



Simultaneous quantitative analysis of four hydrocarbon gases in a mixture at ppb-level concentrations using EP-IR spectrometry.

Summary

An EPIR spectrometer manufactured by Aspectrics, Inc. was tested both for its capacity to resolved chemical homologs with significantly overlapping spectral features and for its sensitivity expressed as a function of time in detecting such homolog chemical species.

When challenged with the resolution of methane, ethane and propane in a mixture at concentrations varying from 500 to 1,000 ppm, the instrument performed adequately in the 3–5 μm region, enabling clear and distinct spectral characterization of all three hydrocarbon in the gas phase as they were present together in the mixture.

Further testing using a 5-meter folded gas cell demonstrated that the instrument's detection threshold was ranging between 194 ppb and 775 ppb (butane and methane, respectively) after only 1 second of spectral collection time, between 25 ppb and 100 ppb (butane and methane, respectively) after 60 seconds (1 minute) of spectral collection, and between 12 and 45 ppb (butane and methane, respectively) after only 300 seconds (5 minutes) of spectral collection. The other gases used in this test (ethane, propane and carbon monoxide) were detected at concentrations comprised within these ranges.

Introduction

EP-IR spectrometry is proposed as a valid and advantageous alternative to other IR wavelength generation devices such as NDIR and FTIR spectrographs and spectrometers by retaining the desirable attributes of these technologies (size and cost of NDIR; abundant spectral information of FTIR), yet leaving their typical drawbacks behind (limited spectral information and lack of ruggedness for NDIR and FTIR, respectively.)

EPIR spectroscopy is based upon the use of an encoder disk onto which all wavelengths in a given region of interest are uniquely modulated, and the final spectral intensities computed via a Fourier transform. Current technology allows up to 256 user-defined micro-regions of the spectrum to be measured simultaneously by a single detector (multiplexing advantage), hence providing the opportunity for simultaneous quantitative analysis of several components as well as the implementation of complex chemometrics methods.

Material & Methods

An Advanced Photometrics, Inc. API Spectral Engine configured for the 3 – 5 μm region providing a data point every 15 nm was used for this experiment. A glow-bar source and a PbSe (lead selenide) detector with single stage thermoelectric cooling were used.

The instrument was set to collect 100 spectra per second (scan at 100 Hz).

A first set of experiments were completed using a 15 cm pathlength gas cell. They consisted of the analysis of three common low-molecular weight hydrocarbons: methane, ethane and propane. The goal was to test the EPIR spectrometer's capacity to spectroscopically resolve three homolog species in a mixture, despite the high degree of similarity between the spectra of the three compounds and the significant band overlapping typically observed in the 3 - 5 μm region.

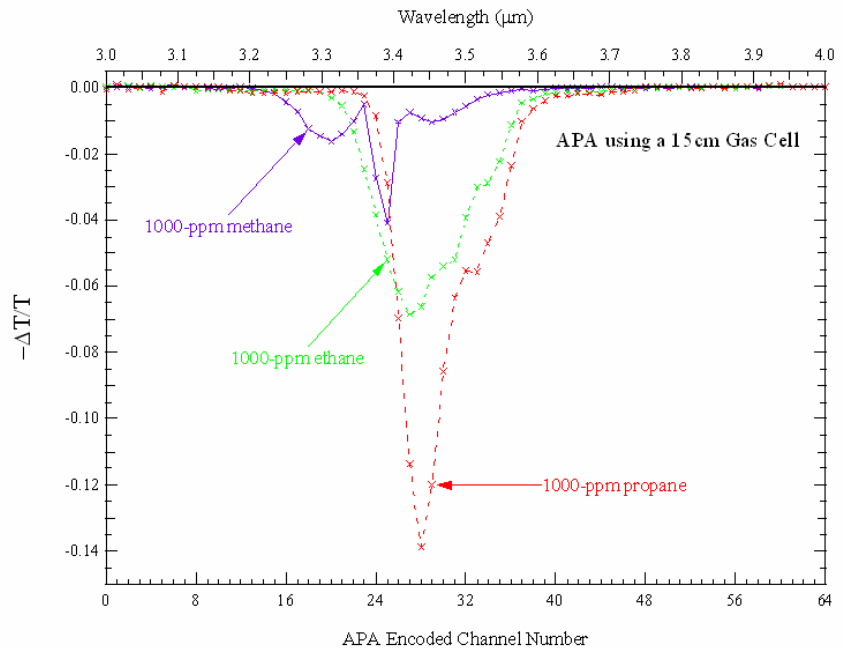


The second set of experiments relied upon the use of a 5-meter folded pathlength cell and focused on the determination of the threshold of sensitivity (or Level Of Detection, LOD) of the EPIR spectrometer as a function of scanning time for 4 homolog hydrocarbon gases (methane, ethane, propane, and butane) and carbon monoxide (CO) present in a mixture.

