مجلة الدراسات التربوية والعلمية - كلية التربية - الجامعة العراقية
العدد الخامس والعشرون - المجلد الثالث عشر - علوم الكيمياء - آب 2025 م
doi.org/10.52866/esj.2023.13.25.12

Calculation of The pka Value of Schiff's base Theoretically

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Abstract:

The study aims to compare theoretically calculated pka values with practically calculated values and find the difference between the two values for some Schiff bases. Explanation of the impact of substitutions in the compounds studied on calculated values. The study was conducted in quantitative mechanics using the AM1 and HF/B3LYP/6-31G methods. Theoretical calculations have succeeded in finding very close to practical values and a simple error averaging 0.033 error margin, enhancing the strength and effectiveness of theoretical studies to calculate many of the chemical compounds' physical and chemical variables in less time and cost than practical calculations.

Keywords: AM1, HF, pKa **,** Schiff's base , Imines , Computational Chemistry

حساب قيم pka لبعض قواعد شيف نظريًا

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مستخلص:

تهدف الدراسة إلى حساب ومقارنة قيم pka المحسوبة نظريًا بالقيم المحسوبة عمليًا وإيجاد الفرق بين القيمتين لبعض قواعد شيف، وفهم تأثير التعويضات على القيم المحسوبة. أجريت الدراسة في برامج الميكانيكا الكمية باستخدام طريقتين هما AM1 و HF/B3LYP/6-31G. ونجحت الحسابات النظرية في العثور على قيم مقاربة جدًا من القيم العملية وبمعدل خطأ بسيط بمتوسط 0.033، مما عزز قوة وفعالية الدراسات النظرية لحساب العديد من المتغيرات الفيزيائية والكيميائية للمركبات الكيميائية في اقل وقت وجهد وتكلفة أقل من الحسابات العملية .

الكلمات المفتاحية: AM1، HF، pKa، قاعدة شيف، الايمينات، الكيمياء الحسابية .

1. Introduction

The pKa value is a significant property in chemistry since it indicates a material's propensity to either donate or accept protons. This aids industrial processes, particularly in pharmaceutical medication manufacture.[1] The pKa value is essential for proton transfers to and from cells in biological systems and cellular processes.[2] The qualities examined pertain to the acid-base behavior of substances. Consequently, finding a constant acidity is essential for improving our comprehension of further attributes. It is crucial in the pharmaceutical industry, pharmaceutical design, chemical manufacturing, and environmental sectors concerning the destiny of harmful compounds.[3,4] The pKa value has become a standard physical and chemical indication associated with the pH value. Diverse experimental methodologies have been employed to identify novel materials, and the calculation of pKa values is essential for many researchers in this field.[5] Schiff's bases are organic compounds (imines) distinguished by a hydrocarbon group bonded to the nitrogen atom in their structure. R2C=NR.[6] These bases, synthesized from aromatic amines and aromatic aldehydes, possess many applications in inorganic, biological, analytical, and industrial chemistry.[7] Possesses several applications in biological domains, including anti-cancer agents, bacteria, anti-inflammatory compounds, viruses, and anti-oncological treatments.[8] There are many ways to measure the value of pka, including highly sensitive spectroscopic methods, whose value is found in aqueous solutions. The stability and spread of the drug are assessed within the body and then absorbed. This is the primary objective of this process to calculate the division of pka.[9] The C=N imine group in the Schiff base structure promotes the rotation of the aromatic ring, mitigating stress caused by the spatial displacement of large neighboring particles on the rings. The pKa values are influenced by changes in electronic effects and geometry due to the molecular spatial arrangement. This variable can be evaluated using quantitative mechanical techniques.[5] The present study calculated electronic density, total molecular energy, and orbital energies. While there are many practical methods for estimating pKa

values, the theoretical method is no less important and accurate than practical methods for saving effort, time, and economic cost, in addition to the accuracy of the result.[10] This study focuses on theoretical methods, avoiding the need for laboratory devices and chemicals when they are inaccessible. Use this search in two ways: Semi-empirical/AM1 and Ab initio/HF. These two are essential quantum mechanical methods to assess their effectiveness in determining pKa values for selected Schiff rules and predicting pKa values for related vehicles without experimental work.[11]

Computational chemistry

Computational chemistry constitutes an advanced approach within the field of chemistry. The objective is to ascertain the fundamental properties of the chemical molecule and compare them with values derived from experimental approaches. Computational chemistry includes several mathematical techniques, which can be classified into two main categories.[12]

