Supporting Information for

In the pursuit of a 'disappearing' anhydrous phase of antipyrine-dipicolinic acid (ANT-DPA) co-crystal: explained through relative stability and charge density analyses

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Table S1 Experimental and theoretical lattice parameters of both cocrystals. Theoretical parameters are obtained from periodic DFT calculations.

Parameter	Hydrated form		Anhydrous form	
	Experiment	Theory	Experiment	Theory
a (Å)	18.4087	18.2524	6.6207	6.5349
b (Å)	8.0394	8.0759	13.4523	13.3528
c (Å)	23.69	23.2077	36.69120	36.6821
β (°)	91.284	89.5857	-	-
Volume (Å^3)	3505.1	3420.81	3267.9	3051.88

Table S2. Bader charges of individual atoms of both cocrystals obtained from periodic DFT calculations.

Hydrated form		Anhydrous form	
Atom	Charge	Atom	Charge
O1	-1.199	O1	-1.223
O2	-1.196	O2	-1.179
O3	-1.200	N3	-1.130
O4	-1.177	N1	-0.822
O5	-1.174	O4	-1.165
O6	-1.213	N2	-0.810
N1	-0.820	O3	-1.197
N2	-0.801	C2	-0.002
N3	-1.119	H2A	0.087
C1	0.296	C3	0.407
C2	-0.017	C14	0.508
H2	0.064	C1	1.208
C3	-0.033	O5	-1.192

H3	0.062	C6	0.312
C4	-0.043	C10	0.505
H4a	0.077	C4	-0.019
C5	-0.028	C15	1.561
H5	0.075	C13	0.002
C6	0.004	H13	0.076
H6	0.078	C5	0.330
C7	0.420	C12	0.001
C8	-0.005	H12	0.130
H8	0.092	C9	-0.026
C9	1.174	H9	0.073
C10	0.302	C11	-0.002
C11	0.000	H11	0.089
C12	0.496	C16	1.582
C13	-0.003	C7	-0.012
H13	0.108	H7	0.096
C14	-0.009	C8	-0.017
H14	0.072	H8	0.019
C15	-0.011	H2	0.662
H15	0.106	H4	0.659
C16	0.490	H1	0.047
C17	1.568	H3	0.109
C18	1.602	H5	0.070
H6a	0.611	H6	0.057
H1	0.655		
H6b	0.615		
H4	0.662		
H11a	0.068		
H11b	0.063		
H11c	0.072		
H10a	0.083		
H10b	0.061		
H10c	0.081		

Table S3

Hydrogen-bond geometry (Å, °) of hydrated form

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
C4—H4*a*···O5^{i}	1.09	2.42	3.348 (2)	142 (1)
C6—H6···O1	1.09	2.58	3.007 (2)	102 (1)
O2—H1···O1	1.11	1.38	2.4378 (17)	157 (1)
O2—H1···C8	1.11	2.51	3.265 (2)	124 (1)
O2—H1···C9	1.11	2.06	3.089 (2)	154 (1)
O6—H6*b*···O3	0.99	1.89	2.8767 (17)	176 (1)
O6—H6*b*···N3	0.99	2.44	2.9060 (18)	108 (1)
O4—H4···O6	1.02	1.74	2.6588 (17)	148 (1)
O4—H4···N3	1.02	2.14	2.7132 (18)	114 (1)
C10—H10*c*···C11	1.09	2.62	3.036 (3)	102 (1)
C11—H11*c*···O3^{ii}	1.10	2.60	3.560 (2)	147 (1)
C10—H10*c*···C5^{ii}	1.09	2.42	3.423 (3)	152 (1)
C15—H15···C3^{iii}	1.09	2.78	3.565 (3)	129 (1)
O6—H6*a*···O3^{iv}	0.98	1.95	2.8604 (17)	153 (1)
C3—H3···N3^{v}	1.09	2.38	3.328 (2)	144 (1)
C6—H6···C14^{vi}	1.09	2.67	3.564 (3)	139 (1)

Symmetry codes: (i) $x-\frac{1}{2},-y+\frac{1}{2},z-\frac{1}{2}$; (ii) $x,y+1,z$; (iii) $x+\frac{1}{2},-y+\frac{3}{2},z+\frac{1}{2}$; (iv) $-x+\frac{3}{2},-y+\frac{1}{2},-z+1$; (v) $-x+1,-y+1,-z+1$; (vi) $-x+\frac{3}{2},-y+\frac{3}{2},-z+1$

