MATERIAL SUPPORTING TO

Structural and vibrational characterization of anhydrous and dihydrated species of trehalose based on the FTIR and FTRaman spectra and DFT calculations

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Table S1. Atomic MK and NPA charges for the four trehalose forms in gas phase using the B3LYP/6-31G*Method[a]

	MK´s charges					NPA´s charges				
	Anhydrous			Dihydrated		Anhydrous			Dihydrated	
Atoms	αα	αβ	ββ	Atoms	αα	αα	αβ	ββ	Atoms	αα
1 O	-0.304	-0.304	-0.3040	1 O	-0.230	-0.662	-0.663	-0.662	1 O	-0.632
2 O	-0.288	-0.323	-0.3038	2 O	-0.413	-0.610	-0.606	-0.605	2 O	-0.592
3 O	-0.219	-0.340	-0.1653	3 O	-0.478	-0.588	-0.589	-0.602	3 O	-0.636
4 O	-0.607	-0.577	-0.5928	4 O	-0.714	-0.754	-0.754	-0.754	4 O	-0.802
5 O	-0.602	-0.576	-0.6032	5 O	-0.582	-0.754	-0.755	-0.752	5 O	-0.755
6 O	-0.613	-0.614	-0.6037	6 O	-0.643	-0.768	-0.769	-0.769	6 O	-0.774
7 O	-0.588	-0.595	-0.5502	7 O	-0.606	-0.769	-0.769	-0.744	7 O	-0.770
8 O	-0.647	-0.591	-0.5949	8 O	-0.633	-0.758	-0.765	-0.765	8 O	-0.772
9 O	-0.617	-0.610	-0.6026	9 O	-0.622	-0.760	-0.760	-0.746	9 O	-0.760
10 O	-0.615	-0.597	-0.5920	10 O	-0.577	-0.747	-0.750	-0.750	10 O	-0.753
11 O	-0.631	-0.631	-0.5724	11 O	-0.665	-0.752	-0.750	-0.752	11 O	-0.798
12 C	-0.147	0.127	0.0749	12 C	0.075	0.374	0.375	0.375	12 C	0.374
13 C	-0.271	-0.003	-0.1600	13 C	0.084	0.377	0.377	0.374	13 C	0.381
14 C	0.316	0.101	0.2131	14 C	0.226	0.028	0.022	0.022	14 C	0.030
15 C	0.301	0.161	0.3246	15 C	0.141	0.028	0.028	0.021	15 C	0.032
16 C	0.061	0.234	0.1908	16 C	0.131	0.045	0.046	0.046	16 C	0.055
17 C	-0.027	0.078	-0.0398	17 C	0.121	0.045	0.045	0.051	17 C	0.039
18 C	0.164	0.081	0.0840	18 C	0.202	0.058	0.054	0.054	18 C	0.046
19 C	0.154	0.074	0.3901	19 C	-0.015	0.060	0.059	0.055	19 C	0.060
20 C	-0.009	0.010	0.0573	20 C	0.212	0.037	0.032	0.030	20 C	0.042
21 C	0.084	0.199	-0.4311	21 C	0.283	0.045	0.046	0.027	21 C	0.033
22 C	0.185	0.179	0.1670	22 C	0.169	-0.106	-0.107	-0.107	22 C	-0.110
23 C	0.139	0.126	0.1944	23 C	0.091	-0.109	-0.109	-0.106	23 C	-0.117
24 H	0.237	0.162	0.1693	24 H	0.180	0.251	0.250	0.250	24 H	0.230
25 H	0.243	0.169	0.1883	25 H	0.136	0.237	0.237	0.237	25 H	0.232
26 H	0.080	0.116	0.0834	26 H	0.033	0.249	0.256	0.256	26 H	0.231
27 H	0.104	0.111	0.0786	27 H	0.112	0.248	0.248	0.245	27 H	0.245
28 H	0.065	0.005	0.0103	28 H	0.052	0.209	0.212	0.211	28 H	0.216
29 H	0.092	0.053	0.0437	29 H	0.062	0.208	0.208	0.200	29 H	0.227
30 H	0.062	0.069	0.0677	30 H	0.037	0.217	0.226	0.227	30 H	0.228
31 H	0.062	0.073	0.0957	31 H	0.095	0.217	0.217	0.248	31 H	0.214
32 H	0.145	0.073	0.0592	32 H	-0.004	0.227	0.226	0.228	32 H	0.215
33 H	0.147	0.107	0.2350	33 H	0.074	0.230	0.229	0.234	33 H	0.249
34 H	0.008	0.052	0.0491	34 H	0.006	0.197	0.220	0.220	34 H	0.209
35 H	0.105	0.071	0.0697	35 H	0.063	0.240	0.224	0.225	35 H	0.233
36 H	0.026	0.028	0.0499	36 H	0.024	0.203	0.203	0.211	36 H	0.204
37 H	0.051	0.048	0.0294	37 H	0.115	0.222	0.221	0.207	37 H	0.248
38 H	0.390	0.376	0.3779	38 H	0.485	0.482	0.482	0.481	38 H	0.512
39 H	0.409	0.385	0.4050	39 H	0.389	0.483	0.481	0.481	39 H	0.485
40 H	0.416	0.408	0.4012	40 H	0.437	0.491	0.494	0.493	40 H	0.493
41 H	0.418	0.416	0.3969	41 H	0.417	0.492	0.491	0.483	41 H	0.492
42 H	0.455	0.418	0.4202	42 H	0.430	0.491	0.492	0.492	42 H	0.495
43 H	0.443	0.440	0.4015	43 H	0.457	0.492	0.492	0.473	43 H	0.494
44 H	0.408	0.392	0.3882	44 H	0.379	0.477	0.478	0.478	44 H	0.481
45 H	0.419	0.420	0.3994	45 H	0.450	0.477	0.477	0.479	45 H	0.513
				46 O	-0.794				46 O	-0.964
				47 O	-0.851				47 O	-0.979
				48 H	0.424				48 H	0.485

