

**QSAR Modeling, Molecular Docking and Cytotoxic Evaluation for Novel  
Oxidovanadium(IV) Complexes as Colon Anticancer Agents**

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**Table S1** The experimental data of oxidovanadium(IV) complexes.

NO ·	Metal conc. ( $\times 10^{-4}$ moles)	Ligand conc. ( $\times 10^{-4}$ moles)	[M]/([M] + [L])	[VO(SO <sub>4</sub> )(CBZ )] 8H <sub>2</sub> O	[VO(CTZ) <sub>2</sub> ] 2H <sub>2</sub> O	[VO(LOR) <sub>2</sub> ] SO <sub>4</sub>	[VO(SO <sub>4</sub> )(SCZ)] 7H <sub>2</sub> O
				Absorbance			
				at 256 nm	at 208 nm	at 389 nm	at 210 nm
<b>1</b>	0.72	2.52	0.22	1.15	1.12	0.75	0.86
<b>2</b>	0.72	2.16	0.25	1.06	1.03	0.62	0.83
<b>3</b>	0.72	1.80	0.28	0.95	0.93	0.52	0.76
<b>4</b>	0.72	1.44	0.33	0.85	0.84	0.42	0.69
<b>5</b>	0.72	1.08	0.40	0.72	0.71	0.31	0.57

<b>6</b>	0.72	0.72	0.50	0.61	0.67	0.22	0.52
<b>7</b>	0.72	0.36	0.60	0.50	0.59	0.11	0.46
<b>8</b>	0.72	0.00	1.00	0.38	0.49	0.07	0.41

**Table S2** Thermogravimetric analysis data for the oxido vanadium(IV) complexes.

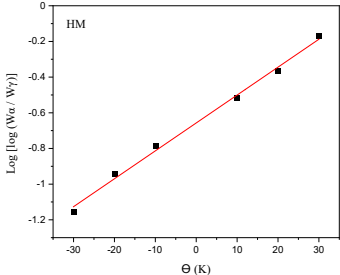
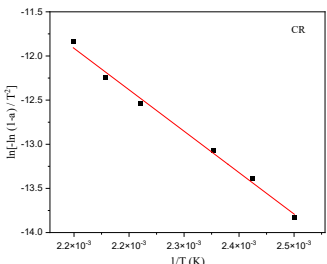
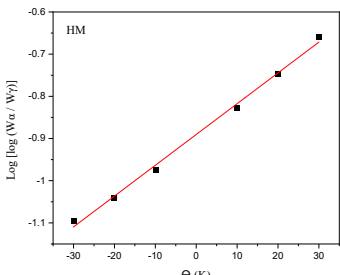
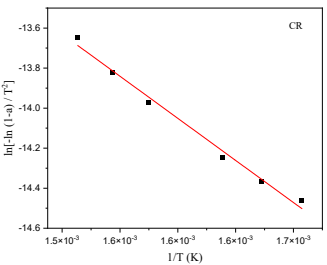
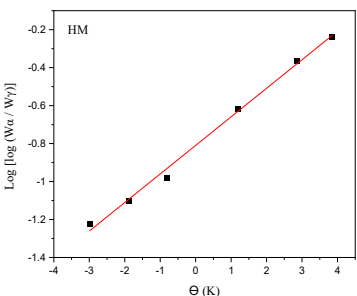
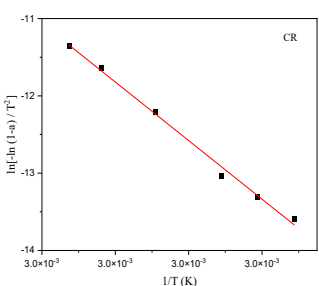
<b>Complex</b>	<b>Step</b>	<b>Temp. range (°C)</b>	<b>Weight loss % found (calc)</b>	<b>Assignments</b>	<b>Total mass loss/% found (calc)</b>	<b>Final solid- state residue %</b>
[VO(SO <sub>4</sub> )(CBZ)] 8H <sub>2</sub> O	1st	25–218	55.19 (55.15)	7H <sub>2</sub> O+ C <sub>4</sub> H <sub>7</sub> N <sub>2</sub> O <sub>3</sub> S	82.74 (82.54)	VO <sub>2</sub>  17.63 (17.45)
	2nd	218–800	27.55 (27.39)	C <sub>5</sub> H <sub>3</sub> O <sub>2</sub> S		
[VO(CTZ) <sub>2</sub> ] 2H <sub>2</sub> O	1st	55–100	4.09 (4.12)	2H <sub>2</sub> O	90.55 (90.45)	VO <sub>2</sub>  9.44 (9.55)
	2nd	100–788	86.46 (86.33)	C <sub>42</sub> H <sub>48</sub> Cl <sub>2</sub> N <sub>4</sub> O <sub>5</sub>		
[VO(LOR) <sub>2</sub> ] SO <sub>4</sub>	1st	119–341	42.36 (42.35)	C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>10</sub> S <sub>2</sub>	90.62 (90.85)	VO <sub>2</sub>  9.38 (9.15)
	2nd	341–552	48.26 (48.09)	C <sub>19</sub> H <sub>12</sub> N <sub>6</sub> OS <sub>3</sub>		
[VO(SO <sub>4</sub> )(SCZ)] 7H <sub>2</sub> O	1st	25–232	69.37 (70.01)	7H <sub>2</sub> O+C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub>	85.59 (86.54)	VO <sub>2</sub>  14.40 (13.45)
	2nd	232–998	16.22 (16.53)	C <sub>4</sub> HN <sub>2</sub> O		

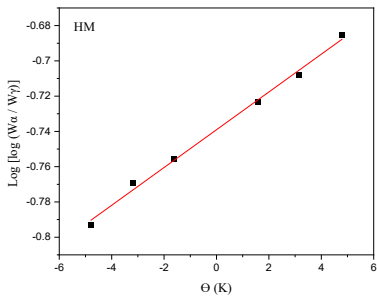
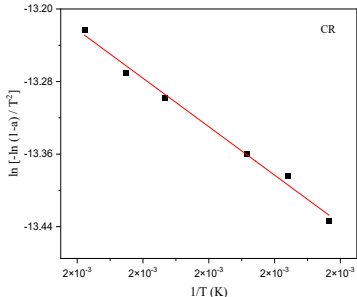
**Table S3** Kinetic parameters of thermal decomposition steps for oxidovanadium(IV) complexes

Complex	Temp. range C°	Method	Ea (kJmol <sup>-1</sup> )	A (s <sup>-1</sup> )	ΔS (J mol <sup>-1</sup> K <sup>-1</sup> )	ΔH (kJmol <sup>-1</sup> )	ΔG (kJ mol <sup>-1</sup> )	Correlation coefficient (R)
[VO(SO <sub>4</sub> )(CBZ)] 8H <sub>2</sub> O	25-218	CR	4.88×10 <sup>4</sup>	2.03×10 <sup>3</sup>	- 1.85×10 <sup>2</sup>	4.52×10 <sup>4</sup>	1.25×10 <sup>5</sup>	0.99
		HZ	5.62×10 <sup>4</sup>	3.58×10 <sup>4</sup>	- 1.61×10 <sup>2</sup>	5.26×10 <sup>4</sup>	1.22×10 <sup>5</sup>	0.99
		Average	5.25×10 <sup>4</sup>	1.90×10 <sup>4</sup>	- 1.73×10 <sup>2</sup>	4.89×10 <sup>4</sup>	1.24×10 <sup>5</sup>	0.99
	218- 800	CR	4.37×10 <sup>4</sup>	3.12	- 2.42×10 <sup>2</sup>	3.85×10 <sup>4</sup>	1.89×10 <sup>5</sup>	0.98
		HZ	5.43×10 <sup>4</sup>	9.95×10	- 2.13×10 <sup>2</sup>	4.91×10 <sup>4</sup>	1.82×10 <sup>5</sup>	0.99
		Average	4.90×10 <sup>4</sup>	5.13×10	- 4.91×10 <sup>2</sup>	4.38×10 <sup>4</sup>	1.85×10 <sup>5</sup>	0.98
[VO(CTZ) <sub>2</sub> ] 2H <sub>2</sub> O	25-100	CR	1.20×10 <sup>5</sup>	1.91×10 <sup>3</sup>	- 1.83×10 <sup>2</sup>	1.17×10 <sup>5</sup>	1.87×10 <sup>5</sup>	0.99
		HZ	1.44×10 <sup>4</sup>	4.77×10	- 2.52×10 <sup>2</sup>	1.17×10 <sup>4</sup>	9.56×10 <sup>4</sup>	0.99
		Average	6.71×10 <sup>4</sup>	9.55×10 <sup>2</sup>	- 2.18×10 <sup>2</sup>	6.43×10 <sup>5</sup>	1.37×10 <sup>5</sup>	0.99
[VO(LOR) <sub>2</sub> ] SO <sub>4</sub>	119- 341	CR	4.51×10 <sup>4</sup>	5.88×10 <sup>2</sup>	- 1.96×10 <sup>2</sup>	4.11×10 <sup>4</sup>	1.34×10 <sup>5</sup>	0.99

