



### Detection of Chemical Precursors of Explosives

**Precursors provide early warning.**

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Certain selected chemicals associated with terrorist activities are too unstable to be prepared in final form. These chemicals are often prepared as precursor components, to be combined at a time immediately preceding the detonation. One example is a liquid explosive, which usually requires an oxidizer, an energy source, and a chemical or physical mechanism to combine the other components. Detection of the oxidizer (e.g.  $H_2O_2$ ) or the energy source (e.g., nitromethane) is often possible, but must be performed in a short time interval (e.g., 5–15 seconds) and in an environment with a very small concentration (e.g., 1–100 ppm), because the target chemical(s) is carried in a sealed container.

These needs are met by this invention, which provides a system and asso-

ciated method for detecting one or more chemical precursors (components) of a multi-component explosive compound. Different carbon nanotubes (CNTs) are loaded (by doping, impregnation, coating, or other functionalization process) for detecting of different chemical substances that are the chemical precursors, respectively, if these precursors are present in a gas to which the CNTs are exposed. After exposure to the gas, a measured electrical parameter (e.g. voltage or current that correlate to impedance, conductivity, capacitance, inductance, etc.) changes with time and concentration in a predictable manner if a selected chemical precursor is present, and will approach an asymptotic value promptly after exposure to the precursor.

The measured voltage or current are compared with one or more sequences of their reference values for one or more known target precursor molecules, and a most probable concentration value is estimated for each one, two, or more target molecules. An error value is computed, based on differences of voltage or current for the measured and reference values, using the most probable concentration values. Where the error value is less than a threshold, the system concludes that the target molecule is likely. Presence of one, two, or more target molecules in the gas can be sensed from a single set of measurements.

*This work was done by Jing Li of Ames Research Center. Further information is contained in a TSP (see page 1). ARC-15566-5*

### Detecting Methane From Leaking Pipelines and as Greenhouse Gas in the Atmosphere

**Remote detection will speed up response time.**

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Laser remote sensing measurements of trace gases from orbit can provide unprecedented information about important planetary science and answer critical questions about planetary atmospheres. Methane ( $CH_4$ ) is the second most important anthropogenically produced greenhouse gas. Though its atmospheric abundance is much less than that of  $CO_2$  (1.78 ppm vs. 380 ppm), it has much larger greenhouse heating potential.  $CH_4$  also contributes to pollution in the lower atmosphere through chemical reactions, leading to ozone production. Atmospheric  $CH_4$  concentrations have been increasing as a result of increased fossil fuel production, rice farming, livestock, and landfills. Natural sources of  $CH_4$  include wetlands, wild fires, and termites, and perhaps other unknown sources. Important sinks for  $CH_4$  include non-saturated

soils and oxidation by hydroxyl radicals in the atmosphere.

Remotely measuring  $CH_4$  and other biogenic molecules (such as ethane and formaldehyde) on Mars also has important implications on the existence of life on Mars. Measuring  $CH_4$  at very low (ppb) concentrations from orbit will dramatically improve the sensitivity and spatial resolution in the search for  $CH_4$  vents and sub-surface life on other planets.

A capability has been developed using lasers and spectroscopic detection techniques for the remote measurements of trace gases in open paths. Detection of  $CH_4$ ,  $CO_2$ ,  $H_2O$ , and  $CO$  in absorption cells and in open paths, both in the mid-IR and near-IR region, has been demonstrated using an Optical Parametric Amplifier laser transmitter developed at GSFC. With this transmitter, it would be

possible to develop a remote sensing methane instrument.

$CH_4$  detection also has very important commercial applications. Pipeline leak detection from an aircraft or a helicopter can significantly reduce cost, response time, and pinpoint the location. The main advantage is the ability to rapidly detect  $CH_4$  leaks remotely. This is extremely important for the petrochemical industry. This capability can be used in manned or unmanned airborne platforms for the detection of leaks in pipelines and other areas of interest where a  $CH_4$  leak is suspected.

*This work was done by Haris Riris, Kenji Numata, Steve Li, Stewart Wu, Anand Ramanathan, and Martha Dawsey of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16184-1*