



Computation and interpretation of vibrational spectra on the structure of Losartan using ab initio and Density Functional methods



B. Latha^{a,e}, S. Gunasekaran^b, S. Srinivasan^c, G.R. Ramkumaar^{d,*}

^a Department of Physics, Dr. M.G.R. Educational & Research Institute University, Chennai 600095, TN, India

^b Research and Development, St. Peter's Institute of Higher Education and Research, St. Peter's University, Avadi, Chennai 600054, TN, India

^c PG and Research Department of Physics, Presidency College, Chennai 600005, TN, India

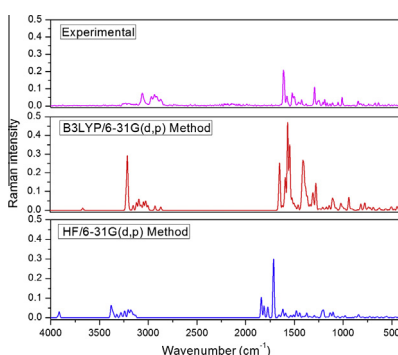
^d Department of Physics, C. Kandaswami Naidu College for Men in Anna Nagar East, Chennai 600102, TN, India

^e Department of Physics, SCSVMV University, Enathur, Kanchipuram 631561, TN, India

HIGHLIGHTS

- FT-IR, FT-Raman and UV-Vis spectra of Losartan in the solid phase were recorded and analyzed.
- Selected vibrational assignment and spectroscopic analysis have been carried out.
- Natural atomic analysis explained the intramolecular hydrogen bonding.
- The calculated HOMO and LUMO energies show that charge transfers occurs within molecule.
- The ¹³C and ¹H NMR chemical shift data assignment for Losartan have also been reported.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 23 February 2014

Received in revised form 4 May 2014

Accepted 9 May 2014

Available online 16 May 2014

Keywords:

Losartan

FT-IR

UV-Visible

Hyperpolarizability

NBO

ABSTRACT

The solid phase FTIR and FT-Raman spectra of Losartan have been recorded in the region 400–4000 cm⁻¹. The spectra were interpreted in terms of fundamental modes, combination and overtone bands. The structure of the molecule was optimized and the structural characteristics were determined by Quantum chemical methods. The vibrational frequencies yield good agreement between observed and calculated values. The infrared and Raman spectra were also predicted from the calculated intensities. (¹H and ¹³C) NMR spectra were recorded and resonance chemical shifts of the molecule were calculated. UV-Visible spectrum of the compound was recorded in the region 200–600 nm and the electronic properties HOMO and LUMO energies calculated by TD-HF approach. NBO atomic charges of the molecules and second order perturbation theory analysis of Fock matrix also calculated and interpreted. The geometrical parameters, energies, harmonic vibrational frequencies, IR intensities, Raman intensities, and absorption wavelengths were compared with experimental and theoretical data of the molecule.

© 2014 Elsevier B.V. All rights reserved.

Introduction

Vibrational spectroscopy has significant contribution towards the studies of structure and physio-chemical properties of molecular systems [1–3]. IR spectroscopy—among spectroscopic tech-

niques that provided detailed information about molecular structure. This is the most appropriate tool to perform the vibrational assignment and to elucidate the structure and confirmation of the molecule. In the present study, Infrared, Raman and UV-Visible have been applied to obtain the maximum amount of informations from the spectra of the title compound. Losartan is an effective anti-hypertensive drug. Hypertension is one of the most

* Corresponding author. Tel.: +91 9884351008.

E-mail address: gr.ramkumaar@yahoo.com (G.R. Ramkumaar).

important causes of premature death worldwide. The WHO identified hypertension as the leading cause of cardio vascular mortality. As the momentum picks up every year, the WHL is confident that almost all the estimated 1.5 billion people are affected by elevated blood pressure can be reached [4]. Different classes of anti-hypertensive drugs are used to control blood pressure. Losartan belongs to the class of Angiotensin II Receptor Blocker (ARB) and it is chemically known as 2-butyl-4-chloro-1-((4-[2-(2H-1,2,3,4-tetrazol-5-yl)phenyl] methyl)-1H-imidazol-5-yl) methanol. It is a white crystalline powder which is highly soluble in water. Its molecular formula is $C_{22}H_{23}ClN_6O$ whose molecular mass is 422.91 g. Losartan is a selective competitive Angiotensin II Receptor Blocker type I (AT1) receptor antagonist, reducing the end organ responses to angiotensin II. Losartan administration results in decrease in total peripheral resistance (after load) and cardiac venous return (pre-load). All of the physiological effects of angiotensin II, including stimulation of release of aldosterone, are antagonized in the presence of Losartan. Losartan include the tetrazole group. Tetrazole are the classes of synthetic organic heterocyclic compounds, consisting of five-member ring of four nitrogen and carbon atom (plus hydrogen atom) [5].

