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FTIR Spectroscopic Characterization and Structural Confirmation of Pegylated FE_3O_4-β-Cyclodextrin Nanocarriers

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Abstract

Fourier Transform Infrared spectroscopy is widely employed for the identification of functional groups and confirmation of molecular structure in chemical formulations. In the present investigation, a formulation comprising iron oxide, polyethylene glycol, and beta-cyclodextrin was subjected to Fourier Transform Infrared spectroscopic analysis to evaluate its chemical composition and structural integrity. The recorded spectrum exhibited characteristic absorption bands corresponding to the functional groups of the constituent components, identified based on their specific vibrational frequencies. The absence of significant peak shifts or the appearance of additional bands indicates chemical stability and compatibility among the formulation components. These findings confirm the structural integrity of the formulation and demonstrate the effectiveness of Fourier Transform Infrared spectroscopy as a reliable technique for chemical characterization.

Keywords: Fourier Transform Infrared spectroscopy; iron oxide; polyethylene glycol; beta-cyclodextrin; formulation characterization; functional group analysis

Introduction

Comprehensive chemical characterization is essential for understanding the molecular structure, functional groups, and stability of newly developed formulations. Fourier Transform Infrared spectroscopy is one of the most widely employed analytical techniques due to its sensitivity, accuracy, and ability to provide detailed information on molecular vibrations and chemical bonding.

Fourier Transform Infrared spectroscopy enables the identification of functional groups through characteristic absorption bands arising from stretching and bending vibrations of chemical bonds. This technique is particularly valuable for confirming the structural integrity and compatibility of formulation components. A formulation composed of iron oxide, polyethylene glycol, and beta-cyclodextrin represents a chemically significant system that requires structural validation prior to further experimental investigations or application-based studies. Therefore, the present study aims to characterize this formulation using Fourier Transform Infrared spectroscopy and to interpret its spectral features in terms of functional group composition and chemical stability.

Sample Preparation

The formulation consisted of iron oxide coated with polyethylene glycol and beta-cyclodextrin. A representative sample was used directly for Fourier Transform Infrared spectroscopic analysis without any additional chemical treatment.

Fourier Transform Infrared Spectroscopic Analysis

Fourier Transform Infrared spectroscopic analysis was carried out using a Bruker spectrometer. The spectrum was recorded in the wavenumber range of 4000–400 cm^{-1} under ambient conditions. The obtained spectrum was analyzed to identify characteristic absorption bands corresponding to the functional groups present in the formulation.

Results and Discussion

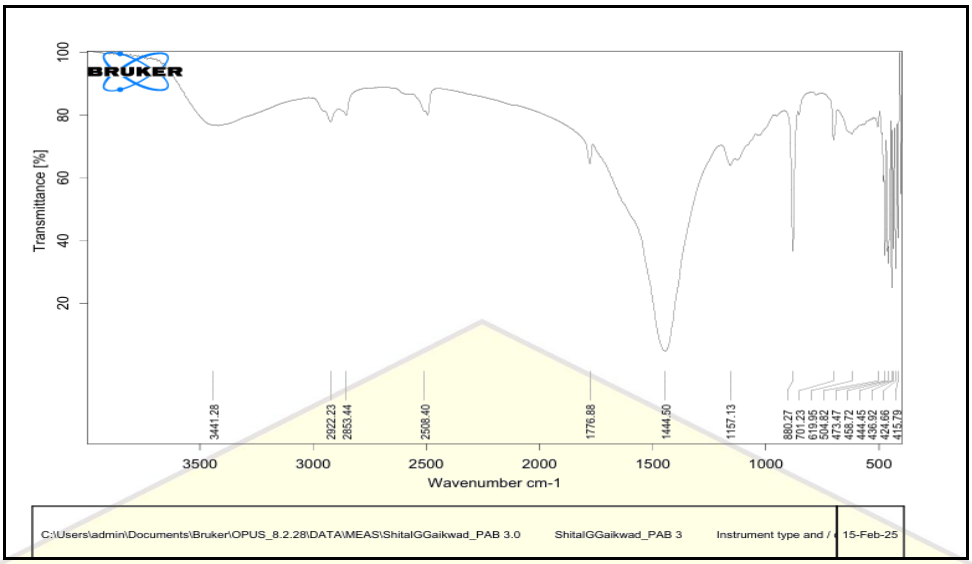

Figure 1. Fourier Transform Infrared (FTIR) spectrum of the formulation composed of iron oxide coated with polyethylene glycol and beta-cyclodextrin, showing characteristic absorption bands corresponding to major functional groups.

The Fourier Transform Infrared spectrum of the formulation composed of iron oxide, polyethylene glycol, and beta-cyclodextrin revealed multiple well-defined absorption bands, confirming the presence of various functional groups. A broad absorption band observed around 3400 cm^{-1} is attributed to O–H or N–H stretching vibrations, indicating the presence of hydroxyl or amine groups originating from polyethylene glycol and beta-cyclodextrin.

Absorption peaks appearing in the region of 2920–2850 cm^{-1} correspond to aliphatic C–H stretching vibrations associated with the polymeric components of the formulation. A strong absorption band observed between 1700–1600 cm^{-1} suggests the presence of carbonyl or amide functional groups, which contribute to the structural framework and stability of the formulation.

Bands detected in the 1400–1500 cm^{-1} region may be attributed to C–N stretching or aromatic C=C vibrations, while absorption peaks in the range of 1000–1200 cm^{-1} correspond to C–O stretching vibrations, confirming the presence of oxygen-containing functional groups characteristic of beta-cyclodextrin and polyethylene glycol.

The overall spectral pattern shows no unexpected peaks or significant shifts, indicating the absence of undesirable chemical interactions among the formulation components. These observations confirm the chemical compatibility, structural integrity, and stability of the formulation.

Conclusion

The Fourier Transform Infrared spectroscopic analysis successfully confirmed the chemical structure and functional group composition of the formulation containing iron oxide, polyethylene glycol, and beta-cyclodextrin. The presence of characteristic absorption bands corresponding to expected molecular vibrations indicates structural stability and compatibility among the formulation components. This study establishes Fourier Transform Infrared spectroscopy as a reliable and effective technique for chemical characterization and structural confirmation, providing a strong foundation for further chemistry-based and application-oriented research involving this formulation.

Acknowledgements

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Conflict of Interest

The authors declare that there is no conflict of interest associated with this study.

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