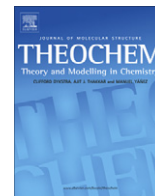




Contents lists available at ScienceDirect

Journal of Molecular Structure: THEOCHEM

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

Quantum chemical studies on the potentially important imidates

Tarek M. El-Gogary¹

Chemistry Department, Faculty of Science, Jazan University, Saudi Arabia

ARTICLE INFO

Article history:

Received 18 February 2008

Received in revised form 5 April 2008

Accepted 8 April 2008

Available online 22 April 2008

Keywords:

Ab initio

Intramolecular hydrogen bonds

Transition state

Activation energy

Imidates

ABSTRACT

The conformational space for the imidates **1–5** was explored with the Monte Carlo conformational search varying all the torsional degrees of freedom. Geometry optimization of the most stable conformers of imidates **1–5** were performed at the level B3LYP/6-31+G(d). Computed geometrical parameters were compared with the X-ray reported results. Hydrogen bonding, both intra- and intermolecular with methanol as solvent were computed at different computational levels in gas phase and DMSO. Intramolecular hydrogen bond strength does not exceed the limit of 8.50 kcal/mol due to geometry restrictions while, on the other hand, intermolecular hydrogen bond strength approaches 30.00 kcal/mol. Transition states of the inter-conversion between the most stable conformers (rotamers) were located and activation barrier of the inter-conversion processes was computed at different levels in gas phase and DMSO. Infrared spectra of these compounds were simulated and compared with experimental results. The carbonyl of the ester group shows bond stretching vibrational frequency at 1706–1812 cm⁻¹ which agrees well with the experimentally recorded values at 1708–1740 cm⁻¹.

© 2008 Elsevier B.V. All rights reserved.

1. Introduction

Imidates are important compounds that find uses in organic synthesis as building blocks and intermediates in many reactions for example in the Mumm rearrangement and the Overman rearrangement. These compounds also find use as ligands [1]. The ever-increasing demand for the design and synthesis of small molecule peptidomimetics [2–12] as pharmaceutical probes and drug leads has led to hectic research activities in the area of new drug discovery. 2-(2,2,2-Trichloro-ectimidoyloxymethyl)-acrylic acid alkyl ester imidate compounds (see Scheme 1) are interesting derivatives to be inserted into oligopeptides moieties to induce conformational constrictions. In addition, they can be considered precursors of hydroxy amino acids. In these compounds, the presence of a diversified functionality, such as carbonyl ester and imidates, that can undergo inter- or intramolecular hydrogen bonding, makes them interesting for quantum chemical calculations. In this work, the conformational space for molecules **1–5** (Scheme 1) was explored using the Monte Carlo conformational search varying all the torsional degrees of freedom. Geometry optimization of the most stable conformers of imidates **1–5** were performed at B3LYP/6-31+G(d) level. Hydrogen bonding, both intra- and intermolecular were computed at MP2/6-31+G(d) in gas phase and DMSO. Infrared spectra of these compounds were simulated and compared with experimental results.

2. Computations

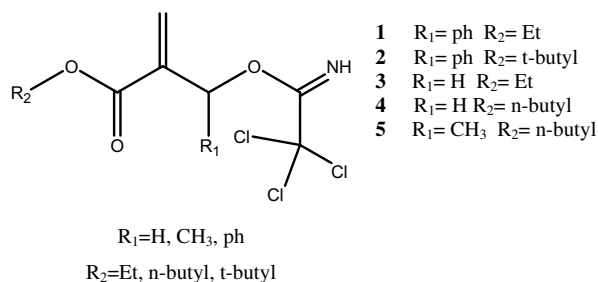
Calculations on the isolated molecules and molecular complexes were performed within GUASSIAN 03 [13] program package. Equilibrium geometries were determined and confirmed by a subsequent calculation of force constants and vibration analysis. Calculations were performed using the closed-shell Hartree–Fock, Becke's three parameter density functional theory (DFT) [14] in combination with the Lee, Yang and Parr correlation functional [15] (B3LYP) and second-order Møller–Plesset perturbational method (MP2) [16–20]. The basis set used with these methods is the split valence diffuse function 6-31+G* [21,22]. The conformational space for molecules **1–5** was explored using MacroModel package 5.5 [23]. The Monte Carlo conformational search was performed using MM2* force field varying all the torsional degrees of freedom using the solvation model GB/SA [24]. This solvation model treats the solvent (DMSO) as an analytical continuum starting near the van der Waals surface of the solute. The frequencies are consistently overestimated at B3LYP/6-31+(d), which is due to the neglect of correlation energy and presence of anharmonicity in the molecular vibrations. Therefore, frequencies were scaled by a factor 0.98062 [25].

