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Ab-initio study of Derivative of Thiadiazole molecules

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Abstract

Thiadiazole and its derivatives are important organic reaction intermediates and are widely used as anticonvulsant, antidepressant, analgesic, antiinflammatory, antiplatelet, antimalarial, antimicrobial, antimycobacterial, antitumoral, antiviral, diuretic and muscle relaxant activity. F For this reason, the vibrational and electronic properties of 1,3,4-thiadiazole derivatives can be investigated. In the present work, we have investigated the vibrational spectroscopy, HOMO-LUMO, band gap, chemical potential, electronegativity and electron affinity using Ab-intio methodology.

Keywords: Thiadiazole Derivatives, HOMO-LUMO, vibrational spectrum, Ab-initio

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1. Introduction

Leishmaniasis is a parasitic disease caused by protozoan parasites of the genus Leishmania and is generally recognized as a significant public health problem, affecting millions of people mainly living in large areas of tropical and subtropical regions. Currently, only a limited number of drugs are available for the treatment and control of this Leish-maniasis disease, all of which are associated with limiting factors such as high toxicity, variable efficacy, long dosing schedules, and/or parenteral administration [1, 2].

To date, no vaccine has been commercialized against any clinical form of leishmaniasis and its treatment relies entirely on chemotherapy based on the use of pentavalent antimalarial drugs. Other drugs, such as pentamidine, miltefosine, and amphotericin B, are used as alternative drugs for resistant parasites. All of those drug treatments have serious side effects, with the emergence of some resistant strains. Furthermore, the usual treatment is unaffordable for many afflicted countries. Therefore, there is always a need to design new potent, safe and affordable drugs [3-5]. Studying classes of compounds that are potentially bioactive or older active compounds for alternative uses is a promising strategy for discovering new therapeutic leads. Nitrogen heterocycles such as quinolines, pyrimidines, acridines, phenothiazines, indole quinones in general, and thiadiazole derivatives in particular, as well as their reduced derivatives, have been tested in antileishmanial trials over the years.

Thiadiazole derivatives since their discovery in twentieth century have demonstrated a broad spectrum of pharmaco- logical properties [6]. They were used initially as antibacterial agents [7] and rapidly revealed an interesting antiproliferative activity against both protozoa and tumor cells [8, 9]. Consequently, these derivatives have been extensively used in antiparasitic chemotherapy and a large variety of new thiadiazole derivatives were synthesized and evaluated for in vitro antileishmanial activity [10,11]. Today, traditional methods for drug discovery and development have been gradually replaced by modern methods, in which computational techniques have become indispensable in the drug development pipeline by reducing the amount of synthetic work and biological evaluation required to obtain desired results.

In this work we present vibrational and global descriptors of thiadizole derivatives using ab-initio methodology.

2. Methodology

The simplest type of ab initio electronic structure calculation is the Hartree-Fock (HF) scheme, in which the instantaneous Coulombic electron-electron repulsion is not specifically taken into account. Only its average

effect is included in the calculation. This is a variational procedure, therefore the obtained approximate energies, expressed in terms of the system's wave function, are always equal to or greater than the exact energy, and tend to a limiting value called the Hartree-Fock limit as the size of the basis is increased. It is supplemented with standard 6- 311G(d,p) basis set at Gaussian 09 program for the computation of molecular structure, bond length, bond angles, and vibrational frequencies along with IR intensities and Raman scattering activities. The 6-311G(d,p) split valence-shell basis set augmented by d polarization function on heavy atoms and p polarization function on hydrogen atoms have been used [12, 13].

3. Results and discussions

The optimized geometries of thiadizole derivatives are shown in the figure 1 and the minimum energy of molecules are -2141.611 a.u. and -1871.1836 a.u. respectively. Infrared and Raman spectroscopy involve the study of the interaction of radiation with molecular vibrations but differs in the manner in which photon energy is transferred to the molecule by changing its vibrational state. IR spectroscopy measures transitions between molecular vibrational energy levels as a result of the absorption of mid-IR radiation. This interaction between light and matter is a resonance condition involving the electric dipole- mediated transition between vibrational energy levels. Raman spectroscopy is a two-photon inelastic light-scattering event. Here, the incident photon is of much greater energy than the vibrational quantum energy, and loses part of its energy to the molecular vibration with the remaining energy scattered as a photon with reduced frequency. In the case of Raman spectroscopy, the interaction between light and matter is an off-resonance condition involving the Raman polarizability of the molecule. The IR and Raman activity of the molecules are shown in figure 2 & 3.

