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Signature SERIES

Nanotechnology Detection Sensors for Food Quality and Safety Control

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Doron Shalom, M.Sc., Lev Dayan, Ph.D., Abraham Shanzer, Ph.D., Shimon Shatzmiller, Ph.D., Adin Schwimmer, Ph.D., and Joseph Frey, Ph.D.

The novel use and successful integration of nanotechnology-based food sensors holds tremendous benefits in detecting contamination in food quality and safety applications. The sensors can be used "inline" and integrated into existing manufacturing lines or as "standalone" in rapid and portable food contamination detectors. There are typically five major categories of use for food sensors:

• Authenticity assessment (quality evaluation of raw materials)
• Freshness evaluation (quality evaluation of raw materials)
• Food and beverage quality control assessment (product consistency)
• Process monitoring (product consistency)
• Shelf-life assessment (quality deterioration of products)

Current Gaps in the Food Industry
One of current drawbacks in food inspection methods is the fact that the complexity of most food aromas makes them difficult to be characterized with conventional flavor analysis techniques, such as gas chromatography/mass spectrometry. Another example is the sensory analysis by a panel of food experts, which is a costly process as it requires trained professionals who can work for only relatively short periods. Additional problems, such as the subjectivity of human response to odors and the variability between individuals, cause further difficulties. Hence, the need for reliable food sensor technologies whose strengths include high sensitivity and correlation with data from human sensory panels for several specific applications in food and beverage control remains a key industry challenge (Figure 1).

Figure 1: Photos demonstrating milk, dairy, wine and water processing and quality control inspection

Nanotechnology Detection Sensors offering Safe and Green Solutions
One of the emerging developments in the food sensors industry is based on a novel and patented scientific approach using high-frequency quartz crystal microbalance (HF-QCM) sensor technology. The HF-QCM sensors can be recalled

as “electronic-nose” and “electronic-tongue” and are capable of operating at relatively low temperatures when necessary, have short calibration and training requirements, fast recovery time between runs and maintenance procedures to maintain low operating costs. HF-QCM sensors also have short recording and analysis times, particularly when used in highly stable "plug & play" sensor arrays. As most applied markets and industries tend to move more toward miniaturization of analytical laboratory instrumentation, the current approach strives for the development of innovative food sensors, which will be gradually integrated "inline" and/or as "standalone" rapid and portable detectors. The results can be stored and processed by integrating the sensors in suitable computational analyses.

The scientific approach behind HF-QCM as a detection method is based on the piezoelectric theory where molecules adsorbed on the surface of selective chemical or biological coatings create changes in the mass weight of the HF-QCM sensors (Figure 2). This process affects their resonating frequency and provides a unique digital signature or fingerprint for each target substance. The changes are accurately measured within seconds through a combination of HF-QCM sensors and powerful pattern recognition algorithms.

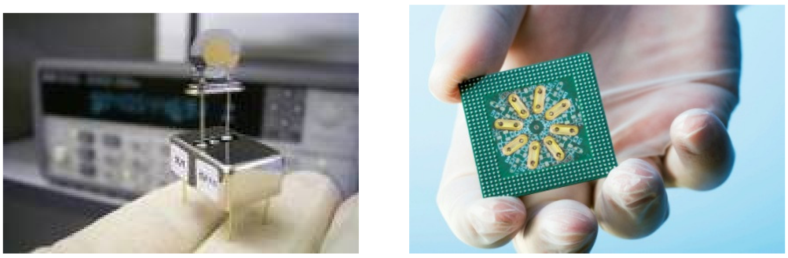

Figure 2: MS Tech's advanced sensor arrays and the concept for "in-line" sensor arrays & portable detection products

HF-QCM sensors are capable of analyzing target molecules in non-contact vapor sampling and/or surface swipe techniques while reaching high sensitivity levels of 1×10^{-9} to 1×10^{-12} g. The sample identification process occurs when pattern recognition algorithms process the received digital signature and match it with an existing database of substances stored in the instrument. HF-QCM sensors responses create a digital signature characterizing the HF-QCM Sensor Matrix reaction to a specific material inserted for analysis. The Sensor Matrix response for a given sample is systematically measured and consistent, to the extent that the likely ranges of target molecules and typical interferents have been previously inserted to the database. The distribution of the Sensor Matrix responses to analyzed samples can be plotted as histograms. This technological concept enables a fast adaptation and flexibility in “learning” to detect and identify new target substances, while keeping low false alarm rates.