1. Molecular Mechanics fundamentally depends on Newton's ideas and their application to atoms, neglecting the effects of electrons.[13]

2. Quantum Mechanics essentially encompasses the equation formulated by Schrödinger, which describes particles, whereas Quantum mechanical approaches are categorized based on the influence of electrons.[14]

This research concentrates on Ab initio techniques in primary calculations, where Ab initio denotes calculations derived from first principles. It includes mathematical solutions for all arithmetic integrals, facing difficulties due to the vast quantity of integrals necessitating computation and the fundamental calculation methods required. This study encompasses two categories of methodologies.[15] The Hartree Fock (HF) method is the Ab initio approach prevalent in theoretical studies, particularly following advancements in electronic computations.[16] The AM1 technique is a Semi-empirical approach in computational chemistry that efficiently estimates molecule characteristics. Their updates enhance the precision of computations regarding the links between atoms and energy variables. Despite its difficulties in comprehending and analyzing non-contributory interactions with high precision, it is highly successful for large molecules.[17]

Theoretical study

This study in computational chemistry involved using two methods, the AM1 and HF methods, to calculate theoretical pka values.[18] Table 1 includes the selection of specific Schiff base compounds, their nomenclature and substitutions, and their pKa ionization constants.[19] Physical variables for these compounds were analyzed using chemical software, specifically ChemOffice 16.0, Gaussian09W, and GaussView. The program's MM2 molecular mechanics approach helps reduce the energy required to achieve the most stable configuration. Chemical software, ChemOffice 16.0, Gaussian09W, and GaussView, were used to assess the physical properties of these compounds[20]. It also allows energy calculations for comparative analysis between two bodies of the same molecule and the vacuum reactions of occupied molecules by examining molecular motion and evaluating angle by molecular dynamics.[21] The data is accessible via quantum mechanics techniques, employing Gaussian0.9W and ChemOffice software, and is comprehensive. This encompasses the energies of molecular orbitals (HOMO - LUMO)[22], thermal stability of various molecular structures, molecular and atomic charges obtained from molecular orbital coefficients, voltage or electrostatic energy, dipole moments, transition state energies, and bond dissociation energy. Statistical regression analysis was performed using the program's theoretically derived variables and the pKa values acquired from empirical experiments. This analysis employed the correlation coefficient between the chosen independent variables and the pKa value, as indicated in Table 9. The influence of factors on the compounds under investigation and their capacity to correlate theoretical pKa values with practical values were assessed using R^2 coefficient values.[23]. The correlation coefficient values were calculated by straight linear regression analysis utilizing the Social Science Statistical Program (SPSS) 2018.

Relational analysis in chemistry

This study used the SPSS statistical program only for the accuracy of the results obtained and the ease and speed of its work. This process entails identifying the relationship among multiple variables, which is advantageous in com-

putational chemistry. It frequently assesses the correlation between two data sets: one from empirical research and the other from existing literature or prior studies. Theoretically, calculated data establishes a relationship when plotted as a dependent variable (Y) against empirical data. The independent variable, denoted as X, typically exhibits linear relationships, resulting in straight lines defined by a vertical intercept (b) and a slope (a), which reflect the variable's response to subsequent changes. The equation of the straight line can be articulated as follows:

$$Y = ax + b \quad \ldots\ldots\ldots \quad (1)$$

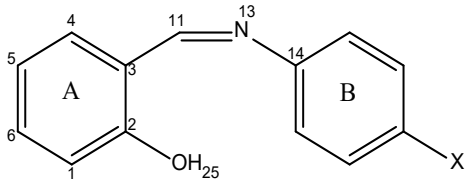
The straight-line equation can be derived when points lie within the margin of the experimental line. If it is beyond the margins of experimental error, the correlation between (Y, X) is non-linear. This suggests that a solitary variable is insufficient to clarify the experimental results, necessitating the inclusion of other elements in the study to represent a given system accurately. This study will focus on multiple regression analysis. The equation for multiple linear regression of the dependent variable (Y) can be expressed with various independent variables (X1, X2, X3,...), as demonstrated in the following figure:

$$Y = a0 + a1x1 + a2x2 + a3x3 + a4x4 \quad \ldots\ldots\ldots \quad (2)$$

The analysis can be evaluated by the values of the deviation coefficient and standard association .[22]

2. Results and discussion

Theoretical research necessitates the identification of numerous physical constants of Schiff's compounds under examination. It illustrates the capacity of statistical analysis to ascertain the theoretical pKa from physical variables computed by the utilized software, including values such as HOMO, LUMO, Ƞ, ω, and μ. Subsequent tables will present values derived from these constants alongside the names of calculated compounds, their structural configurations, and practical values.



