XX JCET LECTURE, 17.05.2013, 9.00

Biomedical Applications of Vibrational Spectroscopy - Disease Diagnostics and Beyond

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The presentation will describe the efforts of the group in DIT to develop the applications of vibrational spectroscopy for disease diagnostics and beyond, into the realm of in vitro characterisation of the effects of external agents, including chemotherapeutic agents and nanomaterials.

The potential of vibrational spectroscopy, both Raman scattering and FTIR absorption, for label free screening and analysis of disease onset and progression is well established, and applications in cervical tissue biopsies and cytological samples will be described. In skin samples, the relative merits of the two techniques will be compared and contrasted, demonstrating that Raman spectroscopy provides significantly better spectral and spatial resolution. In skin tissue sections, Raman can be employed to profile the different layers of the epithelium, and to monitor the effects of solar radiation damage, demonstrating that the techniques can be used to analyse the early onset of tissue dysfunction at a molecular level.

In cervical cell lines, spectroscopy can discriminate between cells of different degrees of infection with the Human Papilloma Virus, and it is demonstrated that partial least squares regression can be employed to correlate the changes in the spectral profiles to both HPV copy number as well as the upregulation of the protein p16INK4A.

In a lung adenocarcinoma cell line, the action of the commercial chemotherapeutic agents cisplatin and vincristine can be characterised on a subcellular level using Raman spectroscopy. Characteristic spectroscopic signatures of groove binding and intercalation can be identified and differentiated, and the direct chemical effects of the action of the drug can be differentiated from the indirect physiological effects. Multivariate regression models can be established to compare the efficacies of the different chemotherapeutic agents.

In the field of nanotoxicology, Raman spectroscopy can be demonstrated to be an effective monitor of the cellular response, but also as an effective technology to localise and identify the nanoparticles subcellularly, as well as to explore the local environment of the nanoparticle and thus probe the subcellular trafficing and mechanisms of response.

Vibrational spectroscopy is thus demonstrated to represent a truly label free probe of cellular responses beyond the realm of disease diagnostics.

Biography

Professor Hugh J. Byrne is the Head of the Focas Research Institute, Dublin Institute of Tectnology. He has over 25 years experience in research science and has published over 250 peer reviewed journal and conference papers.

He has been responsible for over €20 million in funded projects, including PRTLI Cycles 1, 4 and 5 an well as SFI, EI and EU projects and has over 15 years of experience in the management and development of research infrastructure.

He has supervised over 30 PhD students.

Prof. Byrne received his Bachelor of Arts (moderatorship) degree in Experimental Physics, from Trinity College Dublin in 1985.

He received his PhD in Experimental Physics, from Trinity College Dublin, 1989 with a research thesis entitled "On the Origins and Nature of the Nonlinear Optical Properties of Organic One Dimensional Polymers".

He held a postdoctoral research fellowship in Physics Department, Trinity College Dublin from October 1989 - April 1991, before taking up a position as Research Scientist at the Max-Planck-Institut für Festkörperforschung, Stuttgart, from April 1991-July 1995, funded in part by a Marie-Curie Fellowship.

After a period as Visiting Research Scientist at the National Institute of Materials and Chemistry Research, Tsukuba, Japan, October 1995- January 1996, he was appointed to the staff of DIT in January 1996, as lecturer in the School of Physics. In 2000, he was seconded as manager of the Focas Research Institute at DIT, and was awarded Honarary Professorship of DIT (internationally reviewed) in December 2008.

Principle research interests are in applications of spectroscopy and the study of molecular and nano-materials. Recent activities have extended to biospectroscopy for diagnostics and biochemical analysis as well as nano-bio interactions.

http://www.dit.ie/focas/personnel/professorhughbyrne/listofpublications/

- “Raman Spectroscopic mapping for the analysis of solar radiation induced skin damage”, S. M. Ali, F. Bonnier, K. Ptasinski, H. Lambkin, K. Flynn, F.M. Lyng, H.J. Byrne, Analyst, (2013) DOI:10.1039/C3AN36617K
- "Identifying and localizing intracellular nanoparticles using Raman Spectroscopy", Jennifer Dorney, Franck Bonnier, Amaya Garcia, Alan Casey, Gordon Chambers, Hugh J. Byrne, Analyst, 137, 1111-1119 (2012)
- "Comparison of subcellular responses for the evaluation and prediction of the chemotherapeutic response to cisplatin in lung adenocarcinoma using Raman spectroscopy", Haq Nawaz, Franck Bonnier, Aidan D. Meade, Fiona M. Lyng, Hugh J. Byrne, Analyst, 136, 2450-2463 (2011)
- "Correlation of p16INK4A expression and HPV copy number with cellular FTIR spectroscopic signatures of cervical cancer cells", Kamila M. Ostrowska, Amaya Garcia, Aidan D. Meade, Alison Malkin, Ifeoluwapo Okewumi, John J. O’Leary, Cara Martin, Hugh J. Byrne and Fiona M. Lyng, Analyst, 136, 1365-1373 (2011)
- "Imaging live cells grown on a three dimensional collagen matrix using Raman microspectroscopy", F. Bonnier, P.Knief, B. Lim, A.D.Meade, J. Dorney, K. Bhattacharya, F.M. Lyng, H.J. Byrne, Analyst, 135, 3169-3177 (2010)
- "Vibrational Spectroscopy for Pathology, from biochemical analysis to diagnostic tool", Fiona Lyng, PhD, Eoghan Ó Faoláin, Jennifer Conroy, Aidan Meade, Peter Knief, Brendan Duffy, Mary Hunter, Joe Byrne, Peter Kelehan, Hugh J Byrne, Experimental and Molecular Pathology, 82, 121-129 (2007)