49	H	0.385	49	H	0.503
50	H	0.413	50	H	0.482
51	H	0.436	51	H	0.508

[a]This work

Table S2. Atomic MK and NPA charges for the four trehalose forms in solution using the B3LYP/6-31G*Method[a]

MK´s charges						NPA´s charges				
	Anhydrous			Dihydrated			Anhydrous			Dihydrated
Atoms	αα	αβ	ββ	Atoms	αα	αα	αβ	ββ	Atoms	αα
1 O	-0.232	-0.226	-0.288	1 O	-0.219	-0.652	-0.654	-0.657	1 O	-0.647
2 O	-0.346	-0.287	-0.291	2 O	-0.278	-0.611	-0.608	-0.606	2 O	-0.610
3 O	-0.279	-0.324	-0.191	3 O	-0.439	-0.591	-0.590	-0.601	3 O	-0.626
4 O	-0.548	-0.577	-0.595	4 O	-0.686	-0.736	-0.750	-0.752	4 O	-0.731
5 O	-0.556	-0.587	-0.603	5 O	-0.602	-0.736	-0.750	-0.751	5 O	-0.733
6 O	-0.585	-0.585	-0.581	6 O	-0.630	-0.746	-0.745	-0.745	6 O	-0.743
7 O	-0.567	-0.580	-0.546	7 O	-0.607	-0.745	-0.766	-0.743	7 O	-0.745
8 O	-0.593	-0.537	-0.548	8 O	-0.618	-0.759	-0.748	-0.749	8 O	-0.759
9 O	-0.585	-0.611	-0.593	9 O	-0.633	-0.760	-0.762	-0.744	9 O	-0.756
10 O	-0.605	-0.586	-0.610	10 O	-0.570	-0.747	-0.746	-0.747	10 O	-0.757
11 O	-0.636	-0.625	-0.580	11 O	-0.661	-0.746	-0.747	-0.750	11 O	-0.770
12 C	-0.037	0.035	0.040	12 C	-0.163	0.375	0.376	0.374	12 C	0.376
13 C	-0.199	-0.140	-0.128	13 C	-0.054	0.377	0.377	0.376	13 C	0.380
14 C	0.116	0.136	0.234	14 C	0.271	0.040	0.025	0.026	14 C	0.039
15 C	0.139	0.257	0.293	15 C	0.248	0.039	0.030	0.024	15 C	0.041
16 C	0.228	0.246	0.184	16 C	0.054	0.045	0.053	0.054	16 C	0.045
17 C	0.164	0.035	-0.038	17 C	0.122	0.045	0.043	0.046	17 C	0.045
18 C	-0.053	0.079	0.141	18 C	0.230	0.046	0.054	0.054	18 C	0.046
19 C	-0.095	0.020	0.356	19 C	0.046	0.047	0.057	0.054	19 C	0.045
20 C	0.113	-0.165	-0.173	20 C	0.030	0.033	0.024	0.021	20 C	0.035
21 C	0.244	0.254	-0.343	21 C	0.235	0.043	0.047	0.026	21 C	0.037
22 C	0.140	0.177	0.294	22 C	0.082	-0.107	-0.111	-0.111	22 C	-0.117
23 C	0.050	0.103	0.212	23 C	0.090	-0.109	-0.110	-0.107	23 C	-0.117
24 H	0.215	0.184	0.182	24 H	0.247	0.246	0.245	0.248	24 H	0.241
25 H	0.229	0.203	0.189	25 H	0.192	0.235	0.234	0.234	25 H	0.232
26 H	0.147	0.141	0.112	26 H	0.047	0.250	0.265	0.265	26 H	0.255
27 H	0.164	0.102	0.090	27 H	0.093	0.250	0.251	0.246	27 H	0.251
28 H	0.042	-0.012	0.004	28 H	0.091	0.213	0.205	0.204	28 H	0.213
29 H	0.062	0.066	0.046	29 H	0.063	0.213	0.211	0.204	29 H	0.215
30 H	0.088	0.084	0.067	30 H	0.058	0.220	0.227	0.228	30 H	0.224
31 H	0.096	0.095	0.096	31 H	0.082	0.220	0.220	0.248	31 H	0.221
32 H	0.130	0.140	0.123	32 H	0.074	0.229	0.223	0.228	32 H	0.229
33 H	0.140	0.104	0.201	33 H	0.078	0.231	0.229	0.235	33 H	0.234
34 H	0.025	0.035	-0.004	34 H	0.049	0.198	0.203	0.204	34 H	0.216
35 H	0.102	0.074	0.042	35 H	0.097	0.239	0.222	0.222	35 H	0.243
36 H	0.049	0.029	0.039	36 H	0.028	0.200	0.202	0.211	36 H	0.191
37 H	0.062	0.050	0.020	37 H	0.115	0.218	0.221	0.208	37 H	0.240
38 H	0.365	0.368	0.376	38 H	0.457	0.474	0.477	0.475	38 H	0.474
39 H	0.383	0.380	0.405	39 H	0.394	0.474	0.476	0.478	39 H	0.475
40 H	0.386	0.392	0.389	40 H	0.437	0.471	0.482	0.482	40 H	0.472
41 H	0.385	0.407	0.393	41 H	0.408	0.471	0.489	0.481	41 H	0.473
42 H	0.412	0.390	0.390	42 H	0.419	0.477	0.479	0.480	42 H	0.480
43 H	0.416	0.440	0.397	43 H	0.449	0.477	0.490	0.472	43 H	0.480
44 H	0.396	0.400	0.401	44 H	0.390	0.475	0.479	0.479	44 H	0.490
45 H	0.427	0.416	0.395	45 H	0.443	0.474	0.474	0.477	45 H	0.490
				46 O	-0.758				46 O	-0.647
				47 O	-0.820				47 O	-0.610
				48 H	0.411				48 H	-0.626

49	H	0.369	49	H	-0.731
50	H	0.403	50	H	-0.733
51	H	0.433	51	H	-0.743

[a]This work

Table S3. Calculated molecular electrostatic potential (a.u.) for the four trehalose species in gas phase and aqueous solution