X= Cl , Br , CN , CH_3 , CN , NO_2 , OMe , F

Figure 1. Atomic composition and enumeration for the specified compounds presented in the table (1)

ChemOffice 16.0 was utilized to determine the reduced MM2 power status, followed by the calculation of HOMO and LUOM utilizing Gaussian09W software. The remaining constants enumerated in Table 3.4 have been identified. The research was conducted via Ab initio (AM1), Hartree-Fock (HF), and B3LYP methodologies. The two methods employed were widely prevalent and utilized in this research domain. The theoretically computed values of physical constants using HF and AM1 approaches were subsequently compared with experimentally obtained pKa constants, including constructing mathematical equations to compute pKa for unknown substances, which is challenging to determine in reality.

Effect of spatial arrangement

The term "spatial arrangement" refers to the geometrical arrangement of the Schiff base, the relative arrangement of atoms, and the forces that influence them. The Vacuum Effect factor significantly contributes to the expulsion of electrons, hence reducing the dissonance among electrons in the molecular space. The second effect is the site's impact on the ring, which includes Van der Waals forces, tensile forces, and flexibility, along with other troops described in Table 2. Statistical analysis showed differing active sites' impact on Schiff base compounds' reaction centers from differing correlation values between theoretically calculated variables and the empirical pKa value. The theoretical values of these variables obtained by the MM2 approach are shown in Table 2. The pKa values shown in Table 2 are influenced by Receptor or donor substitutes for electrons, which affect the compound's ability to donor a proton from being granted. At the same time, the CN Group notes that although it is a robust drag group, it has given a small value compared to others to enter the nitrogen atom in a resonant state with the ring, providing the highest ion stability resulting from disintegration.

Table 1. Names, structural formulae, and ionization constant values for Schiff base compounds

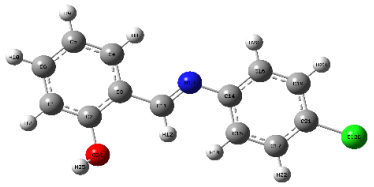
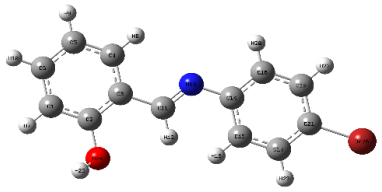
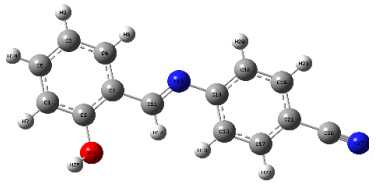
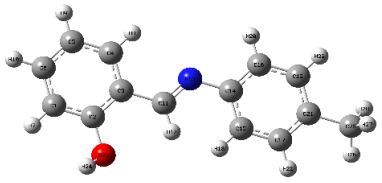
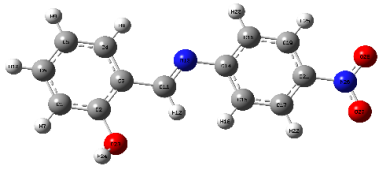
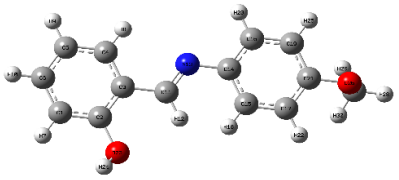
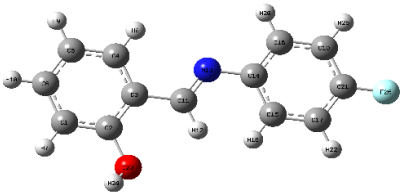
No	X	Name	Structure	pKa
1	Cl	(Z)-2-(((4-chlorophenyl)imino) methyl)phenol		10.33
2	Br	(Z)-2-(((4-bromophenyl)imino) methyl)phenol		10.42
3	CN	(Z)-4-((2-hydroxybenzylidene) amino)benzonitrile		10.13
4	Me	(Z)-2-((p-tolylimino)methyl)phenol		10.27
5	NO_2	(Z)-2-(((4-nitrophenyl)imino)meth-yl)phenol		10.15
6	OMe	(Z)-2-(((4-methoxyphenyl)imino) methyl)phenol		10.61
7	F	(Z)-2-(((4-fluorophenyl)imino) methyl)phenol		10.56

