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The Increasing Relevance of FTIR Spectroscopy in Biomedicine

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Introduction

Research into the utilization of FTIR based spectroscopic methods has been going on for close to about 25 years with the field expanding from the initial days of cancer diagnosis to now where it includes various diseases occurring due to pathogens, genetic and environmental factors as well as lifestyle and age related factors. In parallel there have been developments in terms of both instrumentation sophistication and computational methods, to make it more clinically appealing while increasing the sensitivity and specificity of the technique. As the field has diversified over the years, a few reports are highlighted that establish the growing acceptance of FTIR spectroscopy as a reliable technique in both basic and applied research in the field of biomedicine.

The field of IR based diagnosis emerged with the validations that carcinogenic and normal tissues from various organs could be differentiated based on their absorbance in the IR region (mostly mid-IR) that was related to the alteration in the chemical composition [1-4]. The concept of unique fingerprinting was subsequently well established with studies from many different laboratories reporting that each cell or tissue type ranging from microbial cell [5] to complex human tissues have characteristic absorbance spectrum [6-8]. Making the system of diagnosis reagent free has been the ultimate challenge in using the technique in routine clinical set ups. While computational analysis for data processing were continuously being developed to increase the sensitivity and specificity of the technology, progress has also been made to provide a unique platform for predicting diseases from examination of biopsies [9,10]. This in turn is expected to pave the way for real time diagnosis at the site of surgery. Similarly, the ability to utilize both the transverse [11] as well as longitudinal sections [10] of a biopsy for obtaining information on the status of complex tissues like colon provides a unique potential to FTIR based measurements compared to conventional techniques like Immunofluorescence. Likewise the ability to predict the abnormality from both higher and lower wavenumbers of the spectra independently or in combination using biomarkers derived from spectral data and the possibility of using common biomarkers for several diseases have led to the possibility of deployment of this technique in clinical setting for a variety of disease diagnosis [12,13].

Though the field began with studies on cancerous tissues which were used as samples in the initial period owing to their well defined architecture it has since expanded to other types of tissue abnormalities [14] and utilization of animal models [15]. Malignant tissues, melanoma and other types of abnormal tissues have been used for an altogether different purpose, namely as model systems for development of computational methods to analyze the data to increase the specificity and sensitivity of the technology. This is one aspect of the technology that has been steadily progressing with the interdisciplinary research and software development. The earliest studies depended heavily on spectral differences that were obvious either as wavenumber shifts or as changes in band intensities or effective ratios derived from intensities at wavenumber corresponding to originate from biological components, for classification of normal and abnormal tissues [1,2,7,11-13]. As the field progressed, the advanced techniques like cluster analysis and linear discriminant analysis (LDA) were developed to make the data analysis more objective. Further improvements and application of mathematical propositions has been leading to methods which enable categorization of spectral data which have very low variability by the earlier techniques, enabling these samples to be classified without ambiguity. Computational analyses like probabilistic neural networks (PNN), discriminant – classification function (DCF) and others fall into this category. These computational methods have proved to be a boon while analyzing data obtained through techniques like Focal plane array (FPA) where a high degree of automation is required due to the enormous amount of data generated with each sample. An example of such combination of computational analysis with FPA instrumentation is described by Stenlund et al. [16]. A few of the recent reports are mentioned below to demonstrate the rapid expansion of the research into the different dimensions of biomedicine and spectroscopy.

The ability to develop instrumentation that can monitor molecular changes without staining continuously is an important advance in the field of IR based diagnosis. The recent work of Gelfand et al. [17] establish that it is feasible to measure changes over time *in vitro* without the need for the procedures followed hitherto like fixing and drying to get rid of excess water while performing FTIR spectroscopy. This study highlights not only the ability of FTIR spectroscopy to continuously monitor changes in cells under *in vitro* conditions but provides a platform to employ the system for screening of drugs in the initial stages of a trial. It not only alleviates the need for more complicated procedures such as immunofluorescence or fluorescence activated cell sorting (FACS) or other biochemical methods to monitor changes but also overcomes the necessity of obtaining samples with low water content for FTIR spectroscopy. Additionally, this study delves into understanding the mechanism behind diseases whose pathologies maybe depend on protein conformational changes. Thus, the study opens up the field of not only diagnosing a disease but elucidating the mechanism, which in turn helps to make the technique independent of any other complementary or supplementary method. Earlier studies required immuno (histochemistry) studies in parallel as it was the established gold standard. In this study the only other requirement is of a light microscope with some basic staining which is routinely available in clinical settings and requires very basic level of skill. Thus it overcomes the requirement of personnel with very specific expertise like a pathologist. This would facilitate the use of the technique for routine drug evaluations and being rapid and reagent free is likely to be more popular among the industry personnel as it would significantly reduce recurring expenditure.