		HZ	3.36×10 <sup>4</sup>	1.45×10	- 2.27×10 <sup>2</sup>	2.97×10 <sup>4</sup>	1.38×10 <sup>5</sup>	0.98
		Average	3.93×10 <sup>4</sup>	3.01×10 <sup>2</sup>	- 2.11×10 <sup>2</sup>	2.54×10 <sup>4</sup>	1.36×10 <sup>5</sup>	0.98
	341- 552	CR	5.95×10 <sup>4</sup>	1.49×10	- 2.30×10 <sup>2</sup>	5.34×10 <sup>4</sup>	2.22×10 <sup>5</sup>	0.99
		HZ	1.02×10 <sup>5</sup>	7.42×10 <sup>4</sup>	- 1.59×10 <sup>2</sup>	9.62×10 <sup>4</sup>	2.13×10 <sup>5</sup>	0.99
		Average	8.09×10 <sup>4</sup>	3.71×10 <sup>4</sup>	- 1.95×10 <sup>2</sup>	7.48×10 <sup>4</sup>	2.17×10 <sup>5</sup>	0.99
	[VO(SO <sub>4</sub> )(SCZ)]7H <sub>2</sub> O	25– 232	CR	4.93×10 <sup>4</sup>	4.57×10 <sup>2</sup>	- 1.97×10 <sup>2</sup>	4.57×10 <sup>4</sup>	1.32×10 <sup>5</sup>
HZ			5.69×10 <sup>4</sup>	3.98×10 <sup>4</sup>	- 1.60×10 <sup>2</sup>	5.33×10 <sup>4</sup>	1.23×10 <sup>5</sup>	0.99
Average			5.31×10 <sup>4</sup>	2.02×10 <sup>4</sup>	- 1.79×10 <sup>2</sup>	4.95×10 <sup>4</sup>	1.27×10 <sup>5</sup>	0.99
232- 998		CR	3.56×10 <sup>4</sup>	7.15×10	- 2.37×10 <sup>2</sup>	2.86×10 <sup>4</sup>	2.28×10 <sup>5</sup>	0.99
		HZ	9.92×10 <sup>4</sup>	4.24×10 <sup>3</sup>	- 1.84×10 <sup>2</sup>	9.22×10 <sup>4</sup>	2.47×10 <sup>5</sup>	0.99
		Average	6.74×10 <sup>4</sup>	2.12×10 <sup>3</sup>	- 2.11×10 <sup>2</sup>	6.04×10 <sup>4</sup>	2.37×10 <sup>5</sup>	0.99

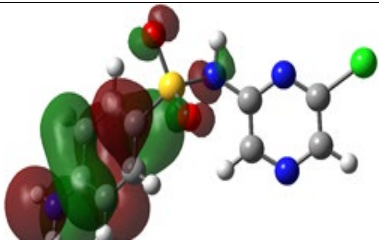
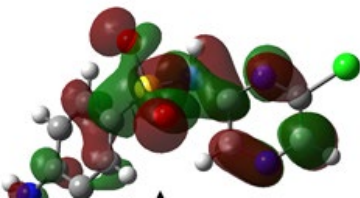
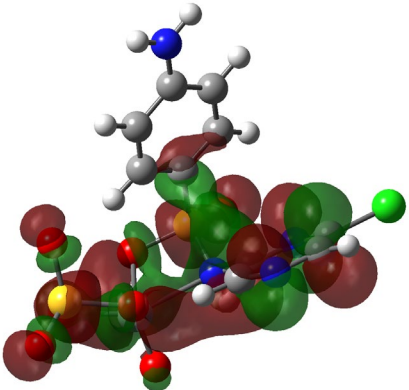
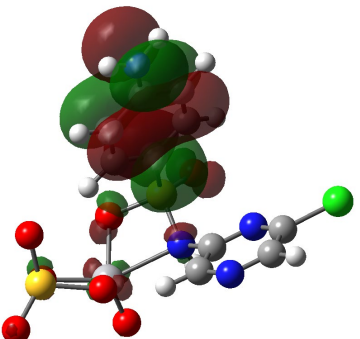
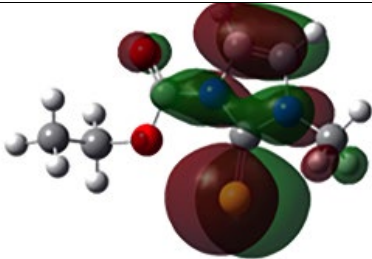
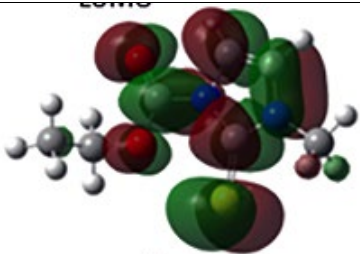
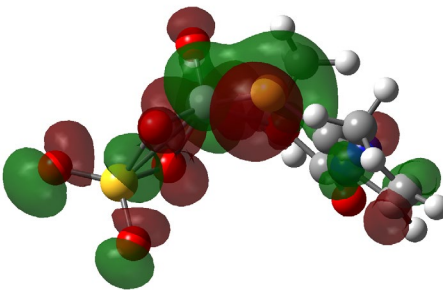
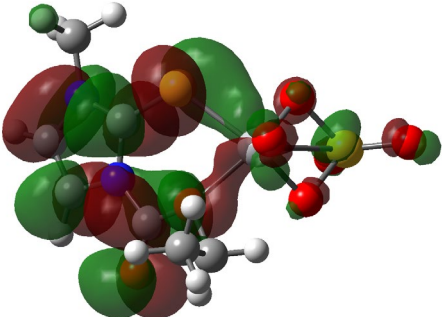
**Table S4** Coats-Redfern (CR) and Horowitz–Metzger (HM) of the oxidovanadium(IV) complexes.

