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Ammonia sensor for agricultural applications using diode laser based on photoacoustic spectroscopy

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Ammonia (NH_3) is considered as an important pollutant species due to its role as precursor in fine particulate matter formation and its impact on ecological nitrogen balance. The main emission source of atmospheric ammonia is the use of animal manure and fertilizers for agricultural soils. One of the sensitive detection methods is the photoacoustic (PA) detection by use of CO_2 laser, developed many years ago. However, for field applications, simple and robust techniques are needed. For these reasons, diode lasers have been applied for measurement of ammonia in ambient air.

The main problem with ambient ammonia measurement is that ammonia is a difficult gas to handle reproducibly due to its polar nature and can easily been absorbed to most of the surfaces. For these reasons, a PA cell and a gas handling were specially manufactured for ammonia monitoring: the cell and the gas handling were made from PVDF (polyviniliden-fluoride) and polyamide, respectively. The PA cell construction was optimized to reduce the outside and flow noise, while amplifying the PA signal. As a light source a wavelength modulated distributed feedback (DFB) diode laser with $\sim$40 mW output light power operating at 1532 nm was applied. This wavelength was selected to avoid interferences of water vapor and CO_2. The laser modulation parameters (i.e. the laser temperature and the unmodulated and modulated part of its driving current) were optimized for maximum measurement sensitivity. Further increase in the system sensitivity, which in parallel resulted in better measurement selectivity, was possible by applying a dual wavelength measurement method, i.e. by measuring the ammonia signal alternately at two different wavelengths. The gas flow

rate through the PA cell was optimized too in order to minimize the effect of the flow noise on the system sensitivity, while keeping the inherent fast response time of the system. The electronics is an integrated unit used for laser current and temperature control, modulation of the laser current, electrical amplification, temporal averaging and evaluation of the microphone signal.

From laboratory calibration of the system a response time of $\sim$50 sec and a minimum detectable concentration (MDC) of $\sim$50 ppb at a measurement time of 10 second was found. Operating the system with a 30 minute integration time resulted in MDC below 10 ppb.

For field measurements the system was supplemented with a membrane pump, which sucks ambient air through the PA cell, with a flow rate of 200 sccm (standard cubic centimeter per minute) and the whole system was integrated into a waterproof housing. Furthermore the system was put on a mast and the height of the sampling is variable between 0.5 to 2 meter above the ground.

A field experiment with the PA system was conducted above an irrigated wheat-field, and another one was performed at different distances around a poultry farm. Both measurements justified the applicability of PA system for field monitoring of ammonia at ppb level.

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