

Composition determined by FTIR of cholesterol

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Abstract

This paper presents the Fourier transform infrared (FTIR) spectroscopic analysis of cholesterol, with the aim of highlighting the characteristic functional groups and confirming its chemical structure. The FTIR spectrum obtained shows significant absorption bands in the region of $\sim 3400\text{ cm}^{-1}$ corresponding to the O–H stretching vibrations of the hydroxyl group. The intense bands in the region of $\sim 2800\text{--}3000\text{ cm}^{-1}$ are associated with the C–H stretching vibrations of the aliphatic chains. Also, a weak band around $\sim 1660\text{ cm}^{-1}$ is observed, attributed to the C=C double bond in the steroid nucleus. The bands in the region of $\sim 1050\text{--}1150\text{ cm}^{-1}$ correspond to the C–O valence vibrations, confirming the presence of the secondary alcohol. The spectrum obtained is consistent with the known chemical structure of cholesterol and validates the purity of the analyzed sample. These results highlight the usefulness of the FTIR technique in the identification of lipid-based biological compounds and in their quality control.

Keywords: Composition, cholesterol, fat

Introduction

Cholesterol is produced by the liver and is found in the blood. It is also found in some animal products, such as egg yolks, organ meats, fatty meats, butter, fatty cheeses, and some shellfish.

When there is too much cholesterol in the blood, this can cause fatty deposits to build up inside the blood vessels, making it harder for blood to flow through them. The gradual blockage of blood vessels in the heart can lead to a heart attack.

Although food companies often promote products as low in cholesterol, recent research has shown that dietary cholesterol actually has only a small influence on the amount of cholesterol in the body^[3].

This is because the liver changes the amount of cholesterol it produces depending on how much you eat. When your body absorbs more cholesterol from your diet, it produces less in the liver.

Current guidelines from major U.S. health organizations for reducing heart disease risk no longer contain specific recommended levels for dietary cholesterol.

Beginning with the 2015-2020 guidelines and continuing with the current 2020-2025 guidelines, the U.S. Dietary Guidelines Advisory Committee has eliminated the previously recommended daily cholesterol limit in favor of a new focus on dietary patterns rather than macronutrients. Its recommendations are based on an extensive review of recent research^[1, 5].

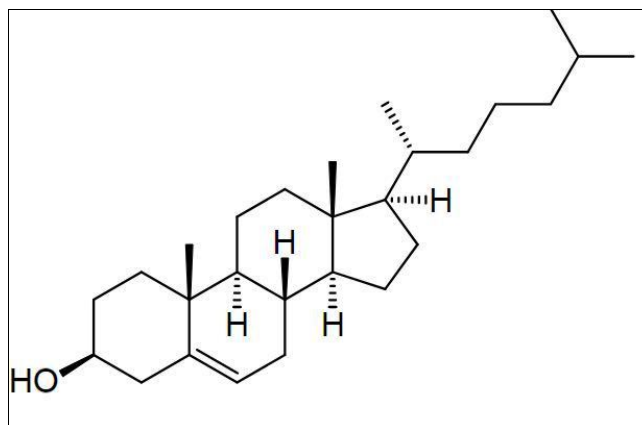
Experts recommend that people over the age of [2] limit saturated fat intake to less than 10% of daily calories. They also recommend replacing saturated fat with unsaturated fat, especially polyunsaturated fat.

Healthy lifestyle choices can help raise beneficial HDL and lower harmful LDL cholesterol.

Fortunately, both cholesterol and triglyceride levels can be lowered with the help of medications and changes in diet and lifestyle.

Material and methods

The structure of cholesterol



Cholesterol sample obtained in powder from Sigma Aldrich Chemicals Co. Ltd. was used in the experiment. The FT-IR spectrum of the title compound was recorded in transmittance mode in the region $4000\text{--}400\text{ cm}^{-1}$ by dispersing and palletizing in KBr pellets using Perkin-Elmer IR spectrometer.



