Electronic tongue: The thermal-electrical impedance sensor measures various properties of a liquid, such as the electrical and thermal conductivity.

Thermal-electrical impedance spectroscopy

For solids, liquids and gases

Affordable multi-parameter measurements

The combination of thermal and electrical impedance spectroscopy provides highly accurate statements about the thermal and electrical conductivity of substances. Fraunhofer IPM is developing novel sensor concepts based on thermal-electrical impedance spectroscopy, which can be used to determine the properties of gases, liquids and solids in technical processes.

Benefits of electrical and thermal impedance spectroscopy combined

In a matter of seconds, humans are able to sense aromas, odors, temperature, texture and the appearance of food and beverages. Our brains are very fast and efficient at processing a vast number of sensory signals. In measurement technology, thermal-electrical impedance spectroscopy provides a comparable high level of sensory performance.

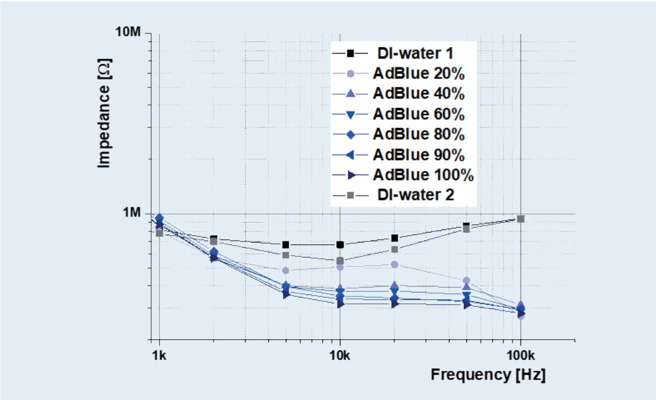
Impedance spectroscopy is used for examining materials and conductivity. In electrical impedance spectroscopy, impedance depends on the frequency of the alternating current. This method is a proven tool for measuring the characteristics of solids and liquids that depend on electrical conductivity. If thermal conductivity rather than electrical conductivity of a material is examined, this is called thermal impedance spectroscopy. Combining both methods allows to make very reliable statements about the characteristics of liquids used in processes.

Additional sensors increase reliability

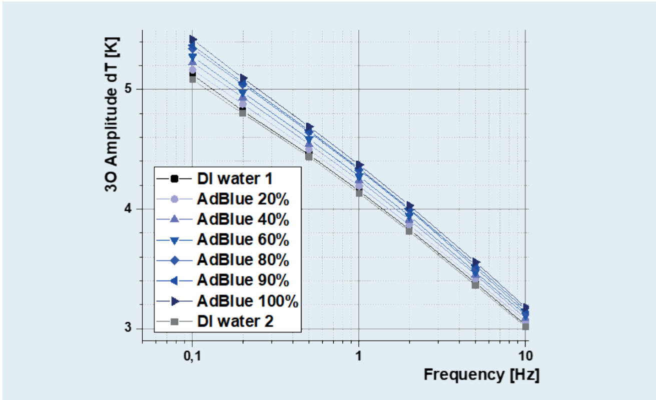
Compared to human sensory organs, today's conventional sensors are almost crude – and therefore cheap to manufacture. However, there is a problem: Due to their size, the measurement structures used are very sensitive

Our service

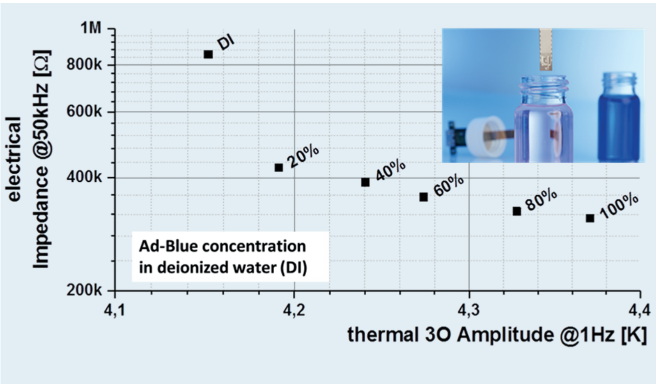
- Simulation-based sensor development (FEM)
- Sensor manufacturing (MEMS)
- Tailor-made readout units for the integration into existing sensor infrastructure
- AI-based data processing



(1) Adding water to AdBlue changes its electrical impedance, which can be concealed by adding table salt.



(2) However, the thermal measurement always measures the AdBlue content.



(3) For technical applications, a simplified measurement is usually sufficient. This reduces the cost for the readout electronics.

to fouling and mechanical damage that affect the contact with the specimen. In industrial environments, such damage or deposits are generally impossible to avoid. When it comes to thermal-electrical impedance measurements, Fraunhofer IPM relies on additional sensors that recognize deposits or damage as changes to the thermal contact between electronic tongue and specimen, increasing the reliability of measurements.

Example of use: AdBlue liquid

For example, thermal-electrical impedance analysis can be used to monitor the AdBlue liquid required for exhaust gas treatment. To cut costs for this expensive urea solution, AdBlue is often diluted with water or the sensor signal for the AdBlue warning light is manipulated with additional electronics.

Changes in electrical impedance due to adulteration with water can be easily compensated by adding table salt (Fig. 1). However, as the measurements at Fraunhofer IPM demonstrate, a thermal measurement would reveal this (Fig. 2). For technical applications, a simplified thermal and electrical measurement is usually sufficient, significantly reducing costs for processing units (Fig. 3).

Combination of multiple thermal measurement structures

Thermal impedance measurements can additionally be used to detect changes in the thermal characteristics of specimens. Such characteristics are directly linked with other characteristics, such as viscosity or surface roughness. Combining several thermal measurement structures also makes it possible to measure flow rate and direction in gases and liquids.

Fraunhofer IPM develops innovative measurement concepts including methods for analyzing and combining individual sensor signals.

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