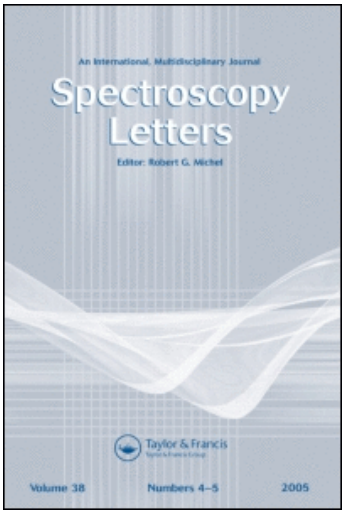

Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

UV Phoelectron Spectra of Biological Xanthines: Theophylline, Theobromine and Caffeine

D. Ajó[a]; M. Biagini Cingi[b]; I. Fragalá[c]; G. Granozzi[d]
[a] Centro di Studio per la Fisica delle Macromolecole del CNR, Padova, Italy [b] Intituto di Chimica Generale dell Università, Venezia, Italy [c] Istituto di Chimica Generale dell Università, Catania, Italy [d] Istituto di Chimica Generale dell Università, Padova, Italy

To cite this Article Ajó, D. , Cingi, M. Biagini , Fragalá, I. and Granozzi, G.(1977) 'UV Phoelectron Spectra of Biological Xanthines: Theophylline, Theobromine and Caffeine', Spectroscopy Letters, 10: 9, 757 — 761
To link to this Article: DOI: 10.1080/00387017708065009
URL: http://dx.doi.org/10.1080/00387017708065009

SPECTROSCOPY LETTERS, 10(9), 757-761 (1977)

UV PHOELECTRON SPECTRA OF BIOLOGICAL XANTHINES : THEOPHYLLINE, THEOBROMINE AND CAFFEINE

Key words : Photoelectron spectra, natural xanthines

D. Ajò
Centro di Studio per la Fisica delle Macromolecole del CNR, Padova (Italy)

M. Biagini Cingi
Istituto di Chimica Generale dell'Università, Venezia (Italy)

I. Fragalà
Istituto di Chimica Generale dell'Università, Catania (Italy)

G. Granozzi
Istituto di Chimica Generale dell'Università, Padova (Italy)

ABSTRACT

Photoelectron spectra of three natural methylated xanthines are discussed by qualitative considerations on the constitutive subunits and the methylation effects. The first band in all three cases can be assigned to enaminic molecular subunit, as in uracil; also the positions of the lone pairs of nitrogen and oxygen atoms are discussed.

INTRODUCTION

The interpretation of the mechanisms through which biological active molecules operate requires a full knowledge of their electronic structure. In the recent years UV photoelectron (PE) spectroscopy, in connection with quantum mechanical calculations, has

been used widely. In particular, the PE spectra of biological purines and pyrimidines have been published[1,2].

A systematic investigation by theoretical and PE techniques on xanthine and natural methylxanthines, whose pharmacological properties are the object of recent studies[3], is in progress in our laboratories. In the present preliminary communication the PE spectra of theophylline (1,3-dimethylxanthine), theobromine (3,7-dimethylxanthine) and caffeine (1,3,7-trimethylxanthine) are reported.

EXPERIMENTAL

The commercial products were purified by chromatography and sublimation. A Perkin-Elmer PS 18 HeI with heated probe was used to record the spectra. The temperature ranged from 120°C to 200°C and the spectra were calibrated using standard peaks from an Ar-Xe mixture.

RESULTS AND DISCUSSION

Fig. 1 shows the PE spectra of the examined compounds. The observed spectra may be separated into three distinct regions (8-9 eV, 9-12 eV and 12-18 eV).

The position of the first band is identical for the three compounds (theophylline, 8.30 eV; theobromine, 8.31 eV; caffeine, 8.32 eV) with a shift to lower ionization potential with respect to the corresponding values of xanthine (8.89 eV)[4], imidazole (8.78 eV)[5] and uracil (9.60 eV)[1]. According to the assignments made for imidazole[5] and uracil[1,2,6], the first band of methylxanthines can be assigned to the π MO mainly localized on the N_3-C_4-C_5 enaminic moiety (see Fig. 1 for numbering). On the basis of

