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A REVIEW ON FTIR SPECTROSCOPIC ANALYSIS

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ABSTRACT

This article examines some of the most recent developments in FTIR spectroscopy in fields pertaining to cell biology and natural tissues. It outlines some of the most popular peak frequencies and their assignments and is the second review article that came from an extensive investigation into the use of spectroscopic technologies in biological studies. By incorporating the majority of the significant peaks seen in natural tissues, these investigations seek to create a library of molecular fingerprints that will aid researchers in determining the chemical structure of biological tissues. There appears to be a significant resemblance in determining the peaks of identical sections of the FTIR spectra despite the use of different techniques. Therefore, it is thought that creating a distinctive collection.

Keywords: FTIR, Natural Tissues, Spectroscopy, Biological Tissues

1. INTRODUCTION

FTIR spectroscopy and other vibrational spectroscopic techniques have potential as non-invasive visual diagnostic instruments for tissues. These spectroscopic approaches have become increasingly popular in biological research in recent years, especially in clinical studies pertaining to cancer and malignancy identification, which have attracted the attention of both clinical and non-clinical researchers. The diagnostic utility of many spectroscopic and imaging techniques in cancer detection has been the subject of numerous investigations (1–12). There is a significant gap, nevertheless, in that the details of peak frequencies and their meanings in relation to distinct functional groups present in biological tissues have not been fully investigated. Additionally, there isn't a publication that focuses on FTIR spectroscopic analyses of biological tissues at the moment, thus researchers must rely on several studies, which frequently leads to spectral data interpretations that are noticeably different. In this article, a significant amount of spectroscopic research on biological tissues is reviewed, and the striking parallels in the characterisation of different peak frequencies are highlighted. Research teams focusing on spectroscopy might thus greatly benefit from the development of an extensive database that incorporates a detailed examination of the body of literature, different

chemical bands, and their accompanying spectral designations. This could therefore lead to significant improvements in the caliber and volume of research being carried out. This article's goal is to present a comprehensive and in-depth compilation of FTIR spectral frequency interpretation. Research teams working on FTIR spectroscopy related to biological tissues are expected to benefit immensely from this work.The method known as FTIR spectroscopy that optically investigates the chemical changes associated with sick tissues using vibrational spectroscopy (13–15). This technique is used to find more cautious analytical ways to assess features in tumor tissues and cells, allowing for the exact and accurate identification of molecular structures, bonding types, and functional groups. Vibrational spectra contain distinct bands that are particular to a given molecule and provide direct information about its biological composition. The vibrations of certain chemical bonds (or a single functional group) within the molecule are frequently represented by the narrow FTIR peaks (16, 17).Raman spectroscopy and its application in biological studies have been well explained (18). FTIR and Raman spectroscopy are both significant methods, and their spectra complement one another, although there are several distinctions between the two. The kinds of samples that each approach can evaluate are arguably the most important differences. While Raman spectroscopy works equally well with aqueous and non-aqueous samples, FTIR primarily concentrates on non-aqueous substances. This discrepancy results from the high absorption bands that water presents, which are a problem mainly related to FTIR spectroscopy (19–21). On the other hand, fluorescence and the substantial impacts of glass (often used as containers) present the biggest obstacles in Raman analysis. In contrast to FTIR, which requires somewhat more extensive sample preparation and does not have confocal imaging capabilities, Raman spectroscopy requires less sample preparation and can do confocal imaging. Furthermore, absorption is the source of the infrared's physical influence, which mostly impacts ionic and dipole bands like O-H, N-H, and C=O. The Raman effect, on the other hand, results from changes in the polarizability of covalent bonds such as C=C, C-S, S-S, and aromatic compounds as well as scattering, which is the emission of scattered light. To put it simply, Raman spectroscopy concentrates on changes in polarizability, whereas FTIR spectroscopy is based on changes in dipole moments during molecule vibrations.