Experimental details

The pure sample of Losartan was obtained from a reputed company in Pondicherry and used as such for experimental purpose. The FTIR spectrum has been recorded in the region 4000–400 cm^{-1} in evacuation mode using KBr pellet technique with 4 cm^{-1} resolution on PERKIN ELMER SYSTEM ONE FTIR/ATR spectrometer at SAIF, IIT Madras, India. FT-Raman has been recorded in the region of 4000–400 cm^{-1} using BRUKER RFS 66V spectrophotometer at SAIF, IIT Madras, India. UV-Visible spectrum has been recorded in the region 200–600 nm using JASCO V-650 at Department of Chemistry, IIT Madras, India. (1H and ^{13}C) NMR spectra have been recorded using BRUKER AVANCE III 500 MHZ NMR at SAIF, IIT Madras, India.

Computational method

In the present work, quantum chemical methods like Hartree-Fock (HF) and Density Functional B3LYP method with the 6-31G(d,p) basis set are employed to study the complete vibrational spectra of the title compound and to identify the various normal modes with greater accuracy.

Literature survey reveals that to the best of knowledge, no DFT/HF method calculations of Losartan have been reported so far. Hence the present investigation was undertaken to study the vibrational spectra of this molecule completely. These calculations have been performed to support our wave number assignments. The vibrational wave numbers have been calculated to improve the simulation of the theoretical spectra. The calculations are performed by Gauss view molecular visualization program and the Gaussian 03W program package on the personal computer.

The optimized molecular structures, vibrational frequencies, thermodynamic properties, NBO analysis, hyperpolarizability, UV-Visible and NMR spectra of the entitled compound were performed using the Gaussian 03W package program which is the modern computational chemistry software packages with gauss view molecular visualization program on the PC at B3LYP/6-31G (d,p) level [6,7].

Prediction of Raman intensities

The Raman activities (S_{Ra}) calculated with Gaussian 03W program converted to relative Raman intensities (I_{Ra}) using RAIN program [8] by the expression:

$$I_i = f(v_0 - v_i)^4 \left(\frac{1}{\nu_i}\right) S_i$$

where ν_0 is the laser exciting [9] wavenumber in cm^{-1} (in this work, we have used the excitation wavenumber $\nu_0 = 9398.5 \text{ cm}^{-1}$, which corresponds to the wavelength of 1064 nm of a Nd:YAG laser), ν_i the vibrational wavenumber of the i th normal mode (cm^{-1}), while S_i is the Raman scattering activity of the normal mode ν_i . f (is a constant equal to 10^{-12}) is a suitably chosen common normalization factor for all peak intensities.

Results and discussions

In this study, we have tried to determine the molecular geometry, vibrational frequencies, (including IR, Raman and Electronic spectra) ^{13}C and 1H chemical shifts, thermodynamic properties, NBO analysis, hyperpolarizability, second order perturbation for the characterization of entitled compound.

Molecular geometry

It is the 3 dimensional arrangement of the atoms that constitute a molecule. It can be specified in terms of bond length and bond angles whereas bond length is the average distance between the centers of two atoms bonded together in any given molecule and bond angle is formed between three atoms across at least two bonds. Molecular geometry is determined by the quantum mechanical behavior of the electrons. Using the valence bond approximation, this can be understood by the type of bonds between the atoms that make up the molecule. The geometry can also be understood by molecular orbital theory where the electrons are delocalized.

As a whole, molecular geometry is equal to general shape of molecule as determined by the relative positions of the atomic nuclei. The shape of a molecule plays a role in determining its properties such as smell, taste and proper targeting of drugs. Apart from that, it gives properties of substance like polarity, color, reactivity, phase of matter and biological activity.

The atomic numbering scheme of the compound is given in Fig. 1 and optimized geometrical parameters are presented in Table 1. The bond lengths are compared with the literature values [10]. From the structural data given in Table 1, it is observed that the various bond length, bond angles are found to be almost same at HF and DFT methods. It can be inferred that the bond to be stronger, the overlap should be greater, which in turn would shorten the distance between the nuclei (i.e.,) bond length. Therefore a stronger bond has shorter bond length [11]. For Losartan, the strongest bonds are formed between $O_2-H_{33} = 0.9553 \text{ \AA}$ (DFT method) and 0.9571 \AA (HF method) which have very small bond distance value compared to others. The next strongest bond is formed between $N_{21}-H_{44} = 0.993$ (DFT method) and 0.992 (HF method). Weakest bond is formed between $C_5-Cl_{26} = 1.7245 \text{ \AA}$ (DFT method) and that of 1.7244 \AA (HF method), which have high bond distance value. The C–X (X:Cl, Br) bond length indicates a considerable increase when substituted in the place of C–H, in other words, bond length increases from C–Cl to C–Br. For C–Cl, the bond length is 1.719 \AA . The calculated value of C–Cl is in good agreement with standard value (Table 1). The C–C bond length of benzene ring (R_2) are observed in the range from 1.3821 \AA to 1.4011 \AA by DFT method and from 1.3820 \AA to 1.4011 \AA by HF method. Likewise, in ring (R_1) the C–C bond length varies from 1.3331 \AA to 1.5007 \AA by DFT method and from 1.3323 \AA to 1.5012 \AA by HF method which are in good agreement with standard values. The other deviations are due to intermolecular interactions in the crystalline state of the molecule. The bond angles obtained by both methods (DFT, HF) correlate well with the

Download English Version:

<https://daneshyari.com/en/article/1229597>

Download Persian Version:

<https://daneshyari.com/article/1229597>

[Daneshyari.com](https://daneshyari.com)