Modern Vibrational Spectroscopy and Micro-Spectroscopy

Theory, Instrumentation and Biomedical Applications

Modern Vibrational Spectroscopy and Micro-Spectroscopy have become commonly used methods in the medical field. This book provides an up-to-date account of the practical means, applications, and potential of mid-infrared and Raman spectroscopy for the medical diagnosis of diseased tissue and cells. It features ten state-of-the-art chapters on the application of these techniques to the detection and classification of prostate, lymphatic, cervical, head and neck, and esophageal cancers, as well as reports on the application of vibrational spectroscopy to the study of individual human cells, and the identification of microorganisms and erythrocytes, which should be of importance to both to vibrational spectroscopists involved in developing technique for medical diagnosis, and to clinicians, histopathologists, medical practitioners and students working in the field, with whom the spectroscopists must work closely in multi-disciplinary teams.

About the author:

Prof. Diem’s early research efforts were in the emerging fields of vibrational optical activity (infrared vibrational circular dichroism and Raman Optical Activity), and their application to the evaluation of the solution structure of small biological molecules. From the mid-1990’s on, Prof. Diem was a co-developer of the application of spectral methods to biomedical imaging, and medical diagnosis. He presently is Professor of Chemistry and Chemical Biology at Northeastern University (Boston, MA), and Science Consultant at a biotech company in Cambridge, MA he co-founded to commercialize applications of spectral methods for clinical diagnoses.

Interview:

GIT: What is your main focus in research, what is your main scientific interest?  
Diem: Over the past two decades, I have been involved in research activities to use the enormous information content of infrared and Raman spectra for medical diagnostics. To this end, tissue sections or cells are imaged using (infrared or
Raman) micro-spectrometers that can collect vibrational spectra from tissue voxels that measure about 10 µm³ or less.

Ten to hundred thousand of such voxel spectra subsequently are analyzed via multivariate algorithms to reconstruct microscopic images based strictly on chemical information. Such images contain information on disease in tissue and cells.

**GIT:** What was the reason to write the book?

**Diem:** Medical researchers employing these new methods of spectral imaging need to be able to find references to the theory of vibrational spectroscopy, including the quantum mechanical background of infrared and Raman spectroscopy. In addition, this book for the first time combines these aspects of classical spectroscopy with the newly developed methodology of analysis of large datasets, including methods of multivariate statistics.

**GIT:** What is the target audience for the book?

**Diem:** The intended audience for this book are post-graduate students and post-docs in physical chemistry, medicinal physics, spectroscopy and biomedical research areas.

**GIT:** What knowledge is a prerequisite for the book?

**Diem:** Readers should have a background in calculus, undergraduate physics, and/or physical chemistry.

**GIT:** What is the structure of the book?

**Diem:** Part 1 of the book deals with the quantum mechanical foundation of infrared and Raman spectroscopy, group theory applied to small molecules, instrumentation and general application of vibrational spectroscopy. Non-linear optical, as well as computational methods used in vibrational spectroscopy, are introduced as well. Part 2 exclusively deals with biophysical and biomedical application of infrared and
Raman spectroscopy, including an introduction to multivariate analysis

**GIT:** Will the miniaturization of spectroscopic equipment open a pathway to portable Micro-Spectroscopes?
**Diem:** It already has!!!

**GIT:** How important is automatization in terms of evaluating the obtained data by clever algorithms?
**Diem:** Since a micro-spectral dataset may consist of 10,000 to 100,000 individual spectra, automated data manipulation is an absolute necessity. Data acquisition already is very automatized, but most instrument manufacturers lack far behind in the analysis method software

**GIT:** What will - in your opinion - be the next big theme in the field?
**Diem:** In infrared micro-spectroscopy: the availability of tunable infrared laser sources, coupled with large room temperature array detectors.
In Raman micro-spectroscopy: non-linear techniques (stimulated Raman or coherent anti-Stokes Raman-based hyperspectral instruments that will increase data acquisition rates.

Diem, M.
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