Table S4

Topological properties of (3,-1) CPs in the intermolecular interactions of hydrated form calculated based on a multipolar atom model refinement using theoretically generated structure factors. distances (Å), electron density (eÅ^{-3}), Laplacian (eÅ^{-5}), Hessian eigenvalues (eÅ^{-5}), ε = ellipticity, G_{CP} = bond kinetic-energy density (kJ mol^{-1} Bohr^{-3}) and V_{CP} = bond potential-energy density (kJ mol^{-1} Bohr^{-3}).

No	**Bonds**	d_{12}	d_{1CP}	d_{2CP}	$\rho_{BCP}(r)$	$\nabla^2\rho_{BCP}(r)$	λ_1	λ_2	λ_3	ε	G_{CP}	V_{CP}
1	O2 – H1···O1	1.334	0.977	0.357	0.730	2.43	-7.176	-7.113	16.72	0.009	229.2	-392.2
		1.334	0.942	0.393	0.894	-4.264	-8.942	-8.887	13.57	0.006	182.1	-480.3
2	O4 – H4···O6	1.687	1.130	0.560	0.331	1.578	-2.323	-2.289	6.19	0.015	78.32	-113.6
		1.687	1.118	0.572	0.357	1.188	-2.287	-2.285	5.76	0.001	77.68	-123.0
3	O6 – H6b···O3	1.894	1.193	0.702	0.241	1.155	-1.509	-1.509	4.172	0	50.15	-68.84
		1.894	1.191	0.704	0.228	1.069	-1.312	-1.308	3.688	0.003	45.96	-62.81

