

Liquids analysis

Online process monitoring

Infrared measuring system for optimized beverage production

The ATR sensor monitors online the concentrations of CO₂, alcohol, and sugar in liquids.

In order to ensure quality in beverage manufacturing, carbon dioxide, alcohol and sugar content need to be measured regularly during production. Knowing precisely how and when chemical reactions take place is crucial to the quality of the beverage. An optical measurement system for liquid analysis by Fraunhofer IPM measures CO₂, alcohol and sugar content in-situ. Monitoring these concentration values online enhances process reliability and efficiency.

ATR sensor element

The method employed is attenuated total reflection (ATR) spectroscopy. This technique makes use of the fact that the field of a light wave, guided in a transparent material, partly extends into the surrounding medium by the so-called evanescent field. At the surface boundary, the wave interacts with the sample and is absorbed at certain material-specific wavelengths. Subsequent to its repeated total internal reflection, the areas absorbed in the beam's spectrum attenuate accordingly, thereby providing concentration measurements of the desired substances.

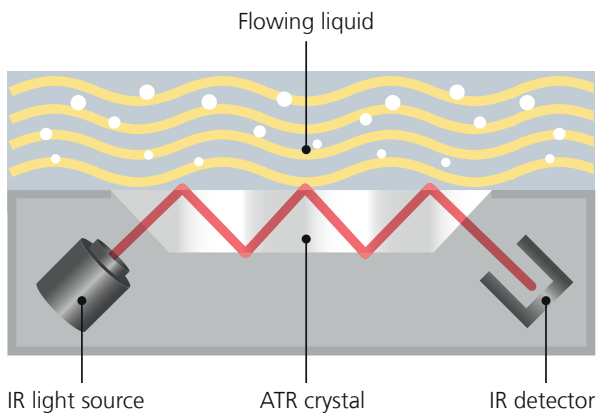
The ATR sensor by Fraunhofer IPM is a compact module that can be spectrally adapted to the properties of different process substances. Its optical setup has been optimized by ray tracing simulations.

Filter technique

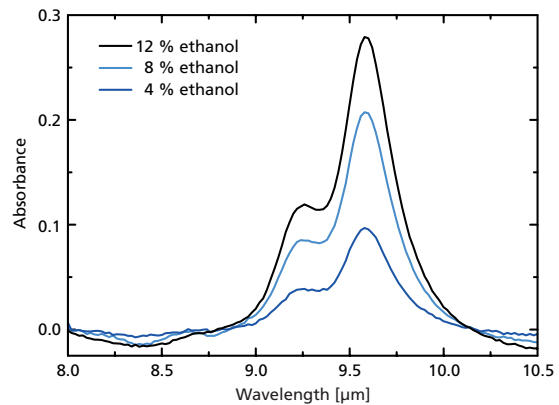
Spectral filter elements are used for distinguishing different ingredients. In case of CO₂, for instance, narrow band-pass filters are employed that are specifically designed to the characteristic absorption bands at wavelengths around 4.27 μm . Looking at sugar and ethanol, their spectroscopic fingerprints lie between 8 μm and 10.5 μm .

Advantages at a glance

- In-situ measurement
- Specific quantification of components
- Product-access with standard flange
- Optical measurement with singlepoint access
- Expandable to multiple components
- Compatible with CIP and SIP processes



Principle of attenuated total reflection ATR:
A beam of light is guided through a crystal, where total internal reflection occurs, before the beam is collected by a detector.



Measured spectra of different ethanol concentrations with spectrally tunable pyroelectric detector.

Spectral analysis

To identify several components simultaneously with one sensor, spectrally tunable pyroelectric detectors are used in combination with these filters. They record full spectral profiles in selected ranges. Registering a quasi-continuous spectral range and analyzing it by means of chemometric data interpretation, makes it possible to distinguish spectrally overlapping components such as different sugars. A linear regression method is used to reduce noise effects on the measured spectra. Furthermore, simulations are performed to determine complex compound compositions by calculating their mixed spectra.

Technical specifications

Light source	Broad-band infrared emitter
ATR sensor	Material: Sapphire (Al_2O_3) Refractive index: $n = 1.66 @ 4.2 \mu\text{m}$ Sensor area: $10 \times 40 \text{ mm}^2$ Measurement speed: 1 sample/s
Detectors	Multi-channel pyrodetector Fabry P�rot interferometer detector
Measurement range	CO_2 : 0 to 10 g/L
Accuracy	0.04 g/L
Pressure capacity	Up to 10 bar
Temperature range	0 to 40 °C

All specifications and features are subject to modification without notice.

Customized system development

The harsh conditions that prevail in beverage manufacturing present a significant challenge. Large fluctuations in temperature and pressure, noise and jarring have an impact on ATR elements, light sources and detectors. Appropriate miniaturized sensor technology ensures that these influences are recorded to correct any potential measurement errors.

The compact detectors operate maintenance free, with no mechanical parts, and are integrated within the sensor head. To maintain a constant inert atmosphere in the sensor head, the module is hermetically sealed.

The costs of the entire system are significantly below those of common Fourier transform infrared (FTIR) spectrometers. A reliable automation, intelligent process and machine control in combination with a comprehensive user interface simplify the implementation and allow optimization in various facilities.

Contact

Dr. Carsten Bolwien
Project Manager Gas and Process Technology
Phone +49 761 8857-191
carsten.bolwien@ipm.fraunhofer.de

Fraunhofer Institute for Physical Measurement Techniques IPM
Georges-K hler-Allee 301
79110 Freiburg, Germany
www.ipm.fraunhofer.de/en

