

RAMAN STUDY OF VIBRATIONAL SPECTRA OF CHLORAMPHENICOL

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Abstract: The NIR-FT Raman and FT-IR spectral analysis of chloramphenicol, a potential antibacterial drug for the treatment of typhoid fever, is carried out along with *ab initio* computations. Presence of blue-shifting H-bonds, and influence of intra-molecular charge transfer interactions, π -electron delocalization and H-bonding are discussed based on the vibrational spectrum.

Chloramphenicol (CLM), now synthesized chemically, but originally isolated from cultures of the bacterium *streptomyces venezuelae*, achieves its antibacterial effect by interfering with protein synthesis in microorganisms. It is effective against bacteria causing diseases, such as rickettsioses, influenza, meningitis and mycoplasma, but is the preferred treatment only for typhoid fever [1]. As part of recent interest in this compound, studies on its fluorescence mechanism have been reported [2]. The present contribution reports the FT-IR and NIR-FT Raman spectral analysis of the molecule supported by *ab initio* computations of optimized molecular geometry and prediction of normal modes, to understand the structural and bonding features, nature of hydrogen bonding, and other factors influencing the vibrational spectrum of the molecule.

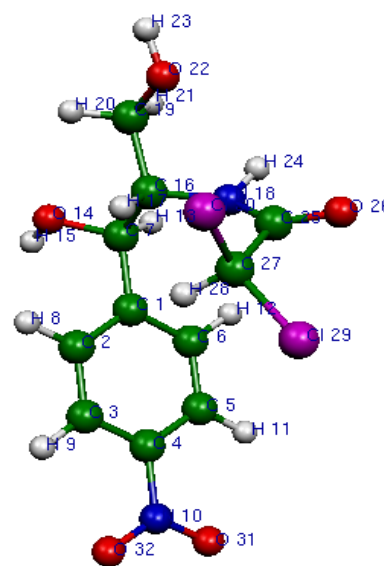
The infrared spectrum of the pure sample of CLM was recorded with sample in KBr pellet, using Nicolet Magna 560 FT-IR spectrometer. The Raman spectrum was obtained using a dispersive Raman micro spectrometer (LabRam, DILOR-Jobin Yvon-Horiba, France) equipped with a 632.8 nm laser line. The *ab initio* calculations performed at the HF/6-31G(d) level using the Gaussian 98 program package [3], also gave the following thermodynamic parameters; self-consistent field (SCF) energy, -1825.424 hartree; zero point vibrational energy, 668.580 KJ/mol; entropy is 624.187 kJ/mol-kelvin; C_v is 280.115 KJ/mol-kelvin; E (Thermal) is 720.594 KJ/mol; Dipole moment is 9.3489 Debye.

Calculated wave numbers of normal modes of vibration and observed Raman and IR bands of CLM, along their vibrational assignments are given in table. The vibrational spectral analysis reveals that the CH_2 asymmetric and symmetric stretching modes are shifted to higher wavenumbers than computed values, probably due to the $\text{C-H}\cdots\text{O}$ blue shifting hydrogen bonds[4]. Carbonyl stretching vibrations generally appear in the region 1750 cm^{-1} – 1700 cm^{-1} . The sharp intense IR band at 1689 cm^{-1} corresponds to $\text{C}_{25}=\text{O}_{26}$ stretching vibration, which is observed as a medium band in Raman spectrum at 1685 cm^{-1} . The lowering of $\text{C}=\text{O}$ stretching wave number is due to presence of strong electronegative atom, nitrogen attached to the carbonyl carbon causing large degree of molecular π – electron delocalization and redistribution of electrons which weakens $\text{C}=\text{O}$ bond. Aromatic nitro compounds have strong IR absorptions due to asymmetric stretching vibrations of the NO_2 group, and are found at 1520 cm^{-1} . The very intense bands corresponding to the symmetric stretching mode of the NO_2 group appears in IR and Raman at 1348 cm^{-1} and 1351 cm^{-1} respectively. The increase in intensity of the symmetric mode arises from presence of electron donating ring substituents [5]. This nitro substitution

plays the key role for the antibacterial activity of the compounds. The intramolecular charge transfer from the donor to acceptor group through the single-double bond conjugated path can induce large changes in both dipole moment and polarizability resulting in IR and Raman activity for the same mode. The simultaneous IR and Raman activation of the ring breathing modes also indicates the charge transfer interaction between the NO₂ and the phenyl ring in CLM. The hydroxyl stretching splits into two bands corresponding to O₂₂-H₂₃ and O₁₄-H₁₅, suggesting presence of stronger intermolecular H-bonding for the O₁₄-H₁₅ group. The effect of hydrogen bonds are observed for the bending vibrations also, which appear at 572 cm⁻¹ and 652cm⁻¹

Table- 1

V _{cal}	V _{IR}	V _{Raman}	Assignments
3678	3476 br		O ₂₂ -H ₂₃ stretch
3660	3350 sbr		O ₁₄ -H ₁₅ stretch
3410	3257 s	3260 w	N ₁₈ -H ₂₄ Stretch
3072	3078 m	3078 m	C ₅ -H ₁₁ , C ₆ -H ₁₂ arom.sym.stretch
3071			C ₃ -H ₉ ,C ₂ -H ₈ arom.sym.stretch
3037		3058 wsh	C ₂₇ -H ₂₈ .stretch
3034		3039 w	C ₂ -H ₈ ,C ₃ -H ₉ arom asym stretch
3025		3004 m	C ₆ -H ₁₂ ,C ₅ -H ₁₁ arom..asym.stretch
2955		2984 sh	C ₁₆ -H ₁₇ ..stretch
2937	2953 w	2964 m	CH ₂ asym.stretch
2826	2900 w	2904 m	CH ₂ sym.stretch
1786	1686 vvs	1685 m	C=O stretch
1615	1607 w	1601 m	8a ring stretch
1583	1560 s	1563 vvw	8b ring stretch
1505	1520 vs	1520 vvw	NO ₂ asym.stretch
1499	1496wsh	1495 vw	CH ₂ bend .
1349	1348 vs	1351 vvs	NO ₂ sym.stretch
1295	1288 w	1294 w	Arom CH bend
1249	1242 m	1246 w	CH ₂ twisting
994	977 m	975 m	Ring breathing
876	877 wsh	866m	Arom C-H o.p. bend
864	851 m	847 m	Ring breathing



Molecular structure of the CLM

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