4	O6 – H6a···O3^{iv}	1.938	0.738	1.208	0.204	1.299	-1.2	-1.172	3.671	0.024	45.65	-55.93
		1.938	0.737	1.209	0.204	1.297	-1.2	-1.17	3.67	0.025	45.64	-55.95
5	C3 – H3···N3^{v}	2.397	0.948	1.449	0.075	0.963	-0.278	-0.227	1.467	0.225	21.7	-17.17
		2.397	0.948	1.449	0.075	0.964	-0.28	-0.23	1.47	0.225	21.72	-17.19
6	C10 – H10c···C5^{ii}	2.447	0.969	1.478	0.074	0.817	-0.24	-0.182	1.239	0.322	18.9	-15.54
		2.447	0.969	1.479	0.074	0.817	-0.24	-0.18	1.24	0.321	18.91	-15.56
7	C4 – H4a···O5^{i}	2.394	0.969	1.426	0.064	0.899	-0.252	-0.24	1.391	0.052	19.53	-14.56
		2.394	0.969	1.426	0.064	0.903	-0.25	-0.24	1.4	0.051	19.59	-14.58
8	C6 – H6···C14^{vi}	2.659	1.061	1.613	0.051	0.553	-0.155	-0.08	0.788	0.932	12.25	-9.44
		2.659	1.061	1.613	0.051	0.554	-0.16	-0.08	0.79	0.934	12.28	-9.46
9	C11 – H11c···O3^{ii}	2.582	1.080	1.504	0.044	0.589	-0.164	-0.139	0.892	0.182	12.43	-8.82
		2.582	1.079	1.504	0.044	0.592	-0.16	-0.14	0.9	0.182	12.48	-8.84
10	C15 – H15···C3^{iii}	2.769	1.124	1.647	0.037	0.472	-0.097	-0.056	0.626	0.734	9.85	-6.84
		2.769	1.124	1.648	0.037	0.473	-0.1	-0.06	0.63	0.734	9.87	-6.86
11	C11 – H11b···O1	2.688	1.137	1.552	0.035	0.516	-0.112	-0.068	0.696	0.637	10.53	-7
		2.688	1.137	1.552	0.035	0.519	-0.11	-0.07	0.7	0.638	10.57	-7.02
12	C3 – H3···O6^{v}	2.683	1.126	1.564	0.034	0.545	-0.093	-0.049	0.686	0.901	10.98	-7.13
		2.683	1.126	1.564	0.033	0.547	-0.09	-0.05	0.69	0.894	11.02	-7.14
13	C8 – H8···O6	2.756	1.157	1.600	0.033	0.382	-0.112	-0.101	0.594	0.111	7.99	-5.59
		2.756	1.157	1.600	0.033	0.383	-0.11	-0.1	0.6	0.11	8.02	-5.6
14	C5 – H5···O5	2.767	1.169	1.598	0.031	0.364	-0.107	-0.092	0.563	0.166	7.59	-5.26
		2.767	1.169	1.598	0.031	0.366	-0.11	-0.09	0.56	0.164	7.62	-5.26
15	C8 – H8···O3	2.836	1.342	1.590	0.031	0.478	-0.076	-0.051	0.604	0.491	9.62	-6.23
		2.836	1.342	1.590	0.031	0.48	-0.08	-0.05	0.61	0.489	9.66	-6.25
16	C11 – H11a···C6	2.912	1.195	1.721	0.031	0.339	-0.081	-0.053	0.473	0.537	7.08	-4.94
		2.912	1.195	1.721	0.031	0.339	-0.08	-0.05	0.47	0.534	7.1	-4.95
17	C10 – H10a···O5	2.742	1.242	1.540	0.030	0.56	-0.09	-0.064	0.714	0.406	11.06	-6.88
		2.742	1.242	1.54	0.030	0.562	-0.09	-0.06	0.72	0.406	11.11	-6.9
18	C13 – H13···O6	2.739	1.157	1.585	0.029	0.403	-0.099	-0.087	0.589	0.135	8.18	-5.4
		2.739	1.157	1.585	0.029	0.405	-0.1	-0.09	0.59	0.136	8.22	-5.41
19	C5 – H5···O4	2.789	1.182	1.609	0.026	0.456	-0.081	-0.035	0.572	1.312	9.01	-5.59
		2.789	1.182	1.609	0.026	0.458	-0.08	-0.04	0.57	1.295	9.04	-5.6
20	C10 – H10b···O2	2.769	1.168	1.604	0.026	0.424	-0.087	-0.063	0.574	0.389	8.43	-5.3
		2.769	1.168	1.604	0.026	0.426	-0.09	-0.06	0.58	0.390	8.46	-5.3
21	C11 – H11a···O1	2.84	1.254	1.607	0.026	0.469	-0.082	-0.041	0.592	1.016	9.22	-5.65
		2.84	1.255	1.606	0.025	0.472	-0.08	-0.04	0.59	1.016	9.25	-5.66
22	C10 – H10a···O5	2.895	1.203	1.730	0.025	0.392	-0.063	-0.029	0.485	1.145	7.8	-4.9
		2.895	1.204	1.730	0.025	0.394	-0.06	-0.03	0.49	1.162	7.82	-4.91
23	C2 – H2···O6	2.842	1.219	1.630	0.024	0.438	-0.068	-0.037	0.543	0.872	8.57	-5.21
		2.842	1.219	1.630	0.024	0.44	-0.07	-0.04	0.54	0.877	8.6	-5.22
24	C14 – H14···C4	3.068	1.236	1.837	0.021	0.336	-0.053	-0.024	0.414	1.202	6.6	-4.04
		3.068	1.236	1.837	0.021	0.337	-0.05	-0.02	0.42	1.201	6.62	-4.05
25	C11 – H11a···O4	2.903	1.243	1.660	0.021	0.332	-0.058	-0.04	0.43	0.457	6.51	-3.99
		2.903	1.243	1.659	0.021	0.333	-0.06	-0.04	0.43	0.457	6.53	-3.99
26	C11 – H11c···C2	3.160	1.318	1.853	0.017	0.255	-0.032	-0.017	0.304	0.920	4.99	-3.04
		3.160	1.318	1.853	0.017	0.256	-0.03	-0.02	0.3	0.923	5.01	-3.05
27	C14 – H14···O4	3.052	1.392	1.707	0.015	0.278	-0.043	-0.022	0.343	0.966	5.35	-3.12
		3.052	1.393	1.707	0.015	0.279	-0.04	-0.02	0.34	0.967	5.36	-3.13

Symmetry codes: (i) *x*-1/2, -*y*+1/2, *z*-1/2; (ii) *x*, *y*+1, *z*; (iii) *x*+1/2, -*y*+3/2, *z*+1/2; (iv) –*x*+3/2, -*y*+1/2, -*z*+1; (v) –*x*+1, -*y*+1, -*z*+1; (vi) –*x*+3/2, -*y*+3/2, -*z*+1

