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NASA TECH BRIEF

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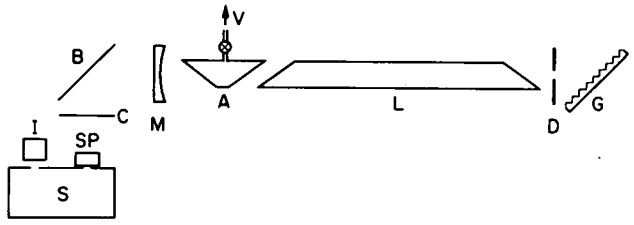
Detection of Nitric Oxide Pollution

Nitric oxide is a major air pollutant and is the precursor to nitrogen dioxide, the trigger molecule in photochemical processes which yield smog. Eye irritation and other discomforts are severe when high



levels of nitric oxide are present in the atmosphere. Although new and improved methods are constantly being sought to measure the high levels of nitric oxide in emissions from automobiles and electrical power plant stacks, special techniques are required to measure the low concentrations ordinarily present in the ambient atmosphere.

Studies of the enhancement of absorption spectra of certain atomic and molecular species inserted in dye-laser cavities have indicated that nitric oxide can be determined at low concentrations. For example, at 1900.04 cm^{-1}, the absorption coefficient of small amounts of nitric oxide in an intra-laser-cavity absorption cell containing helium is enhanced by more than two orders of magnitude.

The apparatus used to make absorption measurements is shown in the diagram; the laser cavity is defined by the grating, G, blazed for 5.4 μm, and the 10-percent-transmission mirror M (10-meter radius). The laser has an interelectrode separation of 119 cm, of which 115 cm are immersed in a liquid nitrogen bath. The laser is run in the CW mode, nominally at 10 kV and 15 mA, and the laser as well as the absorption cell, A, are fitted with calcium fluoride Brewster windows. About 10 percent of the laser output is directed through a chopper onto a sanded flat of calcium fluoride placed at the entrance of an infrared spectrophotometer. The signal is detected by nitrogen-cooled copper-doped germanium, and it is amplified, demodulated by a lock-in amplifier, and displayed on a strip chart. The sensitivity of the laser spoiling to intercavity nitric oxide is enhanced by running the laser at the lowest gain possible.

Mixtures of helium and nitric oxide at pressures of the order of 50 kN/m^2 (0.5 atm) are let into the absorption cell from a gas-handling manifold (not shown in the diagram). For an experimental run, laser power loss measurements are made on successive NO–He mixtures of increasing dilution prepared by expanding a small part of the preceding sample and diluting with helium to about 50 kN/m^2 pressure.

It is anticipated that at nitrogen pressures of about 100 kN/m^2, the sensitivity of the laser output to nitric oxide should be further enhanced because of greater pressure broadening of the NO lines; in view of experimental results, it is estimated that NO concentrations of the order of 100 parts per billion can be easily determined with an intercavity length of 50 cm. Moreover, theoretical considerations suggest that the method is capable of infinite sensitivity, but additional experiments must be performed to establish practical limits.

(continued overleaf)

Note:

Requests for further information may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: TSP 73-10018

Patent status:

NASA has decided not to apply for a patent.

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