Similarly, Kuchuk Baloglu [18] has reported an interesting diversification of the study of metabolic alteration in adipose tissue with lipid related cellular changes by using animal models. This study brings into focus the expansion of FTIR vibrational spectroscopy into animal model based studies in the field of biomedicine. While the field was largely limited to studies of human tissue with a view to establish its relevance to the clinical applications in the former decades, recent work as this further decrease the gap between the basic and translational research requiring FTIR spectroscopy. This study is also important as it has utilized effectively the absorbance from the higher wave region to implicate the changes in the lipid quality and quantity due to increasing obesity. Thus, the study has broadened the horizons to include diseases that are consequences of lifestyle and age. The last important aspect of this study is the ability to study transformation of adipocytes from brown to white type which becomes important for managing obesity especially in those individuals who are susceptible to recurrent obesity after undergoing procedures like liposuction. Since most of the excised fat after a liposuction would be discarded as medical waste, a part of it could be used to develop a system of understanding the entire process through continuous monitoring similar to monitoring during carcinogenesis in cells and tissues using FTIR spectroscopy. The lifestyle changes and increasing cases of obesity would make the technique much relevant in clinical settings to cut down costs of health management. There is however an aspect that has not been addressed completely in this study and that is the increase in absorbance in the region of carbohydrates in case of the obese mice. Whether improper metabolism of the carbohydrates is reflected in the tissues need to be further examined.

An interesting ramification of these studies has also been diagnosis for a disease for forensic purpose using tissue or body fluid [19-22]. Analysis of blood and urine as well as other body fluids by FTIR for different pathologies has been making significant progress. Although IR itself is non-invasive and non toxic, its use is theoretically limited to body surfaces where there is accessibility with surface scanning probes. The possibility of routine evaluation of clinical samples like blood and urine to diagnose a disease by FTIR may further make the technique relevant in the clinical context [23-25].

Recent developments in the field include the amalgamation of other techniques with infrared spectroscopy that may help to pin point changes in cells at the intracellular locations and at molecular levels (Bruker optics). The work of Jimenenz-Hernnandez [26] shows the unique ability of FTIR based technique to analyze the effect of drugs by analyzing the cell cycle stage. This may in future be the approach to screen drugs for different types of malignanacies as the technique eliminates the effect of cell proliferation. Thus it can be successfully used to not only define the different doses but also associate the observed effect with a cellular mechanism like apoptosis which lends it a higher degree of credibility among clinicians as well as basic research scientists. This study included an approach of cross checking the data by post measurement staining of the samples for biological markers using immunofluorescence on the same set of cells for which FTIR was measured. This approach may in future be used, partly overcoming the requirement of having to obtain consecutive sections of a biopsy for FTIR measurements and for immuno-histochemistry to correlate the biochemical changes with observed spectral changes. The study however could have included a flow cytometry component by sorting the cells at different stages of cell cycle and/or apoptosis and then measuring their FTIR spectra which would have perhaps been more convincing such an approach would likely include the FTIR signatures of any bound flurochromes or reagents at different stages of the cell cycle/apoptosis.

We predict that with the requirement for easier techniques that are cheap and rapid, having high sensitivity and specificity to unambiguously diagnose a disease, and due to a growing population, there would be further expansion of the research into the utilization of FTIR based technologies in biomedicine. As technology advances and data analysis and interpretation take on a more objective approach, it is very likely that the technique will become more common and be routinely used for both applied research and basic research. The latest approaches to FTIR based research point in this direction [27].

References

1 Benedetti E, Palatresi MP, Vergamini P, Papineschi F, Spremolla G (1985) New possibilities of research in chronic lymphatic leukemia by means of Fourier transform-infrared spectroscopy-II. Leuk Res 9: 1001-1008.

2 Chiriboga L, Xie P, Yee H, Zarou D, Zakim D, et al. (1998) Infrared spectroscopy of human tissue IV Detection of dysplastic and neoplastic changes of human cervical tissue via infrared microscopy. Cell Mol Biol 44: 219-229.

3 Schultz CP, Mantsch HH (1998) Biochemical imaging and 2D classification of keratin pearl structures in oral squamous cell carcinoma. Cell Mol Biol 44: 203-210.

4 Lasch P, Naumann D (1998) FT-IR micro spectroscopic imaging of human carcinoma thin sections based on pattern recognition techniques. Cell Mol Biol 44: 189-202.

5 Helm D, Labischinski H, Schallehn G, Naumann D (1991) Classification and identification of bacteria by Fourier-transform infrared spectroscopy. J Gen Micro biol 137: 69-79.

6 Jackson M, Mansfield JR, Dolenko B, Somorjai RL, Mantsch HH et al. (1999) Classification of breast tumors by grade and steroid receptor status using pattern recognition analysis of infrared spectra. Cancer Detect Prev 23: 245-253.

