MALDI-TOF Mass Spectrometry Analysis MALDI-8020

Application News

Application of MS Imaging to Food Science and Safety Using the MALDI-8020 Benchtop MALDI-TOF Mass Spectrometer

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User Benefits

- Rapid and easy MS imaging analysis using a benchtop MALDI-TOF MS
- Distribution of a pesticide in plant seeds and oligomers on film surfaces can be observed at a spatial resolution of 50 µm.
- MS imaging enables evaluation of the surfaces of various food-related and industrial materials.

■ Introduction

MS imaging is one of the fastest-growing mass spectrometry applications in recent years. In this technique, a target substance is measured directly from a surface without any labeling or derivatization. Therefore, this technique is often used to visualize the distribution of substances, for example, drug metabolites in biological organisms or functional ingredients in food, which are often difficult label/derivatize.

In this report, we introduce two examples of MS imaging at a spatial resolution of 50 µm: a pesticide on the surface of a plant seed and heat-induced deterioration of food contact material.

■ Methods

A MALDI-8020 benchtop linear mode MALDI-TOF mass spectrometer was used to acquire the MS imaging experiments (Fig. 1). The stage step size was 50 µm.

MS imaging of plant seeds: a pesticide (undisclosed) was sprayed onto a soybean seed. Sections of the seed were prepared under frozen condition (Fig. 2), then coated with α-cyano-4-hydroxycinnamic acid (CHCA) using the iMLayer™ matrix vapor deposition system (Fig. 1). The iMLayer can perform stable and reproducible matrix coating. The obtained data was analyzed using IonView™ (Fig. 2).

MS imaging of PET film: polyethylene terephthalate (PET) film, which is used as food contact material, was heated at 175 °C for 4 and 18 hours. A manual matrix sprayer was used to coat both samples, along with an untreated PET film sample, with dithranol solution containing NaI. The obtained data was analyzed using IMAGEREVEAL™ MS.

Fig. 1 MALDI-8020 benchtop MALDI-TOF mass spectrometer (left).
Automated iMLayer™ matrix vapor deposition system (right).

■ MS imaging of plant seeds

Soybean seeds are often sprayed with pesticides and disinfectants to prevent food damage and diseases. However, it has been suggested that sprayed pesticides may have an adverse effect on insect populations because of residuals in growing plants. For this reason, it is important to identify the quantity and distribution of chemical substances remaining in plant seeds in order to determine an appropriate use of those chemical substances for protecting the environment.

The MS image of the pesticide showed that it was found only on the surface of the seed and did not penetrate inside (Fig. 2A). On the other hand, a heterogeneous distribution of a conceivable metabolite was found inside the seed (Fig. 2B), whereas the optical image of the seed section showed a relatively homogeneous surface (Fig. 2C). The overlaid MS image showed that the distribution of the pesticide and the metabolite is different (Fig. 2D).

Table 1 MS Imaging Conditions

Matrix	: CHCA
Thickness of matrix	: 0.7 µm
Polarity	: Positive
Laser irradiation diameter	: ca. 50 µm
Laser repetition frequency	: 200 Hz

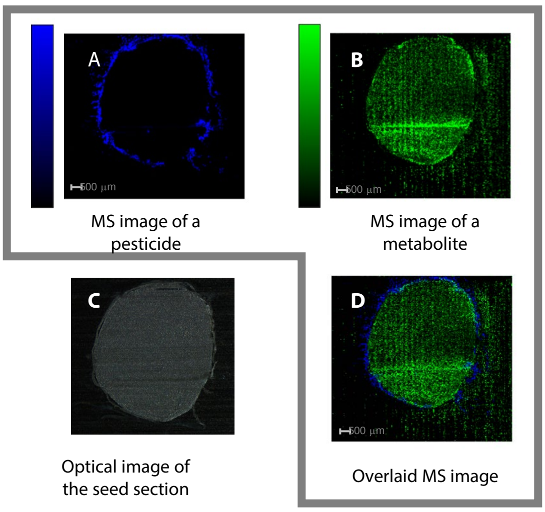

Fig. 2 MS imaging of a pesticide in a plant seed at 50 µm spatial resolution
(matrix: CHCA sublimated by the iMLayer)

■ MS imaging of PET film

Fig. 3 shows the workflow of this experiment. It is widely known that the cyclic trimer of PET is found on the surface of PET films predominantly as [M + Na]+ (m/z 599.3) after heating (see inset in Fig. 4). After 4 hours of heating, the intensity of the trimer increased in contrast to the untreated one (Fig. 4B, Fig. 4C). According to the MS image, the cyclic trimers were distributed throughout the analyzed area (Fig. 4B', Fig. 4C'). After heating for 18 hours, the MS image indicated that the PET trimer was more intensely distributed in the lower portion of the sample of PET film analyzed (see Fig. 4A'), compared with the sample which was treated for 4 hours, in which the intensity distribution of the trimer was more homogeneous throughout the whole sample (Fig. 4B, Fig. 4B').

