HIGHLY SENSITIVE CO GAS BIOMARKER DETECTION ANALYSIS USING LASER BASED SPECTROMETER

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ABSTRACT

The development of CO gas detector based on ICOS spectroscopy technique in combination with CW-DFB-QCL laser has been successfully conducted. The developed gas detection system was designed to identify CO on a human breath analysis condition. The detector's detection limit enhancement compared to the previously reported sub-ppb value is the main focus of this research. In order to gain sub-ppb detection limit, several approaches were implemented such as breath spectral analysis based laser wavelength selection, ICOS spectroscopy technique application, and ICOS cell length reduction. A spectral analysis computer simulation was performed by comparing the spectrum of CO with the spectra of other potential components in the exhaled breath in the mid-infrared region based on HITRAN 2012 database. Simulation result showed that most of the CO spectra are covered by other higher intensity compound. However, 2169.2 cm^{-1} or 4610 nm CO line can be determined as the best wavelength offer for the sensitive and selective detection of CO.

The developed ICOS spectroscopy based CO gas detector has exposed good perform and stability by showing its capabilities to measured a CO gas concentration for more than two hours measurement. The laser is a single mode, thermoelectrically cooled, CW-DFB-QCL (type M9501, Maxion Inc.) operating at a wavelength of 2169.2 cm^{-1} with an optical power of 40mW. To reach the molecular transition of CO, the temperature of the laser is set to 20°C, with a current value of 418 mA, and was fine-tuned by modulating the QCL current with a 12 kHz triangular signal. A high-finesse 15 cm long cavity with an effective optical path length of 400 m has been used as a sample gas cell or an ICOS cell. The cavity is aligned off-axis with respect to the incident laser beam. The developed CO gas detector has shown fast response by able to reach 1 ppbv detection limit within 2 s. The detection limit value which determined from CO concentrations measurement was (0.77 ± 0.06) ppbv for 2.08 ppmv CO concentration. The developed detector was able to measure CO concentration within 0–9 ppmv before saturated. Scratch measurement of a human breath has achieved CO level 0.714 ppmv. The results clearly showed that the QCL-based ICOS gas detector is a robust technique, suitable for fast and sensitive detection of traces of CO. The developed gas detector has achieved sub-ppb detection limit and have great possibilities to be extended to the detection of other gasses or applied to the investigations that involve biomedical applications.

Kata Kunci: *CO, Biomarker, Laser Spectrometer, ICOS, QCL*