Complex	Stage	Horowitz–Metzger (HM)	Coats-Redfern (CR)
$[\text{VO}(\text{SO}_4)(\text{CBZ})] \cdot 8\text{H}_2\text{O}$	25-218		
	218-800		
$[\text{VO}(\text{CTZ})_2] \cdot 2\text{H}_2\text{O}$	25-100		

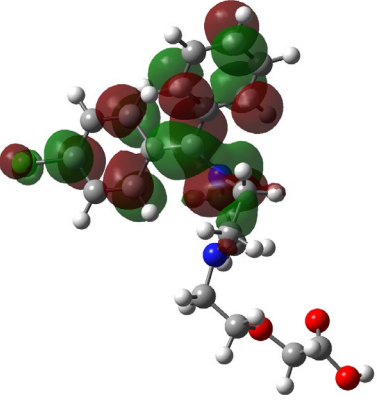
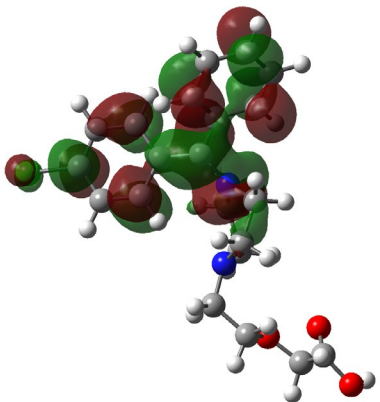
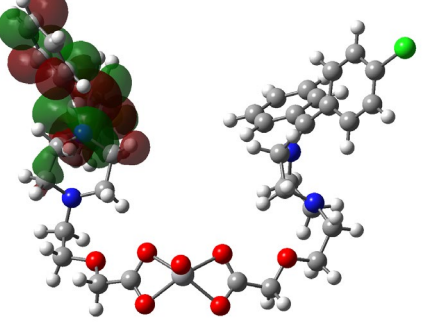
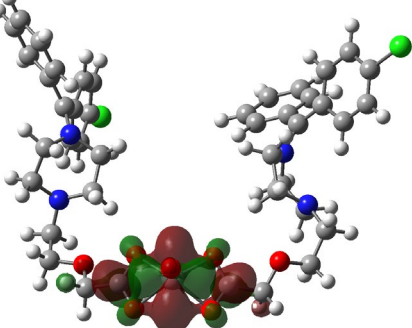
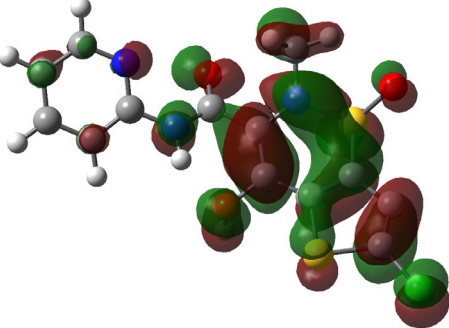
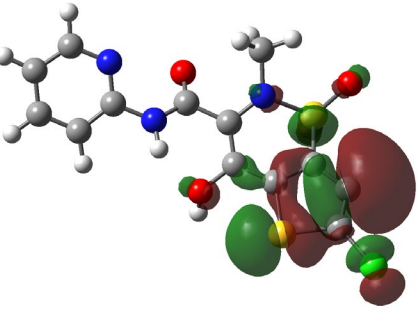
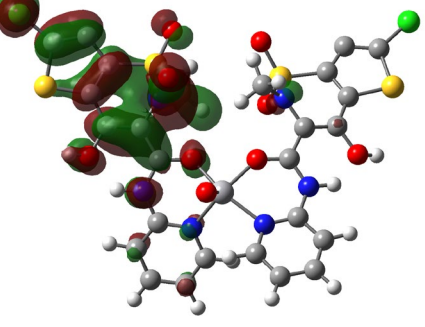
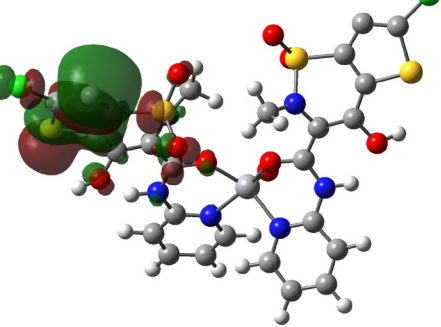
Complex	Stage	Horowitz–Metzger (HM)	Coats-Redfern (CR)																														
	100 - 788	 <p>HM</p> <table><caption>Estimated data for HM plot</caption><tr><th><math>\Theta</math> (K)</th><th><math>\text{Log} [\log (W_\alpha / W_\gamma)]</math></th></tr><tr><td>-4.5</td><td>-0.79</td></tr><tr><td>-3.0</td><td>-0.77</td></tr><tr><td>-1.5</td><td>-0.75</td></tr><tr><td>0.0</td><td>-0.73</td></tr><tr><td>1.5</td><td>-0.71</td></tr><tr><td>3.0</td><td>-0.69</td></tr><tr><td>4.5</td><td>-0.67</td></tr></table>	$\Theta$ (K)	$\text{Log} [\log (W_\alpha / W_\gamma)]$	-4.5	-0.79	-3.0	-0.77	-1.5	-0.75	0.0	-0.73	1.5	-0.71	3.0	-0.69	4.5	-0.67	 <p>CR</p> <table><caption>Estimated data for CR plot</caption><tr><th><math>1/T</math> (K)</th><th><math>\ln [-\ln (1 - \alpha) / T^2]</math></th></tr><tr><td><math>2.0 \times 10^{-3}</math></td><td>-13.20</td></tr><tr><td><math>2.1 \times 10^{-3}</math></td><td>-13.25</td></tr><tr><td><math>2.2 \times 10^{-3}</math></td><td>-13.30</td></tr><tr><td><math>2.3 \times 10^{-3}</math></td><td>-13.35</td></tr><tr><td><math>2.4 \times 10^{-3}</math></td><td>-13.40</td></tr><tr><td><math>2.5 \times 10^{-3}</math></td><td>-13.45</td></tr></table>	$1/T$ (K)	$\ln [-\ln (1 - \alpha) / T^2]$	$2.0 \times 10^{-3}$	-13.20	$2.1 \times 10^{-3}$	-13.25	$2.2 \times 10^{-3}$	-13.30	$2.3 \times 10^{-3}$	-13.35	$2.4 \times 10^{-3}$	-13.40	$2.5 \times 10^{-3}$	-13.45
$\Theta$ (K)	$\text{Log} [\log (W_\alpha / W_\gamma)]$																																
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Complex	Stage	Horowitz–Metzger (HM)	Coats-Redfern (CR)
$[\text{VO}(\text{LOR})_2]\text{SO}_4$	119-341		
	341-552		
$[\text{VO}(\text{SO}_4)(\text{SCZ})]7\text{H}_2\text{O}$	25-232		
	232-998		

**Table S 5** HOMO and LUMO plots of the free ligands and their metal complexes using DFT/B3LY.

Compound	HOMO	LUMO
SCZ		
VO-SCZ		
CBZ		
VO-CBZ		



CTZ		
VO-CTZ		
LOR		
VO-LOR		

**Table S6** Docking interaction calculation of all oxidovanadium(IV) complexes with colon cancer protein (3IG7).

Compound		Receptor	Interaction	Distance E	(kcal/mol)
CBZ	O 22	N LEU 83 (A)	H-acceptor	3.19	-2.3
[VO(SO <sub>4</sub> )(CBZ)]8H <sub>2</sub> O		No measurable interactions			
CTZ		No measurable interactions			
[VO(CTZ) <sub>2</sub> ] 2H <sub>2</sub> O	O 45	ND2 ASN 132(A)	H-acceptor	3.10	-2.0
LOR	O 21	OD1 ASP 145(A)	H-donor	2.82	-6.6
[VO(LOR) <sub>2</sub> ]SO <sub>4</sub>	O 66	ND2 ASN 132(A)	H-acceptor	2.94	-1.8
	N 44	OD1 ASP 86(A)	Ionic	3.92	-0.7
	6-ring	CA GLY 11 (A)	pi-H	4.44	-1.0
SCZ	N 23	N LEU 83 (A)	H-acceptor	3.14	17.9
	O 26	ND2 ASN 132(A)	H-acceptor	3.02	-1.0
[VO(SO <sub>4</sub> )(SCZ) <sub>2</sub> ]7H <sub>2</sub> O	O 35	ND2 ASN 132(A)	H-acceptor	3.37	-1.2

