, because chlorine dioxide is a highly reactive gas, which cannot be compressed, contained/stored, or transported like many other gases. Chlorine dioxide thus must be generated as needed at the site of application. While this gas has exceptional utility, the inability to store it has limited its widespread use. For instance, this gas has been difficult to utilize in many small volume, low concentration applications, and by consumers in residential applications.

Safe, convenient, batch mode preparation of small volumes of chlorine dioxide gas, sulfur dioxide, carbon dioxide, chlorine, gases which contain nitrogen, and other reactive gases continues to receive the attention and interest of many research and development groups. While carbon dioxide and sulfur dioxide, as well as nitrogen-containing gases, are easily stored and transported, the requirements for storage and transport of chlorine dioxide precursor reagents, as well as generation of the gas, are much more complicated. Chlorine dioxide is commonly generated in batch mode through the mixing of metal chlorite and acidic solutions or solutions containing chlorine-based oxidizers.

The patent literature and prior art associated with the storage of chlorine dioxide precursor reagents, and the generation of chlorine dioxide gas can be generally classified into three arenas. The first arena is directed toward mechanical devices and their methods of use. These mechanical devices target the controlled mixing and reaction of chlorine dioxide precursor reagents, separation of the product gas from the reaction solution, increasing the efficiency of reagent use, and ultimately controlling the delivery of gas into a liquid or gas phase system. Examples in this arena are disclosed in U.S. Pat. Nos. 4,683,039, 6,428,696, 6,203,688, and 5,415,759.

The second arena is directed toward powdered materials which contain all or some of the chlorine dioxide precursor reagents and their methods of use. These chemical systems target the protective storage of the precursor reagents, the mechanism of exposure of the dry powder and precursor

reagents to water, and the interaction of the powdered components and precursor reagents with activators, to generate chlorine dioxide. Important considerations in the design of these powdered systems include the concentration of precursor reagents, the stability of the precursor reagents, the need for activating agents, sensitivity to liquid and vapor water, and the rate and duration at which chlorine dioxide gas can be generated. In the majority of powdered and compressed powder systems silicates, zeolites, and desiccants are used to carry the precursor reagents for generating chlorine dioxide and for protecting the reagents from water. Many preparations require spray drying or other rapid means of removing water from the precursor reagents. Exposure to water often initiates reactions yielding chlorine dioxide gas. Much of this prior art requires sophisticated control of materials, chemical reagents, and powder processing technical know-how and specialized packaging. These requirements limit the range of gas concentrations that can be generated, the rate and duration of gas release, and ultimately the types of applications that can be addressed with these materials. Examples in this arena are disclosed in U.S. Pat. Nos. 6,238,643, 6,432,322, 6,605,304, 4,585,482, 6,503,419, and 6,458,735.

The third arena involves the use of solutions which contain the precursor reagents for chlorine dioxide generation. These solutions are often referred to as stabilized chlorine dioxide and usually consist of an aqueous solution of sodium chlorite with an alkaline pH. Exposure of these solutions to an activator, a powdered or aqueous acid solution, yields chlorine dioxide gas. Packets of liquid and powdered reagents are usually combined in a large volume vessel and then diluted with water for application.

Manipulation of concentrated solutions containing both precursor reagents and the reactive gas require extreme care and thus many products utilize dilute solutions of reagents. Additionally, viscous solutions of stabilized chlorine dioxide precursor reagents and/or chlorine dioxide gas containing solutions have been disclosed. These viscous solutions are prepared through the addition of polymer additives commonly used in the food and cosmetic industries. These highly viscous materials, while suitable for niche applications such as skin lotions, are inconvenient and difficult to use in many atmospheric, liquid and solid surface treatment applications. Examples in this arena are disclosed in U.S. Pat. Nos. 4,084,747, 4,330,531, and 6,451,253.

Accordingly, there remains a need for new materials and methods for generating reactive gases, materials and methods which facilitate the storage and transport of gas precursor reagents, materials and methods which facilitate the preparation of solutions which contain a wide range of reactive gas concentrations, and materials and methods which can serve as a platform for safe, inexpensive, and consumer friendly products.

SUMMARY OF THE INVENTION

Compositions, methods, and devices are provided for use in containing and releasing a gas, particularly a reactive gas. In one aspect, a composition is provided that includes a reactive gas, reactive gas precursor, or combination thereof; a fluid in which the reactive gas, reactive gas precursor, or combination thereof is dissolved; and a solid material in which fluid is absorbed or adsorbed, wherein the solid material controls the formation or release of the reactive gas. Examples of reactive gases include chlorine, bromine, iodine, carbon dioxide, oxygen, nitrogen, sulfur dioxide,