Fig 1: Perkin-Elmer spectrophotometer

Results and discussion

FTIR (Fourier Transform Infrared) spectroscopy can be used to analyze cholesterol due to its ability to identify and quantify the presence of specific chemical bonds and functional groups within a sample. Specifically, FTIR can detect the characteristic vibrational bands associated with the hydroxyl group (OH) and the various carbon-hydrogen (CH) bonds present in cholesterol molecules. FTIR spectroscopy works by passing infrared light through a sample and measuring how much light is absorbed at different frequencies.

Different chemical bonds and functional groups vibrate at specific frequencies, and these vibrations absorb infrared light at corresponding frequencies, creating unique "fingerprint" patterns in the spectrum. By analyzing these patterns, researchers can identify the presence and abundance of various molecules, including cholesterol^[6, 12]. FTIR can detect the stretching vibrations of the O-H bond (around 3433 cm⁻¹) and the C-H bonds (around 2850-2935 cm⁻¹) in cholesterol.

FTIR can also be used to quantify the amount of cholesterol in a sample. This is often done by comparing the intensity of specific absorption peaks in the spectrum to a calibration curve generated from known concentrations of cholesterol.

Gallstone Analysis: FTIR is used to determine the composition of gallstones, including the presence and amount of cholesterol.

FTIR can be used to study the structure and interactions of cholesterol in lipid bilayers and other biological systems.

FTIR can be applied to study cholesterol in biological samples, such as blood and tissues, to understand its role in various diseases.

FTIR can be used to analyze the cholesterol content in food products.

FTIR is a non-destructive technique that requires minimal sample preparation.

FTIR spectra can provide valuable information about the chemical structure and composition of cholesterol-containing samples.

FTIR can be used for both qualitative (identification) and quantitative (measurement) analysis of cholesterol^[13, 19].

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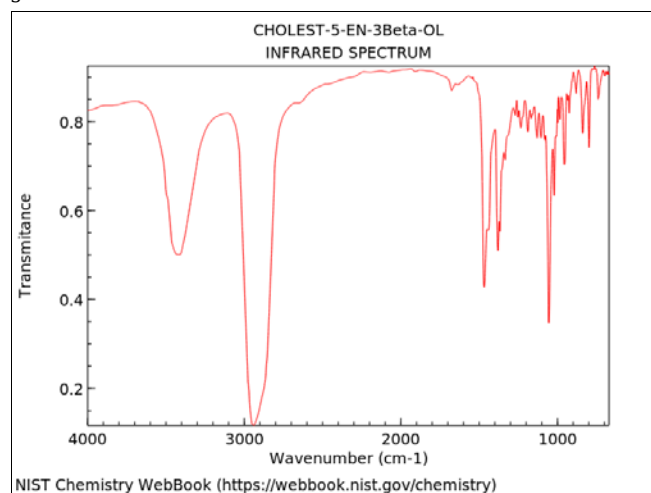


Fig 2: Spectral FTIR colesterol

Conclusions

The FTIR spectrum of cholesterol confirms the presence of functional groups characteristic of its molecular structure. The broad and well-defined band around ~3400 cm⁻¹ highlights the hydroxyl (-OH) group, specific to alcohols. The intense bands in the ~2850–2950 cm⁻¹ region correspond to the C-H stretching vibrations of the aliphatic chains, characteristic of the steroid nucleus and side chain. The presence of a weak band around ~1660 cm⁻¹ indicates the existence of a C=C double bond within the steroid cycle. Also, the bands in the ~1050–1150 cm⁻¹ region are associated with the C-O valence vibrations, confirming the nature of the secondary alcohol. Overall, the obtained FTIR spectrum is in agreement with the chemical structure of cholesterol, demonstrating the identity and purity of the analyzed sample. This analysis emphasizes the efficiency of the FTIR method in the characterization of sterol compounds from a structural and functional point of view.

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