**Table S7** The experimental and the predicted IC<sub>50</sub> values of some of the training set against HCT116 cell.

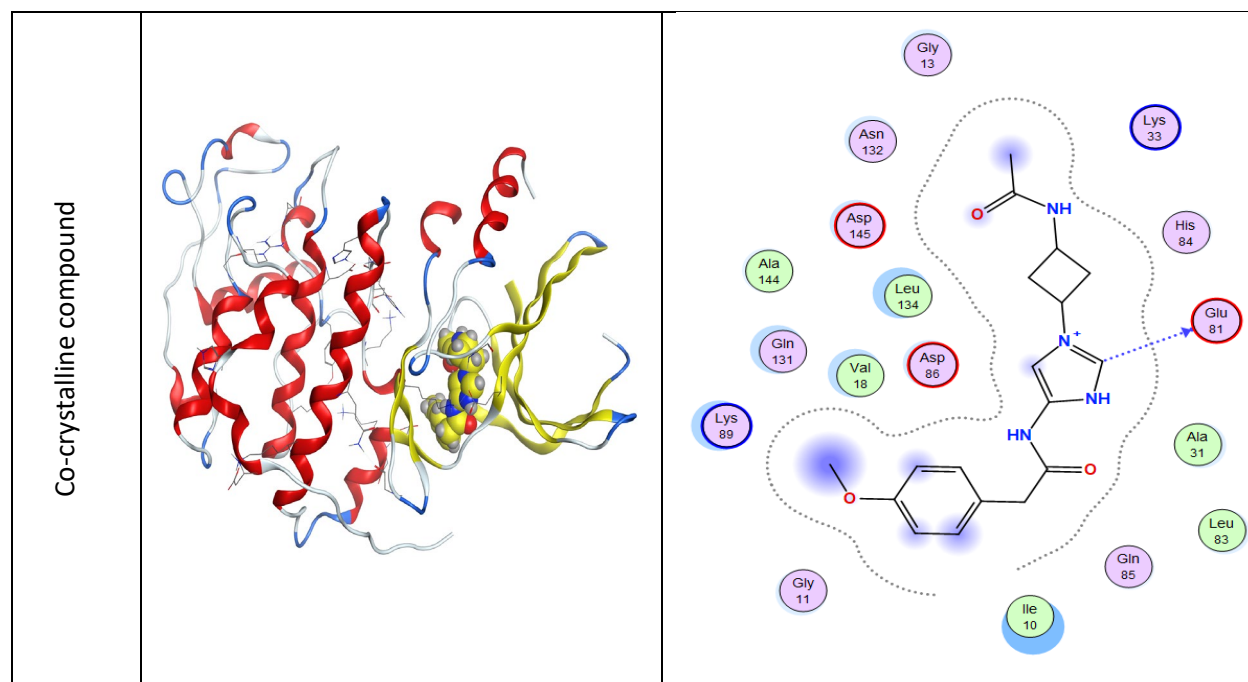
Compounds	IC <sub>50</sub> (experimental)	IC <sub>50</sub> (predicted)	Residual
1a	0.95 ± 0.20	1.72	-0.16099
2a	0.34 ± 0.08	4.21	-0.93851
3a	0.05 ± 0.21	3.72	-0.82802
4a	0.31 ± 0.08	1.06	1.393651
5a	29.23 ± 3.28	36.43	-1.43153
6a	32.90 ± 2.97	34.935	-0.43057
7a	24.39 ± 4.28	27.11	-0.69201
8a	28.70 ± 2.30	23.92	1.129149
9a	33.40 ± 3.30	31.06	0.430793
10a	>50.00	41.93	1.794515
11a	>50.00	51.19	-0.26647

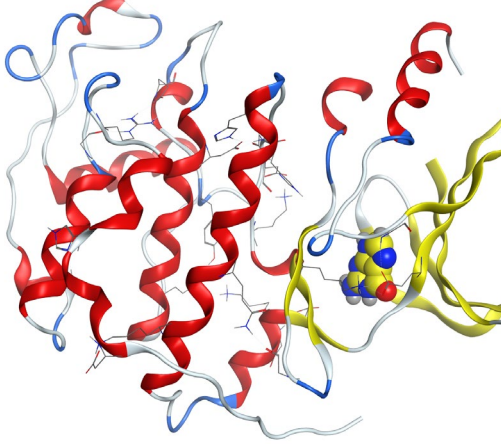
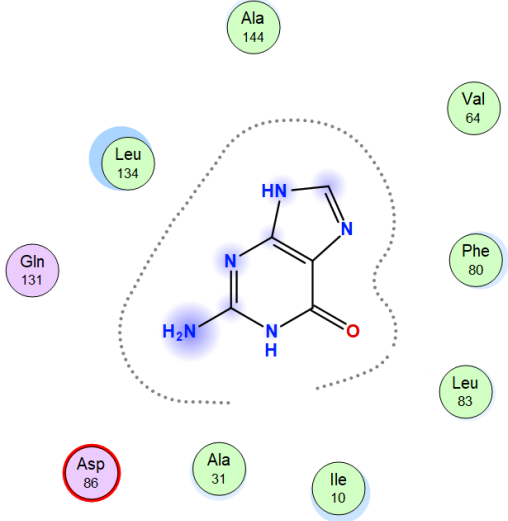
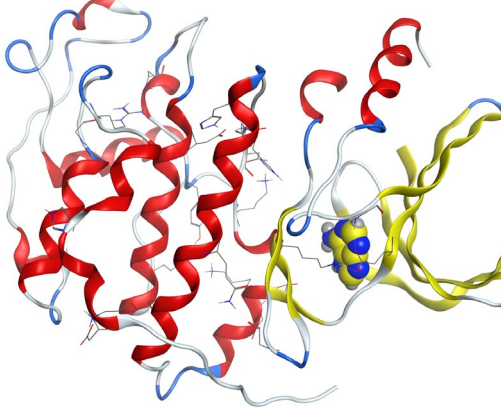
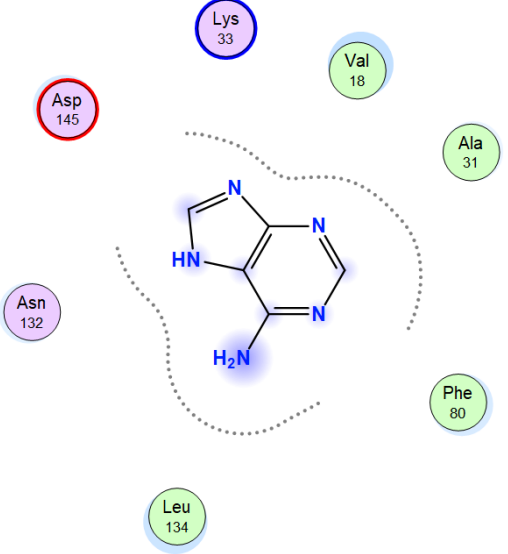
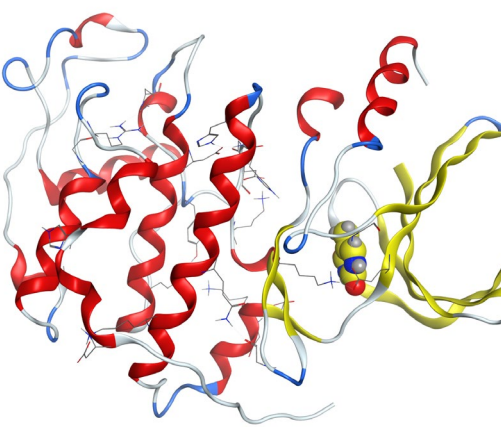
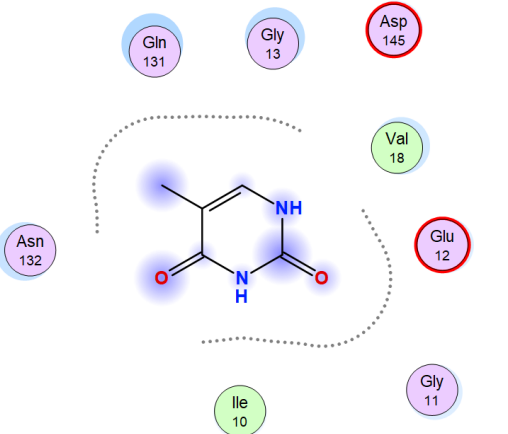
**Table S8.** Docking score and energies of Co-crystalline compound (positive control) and four amino acids (negative control).