Table 2. The theoretically computed values of the variables using the MM2 method

Com.NO	$E_{Stretch}$	E_{Bend}	$E_{Stretch\text{-}Bend}$	$E_{Torsion}$	$E_{Non\text{-}1,4\ VDW}$	$E_{1,4\ VDW}$	$E_{Dipole/Dipole}$	(TE (kcal/mol
1	0.9810	8.5613	0.0941	-1.4338	0.1934	14.1349	0.5551	23.0859
2	0.9860	8.6087	0.1031	-1.4284	0.1361	14.2898	0.5379	23.2331
3	0.9796	8.5510	0.0848	-1.4711	0.0854	14.4921	0.6046	23.3263
4	1.0134	8.6829	0.0850	-2.1878	0.1186	14.3340	0.2238	22.2698
5	1.1046	9.0090	0.1049	-1.1102	1.4755	15.9492	0.8617	25.6311
6	1.1617	9.4434	0.0814	2.2652	-0.5467	16.7155	0.3206	29.4411
7	0.9619	8.5268	0.0818	-1.4592	0.3179	13.5792	0.5738	22.5823

The vacuum effect energy in compounds differs among compounds, as this variability is primarily contingent upon the basic values. Of VDW interventions. 1.4 VDW van der Waals resulting from an augmentation in ring size and fluctuating between (29.4411 kcal/mol 22.2698 kcal/mol). The variables analyzed in the table, such as E Non-1,4 VDW, E Stretch, and E 1.4 VDW, among others, substantially influence molecule stability and pKa values. E Stretch represents the elastic energy of the molecule, reaching its apex in compound seven and lowest point in compound one (1.1617, 0.9619). Increased values indicate structural instability and a rising pKa, whereas decreased values reflect stable connections and a falling pKa. E Non-1,4 VDW refers to interactions among non-adjacent atoms, with the maximum value observed in sequence three and the minimum in sequence two (1.4755, -0.5467). Increased values improve structural stability and raise pKa, whilst lowered values indicate weaker interactions and lower pKa. E 1.4 VDW refers to the interactions between closely related atoms, with the peak value at sequence seven and the lowest value at

sequence one (16.7155,13.5792). Increased values exacerbate the difficulty of proton disassociation and raise pKa, whereas decreased values make the molecule more prone to ionization and lower pKa. This is substantiated by a statistical analysis of these parameters and pKa[24].

Theoretical calculations of energy variables

The HOMO and LUMO measurements of the orbital energy of the compounds for investigation were computed using the Ab initio PM3 and HF/6-31G processes. The orbital energies are used to derive several functions related to molecule stability and their tendency for both electrophilic or the nucleophilic interactions[22]. These functions include molecular hardness (Ƞ), electronic chemical voltage (μ), and a spherical electrophilic manual (ω), and the energy gap Δ(L-H) from the difference between molecular orbits was also calculated, which was computed using designated equations. These values are aggregated with shipping atoms and bond lengths in Tables 3 and 4.

Table 3. Theoretical calculations of energy variables for Schiff base compounds utilizing the Ab initio AM1 method.

COM NO	HOMO (ev)	LUMO (ev)	Ƞ (ev)	μ (ev)	ω (ev)	Δ(L-H) (eV)
1	-0.3232	-0.0238	0.1497	-0.1735	0.1005	0.2994
2	-0.3253	-0.0254	0.1499	-0.1754	0.1026	0.2999
3	-0.3326	-0.0332	0.1497	-0.1829	0.1118	0.2994
4	-0.3159	-0.0169	0.1495	-0.1664	0.0927	0.2990
5	-0.3439	-0.0479	0.1480	-0.1959	0.1296	0.2961
6	-0.3092	-0.0163	0.1465	-0.1628	0.0905	0.2929
7	-0.3219	-0.0237	0.1491	-0.1728	0.1001	0.2982

Table 4. Theoretical calculations of energy variables for Schiff base compounds utilizing the HF (6.31G) methods.

