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Environment and solute-solvent interaction effects on photo-physical behaviors of Folic acid and Folinic acid drugs

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ABSTRACT

In this paper, spectral properties of Folic acid and Folinic acid as widely used drugs in the treatment of some diseases have been studied in various environments with different polarity. Our results show that the absorption, emission and stokes shifts of solute molecules depend strongly on molecular surrounding characteristics, solute-solvent interactions and, different active groups in their chemical structures. In order to investigate the contribution of specific and nonspecific interactions on various properties of drug samples, the linear solvation energy relationships concept is used. Moreover, the calculated dipole moments by means of solvatochromic method show that the high values of dipole moments in excited state are due to local intramolecular charge transfer. Furthermore, the obtained results about molecular interactions can be extended to biological systems and can indicate completely the behaviors of Folic acid and Folinic acid in polar solvents such as water in body system.

1. Introduction

Folic acid and Folinic acid with various organic groups in their chemical structures are very important for performing specific and vital functions in human body system. They play key role in the preservation of health and lack of them lead to specific diseases. In recent years, they have been considered due to their anti-cancer properties [1–6].

In addition to this common feature, Folic acid as a water-soluble vitamin is involved in single carbon transfer reactions in metabolism, formation of red blood cells and amino acids and, Folinic acid is widely used in the prevention and treatment of vitamin deficiencies [4,7,8].

Presence of different active groups in the chemical structures of these groups of materials can lead to appearance of different properties. Additionally, the studies have shown that the photo-physical properties of different groups of materials can be affected due to solvent media characteristics. Despite extensive efforts yet empirical studies in this area continues [9–12].

Generally, the most of the experimental works with different purposes are performed in the solution state. In this case, performance of solute molecules, especially drugs molecules, are affected by environment molecules characteristics. Solvent dependent phenomena originate from either non-specific (dielectric enrichment) or specific (hydrogen bonding and intermolecular charge transfer) solute-solvent interactions. Solvent effects can be investigated by means of solvent polarity scales and solvatochromic parameters [9]. There are many different chemical and physical processes that individual solvent polarity parameters cannot descript completely the nature and degree of solute-solvent interactions, so multi-parameter solvent polarity scales are used. This method is based on linear free-energy relationship and formulated as Kamlet-Abboud-Taft [13] equation (Eq. (1)).

$$\Delta\nu = \Delta\nu_0 + a\alpha + b\beta + s\pi^* \quad (1)$$

π^*, β and α indicate dipolarity/polarizability [14], hydrogen bond acceptor (HBA) basicity [15] and hydrogen bond donor (HBD) acidity [16]. $\Delta\nu_0$ is also a regression value for the solute polarity in reference solvent. The remaining parameters (a, b and s coefficients) obtain of employing multi linear regression analysis and

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Table 1
The chemical structure and molecular weight of the used samples under study.

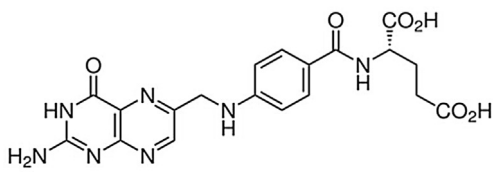
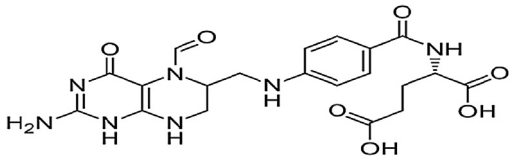
Molecular structure	Molecular weight (g/mol)	Molecular name
	441.39	Folic acid
	473.43	Folinic acid

Table 2
Spectroscopic polarity parameters, physical properties and polarity functions of employed solvents.

Solvent	ε_r	n	α	β	π^*	$f(\varepsilon,n)+2g(n)$	$f(\varepsilon,n)$
Water	78.4	1.333	1.17	0.47	1.09	1.364	0.912
DMSO	46.68	1.479	0	0.76	1	1.47	0.84
DMF	38	1.43	0	0.69	0.88	1.42	0.838
Ethylene glycol	37	1.43	0.9	0.52	0.92	1.42	0.836
Methanol	32.7	1.329	0.98	0.66	0.6	1.302	0.854
Ethanol	24.5	1.361	0.86	0.75	0.54	1.302	0.812
2-Propanol	19.92	1.377	0.76	0.84	0.48	1.29	0.778
1-Butanol	17.5	1.399	0.84	0.84	0.47	1.292	0.75
Dichloromethane	8.93	1.424	0.13	0.1	0.73	1.164	0.59
1-Decanol	8	1.437	0.7	0.85	0.45	1.145	0.553
Cyclohexane	2.02	1.426	0	0	0	0.575	−0.003

estimate the relative contribution of solvent molecules in spectral behavior of solute molecules.

Moreover, obtained spectral shifts of samples in solvent media are used as a simple technique for measuring of ground and excited state dipole moments. Obtained values can give important information about the electronic and geometrical structure of the molecules in ground and excited state.

In this experimental work, the environment effects on photophysical characteristics of Folic acid and Folinic acid are studied. UV–Visible absorption and emission spectra in solvents with different polarity were recorded at room temperature. Then the obtained spectral shifts of samples were used for measuring dipole moments of ground and excited states.

Table 4
Maximum absorption and fluorescence spectra of Folinic acid (*p*-Aminobenzamide) in selected solvents with different polarity.

Solvent	$(Abs)\lambda_{max}$(nm)	$(Fluo)_{\lambda max}$ (nm)
Folinic acid		
Water	286.5	364
DMSO	290	350
DMF	294	347
Ethylene glycol	292	353
Methanol	294	350
Ethanol	315	353
2-Propanol	313	353
1-Butanol	279	346
1-Decanol	277	306
Cyclohexane	286	333

The spectral properties and experimental results of Kamlet-Abboud-Taft equation in different solvent media will give important information about charge distribution and solute-solvent specific and non-specific interactions effects that can be extended to biological systems.

2. Experimental

2.1. Materials

In this work, the prepared Folic acid and Folinic acid (Table 1) samples were used without further purification and their properties were studied is different solvent environments. All the solvents were also of the highest available purity from Merck and the spectroscopic solvent polarity parameters of them were listed in

Table 3
Maximum absorption and fluorescence spectra of Folic acid in selected solvents with different polarity.

Solvent	$(Abs)\lambda_{1max}$(nm)	$(Fluo)_{\lambda 1max}$ (nm)	$(Abs)_{\lambda 2max}$ (nm)	$(Fluo)_{\lambda 2max}$(nm)
Folic acid				
Water	275	345	346	443
DMSO	287	344	360	436
DMF	285	342	359	420
Ethylene glycol	284	352	355	436
Methanol	284.5	352	354.5	441
Ethanol	285.5	351	355	438
2-Propanol	284	347	357	420
1-Butanol	274	334	–	–
Dichloromethane	278	336	–	–
1-Decanol	274	308	–	–
Cyclohexane	280.5	336	–	–