Photoacoustic spectroscopy for food control

Identification

Key words
Photoacoustic, photothermal, spectroscopy, food control, fermentation

Latest version 2012/10/08
Completed by UTCN

How does it work?

Primary objective
Food process monitoring and food quality control

Working principle
A pulsed monochromatic light of a specific wavelength with a low-to-moderate intensity can interact with a sample (solid, liquid, gas) generating acoustic waves by a thermoelastic mechanism. Thus, the absorbed pulsatory radiation generates a pulsatory heating of the sample followed by pulsatory pressure changes and results in an emission of acoustic waves. These waves can be detected using a microphone or other transducers [1, 2].

The sound waves produced in this way have the same frequency as that of the modulated (chopped) light beam. By measuring the photoacoustic (PA) signal intensity of the sample at different wavelengths of the incident light, the photoacoustic spectrum of the sample is obtained. The PA spectra obtained by using IR pulsed radiation offer information about the structure and dynamics of the molecules (energy, frequency) that constitute the examined sample. This information may be correlated with the chemical quality of food products.

Photoacoustic spectroscopy (PAS) is a very stable analytical method that offers many advantages: ease of sampling, outstanding sensitivity, linearity, repeatability, rapid response and low drift [1, 2].

Images

Additional effects
PAS can produce a heating surface, thus the analyzed product cannot be used for other measurements.

Important process parameters
Radiation frequency, radiation intensity, the interval between radiations pulses, energy density on the sample surface.

Important product parameters
Dimension, opacity, product composition.
What can it be used for?

**Products**
- Solid products: meat and meat products, fish and related products, cheese, cereals and cereals products control, food grains (detection of mycotoxigenic fungi), fruits and vegetables control, egg and egg products (to determine the effects of gamma irradiation in egg powders), skim milk powder, milk protein concentrate (to determine the iron content and the effects of the temperature treatment and of light exposure on stability of milk protein concentrate), paprika (to detect the adulteration by red lead), fat, dyes for food technology [3-6]
- Liquid: milk, wine, beer, oil, fat [7, 8]
- Gas: gas emission during food processing

**Operations**
- Food quality control (based on qualitative and quantitative measurements)
- Food processing control (i.e., fermentation process control, moistening level control, gas emission control)

**Solutions for short comings**
PAS is a stable, rapid and simple sampling method. PAS can replace or complement the conventional reflectance measurement technique.

What can it NOT be used for?

**Products**
- Heat sensitive products (ex. apple-banana puree, creamy pasta broccoli).
- Products that show a high penetration depth for IR radiation (ex. lasagna, meat, milk, yogurt).

**Operations**
Operations that must avoid heating. PAS may produce undesirable heating of some products with higher IR absorption capacity since the temperature increase may be of several dozens of degrees.

**Other limitations**

**Risks or hazards**
No risks or hazards related to this technology are known. PAS is a non-destructive technique.

Implementation

**Maturity**
Currently, PAS is not frequently used in food industry, although there are good perspectives for wider use in the near future.

**Modularity /Implementation**
The technology can be inserted in an existing production line without specific requirements.
PAS is adaptable and can be used in combination with other techniques (e.g., IR spectroscopy, Electron paramagnetic resonance spectroscopy), in a continuous or non-continuous mode.

**Consumer aspects**
Not known.

**Legal aspects**
There are no regulations concerning the use of PAS in food technology. The uses of PAS have to respect the regulations concerning the specific product for which it was utilized. The use of PAS in food technology falls in the scope of Regulation (EC) 258/97 on novel foods and novel food ingredients (because the heat generated by this technology might modify the structure of the product). This regulation requires approval for a number of products performed based on current scientific knowledge. For most applications novel food approval, declaration or labeling is required.

**Environmental aspects**
Environmentally friendly.
Facilities that might be interesting for you

<table>
<thead>
<tr>
<th>Title</th>
<th>Institute/company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Flow Fractionation</td>
<td>INPT - EI Purpan</td>
</tr>
<tr>
<td>Fruit &amp; vegetable analysis</td>
<td>INRA - SQPOV</td>
</tr>
<tr>
<td>Gas analysis</td>
<td>INRA - SPO</td>
</tr>
<tr>
<td>Mastersizer FBR</td>
<td>Wageningen UR - FBR</td>
</tr>
<tr>
<td>Microbiological analysis</td>
<td>INRA - SQPOV</td>
</tr>
<tr>
<td>Multi-user olfactometer</td>
<td>Ecole des Mines d'Alès</td>
</tr>
<tr>
<td>PlantLipPol-Green</td>
<td>UMR IATE</td>
</tr>
</tbody>
</table>

Further Information

**Institutes**
- UTCN, Fraunhofer Institute for Biomedical Engineering, UPC, Wageningen UR,
- Poznań University of Technology, University of West Hungary, National Institute for Laser Plasma and Radiation Physics

**Companies**
- M-u-t, PAS-Analytik, Alpes Lasers, MTEC, Daylight Solutions, LumaSense Technologies

**References**

Source: