

1 The ATR sensor monitors online the concentrations of CO<sub>2</sub>, alcohol, and sugar in liquids.

2 Optimizing production in a brewery by controlling important fermentation parameters directly within the process.

## LIQUIDS ANALYSIS

### ONLINE PROCESS MONITORING WITH AN INFRARED MEASUREMENT SYSTEM

In order to ensure quality in drinks 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 drinks. For this reason, taking samples at regular intervals during production and analyzing them in a laboratory is standard practice in the beverage industry. Continuous inline measurements would simplify this procedure significantly. An optical measurement system for liquid analysis by Fraunhofer IPM measures CO<sub>2</sub>, alcohol and sugar content in-situ. Monitoring these concentration values online enhances process reliability and efficiency.

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.

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#### ATR sensor element

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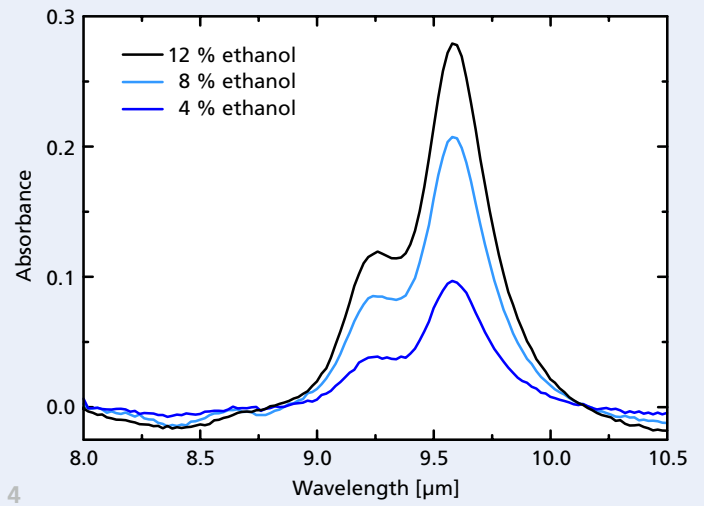
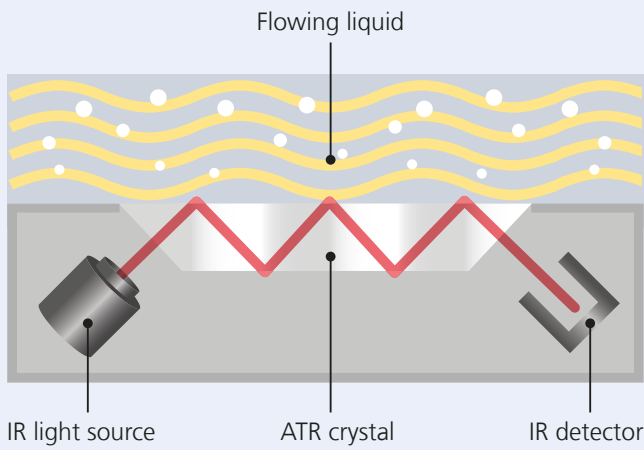
The method employed is attenuated total reflection (ATR) spectroscopy. This technique makes use of the fact that the field

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#### Filter technique

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Spectral filter elements are used for distinguishing different ingredients. In case of CO<sub>2</sub>, for instance, narrow band-pass filters



are employed that are specifically designed to the characteristic absorption bands. CO<sub>2</sub> exhibits particularly characteristic absorption bands at wavelengths around 4.27 μm. Looking at sugar and ethanol, their spectroscopic fingerprints lie between 8 and 10.5 μm.

### 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, e.g. 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.

### 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

**3** 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.

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

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.

### Technical specifications

Light source	Broad-band infrared emitter
ATR sensor	Material: Sapphire (Al <sub>2</sub> O <sub>3</sub> ) Refractive index: $n = 1.66 @ 4.2 \mu\text{m}$ Sensor area: 10 x 40 mm Measurement speed: 1 s
Detectors	Multi-channel pyrodetector Fabry Péro interferometer detector
Measurement range	CO <sub>2</sub> : 0-10 g/l
Accuracy	0.04 g/l
Pressure capacity	up to 10 bar
Temperature range	0-40 °C

All specifications and features are subject to modification without notice.