METHOD AND APPARATUS FOR SILOXANE MEASUREMENTS IN A BIOGAS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application Serial No. 61/587,391 filed on January 17, 2012, which is owned by the assignee of the instant application and the entire disclosure of which is incorporated by reference herein. The present application is a continuation-in-part of U.S. Application Serial No. 12/720,542 filed on March 9, 2012, which is a continuation-in-part of U.S. Application Serial No. 12/567,981 filed on September 28, 2009, which is a continuation of U.S. Application Serial No. 12/119,244 filed on May 12, 2008, now U.S. Patent No. 7,595,887, which is a continuation of U.S. Application Serial No. 11/240,799 filed on September 30, 2005, now U.S. Patent No. 7,372,573, the entire disclosures of which are incorporated by reference herein.

FIELD OF THE INVENTION

[0002] The invention generally relates to absorption spectrometers, and more particularly to monitoring and measuring concentrations of siloxane compounds in, for example, a biofuel or biogas. The technology also relates to determining a total concentration of all siloxane compounds and/or a total concentration of all silicon-containing compounds in, for example, a biofuel or biogas.

BACKGROUND OF THE INVENTION

[0003] Spectroscopy is the study of the interaction between electromagnetic radiation and a sample (e.g., containing one or more of a gas, solid and liquid). The manner in which the radiation interacts with a particular sample depends upon the properties (e.g., molecular composition) of the sample. Generally, as the radiation passes through the sample, specific wavelengths of the radiation are absorbed by molecules within the sample. The specific wavelengths of radiation that are absorbed are unique to each of the molecules within the specific sample. By identifying which wavelengths of radiation are absorbed, it is therefore possible to identify the specific molecules present in the sample.

apparatus 10 can be used to detect trace amounts of a substance such as siloxanes, sarin, tabun, soman, sulfur mustard, and VX nerve gas with a concentration lower than about 500 ppb. In various embodiments, the concentration can be between about 10 ppb and about 500 ppb, although higher and lower concentrations can be detected depending on the system and the application. In some embodiments, the concentration can be between 5 ppb and about 50 ppb, depending on the species. For example, the apparatus 10 is capable of detecting a trace amount of sarin with a concentration of between about 8.6 ppb and about 30 ppb; a trace amount of tabun with a concentration of between about 12.9 ppb and about 39 ppb; a trace amount of tabun with a concentration of between about 7.3 ppb and about 22.8 ppb; a trace amount of sulfur mustard with a concentration of between about 36.7 ppb and about 370.6 ppb; or a trace amount of VX nerve gas with a concentration of between about 12.9 ppb and about 43.9 ppb.

[00071] Gas renewal rate, which is a measure of the build-up of a fresh gas supply in a sample cell, can be coupled with the Pathlength/NEA ratio, resulting in a detection system response time specified as "X mg/m^3 (or ppb) of gas Y detected in Z seconds". The detection system response time includes the measurement time and the computation time (e.g., about 5 seconds). Table 2 shows exemplary detection system response times for various agents such as sarin, tabun, soman, sulfur mustard, and VX nerve gas.

[00072] Table 2. Exemplary detection system response times for trace gases measured using a detection system of the invention. All response times are in seconds.

Trace gas	Response time for 10 ppb	Response time for 20 ppb	Response time for 30 ppb	Response time for 50 ppb
Sarin	15.4	12	8.7	7.5
Tabun	22.6	12.6	10.2	8.4
Soman	13.7	9.6	8.3	7.2
Sulfur mustard	60	37.5	21.4	13.8
VX nerve gas	22.6	12.6	10.2	8.4

[00073] FIG. 5 is a graph of concentration of a trace gas versus time using a step profile input (e.g., the trace gas enters the sample cell at the beginning of the measurement cycle). The measurement period "A" is the time when data is collected and/or an interferogram is recorded. The computation period "B" is when the interferogram is

24. The method of claim 1, further comprising taking the second spectral measurement over an acquisition period of about 10 seconds to about 20 seconds.

25. The method of claim 1, further comprising determining a value for the total concentration of the one or more silicon-containing compounds such that the at least one surrogate absorption spectrum is substantially similar to the first absorption spectrum.

26. The method of claim 1, further comprising providing the biogas from animal waste, wastewater or a landfill.

27. The system of claim 1, wherein the total concentration is computed by representing spectral features of the one or more silicon-containing compounds in the biogas using a classical least square (CLS) fitting routine based on the first absorption spectrum, the at least one surrogate absorption spectrum and at least one of a baseline value or an offset value.

28. A system for monitoring one or more silicon-containing compounds in a biogas, the system comprising:

a source of a first beam of radiation;

an interferometer receiving the first beam of radiation from the source and forming a second beam of radiation comprising an interference signal;

a sample cell in optical communication with the interferometer;

a flow mechanism establishing a first flow of a non-absorptive gas having substantially no infrared absorptions in a specified wavelength range of interest and a second flow of the biogas through the sample cell;

a cooled detector in optical communication with the sample cell, the cooled detector receiving:

a first interference signal propagating through the non-absorptive gas in the sample cell; and

a second interference signal propagating through a sample gas in the sample cell, the sample gas comprising the biogas;

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a flow mechanism establishing a first flow of a non-absorptive gas having substantially no infrared absorptions in a specified wavelength range of interest and a second flow of the biogas through the sample cell;

a cooled detector in optical communication with the sample cell, the cooled detector receiving:

a first interference signal propagating through the non-absorptive gas in the sample cell; and

a second interference signal propagating through a sample gas in the sample cell, the sample gas comprising the biogas;