Development of an IR-MEMS Sensor for Aqueous CO₂ in Beverages

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Abstract

One of the main parameters for the quality control of beer and other beverages is the amount of dissolved carbon dioxide. At present a so called “volume expansion method” is used where the volume above the sample is expanded and the pressure of the gas is measured. One of the major disadvantages of this method is the dependency of the calibration on the beverage.

With the IR measurement a matrix independent measurement of CO₂aq will be achievable. Another advantage of the IR measurement is the possibility for the simultaneous measurement of sugar concentrations.

To build an affordable small analyzer for CO₂aq a new spectrometer, which is developed by the Carinthian Tech Research Center, is being tested.

FTIR Measurement of CO₂aq

The absorption band of CO₂aq is located at 2343 wavenumbers.

Different concentrations of CO₂aq were prepared by mixing different NaHCO₃ concentrations with a citric acid putter at pH 3 and calibration lines were recorded.

Matrix Effects

The absorption band of CO₂aq is overlapping with the combination band of water and any changes in the structure of water result in a change of the background spectrum for the CO₂ measurement.

Especially the three sugars glucose, fructose and saccharose are of interest because they are ingredients in many carbonized softdrinks.

To study the influence of different sugar concentrations it was necessary to measure many different concentrations in a short time because the CO₂ in the atmosphere is also interfering with the measurement of aqueous CO₂. To accomplish this fact a FA system was used. The CO₂aq solution was prepared by saturating water with CO₂.

The effect of fructose on the water spectrum can clearly be seen in the plotted spectra. Increasing the fructose concentration from zero to the FA peak maximum results in a tilting baseline.

MEMS Spectrometer

The used spectrometer is based on the Czerny-Turner Monochromator principle and was first developed for the near infrared region by the Carinthian Tech Research Center.

The spectrometer uses a micro-electro-mechanical mirror device with a reflection grating surface to disperse the light and the individual wavelengths are scanned over a detector.

To adapt the spectrometer for the middle infrared the grating and the detector had to be changed.

The key advantages of a MEMS based spectrometer are the small size of 100 x 90 x 75 cm³ and the high scanning speed which enables the coadision of many scans to compensate the reduced inherent sensitivity.

For the first measurements with this spectrometer a globar from a Vector 22 spectrometer from Bruker was used. The light was collimated with an off axis mirror and passed a flow cell with a 25 micron spacer. Behind the flow cell the light was focused into the spectrometer by a ZnSe lens.

MEMS Measurement of CO₂aq

The sample preparation for the calibration of the MEMS spectrometer was done with the same solutions as the calibration of the FTIR spectrometer before. To obtain one spectrum 3000 scans were averaged which took approximately 40 seconds.

To demonstrate the capability of the MEMS spectrometer a sample of mineral water was measured. As you can see below the absorbance of CO₂aq can clearly be seen although the sampling technique was far from ideal.

The spectra also show the most critical problem of the first prototypes. Due to the high power of the globar the spectrometer heats up and the detector signal is drifting.

Single-detector micro-electro-mechanical scanning grating spectrometer.
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