3. Results and discussion

3.1. Geometry and conformations

The conformational space for molecules **1–5** was explored using MacroModel package 5.5 [23]. The most stable conformers (**conf1**

E-mail address: tarekelgogary@yahoo.com.¹ Present address: Chemistry Department, Faculty of Science (Dumyat), Mansoura University, Dumyat Al-Gideda, Egypt.



Scheme 1. Structure of imidates 1–5.

and **conf2**) of **1–5** was further subjected to geometry optimization process using B3LYP/6-31+G* method followed by frequency calculation to assure a minimum on the potential energy curve. The geometry optimized structures for **1–5** are shown in Fig. 1. The optimized parameters of imidate **1** is shown here in Table 1. For all the imidates **1–5**, the optimized geometry is given in Table S1 in the Supplementary Material. Fig. 2 shows the optimized structures for the most stable conformers **conf1** and **conf2** of imidate **1**. It is quite known that the B3LYP/6-31+G* level produce high quality geometrical data. Comparing the computed values in Table 1 with the X-ray results [26] proves good agreement. For example, the C=N bond of the imidate ester group computed as 1.264 Å similar to that measured as 1.258 Å [26] and the C–O bond of the imidate ester group computed at 1.341 Å is slightly longer than the experimental value at 1.328 Å [26]. This C–O bond of the imidate

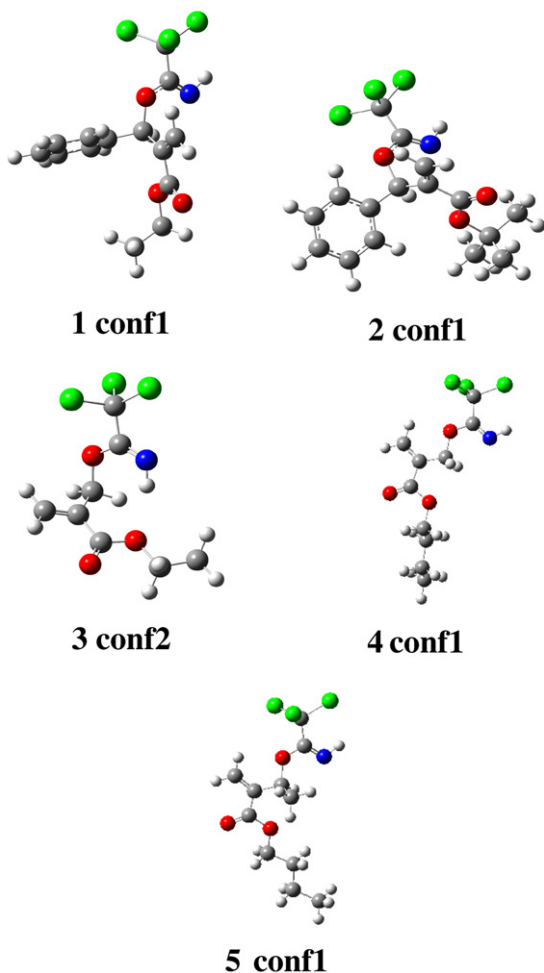


Fig. 1. Optimized geometry of imidates 1–5.