Table S5

Topological properties of (3,-1) CPs in the intermolecular interactions of hydrated form in the gas phase using the isolated crystal geometry and calculated using Multiwfn: distances (Å), electron density (eÅ^{-3}), Laplacian (eÅ^{-5}), Hessian eigenvalues (eÅ^{-5}), ε = ellipticity, G_{CP} = bond kinetic-energy density (kJ mol^{-1} Bohr^{-3}) and V_{CP} = bond potential-energy density (kJ mol^{-1} Bohr^{-3}).

No	Bonds	d_{12}	d_{1CP}	d_{2CP}	$\rho_{BCP}(r)$	$\nabla^2\rho_{BCP}(r)$	λ_1	λ_2	λ_3	ε	G_{CP}	V_{CP}
1	O2 – H1···O1	1.282	0.947	0.336	0.870	0.673	-9.116	-8.962	17.41	0.017	233.3	-448.3
2	O4 – H4···O6	1.836	1.190	0.647	0.226	2.867	-1.230	-1.166	5.26	0.055	81.19	-84.28
3	O6 – H6b···O3	1.997	1.268	0.729	0.155	1.892	-0.746	-0.731	3.369	0.020	53.01	-54.47

Table S6
Hydrogen-bond geometry (Å, °) of an anhydrous form

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
C15—H15···C11^{i}	0.99	2.75	3.571 (3)	141 (1)
C14—H14···O3^{ii}	1.04	2.43	3.472 (3)	175 (1)
C2—H2···O5^{iii}	0.98	2.46	3.202 (3)	132 (1)
C10—H10*C*···C11	0.99	2.62	3.049 (3)	107 (1)
O4—H4*A*···O1	0.91	1.82	2.672 (2)	157 (1)
O4—H4*A*···N3	0.91	2.21	2.683 (2)	112 (1)
O2—H2*A*···C9	0.93	2.70	3.416 (3)	135 (1)
O2—H2*A*···O1	0.93	1.80	2.681 (2)	158 (1)
O2—H2*A*···N3	0.93	2.21	2.695 (2)	112 (1)
C11—H11*C*···O3^{iv}	0.97	2.39	3.351 (3)	169 (1)
C11—H11*B*···O1^{v}	1.02	2.55	3.535 (3)	163 (1)
C6—H6···O5^{v}	0.98	2.26	3.215 (3)	166 (1)

Symmetry codes: (i) *x*, *y*-1, *z*; (ii) -*x*+1/2, *y*-1/2, *z*; (iii) *x*, *y*+1/2, *z*-1/2; (iv) -*x*+1/2, *y*+1/2, *z*; (v) *x*, *y*+1/2, *z*+1/2.

Table S7

Topological properties of (3,-1) CPs in the intermolecular interactions of an anhydrous form experimental values (above) and theoretical values (below): distances (Å), electron density (eÅ^{-3}), Laplacian (eÅ^{-5}), Hessian eigenvalues (eÅ^{-5}), ε = ellipticity, G_{CP} = bond kinetic-energy density (kJ mol^{-1} Bohr^{-3}) and V_{CP} = bond potential-energy density (kJ mol^{-1} Bohr^{-3}).

No	**Bonds**	d_{12}	d_{1CP}	d_{2CP}	$\rho_{BCP}(r)$	$\nabla^2\rho_{BCP}(r)$	λ_1	λ_2	λ_3	ε	G_{CP}	V_{CP}
1	O4—H4A···O1	1.686	1.120	0.567	0.324	1.497	-2.256	-2.142	5.895	0.053	75	-109.2
		1.686	1.124	0.562	0.313	2.102	-1.912	-1.837	5.851	0.041	83.21	-109.2
2	O2—H2A···O1	1.726	1.153	0.576	0.311	1.59	-2.168	-2.024	5.783	0.071	73.62	-103.9
		1.726	1.135	0.592	0.301	1.81	-1.883	-1.783	5.475	0.056	75.09	-100.9
3	C6—H6···O5^{v}	2.219	0.893	1.327	0.097	1.182	-0.42	-0.413	2.014	0.017	27.91	-23.62
		2.219	0.910	1.309	0.107	1.186	-0.47	-0.462	2.118	0.018	29.09	-25.86
4	C11—H11C···O3^{iv}	2.309	0.946	1.364	0.080	0.979	-0.335	-0.329	1.644	0.016	22.44	-18.21
		2.309	0.948	1.362	0.080	0.922	-0.333	-0.333	1.589	0.0002	21.38	-17.63
5	C14—H14···O3^{ii}	2.384	0.959	1.425	0.070	0.829	-0.294	-0.29	1.413	0.014	18.79	-14.99
		2.384	0.980	1.404	0.071	0.858	-0.285	-0.276	1.419	0.032	19.36	-15.34
6	C2—H2···O5^{iii}	2.401	0.993	1.409	0.061	0.988	-0.231	-0.171	1.39	0.352	20.86	-14.81