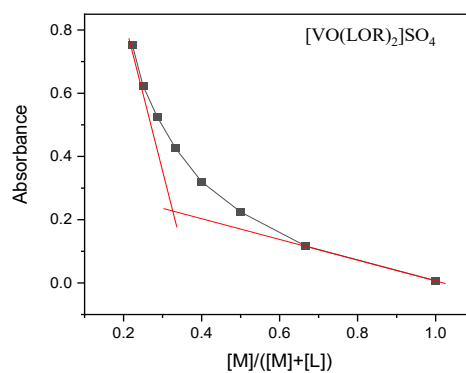
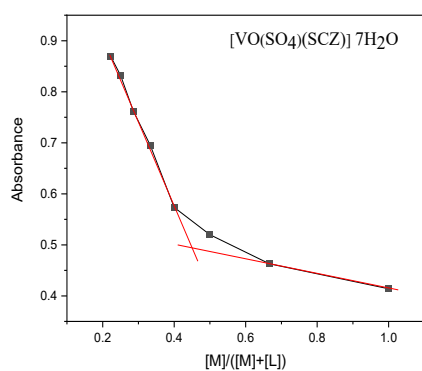
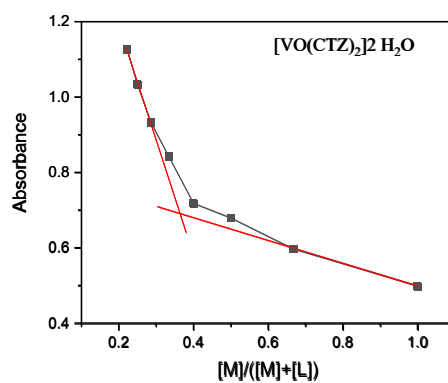
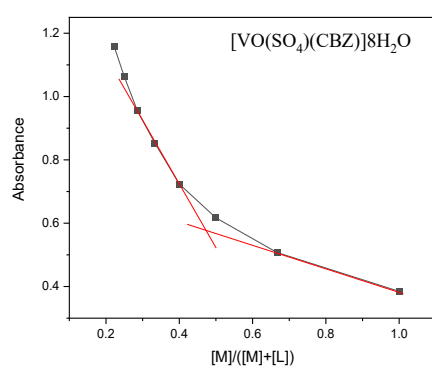
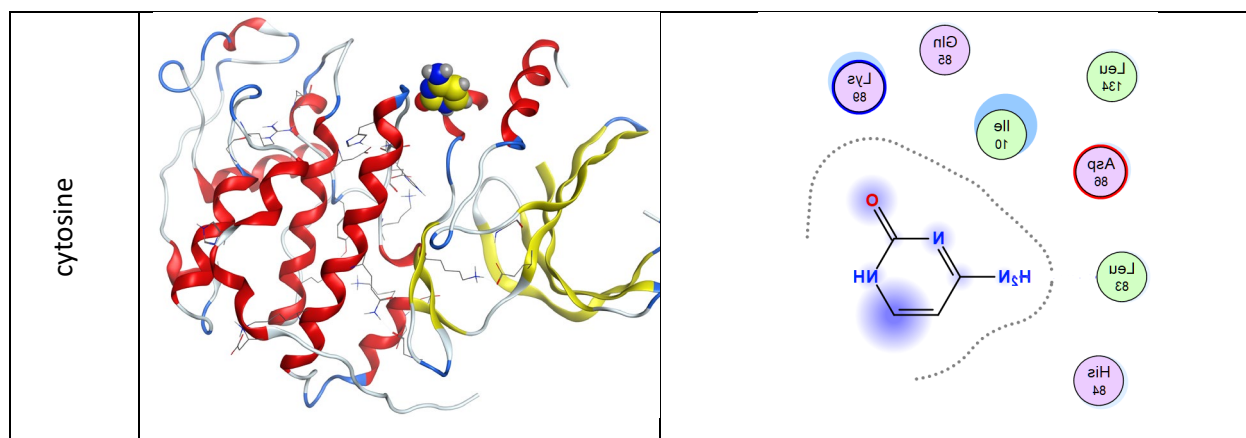
compound	S	rmsd_refine	E_conf	E_place	E_score1	E_refine	E_score2
Co-crystalline compound	-7.30	1.47	-115.39	-30.76	-8.60	-26.01	-7.30
	-7.15	1.30	-113.25	-31.40	-8.52	-25.61	-7.15
	-7.11	2.09	-120.47	-32.17	-8.51	-37.24	-7.11
	-6.91	1.30	-108.56	-50.41	-9.53	-32.68	-6.91
	-6.83	1.05	-115.80	-43.13	-9.18	-26.67	-6.83
guanine	-1.37	4.79	-119.69	-32.70	-7.49	-20.31	-1.37
	-1.29	1.85	-119.29	-51.86	-7.56	-15.73	-1.29
	-1.19	2.35	-119.43	-49.12	-7.43	-13.91	-1.19
	-1.08	2.16	-119.54	-35.00	-6.85	-21.40	-1.08
	-1.07	0.90	-119.44	-39.01	-7.27	-13.49	-1.07
adenine	-1.40	0.30	-104.28	-60.33	-6.35	-18.50	-1.40

	-1.11	1.24	-104.20	-35.37	-5.90	-18.79	-1.11
	-1.10	3.26	-104.22	-36.40	-5.96	-15.12	-1.10
	-1.03	2.13	-104.12	-38.24	-5.95	-19.33	-1.03
	-1.02	1.77	-104.31	-30.58	-6.53	-15.87	-1.02
thymine	-1.26	1.27	-129.54	-29.36	-5.67	-20.51	-1.26
	-0.90	1.99	-129.42	-33.59	-5.64	-23.78	-0.90
	-0.84	1.28	-129.53	-13.76	-6.29	-13.57	-0.84
	-0.83	5.19	-128.85	-28.94	-5.83	-16.47	-0.83
	-0.77	1.94	-129.48	-38.45	-5.70	-16.28	-0.77
cytosine	-0.06	1.25	-145.94	-51.77	-5.56	-18.76	-0.06
	-0.95	1.43	-146.16	-16.57	-5.31	-14.63	-0.95
	-0.82	1.20	-146.13	-29.13	-5.81	-16.63	-0.82
	-0.76	1.23	-146.10	-19.65	-5.51	-10.82	-0.76
	-0.76	9.29	-146.06	-10.77	-5.29	-16.03	-0.76

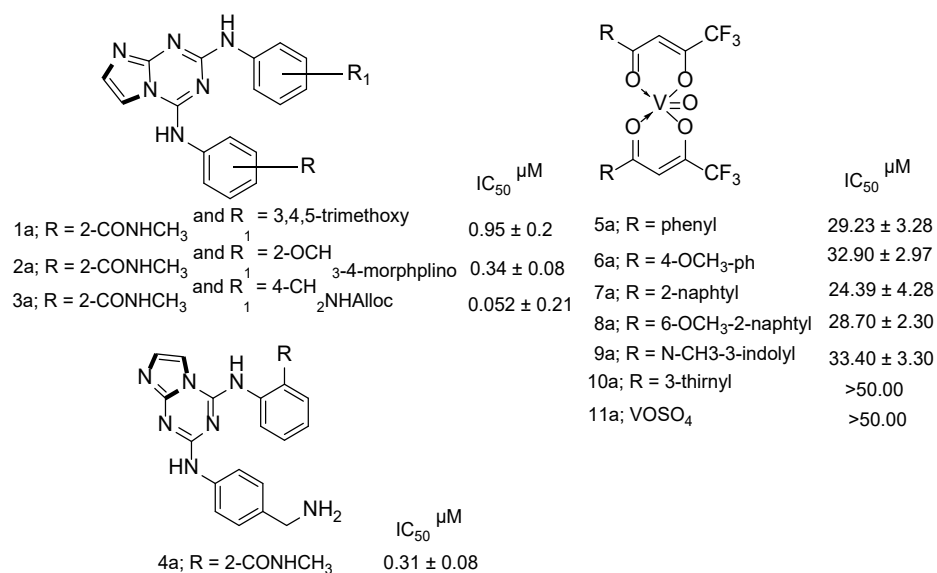
Table S9. 2D and 3D Docking interaction of the Co-crystalline compound (positive control) and four amino acids (negative control).