The results of this quick "intensity mapping" of PET oligomers indicate that the workflow is useful to evaluate the surfaces of food contact materials and various industrial materials.

■ Conclusion

In this report, we demonstrated the application of MS imaging to the fields of food science and safety using the benchtop MALDI-8020. MS images of the pesticide and the oligomer generated at 50 µm spatial resolution were useful to evaluate distributions of the detected components.

The benchtop linear MALDI-TOF MS is amenable to various MS imaging applications thanks to its quick and easy operation, providing positional information which is difficult to obtain from mass spectra alone. Moreover, the combination of the MALDI-8020 and matrix deposition devices is expected to play a role in various food and safety fields, including food packaging and related materials.

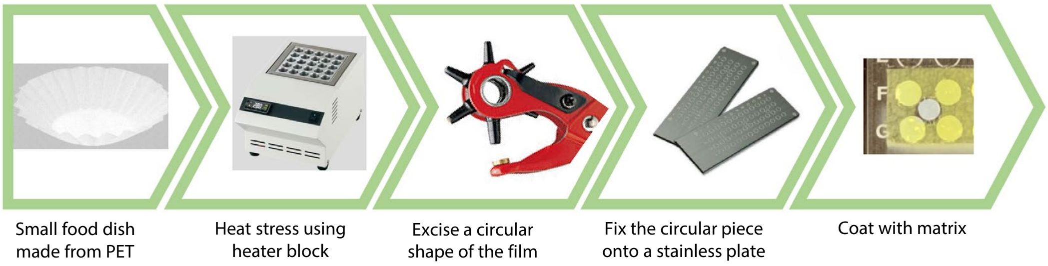

Fig. 3 Preparation of PET film under various heat stress conditions

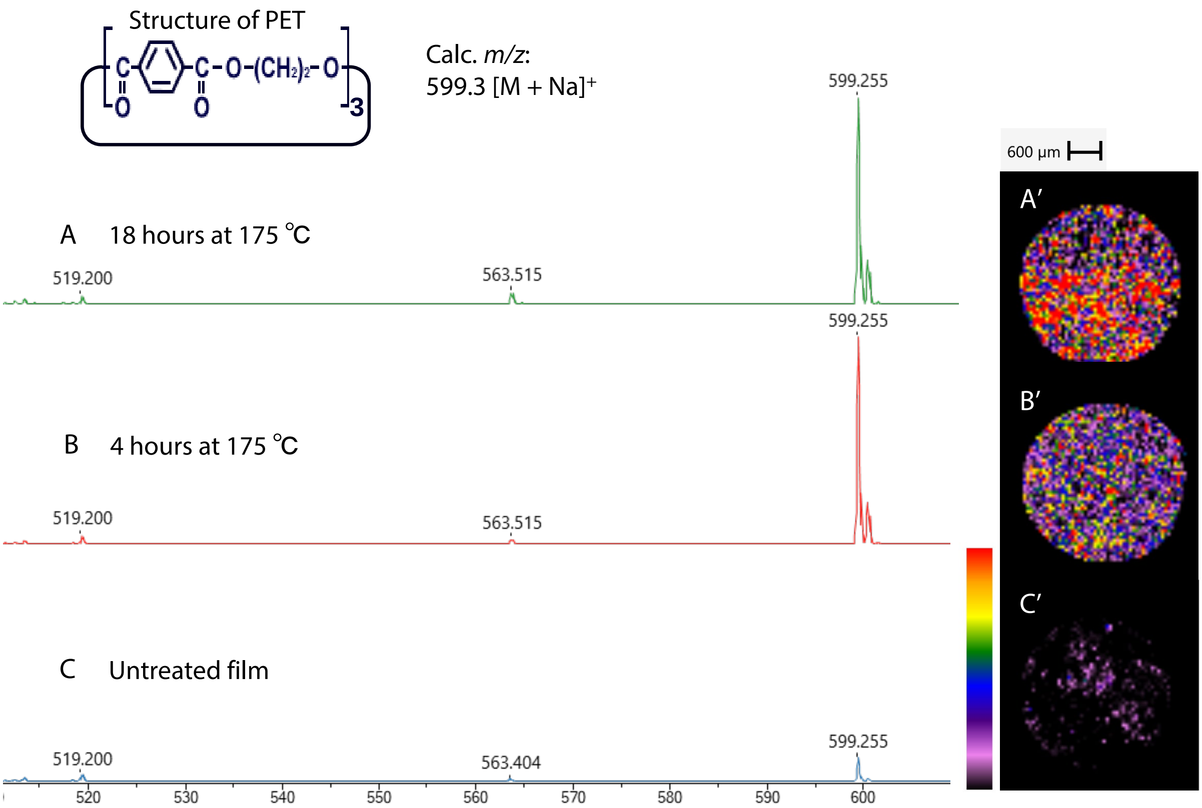

Fig. 4 Left: Mass spectra of the cyclic trimer of PET at the three different heating treatments. Right: MS images from the excised PET film sections at the three different heating treatments.

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