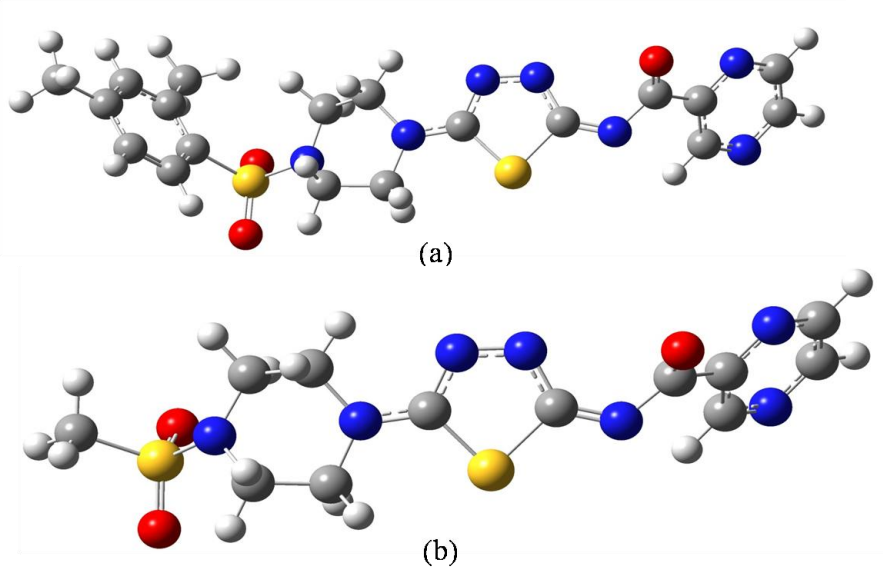

Figure1:- Optimized geometries of thiadizole derivatives

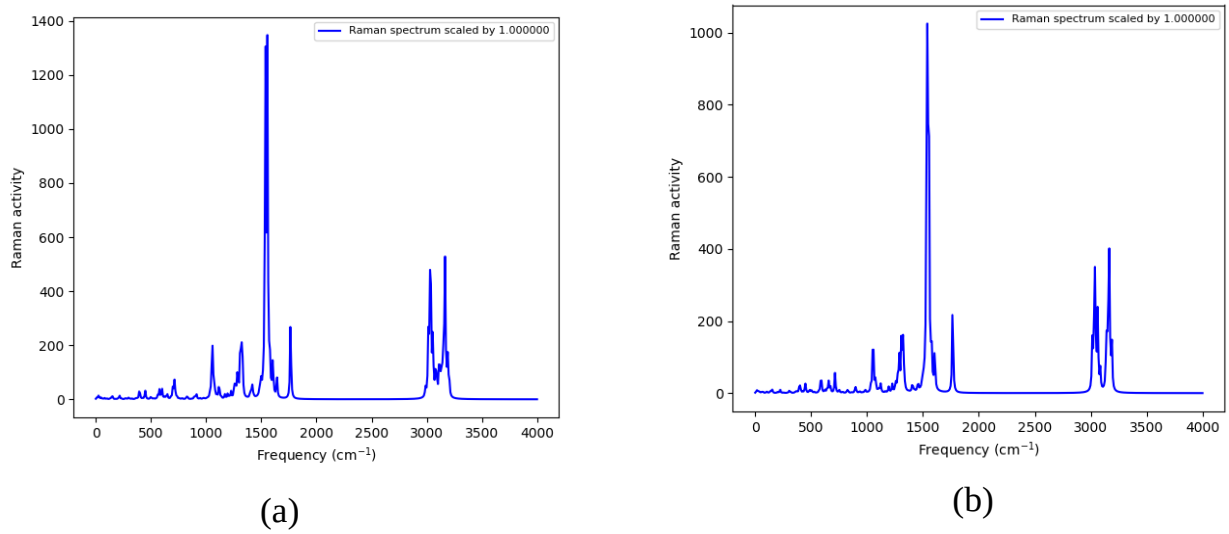

Figure 2:- Raman activity of thiadizole derivatives

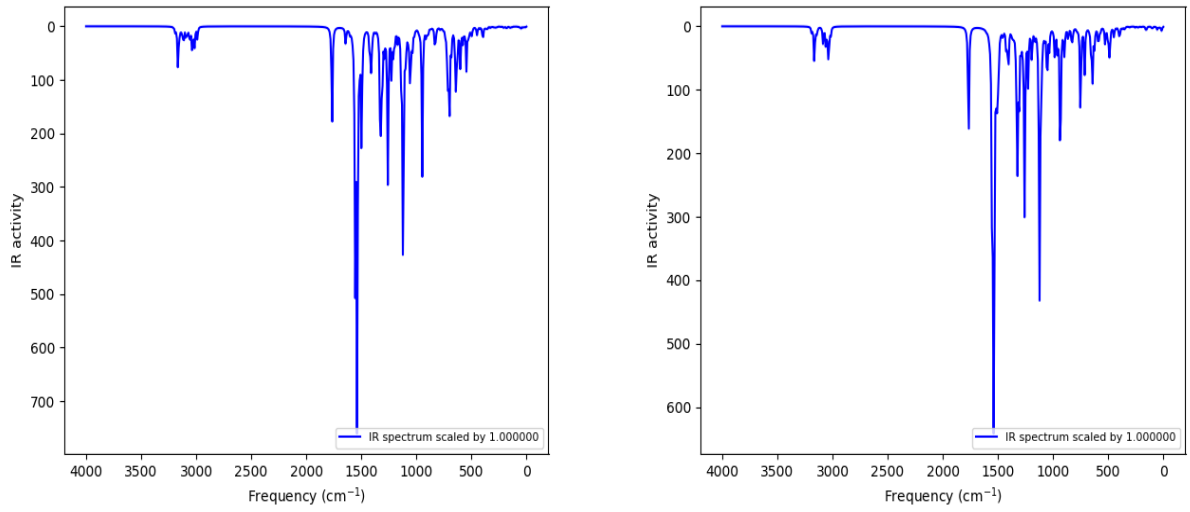

Figure 3:- IR activity of thiadizole derivatives

E_{HOMO}, E_{LUMO} and others parameters such as Ionization Potential (I.P.), Electron affinity (E.A.) are calculated using the Koopman's theorem [14].