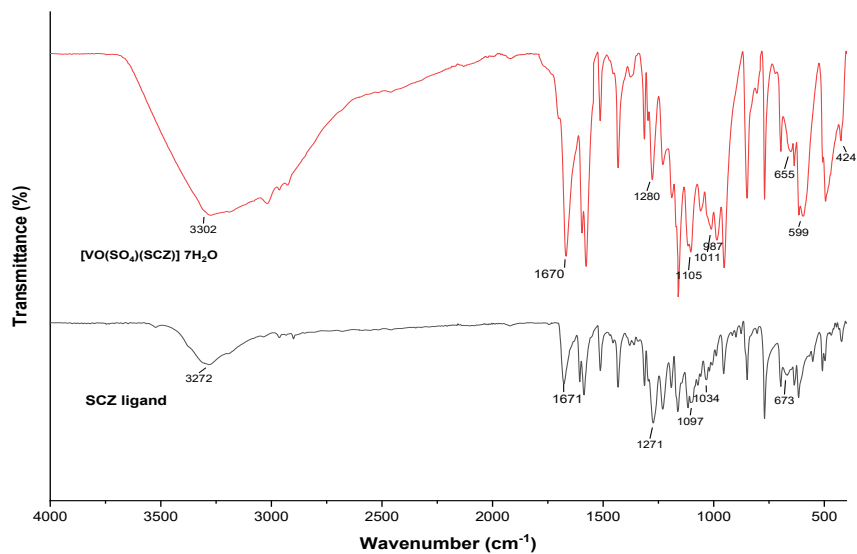
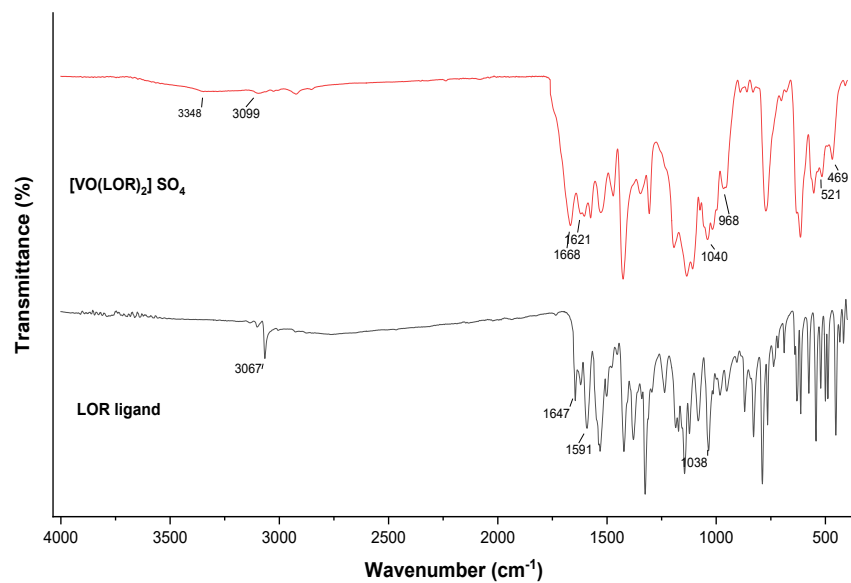
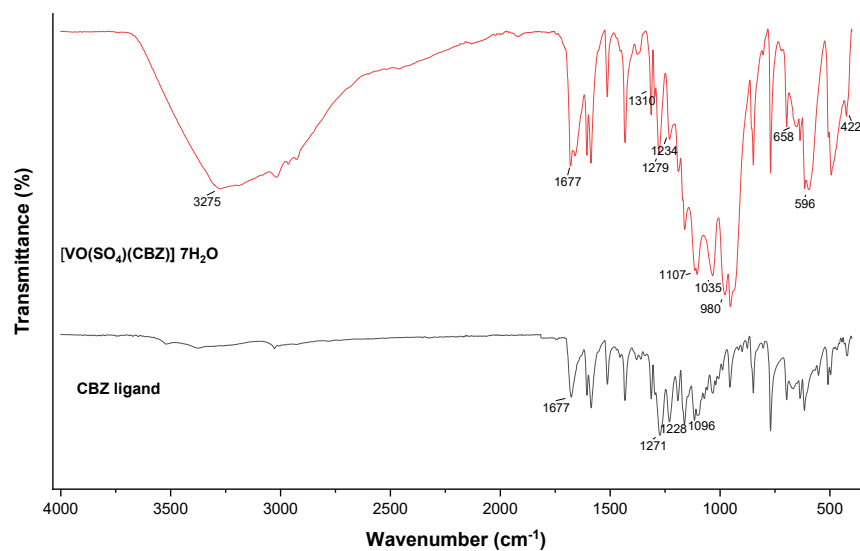
<p>guanine</p>		
<p>adenine</p>		
<p>thymine</p>		



**Figure S1** Molar ratio method plots of oxidovanadium(IV) complexes.

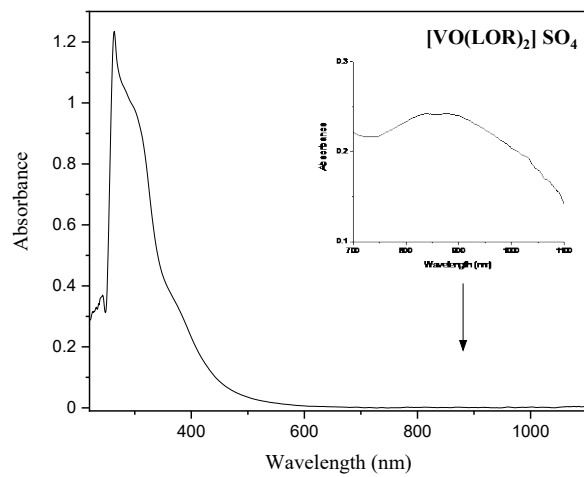
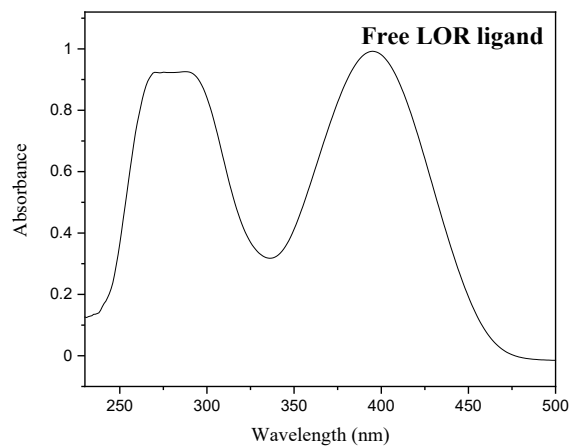
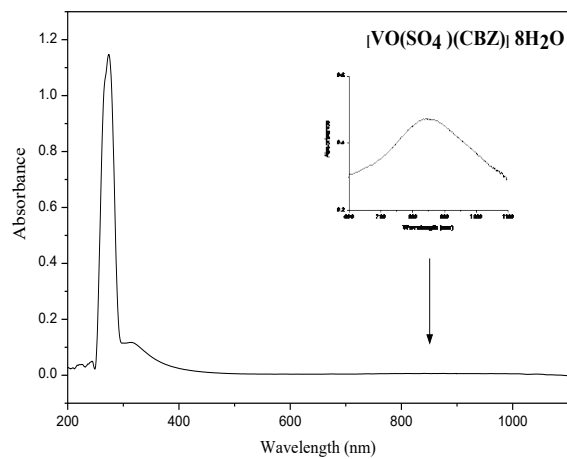
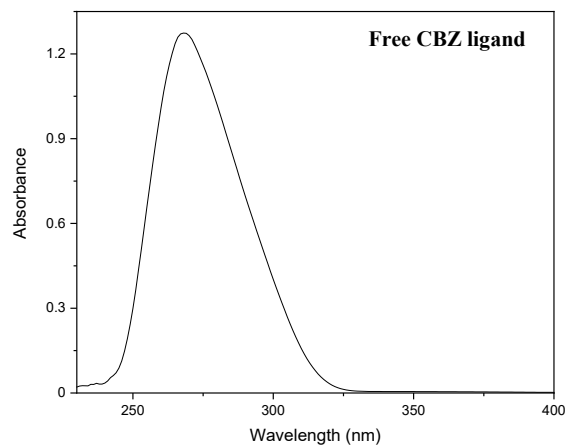