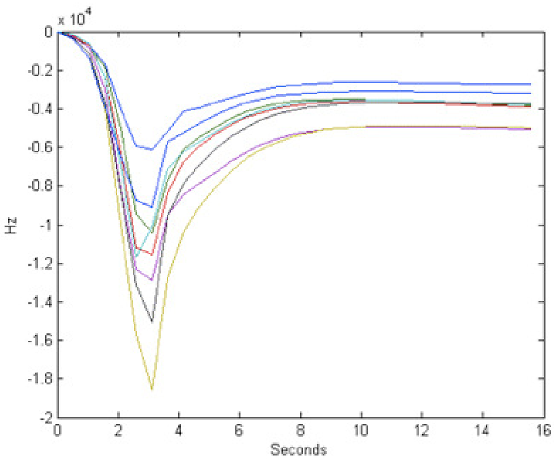

Figure 3: *Digital signature Acetone $(CH_3)_2CO$, an organic chemical compound commonly used for sanitation purposes. The chart above illustrates the sensors' typical response curves.*

The HF-QCM Sensor Matrix is designed as a "plug & play" sensor array that does not use any radioactive source or hazardous materials. It can be integrated in a wide range of systems while maintaining sensitivity and selectivity during high-throughput analysis. Each HF-QCM Matrix can record and store thousands of samples performed since its installation. It can also be integrated in conjunction to Wi-Fi or Bluetooth and used for real-time transmission of contamination alarms and/or test results to remote proxy servers. The result is compact, low power consumption, humidity resistant and cost effective portable detection devices.

Conclusions

Novel, green and safe food sensors play a significant role in the detection and identification of contaminants during the food manufacturing processes. Electronic food sensors can also help scientists develop new methods for keeping consistency of the aroma and flavor of products, as well as exploring ingredients to mask undesirable aromas. Advantages of food sensors include real-time analysis, high sensitivity, reproducibility, selectivity and specificity, low cost-of-ownership and gradual replacement and/or parallel use to complex and cumbersome analytical laboratory instruments.

Whether used "inline" or as "standalone," the sensors can be integrated in conjunction to Wi-Fi technologies and used for real time transmission of contamination alarms and/or test results to remote servers. The potential result is low power consumption, humidity resistant and cost effective portable detection devices and/or a network of sensor arrays providing rapid screening, monitoring and reporting.

Doron Shalom *is the CEO of MS Tech and an industry expert in the development, testing and certification of sensor technologies, detection products and solutions. He can be contacted at doron.s@ms-tech.co.il.* ***Dr. Lev Dayan*** *is the Chief Scientist at MS Tech,* ***Prof. Abraham Shanzer*** *is a Faculty Member in the Department of Organic Chemistry at the Weizmann Institute of Science,* ***Dr. Adin Schwimmer*** *is a Doctor of Veterinary Medicine and* ***Prof. Shimon Shatzmiller*** *is the Head of the Biological Chemistry Department at Ariel University and serves as Scientific Advisor to MS Tech. MS Tech is a world-class designer, innovator and manufacturer of advanced sensors and detection solutions for a wide range of industry applications.*

Resources

1. Neil H. and H. N. Mermelstein. 2008. Sniffing-Out Pathogens. Food Technology Magazine 67-68.
2. Miguel P. and L. Escuder-Gilabert. 2009. A 21st Century Technique for Food Control: Electronic Noses. Analytica Chimica Acta 638:1-15.
3. Wilson D.A. and M. Baietto. 2009. Applications and Advances in Electronic-Nose Technologies. Sensors 9:5099-5148.

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