The I.P. and E.A. can be expressed by HOMO and LUMO orbital energies as follows

$IP = -E_{HOMO}$ and $IP = -E_{LOMO}$

The energy values of HOMO, HOMO and energy gap reflect the chemical activity of the molecule. Frontier molecular orbital parameters such as band gap (E_g), chemical potential (μ), chemical hardness (η), chemical softness (ς),electrophilicity (ω), and the maximum transferred charge are tabulated in table 1.

Table 1:- Global parameters of thiadizole derivatives

Global parameters	TD2	TD3
HOMO(eV)	-8.993	-8.816
LUMO(eV)	-1.164	0.000
IP	8.993	8.816
EA	1.164	0.000
χ	5.079	4.408
μ	-5.079	-4.408
η	3.915	4.408
SOFTNESS	0.128	0.113
ω	3.294	2.204
ΔN_max	1.297	1.000
ΔEg(eV)	7.829	8.816

4. Conclusion

In this computational study, two thiadiazole derivatives were analyzed through the application of vibrational and Global descriptors and investigated IR, RAMAN, Ionization potential, Electron affinity, HOMO-LUMO, Chemical potential, Electronegativity, Global softness and band gap. From the results it is noticed that the ionization potential, electron affinity and softness of TD2 molecule is greater than the TD3 molecule but the values of chemical potential and band gap of TD3 molecule is higher.

References

[1]. S. L. Croft, K. Seifert, and V. Yardley, "Current scenario of drug development for leishmaniasis," Indian Journal of Medical Research, vol. 123, no. 3, pp. 399–410, 2006.

[2]. M. J. McConville and E. Handman, "The molecular basis of Leishmania pathogenesis," International Journal for Parasitology, vol. 37, no. 10, pp. 1047–1051, 2007.

[3]. L. G. Rocha, J. R. G. S. Almeida, R. O. Macêdo, and J. M. Barbosa-Filho, "A review of natural products with antileishmanial activity," Phytomedicine, vol. 12, no. 6-7, pp. 514–535, 2005.

[4]. O. Kayser, A. F. Kiderlen, and S. L. Croft, "Natural products as potential antiparasitic drugs," Studies in Natural Products Chemistry, vol. 26, pp. 779–848, 2002.

[5]. P. Desjeux, "The increase in risk factors for leishmaniasis worldwide," Transactions of the Royal Society of Tropical Medicine and Hygiene, vol. 95, no. 3, pp. 239–243, 2001.

[6]. W. A. Denny, "Acridine derivatives as chemotherapeutic agents," Current Medicinal Chemistry, vol. 9, no. 18, pp. 1655–1665, 2002.

[7]. M. Wainwright, "Acridine—a neglected antibacterial chromophore," Journal of Antimicrobial Chemotherapy, vol. 47, no. 1, pp. 1–13, 2001.

[8]. Antonini, "DNA-binding antitumor agents: From pyrimido[5,6,1-de]acridines to other intriguing classes of acridine derivatives," Current Medicinal Chemistry, vol. 9, no. 18, pp. 1701–1716, 2002.

[9]. M. Demeunynck, F. Charmantray, and A. Martelli, "Interest of acridine derivatives in the anticancer chemotherapy," Current Pharmaceutical Design, vol. 7, no. 17, pp. 1703–1724, 2001.

[10]. V. K. Marrapu, M. Mittal, R. Shivahare, S. Gupta, and K. Bhandari, "Synthesis and evaluation of new furanyl and thiophenyl azoles as antileishmanial agents," European Journal of Medicinal Chemistry, vol. 46, no. 5, pp. 1694–1700, 2011.

[11]. V. K. Marrapu, N. Srinivas, M. Mittal, N. Shakya, S. Gupta, and K. Bhandari, "Design and synthesis of novel tetrahydronaphthyl azoles and related cyclohexyl azoles as antileishmanial agents," Bioorganic & Medicinal Chemistry Letters, vol. 21, no. 5, pp. 1407–1410, 2011.

[12]. Mukherjee, V., and T. Yadav. "Conformational study of neutral histamine monomer and their vibrational spectra." Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 165 (2016): 167-175.

[13]. Gaussian 09, Revision A.02, M. J. Frisch, G. W. Trucks et al. Gaussian, Inc., Wallingford CT, 2016.

[14]. T. A. Koopmans, Physica 1, 104 (1933).