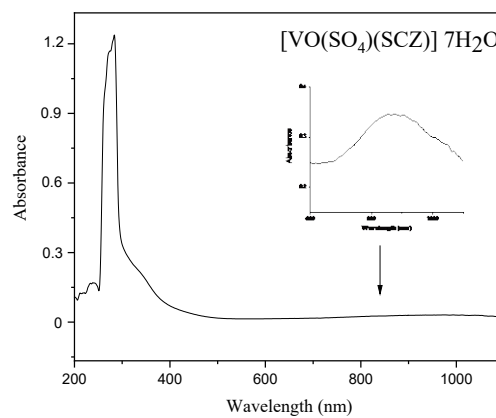
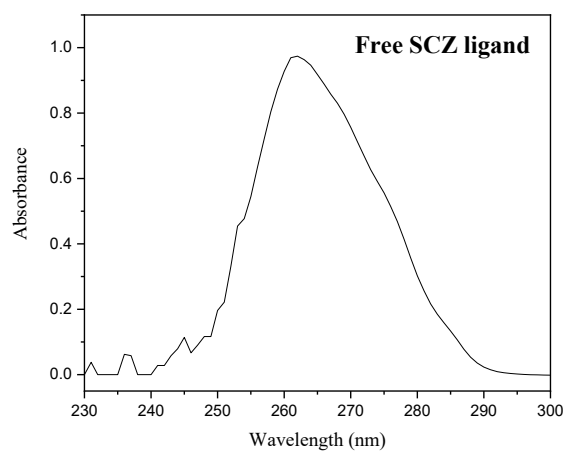
**Figure S2.** Some of the structures of imidazole and oxidovanadium(IV) compounds (training) that were used in the QSAR with their activity against HCT 116.



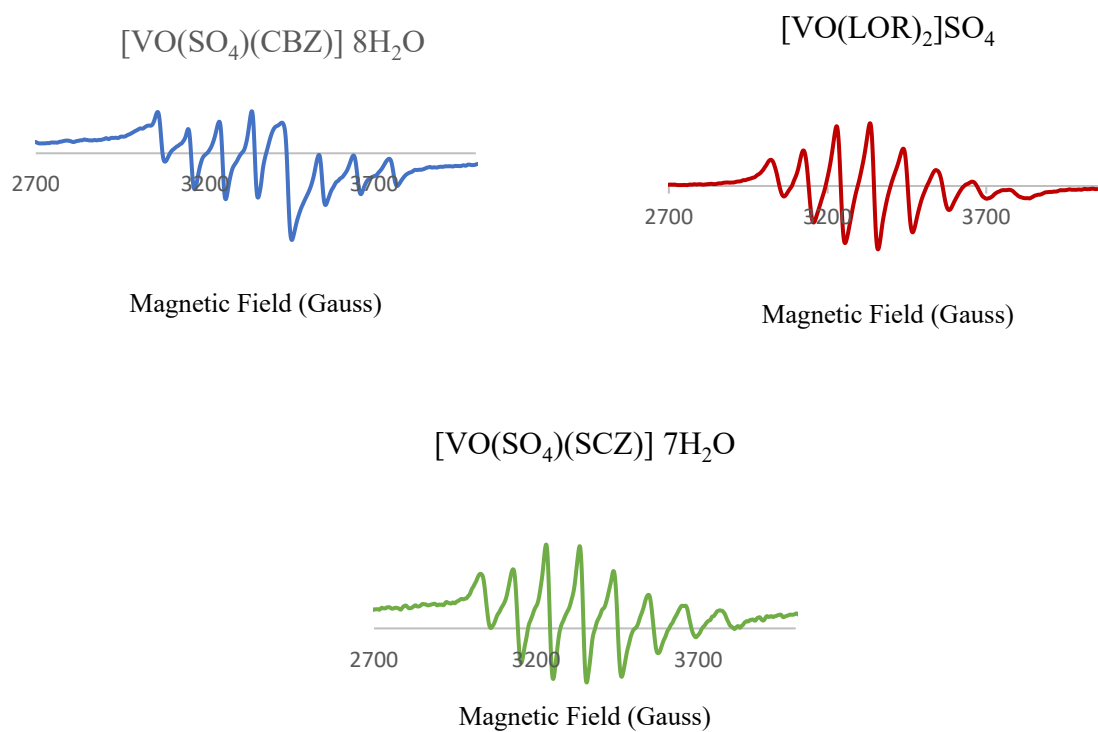
**Figure S1** The FT-IR spectra of free ligands and their oxidovanadium(IV) complex.



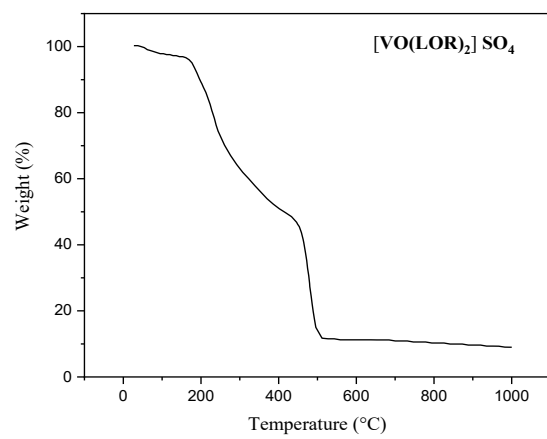
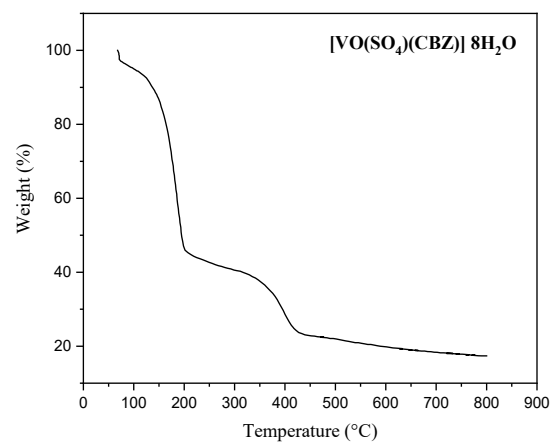


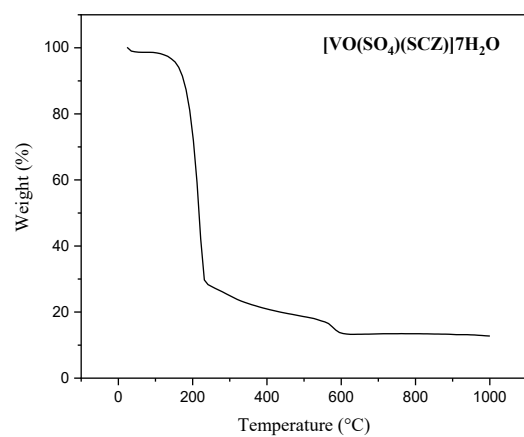


**Figure S2** UV-vis Spectra of free ligands and their oxidovanadium(IV) complexes (inset shows the d-d transition the metal complex).

