

Multiple Array Sensors In The Food Industry

Sensors in the Food Industry including Arrays

Chemical & Biochemical Sensors - Moving from Measurement to Control

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Food Industry deals with a huge number and variety of materials and processes

- Water
 - Carbohydrates
 - Lipids
 - Proteins
 - -----
 - Enzymes
 - Vitamins
 - Minerals
 - Flavours
 - Additives
- Major**
- Minor**

Carbohydrates

- Monosaccharides e.g. Glucose
- Oligosaccharides e.g. Sucrose
- Polysaccharides Structure
- Starch Structure
- Cellulose Dietary fibre
- Gums e.g. guar, xanthan

Lipids

- Milk fats
- Vegetable butters
- Oleic-linoleic acids
- Linolenic acids
- Animal fats
- Marine oils

Proteins

- Muscle
- Egg
- Milk
- Cheese
- Wheat
- Legumes
- Rice

Minor Components

- Enzymes
 - Hundreds
- Vitamins
 - A, D, E, K fat soluble
 - B, C, water soluble
- Minerals
 - Ca, P, Mg, Fe, Cu, Zn, I, Se
- Flavours
 - Hundreds
- Additives
 - Structure

Multiple Array Sensors In The Food Industry

Unit Operations in Food Processing

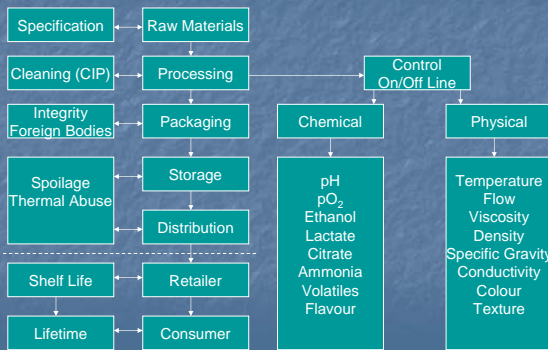
(some)

- Mixing
- Grinding
- Extruding
- Milling
- Drying
- Fermentation
- Cleaning
- Centrifugation

Needs

- Industry, Consumer have similar needs
 - Safety
 - Quality
 - Traceability
 - Cost
- Consumer – generally qualitative
- Industry – quantitative

Food Industry Supply Chain



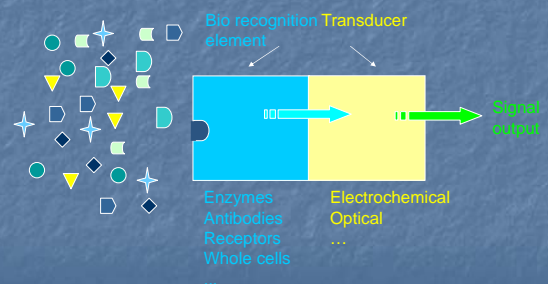
Methods of Food Analysis

- Major Components:
 - Large in lab or on-line instruments
 - Near IR, reflectance spectra, KF titration
- Minor Components:
 - Large in lab or at-line instruments
 - Chromatography, mass spectrometry
 - Chemical/biosensors have a role

Chemical/Bio Sensors

- Minor Components
- Liquid / volatile samples
- Low molecular species

What is a Biosensor? The "classical" definition



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A Biosensor Should Be

- Small, of a size appropriate for use. Not nano size to show how clever you are!
- Manufacturable in large numbers and at low cost
- Rapid. Result within the timescale of the process/diagnostic test
- Economical. Low cost of ownership
- Always considered as a sensor system with the instrument
- Self calibrating. Minimal action by unskilled user
- Probably single use

Sensor Arrays in Foods

Potential Application Areas

- pH
 - **Commonest measurement**
- Clean in Place (CIP)
 - **Hygiene**
- "Artificial Nose"
 - **Great promise for arrays**
- Safety
 - **Paramount**

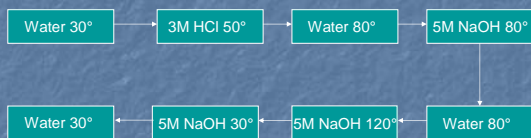
Glass pH Electrode

- **Positives**
 - Robust
 - Wide dynamic range
- **Negatives**
 - Oil
 - Fat
 - Particles
 - Temperature
 - Safety (glass) --- not on/in line

In Line pH Sensors

- Fibre Optic light guide
 - **pH chromophores on tip**
 - **Arrays with range of chromophores**
- ISFET
 - **Operate at high temperature**
 - **Suitable for arrays**
 - **Very small active area ---- fouling issues**

Typical CIP Process



- Sensor arrays here would be valuable to:
- Complement temp., flow, pH
- NaOH contains additives e.g. EDTA, gluconate - **biosensors**
- High temps. (120°C sterilisation) are difficult

"Artificial Nose"

- Freshness
 - **Meat, Fish, Vegetables**
 - Amines, ammonia, sulphides, mercaptans
- Discrimination
 - **Whiskies, Cheeses**
 - Very complex "nose" of organics

Multiple Array Sensors In The Food Industry

Electronic Nose -- Sensitive Elements

- Metal oxide semiconductor
- Organic semiconductors
- As simple resistor devices
- Catalytic metals
- Metal-oxide-semiconductors
- Conducting polymers
- Insect Antennae
- GC Stationary Phase materials

Principle

- Deposited on conductive substrate
- Generally used as device array
 - Many of same elements
 - Combinations of several different elements
- Data treated by advanced statistics:
 - Principal component analysis
 - Neural networks
 - Neuro-fuzzy systems

Where are they Now? 10 Years ago

- Alpha M.O.S.,
- TU Munich, AC
- AromaScan PLC,
- BloodhoundSensors
- Neotronics Scientific
- HKRSensorsysteme
- Nordic Sensor AB
- SRL Sensors
- LennarteElectronics
- MicrosensorSystems
- Tor Vergata AC
- IFAK e.V. AC

Where are they Now? Now

- Alpha M.O.S.
 - Fingerprint mass spectrum instruments
- HKR Sensor systems
 - MS and SAW instruments

Food Safety

- Foreign Bodies
 - Glass, Metal, Stone ----- Physical Methods
- Thermal Abuse ----- Physical Methods
- Contaminants
 - Chemical Methods
 - Biosensors
- Bacteria

Foodborne pathogens

- Enteric Viruses
- Protozoan Parasites
- Mycotoxins
- *Yersinia enterocolitica*
- *Staphylococcus aureus*
- *Campylobacter*
- *Listeria monocytogenes*
- *Salmonella*
- *Escherichia coli*
- *Clostridium botulinum*
- *Bacillus cereus*

Multiple Array Sensors In The Food Industry

- Microbiology is universally used
 - Plate techniques "gold standard"
 - Real-time polymerase chain reaction (PCR) increasingly used
- Audit entire supply chain including machinery and premises

Chemical/Bio Sensor Arrays Future

- Foreign Organisms
 - Frogs in Spinach
 - Rattlesnakes in tomatoes
- Remote Sensing
 - Arrays with wireless comms.

Conclusions

- Most analyses use "big scale" instruments
- Most monitoring is physical
- Sensors are for water soluble and volatiles
- Arrays have not lived up to initial optimism
- Future niche areas for arrays -
 - Bacteriology
 - Animal detection in vegetables
 - Remote sensing