Infrared Micro-spectroscopy of Human Cells and Tissues: Diagnostic and Prognostic Applications

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Advances in micro-spectroscopic instrumentation, and enhanced computing power, have enabled enormous progress in the application of infrared spectroscopy to problems to label-free, objective and reproducible medical diagnoses and prognoses. Infrared spectral histopathology (SHP) and infrared spectral cytopathology(SCP) have been developed for the detection of pre-cancer and cancer in tissue and individual exfoliated cells, respectively. These techniques offer accuracies of over 90 %, and may surpass the overall accuracy typically achieved by classical methods. Theory, instrumentation and results for lung tissue, as well as exfoliated cells from the esophagus, and the oral and cervical epithelium, will be presented.

Person: Max Diem, PhD, Professor, Department of Chemistry and Chemical Biology, Northeastern University, Boston, MA 02115 USA and Head Scientist, Cireca, LLC, Cambridge, MA 02139, USA

Education: Universität Karlsruhe, Karlsruhe, W-Germany, Vordiplom (BS) in Chemistry, 1970, with honors
The University of Toledo, Toledo, OH, USA. Doctor of Philosophy, Physical Chemistry. 1976
Syracuse University (Syracuse, NY), Postdoc. Dept. of Chem., Advisor: Prof. L.A.Nafie, 1976-1978
Academic Positions: City Univ. New York (CUNY), Hunter College, Dept. of Chemistry, Assistant Professor, 1979-1982, Associate Professor, 1983 – 1986, Professor of Chemistry, 1987 – 2005
Northeastern University, Boston, MA, Professor, Dept. of Chem. & Chem.Biol, 2006 – present
Ruhr Universität Bochum, Germany, Lehrstuhl für Biophysik, Guest Professorship, 2010 – 2011
Consultant Positions: Instruments SA, Division d'Yvon-Jobin, Metuchen, NJ, (Software), 1981 – 1987
SPEX Industries, Edison, NJ, Spectroscopy Consultant, 1991 – 1993
InPhoCyte, Inc, White Plains, NY, Chief Science Consultant, 1995 – 1997
Cireca Theranostics, LLC, Cambridge, MA, Head Scientist, 2011 – present

Awards and Honors:
Lester W. Strock Award, Society for Applied Spectroscopy, 2000
Presidential Award for Excellence in Scholarship, CUNY, 2005
Society for Applied Spectroscopy (SAS) National Tour Speaker, 2006
Society for Applied Spectroscopy (SAS) International Tour Speaker, 2011
Society for Applied Spectroscopy (SAS), Society Fellow, 2012 - present

Societies: Biophysical Society, Society for Applied Spectroscopy

Publications: 3 books, 12 book chapters, 180 peer reviewed papers.
Supervised 22 PhD thesis, numerous undergraduate research students.

Synopsis of research fields and accomplishments:
1975–1995: development of novel techniques in vibrational optical activity (infrared vibrational circular dichroism, VCD, and Raman optical activity, ROA):
design and construction of fully computerized ROA and VCD spectrometers,
first ever VCD results of DNA BZ transition, VCD of peptide turns and small cyclic peptides, development of computational methods of VCD intensities

1995-2015: infrared and Raman micro-spectroscopic studies of cell and tissue:
development of label-free Raman microscopic methods to study mitochondrial distribution in cells and drug up-take into cells;
development of multivariate methods for the analysis and visualization of Raman hyperspectral datasets;
evaluation of multivariate algorithms for the analysis of Raman datasets;
development and implementation of infrared optical methods to detect cellular abnormalities;

established large datasets of cellular spectra from the oral, nasopharyngeal, esophageal and cervical cells; established medical utility of method designed methods for supervised and unsupervised multivariate analysis of cells, and correlation with classical cytology;

infrared spectral imaging of tissue and first ever unsupervised pseudo-color maps of tissue;

evaluation of multivariate image analysis algorithms for infrared hyperspectral datasets;

development of methodology for the detection of cancer micro-metastases in lymph nodes;

computational data pre-processing algorithms to reduce confounding spectral effects;

established sensitivity and specificity of infrared-based diagnostic methods on 480 patient lung cancer data set;

designed methods for the correlation between classical and spectral histopathology.