B3LYP/6-31G* method											
Gas phase						Aqueous solution/PCM					
Anhydrous				Dihydrated		Anhydrous				Dihydrated	
Atoms	αα	αβ	ββ	Atoms	αα	Atoms	αα	αβ	ββ	Atoms	αα
1 O	-22.272	-22.273	-22.270	1 O	-22.281	1 O	-22.279	-22.276	-22.272	1 O	-22.281
2 O	-22.283	-22.287	-22.284	2 O	-22.298	2 O	-22.290	-22.289	-22.287	2 O	-22.301
3 O	-22.288	-22.289	-22.281	3 O	-22.269	3 O	-22.296	-22.295	-22.286	3 O	-22.266
4 O	-22.293	-22.291	-22.288	4 O	-22.326	4 O	-22.312	-22.299	-22.294	4 O	-22.331
5 O	-22.292	-22.292	-22.290	5 O	-22.293	5 O	-22.312	-22.294	-22.290	5 O	-22.292
6 O	-22.300	-22.295	-22.293	6 O	-22.312	6 O	-22.302	-22.317	-22.314	6 O	-22.312
7 O	-22.298	-22.297	-22.313	7 O	-22.298	7 O	-22.301	-22.295	-22.313	7 O	-22.295
8 O	-22.307	-22.311	-22.308	8 O	-22.306	8 O	-22.295	-22.305	-22.304	8 O	-22.312
9 O	-22.305	-22.305	-22.307	9 O	-22.304	9 O	-22.292	-22.306	-22.307	9 O	-22.301
10 O	-22.320	-22.322	-22.319	10 O	-22.325	10 O	-22.323	-22.314	-22.312	10 O	-22.321
11 O	-22.311	-22.312	-22.304	11 O	-22.301	11 O	-22.316	-22.317	-22.308	11 O	-22.300
12 C	-14.620	-14.622	-14.619	12 C	-14.631	12 C	-14.628	-14.626	-14.624	12 C	-14.633
13 C	-14.619	-14.620	-14.616	13 C	-14.615	13 C	-14.628	-14.623	-14.619	13 C	-14.615
14 C	-14.672	-14.675	-14.671	14 C	-14.687	14 C	-14.679	-14.681	-14.678	14 C	-14.690
15 C	-14.671	-14.672	-14.671	15 C	-14.671	15 C	-14.679	-14.674	-14.671	15 C	-14.669
16 C	-14.678	-14.674	-14.671	16 C	-14.691	16 C	-14.679	-14.678	-14.675	16 C	-14.690
17 C	-14.676	-14.676	-14.678	17 C	-14.678	17 C	-14.678	-14.674	-14.676	17 C	-14.673
18 C	-14.677	-14.675	-14.673	18 C	-14.689	18 C	-14.676	-14.672	-14.670	18 C	-14.686
19 C	-14.675	-14.675	-14.674	19 C	-14.674	19 C	-14.674	-14.675	-14.674	19 C	-14.668
20 C	-14.679	-14.677	-14.674	20 C	-14.685	20 C	-14.681	-14.676	-14.675	20 C	-14.684
21 C	-14.675	-14.675	-14.670	21 C	-14.673	21 C	-14.677	-14.677	-14.672	21 C	-14.668
