

Early detection of acute rejection in lung transplant recipients using laser-based detection of exhaled nitric oxide

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Exhaled nitric oxide (eNO) is becoming widely recognized as a marker of airway inflammation, aiding in the diagnosis and treatment of a number of diseases, including asthma, chronic obstructive pulmonary disease, pneumonia, and acute allograft rejection (AAR) in lung transplant recipients. In our study, we are evaluating eNO levels from lung transplant patients using a quantum cascade laser (QCL).

Chemiluminescence is widely applied in measuring eNO levels from both children and adults. Two companies, Sievers and more recently Aerocrine have developed analyzers based on a chemiluminescence technique for high precision NO real time monitoring. This technique requires calibration at the same humidity and temperature as breath and only measures NO².

In this work we investigate tunable laser absorption spectroscopy (TLAS) as an effective technique for sensitive, selective and fast response NO monitoring. The mid-infrared spectral range also known as the molecular "fingerprint" region is ideally suited for TLAS since most gases possess strong fundamental rotational-vibrational lines. In addition to NO, we can observe absorption lines of water vapor and CO₂ (see Fig. 1a)

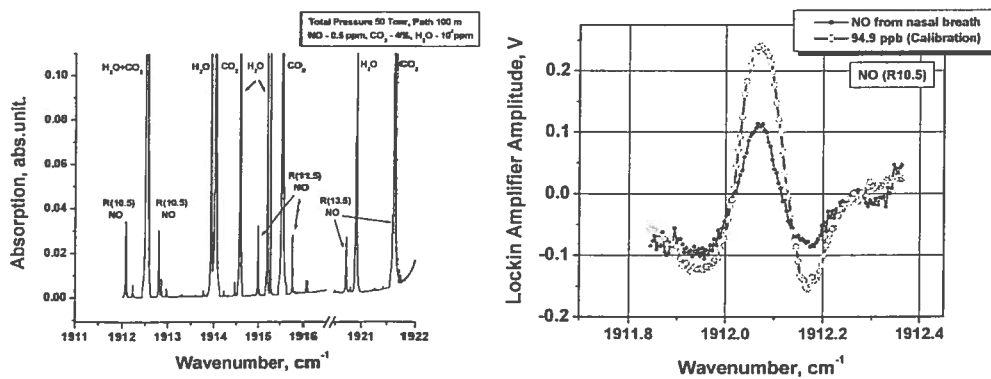


Fig. 1. (a)

HITRAN simulation of mid-infrared absorption spectrum of a NO + CO₂ + H₂O mixture in tuning range of available QC lasers. (b) eNO concentration measurement from nasal breath using wavelength modulation applied to OA-ICOS. A NO concentration of 53 ppb was measured in nasal breath.

Feasibility experiments using OA-ICOS and wavelength modulation spectroscopy were performed in order to determine biogenic NO concentrations from nasal exhaled air (see Fig 1b). The theory of WMS predicts more than order of magnitude lower minimum of detectable absorbance as compared to the direct laser absorption spectroscopy. To further validate that NO is elevated in acute allograft rejection in lung transplant recipients, we measured NO in the breath of lung transplant recipients at the Pulmonary Transplant Service at Methodist Hospital in Houston, Texas.