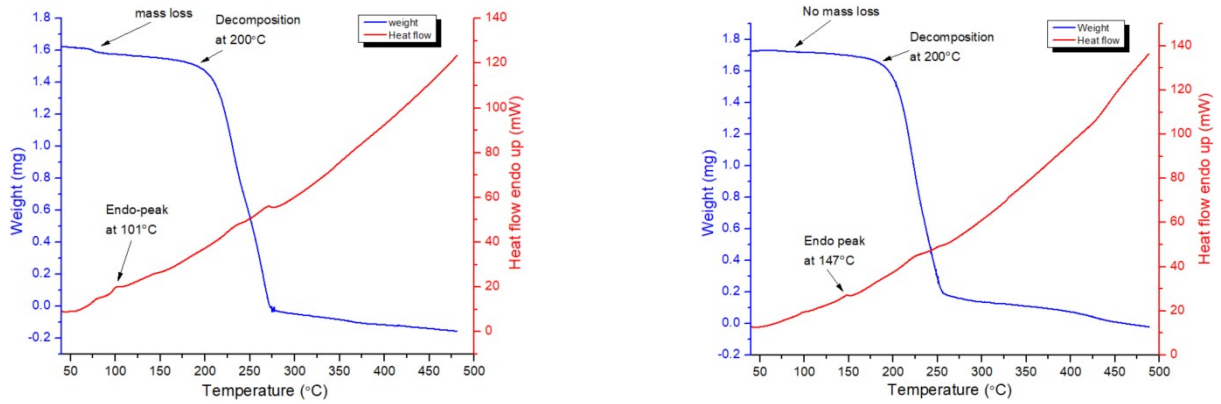
		2.401	1.005	1.397	0.065	0.97	-0.235	-0.194	1.399	0.211	20.89	-15.35
7	C11—H11B···O1^{v}	2.484	1.022	1.463	0.059	0.703	-0.215	-0.211	1.129	0.021	15.54	-11.93
		2.484	1.029	1.456	0.057	0.688	-0.209	-0.194	1.09	0.076	15.13	-11.54
8	C11—H11A···O4	2.645	1.111	1.536	0.040	0.628	-0.129	-0.082	0.838	0.584	12.88	-8.67
		2.645	1.108	1.541	0.041	0.617	-0.119	-0.078	0.814	0.531	12.74	-8.68
9	C10—H10A···O5	2.630	1.104	1.534	0.037	0.666	-0.12	-0.06	0.847	0.992	13.4	-8.67
		2.630	1.122	1.522	0.041	0.644	-0.121	-0.061	0.826	0.983	13.24	-8.93
10	C11—H11B···N3	2.803	1.235	1.609	0.037	0.598	-0.09	-0.044	0.731	1.061	12.14	-8.01
		2.803	1.271	1.602	0.039	0.561	-0.089	-0.039	0.689	1.279	11.58	-7.89
11	C15—H15···C11^{i}	2.698	1.104	1.634	0.036	0.563	-0.122	-0.059	0.744	1.069	11.47	-7.61
		2.698	1.085	1.617	0.046	0.574	-0.119	-0.084	0.777	0.425	12.24	-8.85
12	C4—H4···O5	2.802	1.185	1.618	0.026	0.41	-0.082	-0.058	0.551	0.399	8.16	-5.13
		2.802	1.211	1.592	0.027	0.409	-0.078	-0.065	0.552	0.213	8.19	-5.24
13	C13—H13···C13	3.186	1.363	1.841	0.018	0.251	-0.034	-0.016	0.301	1.114	4.94	-3.03
		3.186	1.387	1.815	0.020	0.239	-0.035	-0.024	0.298	0.416	4.78	-3.07

Symmetry codes: (i) *x*, *y*-1, *z*; (ii) -*x*+1/2, *y*-1/2, *z*; (iii) *x*, *y*+1/2, *z*-1/2; (iv) -*x*+1/2, *y*+1/2, *z*; (v) *x*, *y*+1/2, *z*+1/2.