22 C	-14.692	-14.694	-14.691	22 C	-14.695	22 C	-14.694	-14.681	-14.680	22 C	-14.694
23 C	-14.685	-14.685	-14.676	23 C	-14.678	23 C	-14.687	-14.688	-14.679	23 C	-14.675
24 H	-1.098	-1.099	-1.097	24 H	-1.103	24 H	-1.104	-1.102	-1.101	24 H	-1.103
25 H	-1.096	-1.097	-1.093	25 H	-1.090	25 H	-1.102	-1.097	-1.095	25 H	-1.089
26 H	-1.099	-1.102	-1.099	26 H	-1.118	26 H	-1.107	-1.111	-1.108	26 H	-1.121
27 H	-1.098	-1.098	-1.098	27 H	-1.097	27 H	-1.107	-1.100	-1.097	27 H	-1.096
28 H	-1.108	-1.103	-1.101	28 H	-1.123	28 H	-1.106	-1.108	-1.105	28 H	-1.122
29 H	-1.107	-1.106	-1.109	29 H	-1.110	29 H	-1.105	-1.102	-1.105	29 H	-1.104
30 H	-1.113	-1.110	-1.108	30 H	-1.125	30 H	-1.106	-1.102	-1.099	30 H	-1.120
31 H	-1.111	-1.111	-1.104	31 H	-1.110	31 H	-1.104	-1.111	-1.103	31 H	-1.104
32 H	-1.111	-1.107	-1.105	32 H	-1.115	32 H	-1.113	-1.103	-1.102	32 H	-1.113
33 H	-1.108	-1.109	-1.097	33 H	-1.106	33 H	-1.111	-1.111	-1.100	33 H	-1.101
34 H	-1.124	-1.129	-1.126	34 H	-1.126	34 H	-1.123	-1.112	-1.112	34 H	-1.121
35 H	-1.119	-1.117	-1.114	35 H	-1.122	35 H	-1.120	-1.103	-1.102	35 H	-1.122
36 H	-1.115	-1.116	-1.107	36 H	-1.104	36 H	-1.117	-1.119	-1.110	36 H	-1.101
37 H	-1.116	-1.116	-1.107	37 H	-1.107	37 H	-1.117	-1.119	-1.109	37 H	-1.103
38 H	-0.977	-0.976	-0.973	38 H	-1.009	38 H	-0.995	-0.984	-0.979	38 H	-1.012
39 H	-0.977	-0.976	-0.975	39 H	-0.978	39 H	-0.995	-0.978	-0.975	39 H	-0.977
40 H	-0.982	-0.979	-0.976	40 H	-0.995	40 H	-0.982	-0.998	-0.996	40 H	-0.995
41 H	-0.980	-0.980	-0.994	41 H	-0.981	41 H	-0.981	-0.978	-0.994	41 H	-0.978
42 H	-0.989	-0.993	-0.991	42 H	-0.990	42 H	-0.975	-0.985	-0.983	42 H	-0.994
43 H	-0.987	-0.987	-0.989	43 H	-0.986	43 H	-0.972	-0.989	-0.989	43 H	-0.983
44 H	-1.004	-1.006	-1.003	44 H	-1.009	44 H	-1.007	-0.998	-0.996	44 H	-1.003
45 H	-0.991	-0.992	-0.984	45 H	-0.990	45 H	-0.997	-0.997	-0.989	45 H	-0.988
				46 O	-22.290					46 O	-22.287
				47 O	-22.309					47 O	-22.310