COM NO	LUMO (ev)	HOMO (ev)	Ƞ (ev)	μ (ev)	ω (ev)	(L-H) (ev)
1	0.0716	-0.3027	0.1871	-0.1156	0.0357	0.3743
2	0.0723	-0.2998	0.1860	-0.1138	0.0348	0.3721
3	0.0580	-0.3105	0.1844	-0.1263	0.0433	0.3687
4	0.0836	-0.2852	0.1844	-0.1008	0.0275	0.3688
5	0.0321	-0.3223	0.1772	-0.1451	0.0594	0.3544
6	0.0815	-0.2886	0.1850	-0.1036	0.0289	0.3700
7	0.0752	-0.3002	0.1877	-0.1125	0.0337	0.3754

Table 5. Some linkage lengths and shipments of certain atoms for Schiff base using Ab initio AM1 method

Com.No	Mulliken Charge				Bond Length (A^0)		
	C11	N13	O24	H25	C_2–O_{24}	O_{24}–H_{25}	C_2–C_3
1	0.0072	-0.1641	-0.2553	0.2243	1.37605	0.96878	1.413٧
2	0.0108	-0.1664	-0.2552	0.2246	1.37593	0.96881	1.4136
3	0.0173	-0.1703	-0.2556	0.2256	1.37574	0.96890	1.413٧
4	-0.0011	-0.1602	-0.2549	0.2229	1.37633	0.96868	1.4136
5	0.0309	-0.1774	-0.2559	0.2276	1.37522	0.96905	1.413٨
6	-0.0066	-0.1563	-0.2549	0.2228	1.37640	0.96867	1.413٧
7	0.0042	-0.1618	-0.2555	0.2242	1.37613	0.96877	1.4136

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4	-0.0011	-0.1602	-0.2549	0.2229	1.37633	0.96868	1.4136
5	0.0309	-0.1774	-0.2559	0.2276	1.37522	0.96905	1.413٨
6	-0.0066	-0.1563	-0.2549	0.2228	1.37640	0.96867	1.413٧
7	0.0042	-0.1618	-0.2555	0.2242	1.37613	0.96877	1.4136

Table 6. Some linkage lengths and shipments of certain atoms for Schiff base using the HF (6.31G) method

Com.No	Mulliken Charge				Bond Length (A^0)		
	C11	N13	O24	H25	C_2-O_{24}	O_{24}-H_{25}	C_2-C_3
1	0.1487	-0.5879	-0.8022	0.4246	1.37711	0.94954	1.3934
2	0.1486	-0.5881	-0.8021	0.4244	1.37717	0.94953	1.3933
3	0.1524	-0.5915	-0.8023	0.4259	1.37642	0.94959	1.3935
4	0.1439	-0.5875	-0.8015	0.4223	1.37810	0.94946	1.3932
5	0.1569	-0.5934	-0.8024	0.4273	1.37574	0.94964	1.3937
6	0.1451	-0.5894	-0.8016	0.4229	1.37782	0.94948	1.3932
7	0.1473	-0.5881	-0.8023	0.4240	1.37747	0.94953	1.3933

Table 7. Thermodynamic function values for compounds for Ab initio AM1and HF (6.31G) methods

Com . No	PM3			DFT		
	ΔG° Kcal / mol	ΔH° Kcal / mol	ΔS° KCal / mol.K	ΔG° Kcal / mol	ΔH° Kcal / mol	ΔS° KCal / mol.K
1	100.9619	136.7739	0.120113	109.0580	143.1387	0.114306
2	99.7878	136.4720	0.123040	108.2831	143.1262	0.116862
3	106.4469	142.7810	0.121866	114.3320	148.9651	0.116163
4	123.2912	160.4228	0.124540	132.8168	168.2698	0.118910
5	108.3420	146.3434	0.127457	115.8847	151.8881	0.120756
6	126.5423	164.4314	0.127079	135.1599	171.9671	0.123450
7	102.6989	137.7126	0.117437	110.4241	143.7066	0.111630

These variables were used in regression analysis, and their primary goal was to determine the factors most influential on pKa ionization values and assess the relationship between the values of calculated variables and their impact on pKa values as a subordinate variable. Before assessing the variables and verifying their validity and accuracy, it was crucial to comprehend the interconnections among the unreliable functions, which aids in estimating their reciprocal influences and permits the selection of variables for statistical analysis grounded in sound scientific and statistical principles.

The subsequent tables illustrate the correlation among variables using Ab initio AM1 and HF (6.31G) for Schiff base compounds. This correlation is established by examining both individual and multiple regression in conjunction with pKa values. Both tables exhibit a substantial association among certain variables, particularly with the pKa ionization constant, with these relationships varying according to the employed approach. This study demonstrated a distinct association among particular parameters. We assessed the characteristics that facilitat-

ed our advancement to the subsequent level, which involved doing bilateral and triple statistical analyses to determine the ultimate correlations.

