Fourier Transform Infrared Spectroscopy

Fourier Transform Infrared Spectroscopy (FTIR) is a powerful analytical technique used for studying the interaction between matter and infrared radiation. It is widely employed in various scientific disciplines, including chemistry, materials science, biology, and environmental science. Here's an overview of Fourier Transform Infrared Spectroscopy:

Principle: FTIR spectroscopy is based on the principle that molecules absorb infrared radiation at specific frequencies, corresponding to the vibrational and rotational energy levels of the chemical bonds within the molecule. By measuring these absorption frequencies, FTIR can provide information about the functional groups and chemical composition of a sample.

Instrumentation: An FTIR spectrometer consists of several key components:

Infrared Source: This component emits a broad spectrum of infrared light.

Sample Compartment: The sample being analyzed is placed in the path of the infrared beam.

Interferometer: The heart of the FTIR instrument, the interferometer, is used to modulate the infrared beam.

Detector: A detector records the intensity of the modulated infrared light after it passes through the sample.

Operation: In FTIR spectroscopy, a beam of infrared light is passed through a sample, and the interaction of the light with the sample is measured. The interferometer splits the light into two beams, one that interacts with the sample and another that does not. The two beams are then recombined, creating an interference pattern that contains information about the sample's absorption of infrared radiation across different wavelengths.

Data Processing: The interference pattern obtained from the interferometer is called an interferogram. To obtain the FTIR spectrum, the interferogram is subjected to a mathematical process called the Fourier transform. This process converts the interferogram from the time domain to the frequency domain, yielding an infrared spectrum with peaks at specific wavenumbers (reciprocal of wavelength). Each peak corresponds to a specific vibrational or rotational mode in the sample.

Applications:

Chemical Analysis: FTIR spectroscopy is extensively used for identifying and characterizing chemical compounds. It is especially valuable for analyzing organic and inorganic materials, polymers, and biomolecules.

Quality Control: FTIR is employed in industries like pharmaceuticals and manufacturing for quality control and assurance of products.

Material Science: Researchers use FTIR to study the properties of materials, including the identification of impurities, phase transitions, and structural changes.

Environmental Monitoring: FTIR can be used to analyze air and water samples for the presence of pollutants and contaminants.

Forensics: FTIR spectroscopy is utilized in forensic science to analyze trace evidence and identify unknown substances found at crime scenes.

Biology and Biomedical Research: FTIR is used to study biological macromolecules like proteins and nucleic acids and to investigate tissue samples for disease diagnosis and research.

FTIR spectroscopy provides valuable information about the chemical composition and structure of substances, making it a versatile and widely used analytical technique in various scientific and industrial applications.

Fourier Transform Infrared Spectroscopy (FTIR) has been largely employed by scientific researchers to improve diagnosis and treatment of cancer, using various biofluids and tissues. The technology has proved to be easy to use, rapid, and cost-effective for the analysis of human blood serum to discriminate between cancer versus healthy control samples. The high sensitivity and specificity achievable during sample classification aided by machine learning algorithms, offers an opportunity to transform cancer referral pathways, as it has been demonstrated in a unique and recent prospective clinical validation study on brain tumours. We herein highlight the importance of early detection in cancer research using FTIR, discussing the technique, the suitability of serum for analysis, and previous studies, with a special focus on pre-clinical factors and clinical translation requirements and development [1)]

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Sala A, Anderson DJ, Brennan PM, Butler HJ, Cameron JM, Jenkinson MD, Rinaldi C, Theakstone AG, Baker MJ. Biofluid diagnostics by FTIR spectroscopy: A platform technology for cancer detection. Cancer Lett. 2020 May 1;477:122-130. doi: 10.1016/j.canlet.2020.02.020. Epub 2020 Feb 26. PMID: 32112901.