Themed collection: Biomedical Raman Imaging

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As a powerful analytical technique, Raman spectroscopy has been used to analyze various materials and substances. However, due to its low detection sensitivity, it has not been widely used for imaging, which requires many repetitive measurements. Recent advances in Raman measurement technology, which utilize coherent anti-Stokes Raman scattering (CARS), stimulated Raman scattering (SRS), parallel spectral detection techniques and so on, have made it possible to overcome many of these problems, enabling Raman spectroscopic imaging with high speed and high sensitivity. This has enabled imaging of cells and biological tissues that require high-resolution images, and its application is expanding to fields where Raman spectroscopy has not been used in the past, such as biology, basic medicine, and pharmaceutical research.

Based on this background, we have planned this themed collection. As described below, Raman spectroscopic imaging provides researchers with a wide range of new analytical methods, and we hope that this themed collection will spark the interest of many readers in this technology. Raman spectroscopic imaging is a technique that detects molecular vibrations in a sample and directly observes the spatial distribution of these vibrations. This allows us to observe label-free cells and biological tissues by the spatial distribution of their proteins, lipids, nucleic acids, and other molecules. While the fluorescence labelling method specifically observes a limited number of known targets, the Raman scattering spectrum gives comprehensive molecular information within a sample and allows observation while literally analyzing it.

Raman spectroscopic imaging has not only advanced the use of Raman spectroscopy in the field of medical biology but has also led to new technological developments in analytical methods. Multimodal imaging in combination with other optical imaging modalities, such as fluorescence and harmonic generation, has made it possible to capture life phenomena in greater detail. The linkage with other modalities has also greatly aided understanding of Raman spectra of complex living organisms that are difficult to interpret using spectroscopic findings alone.

Raman tag/probe technology is another new technology brought about by the development of Raman spectroscopic imaging. These are tags/probes that can be detected by Raman scattering. They differ from fluorescent probes in that the tag/probe size can be reduced to label small molecules, and the narrow spectral width of Raman scattering can be used to detect many targets simultaneously over a narrow wavelength range. These two features are bringing new methods such as small molecule/drug imaging, metabolic imaging, and supermultiplex imaging to medical biological research, and are expected to contribute to the development of this field in the future.

Raman spectroscopic imaging technology is gaining recognition as a new modality of bioimaging that combines analysis and imaging. The information provided by Raman spectroscopic imaging can be used for high-content analysis and non-target analysis, which have been attracting attention recently, and we expect that new methods of utilization will be developed in the future. In addition, the development of imaging techniques using other vibrational spectroscopic methods such as infrared spectroscopy and Brillouin spectroscopy is progressing, and the fusion of optical analysis and imaging techniques will continue to advance in the future.