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Application of Raman Spectroscopy in the Food-Packaging Sector

In situ Raman spectroscopy refers to the technique of performing Raman spectroscopic analysis directly within the environment of interest, without the need for sample extraction or preparation. In the context of the food-packaging sector, this technique offers several significant potentialities:

Quality Control

In situ Raman spectroscopy allows for real-time monitoring of various parameters related to food-packaging materials, such as the identification of polymers used in packaging films, detection of contaminants, or monitoring the degradation of packaging materials over time. This can help ensure the quality and safety of packaged food products.

Identification of packaging materials

It enables rapid and non-destructive identification of different packaging materials, including plastics, polymers, coatings, and adhesives. This is crucial for verifying the authenticity and integrity of packaging materials and ensuring compliance with regulatory standards.

Interaction between food and packaging

This is the most challenging function. If Raman spectroscopy lends itself to quality control of fresh foods, such as meat and vegetables, the ability to monitor the reactions occurring at the interface between material and food represents a significant research objective. The challenge lies in being able to monitor the quality of packaged food throughout its storage.

In the case of active packaging, the use of Raman spectroscopy combined with chemometrics can be useful for monitoring the action of the active substance, its release, and interactions with the substrate.

This fact sheet outlines guidelines for the key procedures necessary to monitor the presence of an active filler with antimicrobial activity incorporated into a film and/or coating for food packaging.

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1. Sample Preparation

Samples from packaging material do not need any prior preparation before the analysis. A piece of material containing the filler can be analysed directly before and during the contact with food.

2. Instrument Setup

Raman spectroscopy instrument can be set up according to the specific requirements of the polymeric film analysis: laser wavelength (to avoid fluorescence), laser power (to avoid sample burning) and penetration depth. The optimisation of the instrument parameters has to be carried out depending on the specific characteristics of the material and the fillers/additives.

3. Baseline Correction

This step requires the acquisition of a baseline spectrum of the material in which the additive/filler is incorporated (e.g., PET, PE, PBAT, paper, organic coating).

4. Raman Measurement

The acquisition of Raman spectra of the packaging samples can be performed using different sampling techniques: placing the sample in a Raman microscope (if information about the filler structure and distribution is needed) or in a rotary table or in-situ under real environmental conditions by using hand-held Raman equipment.

5. Data Acquisition

Collect Raman spectra from the packaging sample under consideration of sufficient signal-to-noise ratio and appropriate integration time. Take into consideration that the Raman intensity of the additive can be even 100 times lower than that of common food contact polymers.

6. Data Analysis

Analyse the acquired Raman spectra.

- Peak Identification: Identify and assign Raman peaks.
- Peak Fitting: Fit Raman peaks with mathematical functions for quantitative information (peak intensities, peak positions, peak widths) to determine the relative abundance of the active filler during the contact with food.

7. Interpretation and Reporting

Interpret the results and draw conclusions about the existence of functional additives in food packaging or about the evolution of new molecules which may be indicative of the degree of food perishing.

Conclusion

Raman spectroscopy combined with chemometrics can serve as a valuable analytical tool for understanding the complex mechanisms that may occur at the food-packaging material interface.
The use of complementary techniques such as Raman microscopy can aid in the identification of those most significant signals that can directly or indirectly explain changes in the food during its shelf life.
This can aid in the development of portable Raman instruments to support the evaluation of the quality of packaged foods.

CHARISMA's contribution

The Charisma project, aims to achieve in-situ measurements of degradative reactions at the food-packaging interface, analysing the the performance of active materials containing specific molecules with antimicrobial functions. This will enable the development of in-situ Raman systems potentially capable of monitoring the quality of packaged foods.

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