Table S8

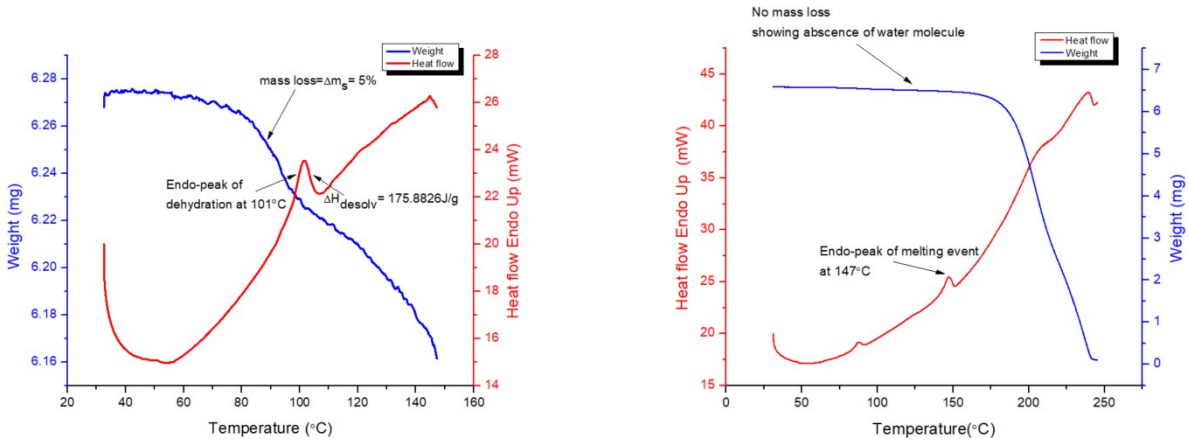
Topological properties of (3,-1) CPs in the intermolecular interactions of an anhydrous form in the gas phase using the isolated crystal geometry and calculated using Multiwfn: distances (Å), electron density (eÅ^{-3}), Laplacian (eÅ^{-5}), Hessian eigenvalues (eÅ^{-5}), ε = ellipticity, G_{CP} = bond kinetic-energy density (kJ mol^{-1} Bohr^{-3}) and V_{CP} = bond potential-energy density (kJ mol^{-1} Bohr^{-3}).

No	Bonds	d_{12}	d_{1CP}	d_{2CP}	$\rho_{BCP}(r)$	$\nabla^2\rho_{BCP}(r)$	λ_1	λ_2	λ_3	ε	G_{CP}	V_{CP}
1	O4—H4A···O1	1.801	1.174	0.628	0.237	2.997	-1.296	-1.279	5.571	0.013	83.7	-85.80
2	O2—H2A···O1	1.816	1.175	0.643	0.222	2.973	-1.185	-1.165	5.323	0.017	81.6	-81.74



(a) **(b)**

Figure S1: TGA/DSC pattern (upto 500 °C) of the co-crystals showing the events of dehydration, melting and decomposition, (a) hydrated form (b) anhydrous form



(a) **(b)**

Figure S2: A repetition of the above mentioned TGA/DSC pattern with higher substrate weight for better visualization of the co-crystals showing the event of dehydration (a) hydrated form (upto 150°C) (b) anhydrous form (upto 250°C)