7 Andrus PG (2006) Cancer monitoring by FTIR spectroscopy. Technol Cancer Res Treat 5: 157-167.

8 Krafft C, Shapoval L, Sobottka SB, Schackert G, Salzer R (2006) Identification of primary tumors of brain metastases by infrared spectroscopic imaging and linear discriminant analysis. Technol Cancer Res Treat 5: 291-298.

9 Salman A, Sebbag G, Argov S, Mordechai S, Sahu RK (2015) Early detection of colorectal cancer relapse by infrared spectroscopy in "normal" anastomosis tissue. J Biomed Opt 20: 75007.

10 Sahu RK, Argov S, Walfisch S, Bogomolny E, Moreh R, et al. (2010) Prediction potential of IR-micro spectroscopy for colon cancer relapse. Analyst 135: 538-544.

11 Argov S, Sahu RK, Bernshtain E, Salman A, Shohat G (2004) Inflammatory bowel diseases as an intermediate stage between normal and cancer: a FTIR-microspectroscopy approach. Biopolymers 75: 384-392.

12 Sahu RK, Argov S, Salman A, Zelig U, Huleihel M, et al. (2005) Can Fourier transform infrared spectroscopy at higher wavenumbers (mid IR) shed light on biomarkers for carcinogenesis in tissues? J Biomed Opt 10: 054017.

13 Mordechai S, Sahu RK, Hammody Z, Mark S, Kantarovich K, et al. (2004) Possible common biomarkers from FTIR microspectroscopy of cervical cancer and melanoma. J Microsc 215: 86-91.

14 Petibois C, Gouspillou G, Wehbe K, Delage JP, Déléris G (2006) Analysis of type I and IV collagens by FT-IR spectroscopy and imaging for a molecular investigation of skeletal muscle connective tissue. Anal Bioanal Chem 386: 1961-1966.

15 Boyar H, Zorlu F, Mut M, Severcan F (2004) The effects of chronic hypo perfusion on rat cranial bone mineral and organic matrix. A Fourier transforms infrared spectroscopy study. Anal Bioanal Chem 379: 433-438.

16 Stenlund H, Gorzsás A, Persson P, Sundberg B, Trygg J (2008) Orthogonal projections to latent structures discriminant analysis modeling on in situ FT-IR spectral imaging of liver tissue for identifying sources of variability. Anal Chem 80: 6898-6906.

17 Gelfand P, Smith RJ, Stavitski E, Borchelt DR, Miller LM (2015) Characterization of Protein Structural Changes in Living Cells Using Time-Lapsed FTIR Imaging. Anal Chem 87: 6025-6031.

18 Kucuk Baloglu F, Garip S, Heise S, Brockmann G, Severcan F (2015) FTIR imaging of structural changes in visceral and subcutaneous adiposity and brown to white adipocyte trans differentiation. Analyst 140: 2205-2214.

19 Lacombe C, Untereiner V, Gobinet C, Zater M, Sockalingum GD, et al. (2015) Rapid screening of classic galactosemia patients: a proof-of-concept study using high-throughput FTIR analysis of plasma. Analyst 140: 2280-2286.

20 Armenta S, de la Guardia M, Alcalà M, Blanco M (2013) Noninvasive double confirmation of cocaine abuse. Anal Chem 85: 11382-11390.

21 Tamošaitytė S, Hendrixson V, Želvys A, Tyla R, Kučinskienė ZA, et al. (2013) Combined studies of chemical composition of urine sediments and kidney stones by means of infrared micro spectroscopy. J Biomed Opt 18: 27011.

22 Gajjar K, Trevisan J, Owens G, Keating PJ, Wood NJ, et al. (2013) Fourier-transform infrared spectroscopy coupled with a classification machine for the analysis of blood plasma or serum: a novel diagnostic approach for ovarian Cancer. Analyst 138: 3917-3926.

23 Barlev E, Zelig U, Bar O, Segev C, Mordechai S, et al. (2015) A novel method for screening colorectal cancer by infrared spectroscopy of peripheral blood mononuclear cells ad plasma. J Gastroenterol 1-2.

24 Ostrovsky E, Zelig U, Gusakova I, Ariad S, Mordechai S, et al. (2013) Detection of cancer using advanced computerized analysis of infrared spectra of peripheral blood. IEEE Trans Biomed Eng 60: 343-353.

25 Zelig U, Barlev E, Bar O, Gross I, Flomen F, et al. (2015) Early detection of breast cancer using total biochemical analysis of peripheral blood components: a preliminary study. BMC Cancer 15: 408.

26 Jimenez-Hernandez M, Brown MD, Hughes C, Clarke NW, Gardner P (2015) Characterizing cytotoxic agent action as a function of the cell cycle using Fourier transform infrared micro spectroscopy. Analyst 140: 4453-4464.

27 Hughes C, Henderson A, Kansiz M, Dorling KM, Jimenez-Hernandez M, et al. (2015) Enhanced FTIR bench-top imaging of single biological cells. Analyst 140: 2080-2085.