Table 8. The correlation coefficient values (R2) for the relation between physical variables and ionization constants (pKa) utilizing the Ab initio AM1method.

	Pka	C11	N13	O24	H25	C2_O	C2_C3	η	LUMO	HOMO	TT	G	H	EStretch	EBend	E14VDW	TE
Pka	1	-0.74	0.77	0.54	-0.66	0.69	-0.46	-0.41	0.67	0.74	0.16	0.19	0.16	0.18	0.32	0.08	0.36
C11		1	-1	-0.90	0.99	-0.99	0.62	0.19	-0.98	-1.00	-0.48	-0.53	-0.48	-0.06	-0.20	0.04	-0.16
N13			1	0.88	-0.98	0.99	-0.61	-0.21	0.97	0.99	0.46	0.50	0.46	0.06	0.20	-0.04	0.17
O24				1	-0.94	0.90	-0.57	-0.13	0.92	0.93	0.57	0.60	0.57	0.15	0.25	0.07	0.17
H25					1	-1.00	0.67	0.09	-0.99	-0.99	-0.47	-0.52	-0.47	0.01	-0.12	0.11	-0.07
C2_O						1	-0.68	-0.09	0.99	0.99	0.43	0.48	0.43	-0.04	0.10	-0.14	0.06
C2_C3							1	-0.47	-0.71	-0.59	0.09	0.04	0.09	0.57	0.47	0.65	0.52
η								1	-0.01	-0.24	-0.66	-0.64	-0.66	-0.94	-0.96	-0.89	-0.95
LUMO									1	0.97	0.37	0.42	0.37	-0.09	0.04	-0.18	0.01
HOMO										1	0.51	0.55	0.51	0.12	0.26	0.02	0.22
TT											1	1.00	1.00	0.73	0.74	0.66	0.59
G												1	1.00	0.69	0.71	0.62	0.57
H													1	0.73	0.74	0.66	0.59
EStretch														1	0.99	0.98	0.93
EBend															1	0.96	0.97
E14VDW																1	0.94
TE																	1

Table 9. The correlation coefficient values (R2) for the relation between physical variables and ionization constants (pKa) utilizing the HF (6.31G) method.

	Pka	C11	O24	H25	C2_O	O_H	μ	HOMO	LUMO	TT	H	S	Stretch	EBend	Stret-Bend	Torsion	Dip-Dip
Pka	1																
C11	-0.66	1															
O24	0.36	-0.80	1														
H25	-0.64	0.99	-0.85	1													
C2_O	0.67	-1.00	0.81	-1.00	1												
O_H	-0.62	0.99	-0.87	1.00	-0.99	1											
μ	0.65	-1.00	0.79	-0.98	0.99	-0.98	1										
HOMO	0.61	-0.99	0.89	-0.99	0.99	-1.00	0.98	1									
LUMO	0.67	-0.98	0.71	-0.96	0.97	-0.96	0.99	0.95	1								
TT	0.17	-0.47	0.86	-0.55	0.49	-0.55	0.44	0.58	0.33	1							
H	0.17	-0.47	0.86	-0.55	0.49	-0.55	0.44	0.58	0.33	1.00	1						
S	-0.03	0.02	0.54	-0.07	0.00	-0.10	-0.03	0.13	-0.14	0.79	0.79	1					
Stretch	-0.11	0.20	0.34	0.12	-0.19	0.11	-0.22	-0.07	-0.31	0.73	0.73	0.94	1				
EBend	0.32	-0.05	0.44	-0.12	0.07	-0.13	0.03	0.15	-0.05	0.72	0.72	0.88	0.89	1			
Bend-Stre	-0.41	0.63	-0.45	0.61	-0.62	0.57	-0.62	-0.60	-0.62	-0.45	-0.45	0.10	0.00	-0.08	1		
Torsion	0.58	-0.21	0.37	-0.22	0.20	-0.23	0.21	0.26	0.18	0.55	0.55	0.64	0.67	0.89	-0.29	1	
Dip-Dip	-0.44	0.94	-0.93	0.96	-0.93	0.96	-0.94	-0.98	-0.90	-0.67	-0.67	-0.21	-0.03	-0.16	0.63	-0.23	1

In the analysis results, we determined that the most important variables affecting pka values in the AM1 method were (N13,C2-O,C2_C3), which possessed the highest correlation coefficient by (0.959) and were selected. The rest of the variables are neglected because they give the lowest correlation transaction values or those with no statistical significance. In the second method, HF, the most accurate and correlative variables were (O24,C2-O,) the value of an association coefficient (0.999). The values of variables have been skipped because these variables have weak or neglected correlation factors with pKa's value in triple statistical analysis results. From this information, these variables were used to find an equation to see results with excellent values. The following table shows the values and variables mentioned.