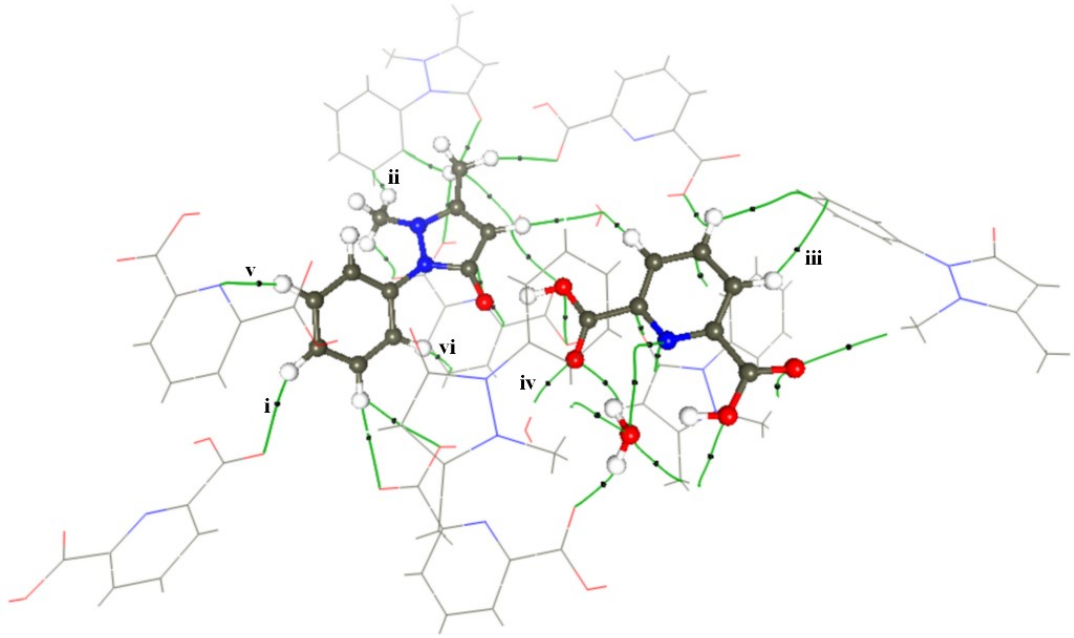


Figure S3: A diagram showing the cluster of hydrated form around reference molecule, green lines show bond path and the black dots shows the critical points. Symmetry codes are same as in Table S3.

