Biomedical Spectroscopy and Imaging 4 (2015) 105–107
DOI 10.3233/BSI-150106
IOS Press

Guest editorial

Isao Noda – Father of two-dimensional correlation spectroscopy

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Isao Noda was born in 1951 in Tokyo, Japan. He came to the United States in 1969 and graduated from Columbia University in the City of New York in 1974 with a BS degree in chemical engineering.

Fig. 1. Professor Isao Noda is currently Adjunct Professor at the Department of Materials Science and Engineering, University of Delaware.

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He also received his MS in bioengineering (1976), as well as MPhil (1978) and PhD (1979) in chemical engineering from Columbia. In 1997 he received a DSc degree in chemistry from the University of Tokyo. After retiring from the Procter and Gamble Company in 2012, he became an Adjunct Professor at the Department of Materials Science and Engineering, University of Delaware. He also holds a position of Chief Science Officer and Senior Vice President of Innovation at MHG, Inc. in Bainbridge, Georgia. He has recently been appointed to the position of Honorary Guest Professor at Peking University, China. He is the winner of seven international awards in the community of spectroscopy, including Bomem-Michelson Award and Ellis R. Lippincott Award, from the Coblentz Society. He is also appointed as member of Editorial Board of several international academic journals and Honorary Guest Professor of several academic institutes. Isao Noda is well known for the development of two-dimensional correlation spectroscopy [1–3,7]. Since the 1980s, two-dimensional NMR has achieved a series of great successes, including the elucidation of three-dimensional structure of proteins from 2D NMR spectra. This achievement encouraged spectroscopists all over the world to develop 2D spectra in other spectroscopic fields such as vibrational spectroscopy. However, direct translation of 2D NMR approach, which is accomplished via double Fourier transformation of a set of time-domain data collected under multiple-pulse excitation, was not feasible at that time. The major obstacle was that vibrational relaxation rates (pico-second range) are many orders of magnitude faster than typical spin relaxation rates (microsecond or even slower) encountered in NMR. Ordinary IR spectrometers cannot provide the rapid excitation and detection of vibrational relaxation responses necessary for carrying out such measurements. To overcome this limitation, Isao Noda proposed a novel concept to generate 2D spectra in spectroscopic fields other than NMR. The idea of Noda's approach can be illustrated in Fig. 2. When spectra of a sample are collected, an external perturbation is applied on the sample. As a result, dynamic spectra as a function of external perturbation are acquired. Subsequently, correlation analysis is carried out on the dynamic spectra so that a pair of 2D correlation spectra, namely 2D synchronous spectrum and 2D asynchronous spectrum, are generated. Two-dimensional correlation spectra spread spectral features

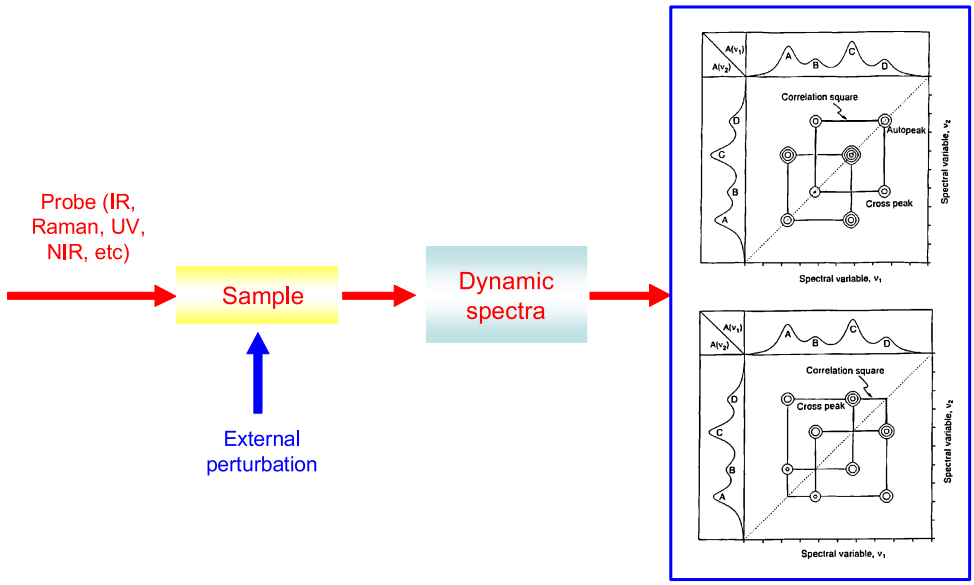

Fig. 2. The concept of perturbation induced 2D correlation spectra. (Colors are visible in the online version of the article; http://dx.doi.org/10.3233/BSI-150106.)

that are over-crowded in conventional one dimension spectra into the two-dimensional spectral space. As a result, 2D correlation spectroscopy possesses great potential in the analysis of congested bands. In addition, cross peaks in 2D correlation spectra may sometimes provide direct evidence of the presence of intermolecular interaction. Moreover, the signs of cross peaks are very important in the study of the sequence analysis of physical–chemical events in many systems.

More than twenty five years have elapsed since Isao Noda first proposed the concept of two-dimensional correlation spectroscopy. Thanks to his pioneering contributions, two-dimensional correlation spectroscopy attracts keen interest from the scientific community and it has become one of the most active fields of research. The generalized 2D correlation analysis has been successfully utilized in almost any reasonable analytical signals observed with a variety of spectroscopic probes, e.g., IR, Raman, X-ray and NMR, as well as those from chromatography or microscopy studies. The scope of 2D correlation spectroscopy has been greatly expanded to a broad range of experimental conditions. The variation of an analytical signal is induced by imposing an external perturbation selected from a large list of possibilities, e.g., mechanical, electrical, thermal, chemical, biological, and many more, to the sample system of interest. Several hundred papers relevant to 2D correlation spectroscopy are being published each year all over the world [4,5]. In the spring of 2014, the Asian Regional Conference on 2DCOS (2DCOS-2014) was held in the beautiful campus of Peking University where Isao Noda was the keynote speaker. Some selected papers from this conference have been published in *Biomedical Spectroscopy & Imaging* including an article by Isao Noda where he describes the development of 2D correlation spectroscopy in life science research [6].

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