Biomedical Applications of FT-IR Difference Spectroscopy Experiences and Perspectives

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FTIR spectroscopy, when applied to biological samples, is a method of instrumental analysis with a rather unusual disadvantage – it provides too much information. Thousands of individual bands contribute to the spectrum, leading to an overlap so extensive that essentially all detail is obscured.

One successful approach for circumventing this problem is FTIR difference spectroscopy. This technique was originally developed by several research groups in the 1980s (particularly Rothschild's group in Boston and Siebert's group in Freiburg) for the study of light-induced reactions in photobiochemical systems such as rhodopsin, bacteriorhodospin and photosynthetic reaction centers. Instead of the complete FTIR spectrum of the protein, only the light-induced changes in the spectrum are recorded. The resulting difference spectra contain far fewer bands than complete infrared spectra, and can thus be interpreted at the level of individual molecular bonds: but at the same time, they retain all the information concerning the structural dynamics associated with the protein's catalytic cycle, and are thus of direct relevance to the study of molecular mechanisms in protein reactions.

This paper presents the experiences of our research group in the development of electrochemical, rapid mixing and flow techniques as triggers for FTIR difference spectroscopy, and the application of such techniques as an analytical tool for biomedical research, drug development and clinical diagnostics. In addition, the paper discusses the future potential for applying FTIR difference spectroscopy to cells and tissues as well as to isolated biological molecules, in combination with synchrotron light sources and IR imaging technologies.