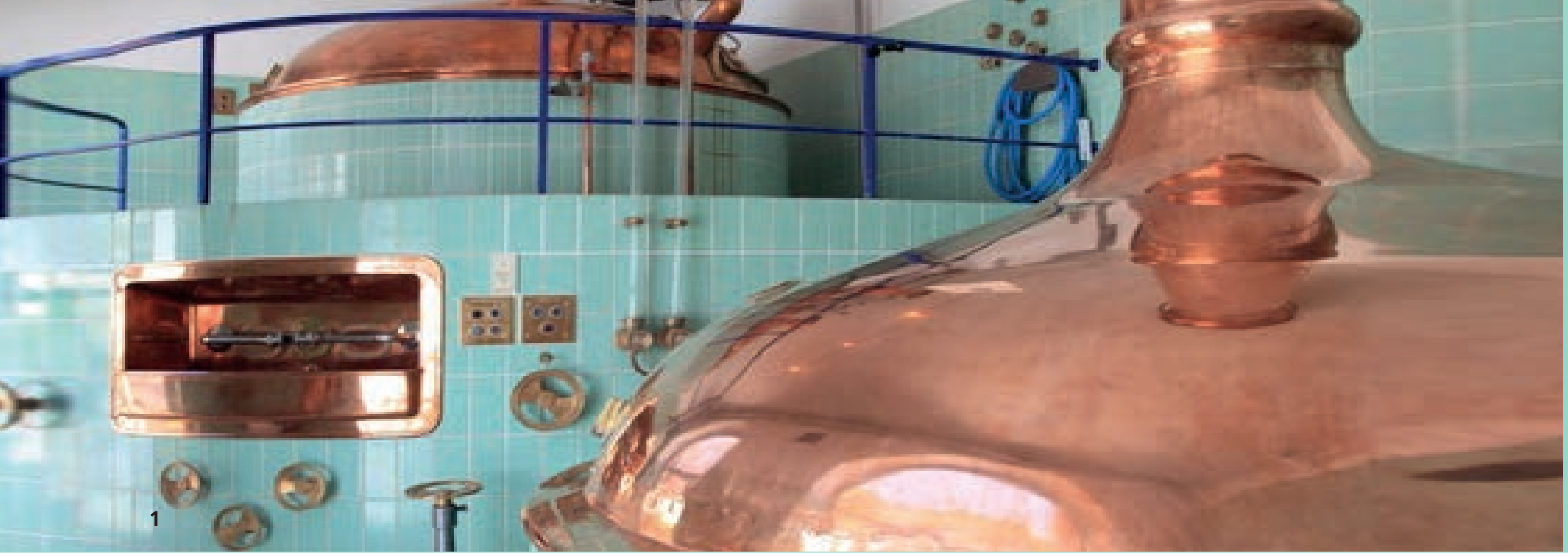

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GROUP **SPECTROSCOPY AND PROCESS ANALYTICS**

Process measurement technology for the beverage industry

In order to ensure quality in drinks manufacturing, CO_2, alcohol and sugar content need to be measured regularly during production. In future, a sensor with online capability based on ATR spectroscopy will record these values continuously – without making a detour to the lab.

Anyone enjoying a beer at the end of a long working day relies on the fact that it will taste as it always does. In alcoholic fermentation, a complex biological process takes place which converts sugars into alcohol and carbon dioxide. Knowing precisely how and when this conversion takes place is crucial to the quality of the beer. For this reason, taking samples at regular intervals during the production of beer, wine and spirits as well as soft drinks, and analyzing them in a laboratory is standard practice. The ability to take measurements directly within the process would therefore simplify the procedure significantly. Together with the Centec Gesellschaft für Labor- und Prozessmesstechnik mbH, Fraunhofer IPM is developing an optical infrared measurement system for liquid analysis that works on the principle of attenuated total reflection (ATR) spectroscopy and, alongside dissolved carbon dioxide and alcohol content, also records levels of sugar in its various forms in-situ.

Compact, spectrally adaptive, pyroelectric detectors

A few isolated inline liquid analysis systems are already available on the market. They measure density, sound, turbidity and the optical refractive index of the liquid in order to draw conclusions concerning relevant variables such as essence, alcohol and original wort, based on calibration and comparison with stored comparative lab data. However, the sum parameters they determine provide no specific information on ingredients and their concentrations. Yet the inaccuracy that results from the fluctuating composition of natural raw ingredients, which may affect product quality, makes this information necessary.

In the new liquid sensor, scientists employ ATR spectroscopy in the mid-infrared range. Here, the light beam passed through the ATR crystal is totally reflected at the crystal boundary surface in contact with the liquid. This beam interacts with the liquid flowing across it via the resulting evanescent field at the crystal surface. After it has passed the entire crystal, the transmitted light is collected by a detector. Pyroelectric detectors with spectral filter elements are used for this purpose. If, for instance, only CO_2 concentrations are to be determined, spectral band-pass filters are employed that are specifically tuned to the characteristic absorption bands of around 4.3 µm. However, to identify several components simultaneously with one sensor, pyroelectric detectors are also being used for the first time in combination with tunable Fabry-Perot filters. They record full spectral profiles in selected ranges. Registering a quasi-continuous spectral range in combination with chemometric methods makes it possible to distinguish spectrally overlapping components (e.g. different sugars, ethanol, etc.). CO_2 and ethanol exhibit particularly characteristic absorption bands in the wavelength range from 3.1 to 4.4 µm. In the case of sugar (and also ethanol), this spectroscopic fingerprint lies between 8 and 10.5 µm. The compact detectors operate maintenance free, with no mechanical parts, and are integrated within a hermetically sealed sensor head. When other parameters, such as temperature, are involved, the concentrations of selected components are determined and read out following chemometric data analysis. Initial test series with a variety of liquids confirm that the sensor supplies sufficiently accurate, reproducible values for CO_2 and ethanol.

ATR INFRARED SPECTROSCOPY In ATR-IR spectroscopy, a beam of light is passed through a reflection element where total internal reflection occurs before the beam is collected by a detector. In this process, an optical near-field forms at the boundary surface of the element – this is the so-called evanescent field which penetrates into the sample. The wave interacts with the sample and is absorbed in certain material-specific wavelength ranges. Subsequent to its repeated total internal reflection, the areas absorbed in the beam's spectrum attenuate accordingly and provide a concentration measurement for the desired substances.

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1 Measurements that can be performed directly within processing will make quality control in drinks production significantly easier.

2 The sensor determines the concentrations of CO_2, alcohol, and sugar in the flowing liquid as a direct part of the process.

A particularly harsh measurement environment

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, however, that these influential factors are recorded so as to correct any potential measurement errors. To maintain a constant inert atmosphere in the sensor head, it must be reliably sealed. As a result, it was necessary to perform testing on custom-made food grade seals in order to guarantee this. Other work focused on determining sugar concentrations and optimizing chemometric evaluation.

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