Table 10. Outcomes of multiple regression analysis. Correlation between specific physical variables and pKa

Method	Variable	R-squared	S.E	Const.	Par X_1	Par X_2	Par X_3
AM1	N13,C2-O,C2_C3	0.959	0.053	5312.06	148.89	-2420.72	-1376.74
HF	,O24,C2-O	0.999	0.044	-2461.39	-1734.88	777.30	0.084

A thorough regression analysis determined the most effective variables affecting the ionization constants of Schiff's base compounds. Simultaneously, the majority were theoretically discarded because their coefficients were small or zero. Thus, these three variables are interconnected, creating a mathematical relationship between them. Evaluation of ionization constant for several Schiff bases being studied.

Based on these data, the mathematical relationships (equations 3 and 4) are employed to compute ionizing constant values for several of Schiff's rules. These are then compared to the empirical values documented in Tables 10 and 11.

$$pka = 5312.06 + (148.89 * N13) + (-2420.72 * C2\_0) + (-1376.74 * C2\_C3) \quad \text{..... (3)}$$

$$pka = -2461.396 + (-1734.887 * 024) + (777.305 * C2\_0) + (0.084 * \Delta S) \quad \text{..... (4)}$$

Table11. Ionization constant values of Schiff bases obtained using experimental and theoretical AM1 and HF methods

Comp.	AM1			HF		
	Actual pKa	Theoretical pKa	Δpka	Actual pKa	Theoretical pKa	Δpka
1	10.330	10.289	0.041	10.330	10.367	-0.037
2	10.420	10.375	0.045	10.420	10.454	-0.034
3	10.130	10.116	0.014	10.130	10.160	-0.030
4	10.270	10.330	-0.060	10.270	10.308	-0.038
5	10.150	10.180	-0.030	10.150	10.190	-0.040
6	10.610	10.603	0.007	10.610	10.646	-0.036
7	10.560	10.576	-0.016	10.560	10.595	-0.035

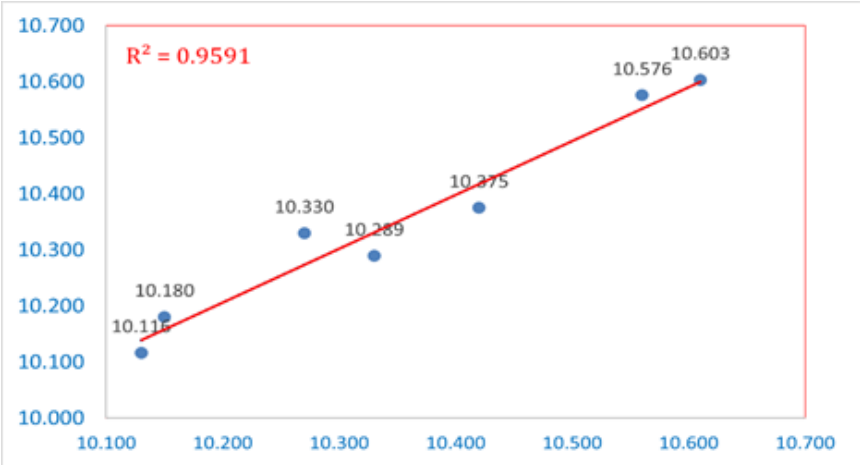

Figure 2. The graphical correlation of theoretical pka values to Schiff's bases is derived from the AM1 method.

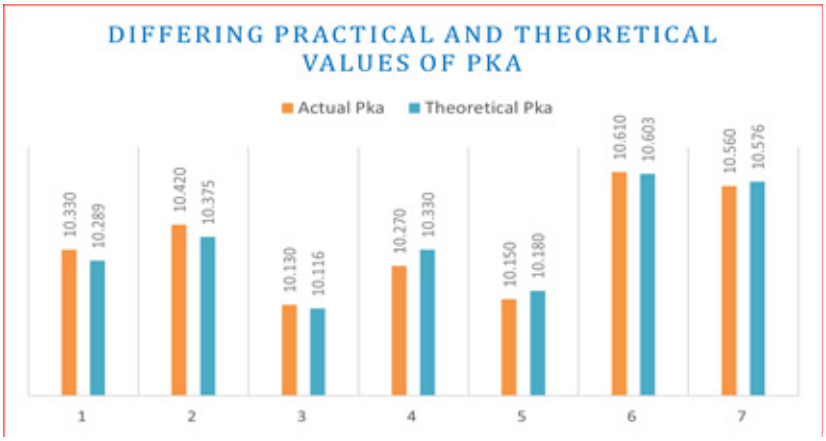

Figure 3. Charting the density or distribution between the practical and theoretical ionization constant of Schiff's bases according to the AM1 method.

