CAPTURE AND RELEASE OF ACID-GASSES WITH ACID-GAS BINDING ORGANIC COMPOUNDS

PRIORITY

This application claims priority from and is a continuation in part of application Ser. No. 12/360,717 which claims priority from provisional patent application No. 61/023,994 and provisional patent application No. 61/099,387. The contents of all of these prior related applications are incorporated herein by reference.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT

This invention was made with Government support under Contract DE-A C0576RLO1830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

BACKGROUND OF THE INVENTION

The release of greenhouse and acid gases into the air produces local and global effects on the environment. The combustion of fossil fuels generates acid gases such as carbon dioxide (CO_2), sulfur oxides (SO_2 and COS), sulfides (H_2S) and nitrogen oxides (NO_x). Fixed combustion sources, such as coal burning power plants, generate significant acid gas emissions released in their flue gas. The capture and removal of the acid gases, carbon dioxide (CO_2), sulfur oxides (SO_2, SO_3, COS and H_2S) and nitrogen oxides (NO_x) from flue gas will become an even greater issue as coal becomes more prominent in America's future energy consumption. The capture of significant amounts of greenhouse and acid gases from emission sources is desired to reduce the environmental effects of these sources.

Current aqueous flue gas scrubbing technologies are typically too energy intensive to be used industrially or often require the use of toxic materials which further complicates implementation. Various current aqueous scrubbing technologies remove sulfur oxides and nitrogen oxides from flue gas trapping these acid gases as the basic salts of their acid gases (thiocarbonates, dithiocarbonates, sulfites and nitrate) using a highly basic solution of caustic soda or lime. In these examples the binding is stoichiometric and irreversible and results in a base that cannot be reused. What is needed therefore is a way of providing an effective method of removing acid gasses that over comes these deficiencies that exist in the prior art embodiments. The present invention provides such a method and system.

SUMMARY OF THE INVENTION

This application describes reversible acid-gas binding organic liquid materials, systems and methods that permit capture of one or more of the several acid gases. These acid-gas binding organic compounds can be regenerated to release the captured acid gasses and enable these organic acid-gas binding materials to be reused. This enables transport of the liquid capture compounds and the release of the acid gases from the organic liquid with significant energy savings compared to current aqueous systems. The acid gas capture compound is preferably a liquid material that can be easily transported to allow movement of the captured material from the scrubbing location to a second stage where the acid gas can be removed for storage or processing. Once the acid gas is removed from the organic liquid, the organic liquid can be returned to the system and the process repeated.

Various embodiments of the present invention are described here in. However it is to be understood that the invention is not limited solely to these described embodiments. The presently described embodiments include acid-gas capturing organic materials (herein referred to as SO_2 binding organic liquids (SO_2BOLs), COS binding organic liquids (COSBOLs), CS_2 binding organic liquids (CS_2BOLs), hydrogen sulfide binding organic liquids (H_2SBOLs) and nitrogen dioxide binding organic liquids (NO_2BOLs)) each material being comprised of a strong organic base (preferably, but not limited to, amidines or guanidines) and a weak acid (preferably, but not limited to alcohols). The alcohol, base and acid gas chemically react together to form hetero-atom analogues. Each of these systems when combined with a target acid gas form hetero-atom analogues of alkyl carbonates that reversibly release the respective acid gas with mild heating and regenerate the underlying binding organic bases. In some embodiments these are single molecules of zwitteronic liquids. While these preferred embodiments have been described it is to be distinctly understood that the invention is not limited thereto but may be variously alternatively embodied and configured according to the particular needs and necessities of the user. In particular the description of the binding organic materials as liquids should not be interpreted as limiting these materials to only a particular form in as much as various materials change phase or form at various temperatures and various alternatives of the present invention may require various alternative uses depending upon the particular needs and necessities of the user.

The capture of acid gases in organic media as alkyl-salts (alkyl-carbonates, -sulfites, -nitrates, xanthates, and thiocarbonates) results in compounds that are capable of releasing the acid gases with less energy input as compared to other methods. The reduced hydrogen bonding in organic systems compared to aqueous systems reduces the thermodynamic stability of the chemically bound acid gas and requires less energy to release the acid gas. In addition, the lower specific heat of organic liquid systems (specific heat ~2 J/g/° K) requires only half the energy to heat the liquid compared to that required to heat the water in aqueous systems (specific heat ~4 J/g/° K).

These features provide for a variety of advantages over the prior art including but not limited to embodiments and applications wherein for example acid gases such as SOx and NOx can be scrubbed from exhaust gasses and captured as acid-gas salts that exhibit low energy binding acid gas capture phenomena. Such a scrubber could be acid gas specific e.g. NO2BOLs and SO2BOLs. The lack of hydrogen bonding and highly delocalized charges would reduce the energy requirement for acid gas removal from these systems. Selective acid gas removal can be temperature dependent, resulting in delivery of each acid gas independently and cleanly. In another embodiment the present invention can be utilized to form thermally stable materials that can also be transported and captured so as to allow for selective capture and sequestration of materials. In addition to being regenerable the present invention also provides for increased capture capacity compared to current alternative embodiments, for example the SO2BOLs have the ability to absorb 3 equivalents molecular equivalents of material due to the combination of physical and chemical absorption that this compound provides.

In yet another application of the present invention these materials can be utilized to serve as a sensor. In one embodi-