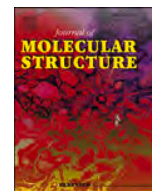




Contents lists available at ScienceDirect

Journal of Molecular Structure

journal homepage: www.elsevier.com/locate/molstr

Spectroscopic (FT-IR, FT-Raman, UV-Vis and NMR) and computational (DFT, MESP, NBO, NCI, LOL, ELF, RDG and QTAIM) profiling of 5-chloro-2-hydroxy-3-methoxybenzaldehyde: A promising antitumor agent

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ARTICLE INFO

Keywords:

DFT
Molecular docking
Fukui functions
Topological analysis
Chemical shifts
Mulliken charges

ABSTRACT

In this study, the benzaldehyde derivative 5-chloro-2-hydroxy-3-methoxybenzaldehyde (5C2H3MB) was characterized using spectroscopic techniques. Geometric parameters and complete fundamental vibrational assignments were simulated using DFT/B3LYP/6-311++G(d,p). The ¹H and ¹³C chemical shifts, computed using the GIAO method, were in agreement with the experimental findings. The electronic properties of 5C2H3MB were analyzed using time-dependent density functional theory (TD-DFT) to determine various electronic parameters, including HOMO-LUMO energies. NBO analysis was performed to determine the numerous hyper-conjugative interactions responsible for the stability of the compound. In addition, Mulliken population analysis and Molecular Electrostatic Potential Surfaces (MESP) analysis were conducted to identify electron-rich, electron-poor, reactive sites, and bonding characteristics of the titled compound. The topological analyses ELF, LOL, NCI, QTAIM, and RDG were performed using Multiwfn software, and global reactivity parameters and Fukui functions were also predicted. Molecular docking studies were conducted to confirm the biological activity by simulating the binding orientation and affinity of 5C2H3MB against transferase inhibitor and human phosphorylated IRE1 alpha, showing a binding energy of -5.1 , -5.3 and -5.9 kcal/mol, indicating its potential as an antagonist.

1. Introduction

In medicinal chemistry and the chemical industry, benzaldehyde derivatives, also known as aromatic aldehydes, are frequently used as intermediates for synthesizing textiles, dyes, agrochemicals, and flavoring agents. They can be naturally extracted from sources like

plants, cinnamon oil, and white rot fungi *Pleurotus sapidus* through the *de-novo* pathway. Substituted benzaldehydes can be engineered to enhance human hemoglobin's oxygen-carrying capacity while inhibiting sickle erythrocyte formation. Also, chalcones that have been replaced and produced by the use of benzaldehyde derivatives have qualities such as anti-proliferative, anti-inflammatory, anti-microbial,

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<https://doi.org/10.1016/j.molstruc.2023.136974>

Received 20 September 2023; Received in revised form 21 October 2023; Accepted 1 November 2023

Available online 2 November 2023

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