48	H	-0.970	48	H	-0.968
49	H	-0.976	49	H	-0.973
50	H	-0.989	50	H	-0.990
51	H	-0.997	51	H	-0.997

[a]This work

Table S4. Wiberg Index for the four trehalose species in gas and aqueous solution phases

B3LYP/6-31G*Method[a]											
	Gas phase					Aqueous solution/PCM					
Atoms	Anhydrous			Dihydrated		Anhydrous				Dihydrated	
	αα	αβ	ββ	Atoms	αα	Atoms	αα	αβ	ββ	Atoms	αα
1 O	1.980	1.978	1.980	1 O	2.015	1 O	1.992	1.990	1.988	1 O	1.998
2 O	2.012	2.019	2.020	2 O	2.023	2 O	2.007	2.011	2.012	2 O	2.008
3 O	2.030	2.030	2.018	3 O	1.998	3 O	2.023	2.023	2.016	3 O	2.011
4 O	1.801	1.802	1.801	4 O	1.759	4 O	1.813	1.806	1.804	4 O	1.817
5 O	1.800	1.799	1.802	5 O	1.799	5 O	1.812	1.803	1.803	5 O	1.816
6 O	1.781	1.786	1.787	6 O	1.775	6 O	1.802	1.798	1.799	6 O	1.804
7 O	1.781	1.781	1.805	7 O	1.779	7 O	1.802	1.783	1.800	7 O	1.802
8 O	1.787	1.786	1.786	8 O	1.777	8 O	1.788	1.799	1.798	8 O	1.787
9 O	1.786	1.785	1.807	9 O	1.785	9 O	1.788	1.781	1.807	9 O	1.791
10 O	1.793	1.788	1.789	10 O	1.790	10 O	1.790	1.788	1.788	10 O	1.809
11 O	1.783	1.784	1.785	11 O	1.784	11 O	1.784	1.783	1.783	11 O	1.770
12 C	3.752	3.753	3.752	12 C	3.763	12 C	3.755	3.753	3.751	12 C	3.754
13 C	3.764	3.765	3.762	13 C	3.762	13 C	3.765	3.768	3.765	13 C	3.760
14 C	3.873	3.868	3.868	14 C	3.885	14 C	3.880	3.865	3.864	14 C	3.880
15 C	3.874	3.874	3.875	15 C	3.876	15 C	3.881	3.873	3.875	15 C	3.880
16 C	3.879	3.875	3.875	16 C	3.875	16 C	3.879	3.892	3.892	16 C	3.880
17 C	3.879	3.879	3.890	17 C	3.871	17 C	3.878	3.877	3.890	17 C	3.880
18 C	3.877	3.875	3.875	18 C	3.868	18 C	3.870	3.874	3.874	18 C	3.870
19 C	3.876	3.876	3.874	19 C	3.878	19 C	3.870	3.876	3.875	19 C	3.871
20 C	3.846	3.854	3.852	20 C	3.857	20 C	3.850	3.858	3.855	20 C	3.850
21 C	3.853	3.854	3.850	21 C	3.827	21 C	3.856	3.855	3.852	21 C	3.832
22 C	3.817	3.815	3.814	22 C	3.819	22 C	3.818	3.827	3.826	22 C	3.800
23 C	3.811	3.812	3.816	23 C	3.807	23 C	3.817	3.815	3.818	23 C	3.834
24 H	0.942	0.942	0.942	24 H	0.952	24 H	0.944	0.944	0.943	24 H	0.948
25 H	0.949	0.949	0.949	25 H	0.951	25 H	0.950	0.951	0.951	25 H	0.951
26 H	0.942	0.939	0.939	26 H	0.951	26 H	0.941	0.933	0.933	26 H	0.938
27 H	0.942	0.942	0.945	27 H	0.944	27 H	0.941	0.941	0.944	27 H	0.940
28 H	0.963	0.960	0.960	28 H	0.959	28 H	0.960	0.963	0.963	28 H	0.960
29 H	0.963	0.963	0.965	29 H	0.954	29 H	0.960	0.961	0.964	29 H	0.959
30 H	0.959	0.953	0.953	30 H	0.954	30 H	0.957	0.952	0.952	30 H	0.955
31 H	0.958	0.958	0.942	31 H	0.960	31 H	0.957	0.957	0.942	31 H	0.957
32 H	0.956	0.955	0.954	32 H	0.960	32 H	0.955	0.958	0.955	32 H	0.955
33 H	0.954	0.955	0.952	33 H	0.947	33 H	0.954	0.955	0.952	33 H	0.952
34 H	0.965	0.955	0.955	34 H	0.959	34 H	0.965	0.964	0.963	34 H	0.958
35 H	0.944	0.951	0.951	35 H	0.949	35 H	0.945	0.953	0.952	35 H	0.943
36 H	0.963	0.963	0.960	36 H	0.962	36 H	0.964	0.963	0.960	36 H	0.968
37 H	0.954	0.954	0.960	37 H	0.941	37 H	0.956	0.954	0.959	37 H	0.945
38 H	0.770	0.771	0.772	38 H	0.741	38 H	0.778	0.775	0.777	38 H	0.778
39 H	0.770	0.771	0.772	39 H	0.767	39 H	0.778	0.776	0.774	39 H	0.777
40 H	0.762	0.759	0.760	40 H	0.760	40 H	0.781	0.771	0.771	40 H	0.779
41 H	0.761	0.761	0.769	41 H	0.761	41 H	0.781	0.763	0.772	41 H	0.779
42 H	0.761	0.761	0.761	42 H	0.757	42 H	0.775	0.772	0.771	42 H	0.773
43 H	0.760	0.760	0.780	43 H	0.759	43 H	0.775	0.762	0.781	43 H	0.772
44 H	0.775	0.774	0.774	44 H	0.772	44 H	0.777	0.773	0.773	44 H	0.762
45 H	0.774	0.774	0.772	45 H	0.740	45 H	0.777	0.777	0.774	45 H	0.764
				46 O	1.591					46 O	1.998
				47 O	1.581					47 O	2.008
				48 H	0.766					48 H	2.011