Table 1
Optimized geometrical parameters^a of imidate **1**

Bond length (Å)		Bond angle (°)		Dihedral angle (°)	
R(1,2)	1.341	A(2,1,5)	117.5	D(5,1,2,3)	175.6
R(1,5)	1.461	A(1,2,3)	108.3	D(5,1,2,4)	−3.7
R(2,3)	1.553	A(1,2,4)	124.1	D(2,1,5,6)	92.2
R(2,4)	1.264	A(3,2,4)	127.6	D(2,1,5,15)	−144.2
R(3,12)	1.803	A(2,3,12)	109.7	D(2,1,5,23)	−26.5
R(3,13)	1.800	A(2,3,13)	111.0	D(1,2,3,12)	58.5
R(3,14)	1.799	A(2,3,14)	109.2	D(1,2,3,13)	178.4
R(4,22)	1.018	A(12,3,13)	108.5	D(1,2,3,14)	−61.7
R(5,6)	1.519	A(12,3,14)	109.7	D(4,2,3,12)	−122.5
R(5,15)	1.519	A(13,3,14)	108.8	D(4,2,3,13)	−2.7
R(5,23)	1.090	A(2,4,22)	112.4	D(4,2,3,14)	117.3
R(6,7)	1.337	A(1,5,6)	109.9	D(1,2,4,22)	178.9
R(6,8)	1.499	A(1,5,15)	106.5	D(3,2,4,22)	0.1
R(7,24)	1.085	A(1,5,23)	107.6	D(1,5,6,7)	13.9
R(7,25)	1.084	A(6,5,15)	113.6	D(1,5,6,8)	−166.8
R(8,9)	1.214	A(6,5,23)	109.1	D(15,5,6,7)	−105.3
R(8,10)	1.353	A(15,5,23)	109.9	D(15,5,6,8)	74.0
R(10,11)	1.449	A(5,6,7)	124.3	D(4,2,3,14)	131.6
R(11,16)	1.521	A(5,6,8)	117.9	D(23,5,6,7)	−49.0
R(11,34)	1.093	A(7,6,8)	117.9	D(1,5,15,17)	110.9
R(11,35)	1.092	A(6,7,24)	119.7	D(1,5,15,21)	−68.1
R(15,17)	1.399	A(6,7,25)	121.8	D(6,5,15,17)	−127.9
R(15,21)	1.400	A(24,7,25)	118.5	D(6,5,15,21)	53.1
R(16,26)	1.096	A(6,8,9)	124.8	D(23,5,15,17)	−5.3
R(16,27)	1.094	A(6,8,10)	111.3	D(23,5,15,21)	175.7
R(16,28)	1.095	A(9,8,10)	123.9	D(5,6,7,24)	179.2
R(17,18)	1.396	A(8,10,11)	116.8	D(5,6,7,25)	−1.4
R(17,29)	1.087	A(10,11,16)	111.1	D(8,6,7,24)	−0.1
R(18,19)	1.396	A(10,11,34)	104.2	D(8,6,7,25)	179.2
R(18,30)	1.087	A(10,11,35)	108.7	D(5,6,8,9)	−174.1
R(19,20)	1.397	A(16,11,34)	111.6	D(5,6,8,10)	6.5
R(19,31)	1.087	A(16,11,35)	111.5	D(7,6,8,9)	5.3
R(20,21)	1.394	A(34,11,35)	109.5	D(7,6,8,10)	−174.1
R(20,32)	1.087	A(5,15,17)	119.8	D(6,8,10,11)	−179.2
R(21,33)	1.086	A(5,15,21)	121.0	D(9,8,10,11)	1.4
		A(17,15,21)	119.2	D(8,10,11,16)	85.3
		A(11,16,26)	109.8	D(8,10,11,34)	−154.3
		A(11,16,27)	110.6	D(8,10,11,35)	−37.7
		A(11,16,28)	110.7	D(10,11,16,26)	175.0
		A(26,16,27)	108.3	D(10,11,16,27)	−65.5
		A(26,16,28)	108.5	D(10,11,16,28)	55.3
		A(27,16,28)	108.9	D(34,11,16,26)	59.2
		A(15,17,18)	120.5	D(34,11,16,27)	178.7
		A(15,17,29)	119.5	D(34,11,16,28)	−60.5
		A(18,17,29)	120.0	D(35,11,16,26)	−63.6
		A(17,18,19)	120.0	D(35,11,16,27)	55.9
		A(17,18,30)	119.8	D(35,11,16,28)	176.7
		A(19,18,30)	120.2	D(5,15,17,18)	−179.1
		A(18,19,20)	119.8	D(5,15,17,29)	1.2
		A(18,19,31)	120.1	D(21,15,17,18)	−0.1

^a See Fig. 2 for atomic numeration.

ester group is shorter than the other C–O bond of the ester group (1.353 Å, Table 1). This is because the double bond character of the former bond is more than that of the latter as the delocalization of the π electrons on the imidate ester group is more than that on the ester group. This is could be explained on the basis of the higher basicity and lower electronegativity of the N atom compared with the O atom. The NCO bond angle computed as 124.1 (°) is smaller than the measured value at 128.2 (°). The geometrical parameters of imidate **1** (Table 1) compare well with the corresponding values of the other imidates **2–4** as shown in Table S1 in the Supplementary Material. The C=O bond of the ester group in **1** computed as 1.214 Å is shorter than that in **2** (1.216 Å), **3** (1.239 Å), **4** (1.239 Å) and **5** (1.240 Å). This could be understandable on the light of the electronic and steric factors of the terminal alkyl group. The OCO bond angle in **1** computed as 123.9 (°) increased to 125.1 (°) in **2** due to the steric hindrance of the bulk *tert*-butyl group. One of the most crucial factors determining the tautomer distribution in the biological media is the environment. Solvation effect has

Download English Version:

<https://daneshyari.com/en/article/5418110>

Download Persian Version:

<https://daneshyari.com/article/5418110>

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