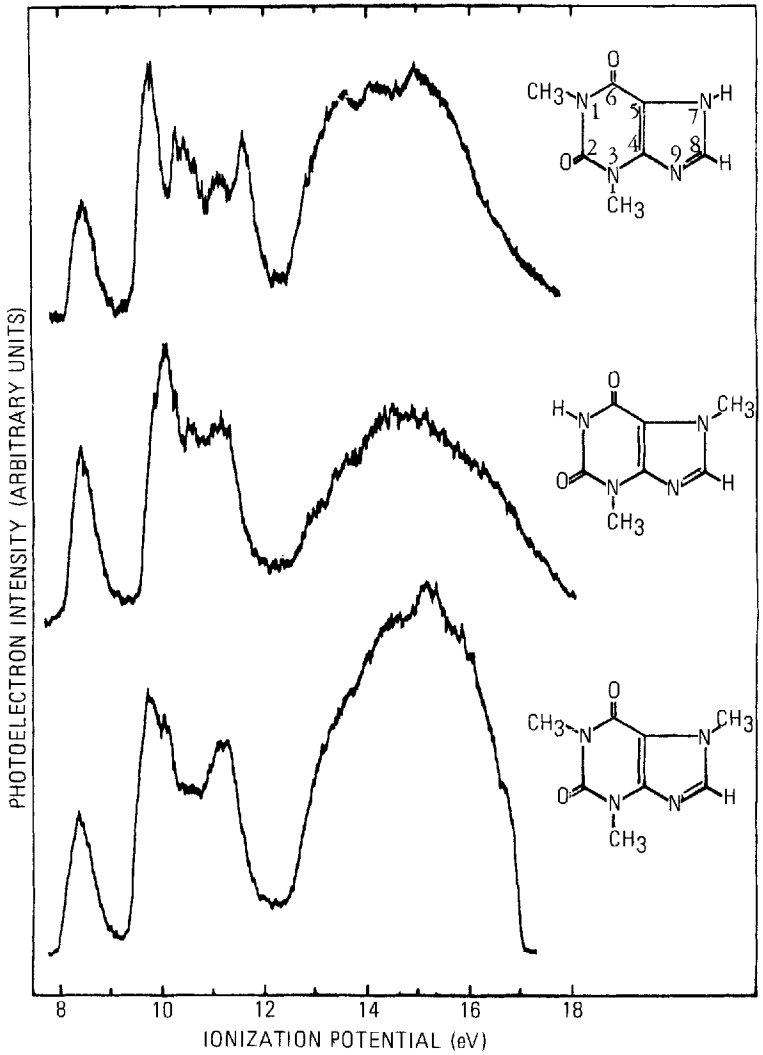

FIG. 1
HeI photoelectron spectra of theophylline, theobromine and caffeine in the 8-18 eV region.

the identical value of the first ionization potential in the three methylated xanthines it can be suggested that methylation on N_1 or N_7 has a poor effect on the first band energy, so that the 0.6 eV shift with respect to xanthine is ascribed to methylation on N_3 . The above results show that the presence of the imidazole ring enhances the electronic independence (already suggested for uracil[7]) of the enaminic moiety from the remaining part of the six-membered ring.

The second region of the spectra (9-12 eV) shows a very complex structure, in which ionization of the σ and π lone pairs of oxygen and nitrogen atoms are included. The first band of this region is likely to correspond to the n_o lone pair of the oxygen atom bonded to C_6, corresponding to C_4 oxygen of uracil. A support to this assignment for this band is given by the coincidence on the one hand between 1-methyluracil (9.9 eV)[2] and theobromine (10.0 eV), on the other between 1,3-dimethyluracil (9.7 eV)[1] and theophylline or caffeine (9.7 eV). Another interesting feature of the second region is the presence, only in the case of theophylline, of an intense band at 11.5 eV. Since the difference of theophylline with respect to the other two compounds is the absence of a methyl group on N_7, it seems reasonable to assign the 11.5 eV band to the imidazole ring. In particular, this band should be ascribed to the σ lone pair of N_9[5], since the π lone pair of N_7 lies at a higher ionization energy[5]. The difference between 11.5 eV in theophylline and 10.3 eV in imidazole[5] for the σ lone pair is to be attributed to the electron withdrawing ability of the six-membered ring; however, in theobromine and caffeine the methylation on N_7 produces a shift of this band to lower ionization potential, so that it is likely to be superim-

posed upon the one at 11.1 eV which is present in all three compounds. A support to this interpretation comes from the comparison of the intensity of the 11.1 eV band in theophylline with that of the other two methylxanthines (Fig. 1).

The third region of the spectra, including all the σ ionization of the backbone, does not provide further information.

These results lead us to conclude that the main features of the spectra of methylxanthines can be interpreted on the basis of the single constitutive subunits and of the expected effects of methylation. A thorough assignment together with the results of quantum mechanical calculations will be reported further on.

REFERENCES

1. D. Dougherty, K. Wittel, J. Meeks and S.P. McGlynn, J. Amer. Chem. Soc., 98, 3815 (1976).
2. A. Padva, T.J. O'Donnell and P.R. LeBreton, Chem. Phys. Lett., 41, 278 (1976).
3. H. Moritoki, M. Morita and T. Kanbe, Eur. J. Pharmacol., 35, 185 (1976).
4. N.S. Hush and A.S. Cheung, Chem. Phys. Lett., 34, 11 (1975).
5. S. Cradock, R.H. Findlay and M.H. Palmer, Tetrahedron, 29, 2173 (1973).
6. A. Padva, P.R. LeBreton, R.J. Dinerstein and J.N.A. Ridyard, Biochem. Biophys. Res. Commun., 60, 1262 (1974).
7. G. Lauer, W. Schafer and A. Schweig, Tetrahedron Lett., 3939 (1975).

Received: 5-25-77
Accepted: 6-28-77