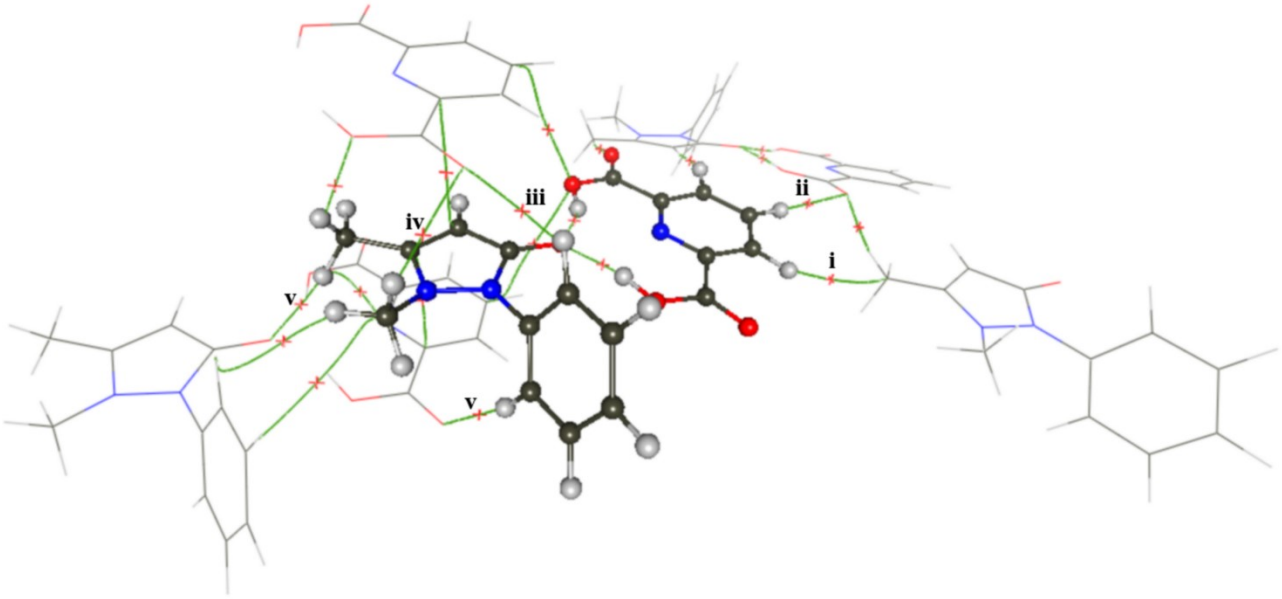
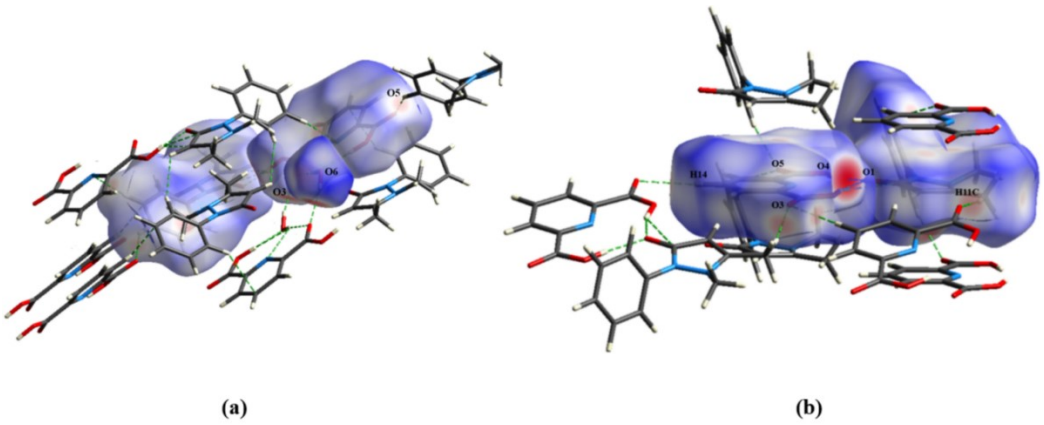
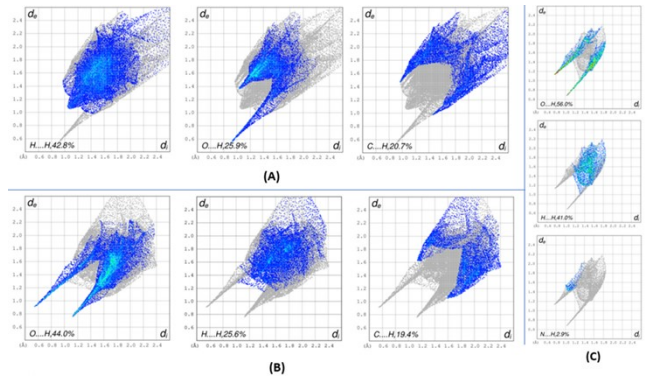


Figure S4: A diagram showing the cluster of an anhydrous form around reference molecule, green lines show bond path and the red cross shows the critical points. Symmetry codes are same as in Table S5.

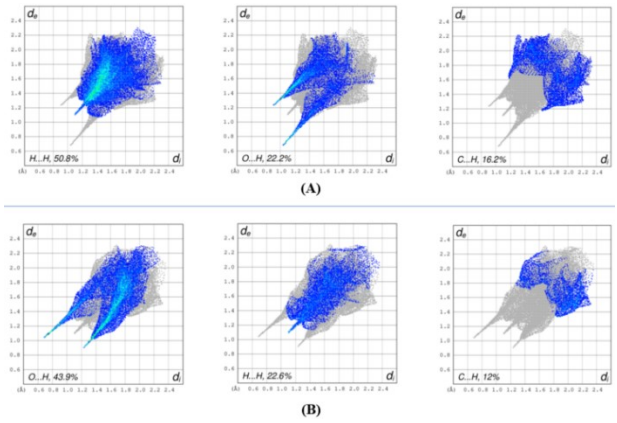


(a) (b)

Figure S5: A Hirshfeld surface calculated for individual fragments (a) hydrated form of **ANT-DPA** cocrystal and (b) anhydrous form of **ANT-DPA** cocrystal, showing the sites of interactions interacting.



(a)



(b)

Figure S6: Fingerprint plots showing percentage contribution of various interactions (a) hydrated form of **ANT-DPA-w** cocrystal (A) antipyrine, (B) dipicolinic acid and (C) water molecule (b) anhydrous form of **ANT-DPA** cocrystal (A) antipyrine, (B) dipicolinic acid.