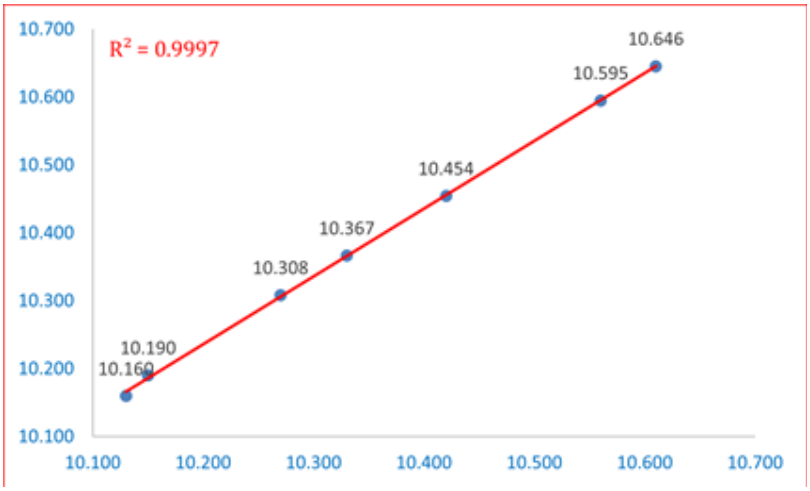

Figure 4. The graphical correlation of theoretical pka values to Schiff's bases is derived from the HF method.

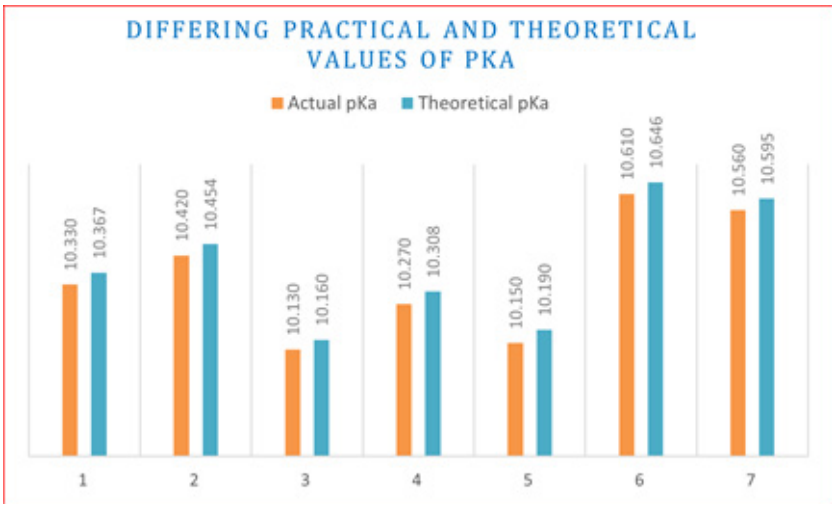

Figure 5. Charting the density or distribution between the practical and theoretical ionization constant of Schiff's bases according to the HF method.

3. Conclusions

This research emphasizes the significance of employing quantum mechanical approaches to determine the ionization constant values of Schiff's bases, utilizing both AM1 and HF methods in theoretical calculations. Certain selected variables in the statistical analysis showed a robust correlation in calculating pKa values for the examined substances. The HF procedure produced accurate results and corresponded more closely with previous experimental findings than the AM1 method. The significance of the chosen variables in the statistical analysis

is evidenced by the alignment between the theoretical pKa values derived using AM1 and HF techniques and the empirical values computed in the prior study.

The recommendations

1. Make the remaining theoretical calculations, such as PM3, and DFT, on the rest of Schiff's base and analyze the data obtained from them.

2. Determining theoretical pKa values using the PM3 and DFT and juxtaposing them with empirical values to assess the convergence in estimates.

3. Conduct theoretical and practical calculations, compare them to Schiff's base with heterogeneous episodes, and analyze the effects of compensations based on their varying positions on the rings.

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