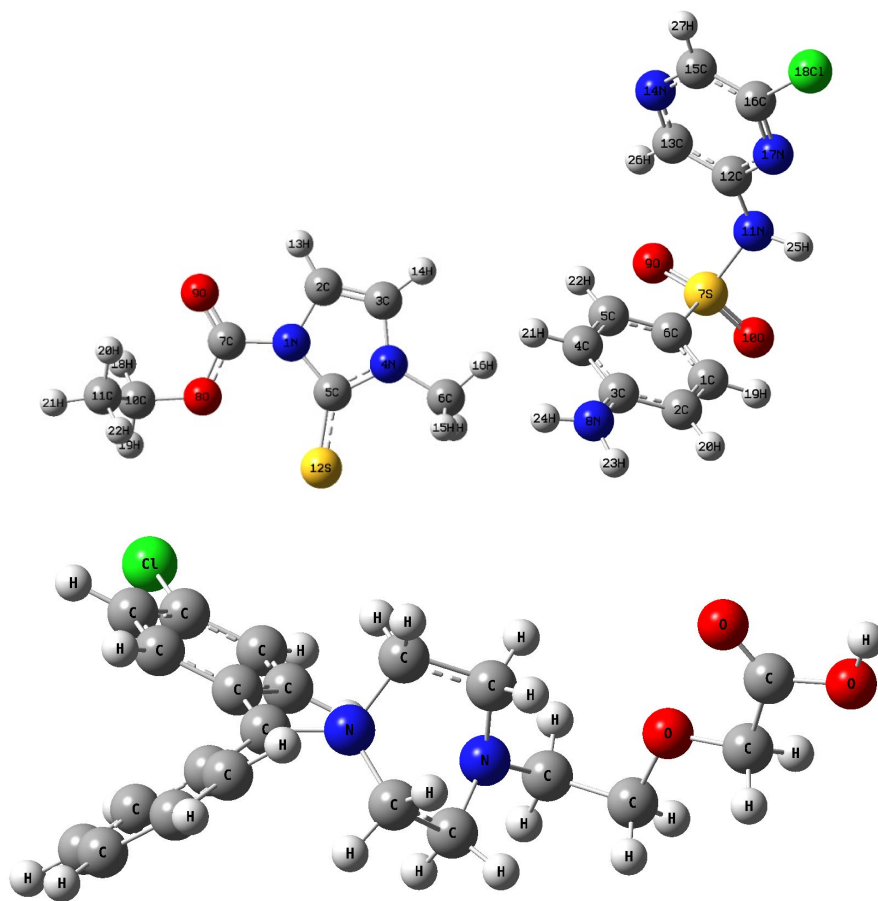


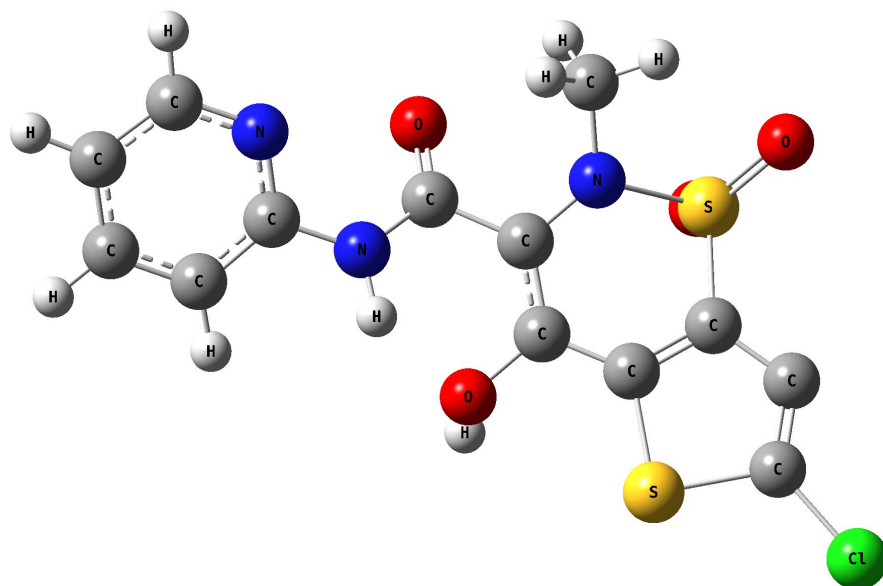
**Figure S3** EPR spectra of oxidovanadium(IV) complexes in DMF and in room temperature.



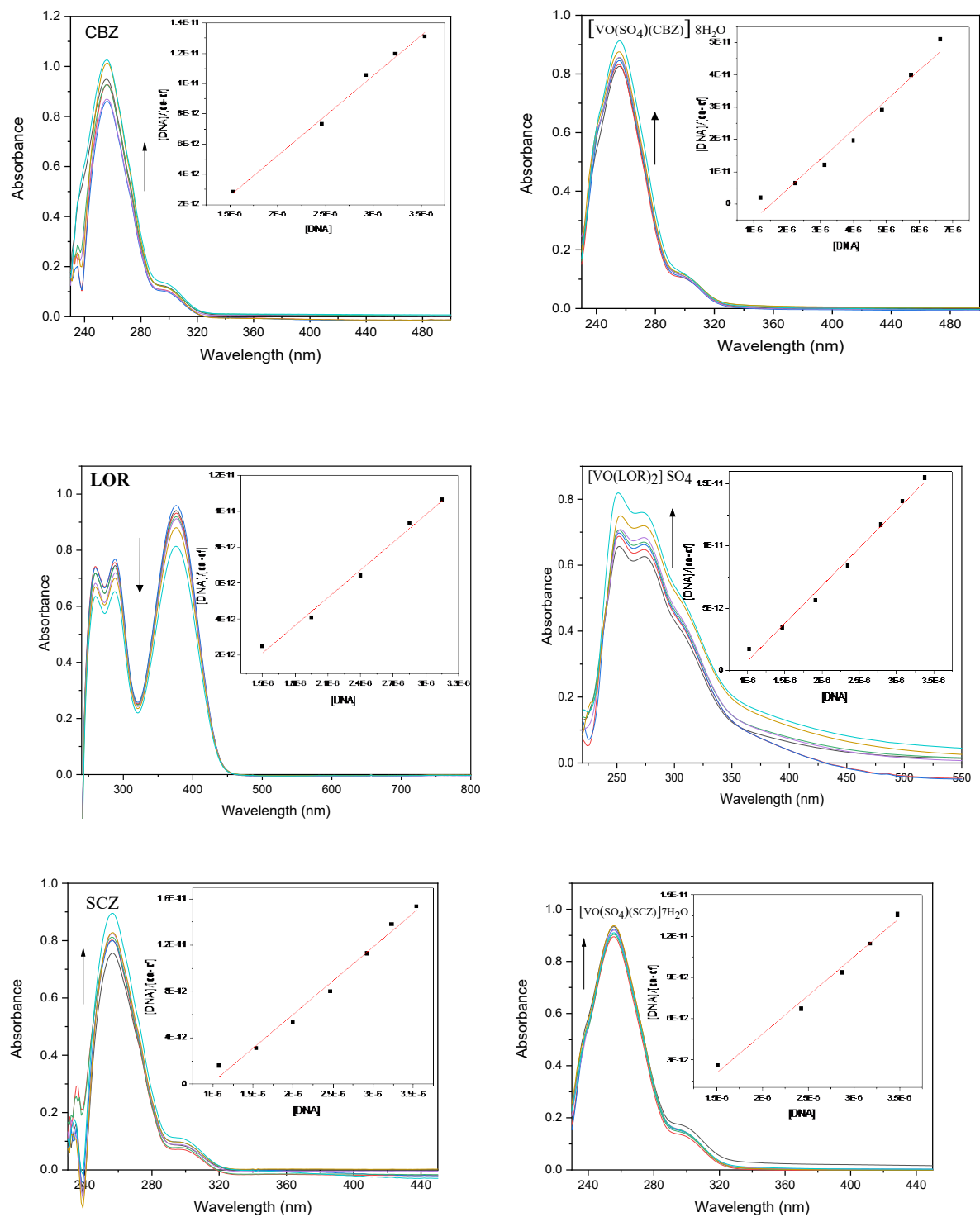


**Figure S4** The TGA curves of synthesized oxidovanadium(IV) complex.





**Figure S5** The optimized geometry of the free ligands gas phase using DFT method LANL2DZ basis sets.



**Figure S6** Absorption spectra of free ligands and their complex in the presence of increasing DNA concentration.