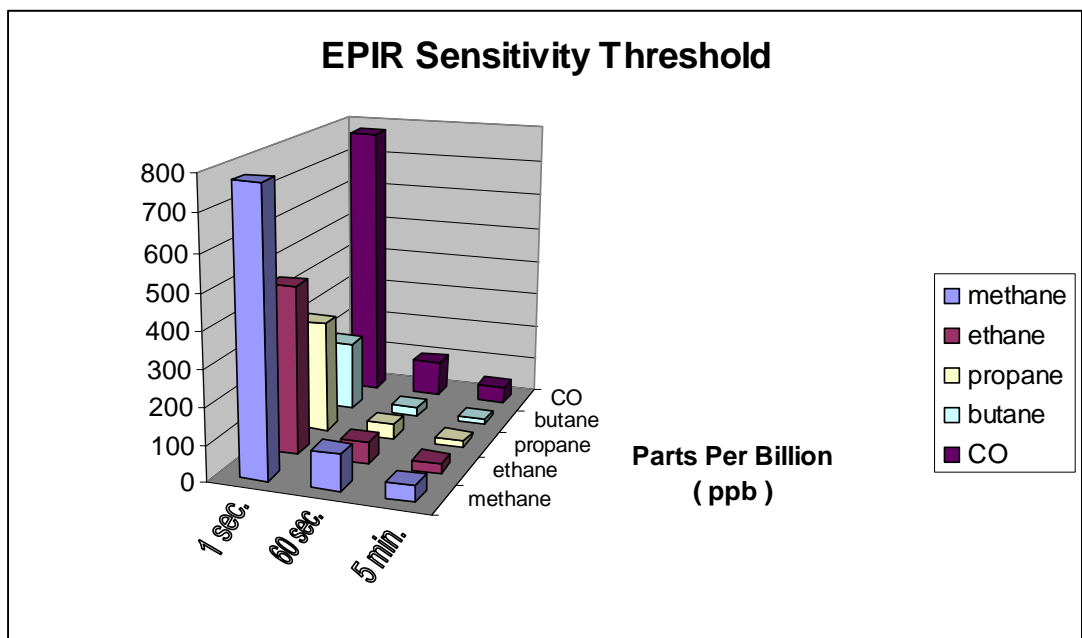
Data were collected using Advanced Photometrics, Inc. proprietary data collection software. Final data treatments and graphing were completed using IGOR Pro (www.wavemetrics.com).

Results

Experiment 1:
Spectral resolution of 3
homolog hydrocarbon gases.



Experiment 2:
Determination
of
instrumental
sensitivity as
a function of
time.





Concentrations of gas detected in a 5-components mixture after 1 second, 1 minute and 5 minutes worth of spectral collection.

Chemical Species	Time of Spectral Collection		
	1 sec	60 sec	300 sec
Methane (CH ₃)	775 ppb	100 ppb	45 ppb
Ethane (C ₂ H ₆)	465 ppb	60 ppb	27 ppb
Propane (C ₃ H ₈)	310 ppb	40 ppb	18 ppb
Butane (C ₄ H ₁₀)	194 ppb	25 ppb	12 ppb
CO	775 ppb	100 ppb	45 ppb

Conclusion

The API Spectral engine clearly demonstrated both the spectroscopic resolution of closely related chemical compounds in a mixture and the sensitivity required to complete fine analytical measurements (tens ppb levels) in a time of only 1 to 5 minutes.

If additionally considering its rugged design, capability of remaining operational in vibrating environments and over a larger than expected range of temperatures, this marks this instrument as a serious candidate for industrial, on-site chemicals sensing applications.

Encoded Photometrics Infra-Red Spectroscopy

EPIR Spectroscopy relies upon a photometrically simple, yet rugged and efficient design, where the incoming infrared beam from the sample is imaged on to a diffraction grating based spectrograph.

The dispersed radiation from the grating is imaged across an aperture above the surface of a rotating encoder disk.

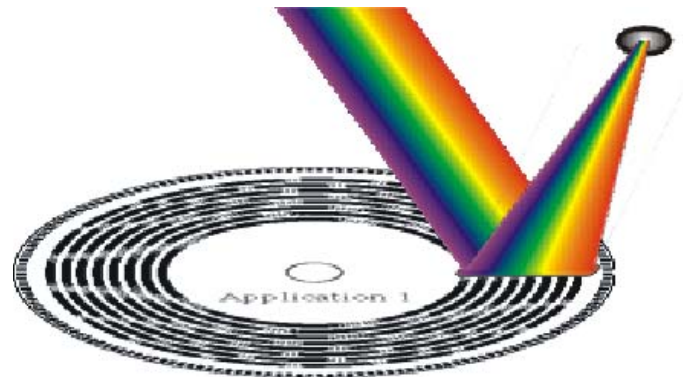
The encoder disk has a series of reflective tracks, which are spatially located within the dispersed grating image to correspond to the wavelengths and wavelength regions used for the analysis.

Each track has a pattern that produces a reflected beam with a unique sinusoidal modulation for each individual wavelength.

The reflected beams are brought to an image on a single detector, which generates a signal that forms a discrete interferogram.

The intensity contribution for each wavelength component is obtained by applying a Fourier transform to the interferogram.

The Encoded Photometrics based instrument is designed to encode the analytical information in the same way as an interferometer...but without the environmentally sensitive components of an interferometer.



● Aspectrics, Inc. (Headquarters)
6900 Koll Center Pkwy, Suite 401
Pleasanton, CA 94566
Tel.: 925-931-9270
Fax: 925-931-9272

Aspectrics, Inc. (Research and Development)
345 Crown Point Circle, Suite 400
Grass Valley, CA 95945
Tel.: 530-477-6355
Fax: 530-272-8440

Aspectrics, Inc. (Business Development)
869 E. Schaumburg Rd, Suite 210
Schaumburg, IL 60194
Tel.: 847-235-3089
Fax: 847-235-3130