Vibrational Spectroscopy and Imaging

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A molecule’s nuclei are not at rest, but rather they oscillate around their equilibrium positions within the molecule. This so-called molecular vibration leads to an oscillatory change in the permanent and/or induced dipole moment.

On the one hand, the oscillatory change in the induced dipole moment, i.e. polarizability, is monitored by means of the Raman effect. On the other hand, the oscillation of the permanent dipole moment can be detected by means of infrared radiation. A glowing bar (“Globar”), a quantum cascade laser, or a synchrotron may act as a light source in the infrared. Infrared imaging helps to elucidate the impact of the aging on human fibrosarcoma cells as reported by Guilbert et al. Continuous monitoring of morphological changes in a non-transformed small intestinal cell line are presented by Zilbershtein et al. on the basis of a novel surface plasmon biosensor design. Drutis et al. extend the use of stimulated Raman imaging to three dimensions, thus enabling the acquisition of structural and chemical three-dimensional images of native skin.

The overall turn-around time from sample taking through measurement and analysis to reporting of the result constitutes a further crucial success factor for an efficient and effective translation of biomedical vibrational spectroscopy into clinical practice. Measurement times as low as 2 seconds are achieved for the SERS-based detection of molecules by Li et al. by means of nanoporous gold disk arrays. Strola et al. report a method to shorten the time needed for Raman-based identification of a single bacterium. Raman spectroscopy may also speed up the assessment of the skin’s health status in terms of transepidermal water loss, hydration, pH, relative amount of ceramides, fatty acids, and cholesterol content, according to Vymvuhore et al. Furthermore, the recent availability of tunable midinfrared lasers may help shorten the measurement process: in the work by Kröger et al., a mouse jejunal thin section is used to show that the combination of a quantum cascade laser illumination with a microbolometer array can reduce the measurement time per unit area and wavenumber interval by approximately three orders of magnitude. Finally, the ambient light background may impose a severe hurdle for practical applicability of Raman spectroscopy in a clinical setting. Zhao et al. investigated the ambient light properties and propose appropriately filtered LED illumination.

In sum, the special section provides a cross section of current research in vibrational spectroscopy and imaging,
from benchtop research to operating rooms, from classical Raman spectroscopy to quantum cascade laser–based imaging, and from model fluids to cancerous tissue.

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