2. FTIR SPECTROSCOPY IN BIOLOGICAL RESEARCH

Numerous biological subjects have been studied using FTIR analysis. The following areas are covered in these studies: cervical (24–32), lung (33–35), breast (21, 36–39), skin (40–44), gastrointestinal (45–48), brain (49–51), oral (52), lymphoid (53), lymphocytes (childhood leukemia) (54), non-Hodgkin's lymphoma (55), prostate (56, 57), colon (58–61), fibroblasts (62), bacteria (63, 64), tumor cells (65), DNA (66), anti-cancer drug (67), tissue processing (68), cancer detection (69), tissue preservation (70), cytotoxicity and thermal effects (71), plant tissue (72), gallstones (73), glucose measurement (74), and bone. This section of the article provides a summary of the experimental methods employed by various research teams. Understanding the elements included in the Materials and Methods of different research is said to enhance one's comprehension of peak definitions that were acquired. Chiriboga and colleagues (25) investigated the maturation and differentiation of epithelial cells in the human cervix using infrared spectroscopy. Different layers of the human cervical squamous epithelium displayed remarkably varied spectral patterns, which correspond to various phases of cellular growth. Thus, it was concluded that this method is a good way to track how cells are maturing and differentiating. Furthermore, a more accurate assessment of the state of the cells released from these tissues would be possible with a thorough analysis of the spectra from each of these layers.Wood and colleagues (26) conducted an FTIR microspectroscopic study to look at cell types and other variables that can make cervical cancer screening more challenging. This study aimed to evaluate the effectiveness of infrared spectroscopy for cervical cancer or dysplasia. It has been discovered that leukocytes, particularly lymphocytes, have spectrum characteristics in the phosphodiester region (1300–900 cm21) that may indicate changes associated with malignancy. Glycogen levels were preserved by employing ethanol as a fixative and dehydrator, which reduced the spectrum alterations in the glycogen area caused by the sample method. In erythrocyte spectra, the relatively weak PO2 2 band was still discernible, while the glycogen band's intensity declined. The spectra of endocervical mucin revealed less glycogen bands and an extremely noticeable ns PO2 2 band that resembled the intensity of the HeLa ns PO2 2 cells. Sindhuphak et al. (27) examined cervical cell samples from Thai women using FTIR spectroscopy and compared the findings with histological diagnosis. 275 cervical cell specimens were obtained from hysterectomy patients. Histological analysis revealed that 108 cases were abnormal and 167 cases were normal. The sensitivity and specificity of FTIR data were 96.3% and 96.4%, respectively, when compared to histology. The percentages of false negatives and false positives were 3.7% and 3.6%, respectively.

In a separate investigation, Mordechai et al. (28) used FTIR micro spectroscopy (FTIR-MSP) to find comparable biomarkers that are present in both cervical cancer and formalin-fixed melanoma in order to differentiate between the two cancer types. Variations the spectrum data was analyzed to determine the concentrations of biomolecules such RNA, DNA, phosphates, and carbohydrates. Although not for melanoma, carbohydrate levels demonstrated promising diagnostic potential for cervical cancer detection. But the DNA/RNA The atio measured at 1121/1020 cm^-1 for both cancer types revealed similar patterns between malignant and non-malignant tissues, with the ratio being higher in the former for both cancers.

3. FTIR – BIOLOGICAL SAMPLES

Fung and associates (31) used pressure-tuning FTIR spectroscopy to study carcinogenesis in the human endometrium. The spectral characteristics of grade I and grade III adenocarcinomas differed from those of normal tissues. Significant alterations in the spectra of malignant samples were observed in the CH stretching region, the C-O stretching bands connected to the C-OH groups of carbohydrates and cellular protein remnants, the symmetric and asymmetric stretching bands of the phosphodiester backbones of nucleic acids, and the pressure dependency of the CH2 stretching mode. These alterations in the spectrum of the endometrium could be consistently replicated. Furthermore, it was first discovered that the normal endometrial epithelium differs from the epithelium of other common human tissues in some structural ways.

CONFLICT OF INTERESTS

None.

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