49	H	0.749	49	H	1.817
50	H	0.769	50	H	1.816
51	H	0.746	51	H	1.804

[a]This work

Table S5. Donor-acceptor interaction energies obtained from the second order perturbation calculations (in kJ/mol) for the trehalose species in gas and in aqueous solution phases at B3LYP/6-31G* level of theory.

GAS PHASE				
Delocalization	Anhydrous			Dihydrated
	αα	αβ	ββ	
*LP(2)O1→σ*O2-C12*	49.37	49.45	46.15	49.57
*LP(2)O1→σ*O3-C13*	45.14	47.74	48.40	62.16
*LP(2)O2→σ*O1-C12*	60.07	63.37	63.66	62.53
*LP(2)O3→σ*O1-C13*	62.95	62.41	59.98	35.82
*LP(2)O4→σ*C12-C14*				45.14
*LP(2)O3→σ*O46-H49*				43.43
*LP(2)O11→σ*O47-H51*				85.65
*LP(2)O46→σ*O11-H45*				99.28
*LP(2)O47→σ*O4-H38*				121.68
ΔE_{Total}	217.53	222.96	218.20	605.26
AQUEOUS SOLUTION (PCM)				
*LP(2)O1→σ*O2-C12*	54.17	53.71	49.99	52.17
*LP(2)O1→σ*O3-C13*	52.67	54.09	50.33	60.53
*LP(2)O2→σ*O1-C12*	55.39	56.89	57.27	57.56
*LP(2)O3→σ*O1-C13*	58.10	57.89	57.52	36.78
*LP(2)O4→σ*C12-C14*				41.34
*LP(2)O3→σ*O46-H49*				16.97
*LP(2)O11→σ*O47-H51*				81.47
*LP(2)O46→σ*O11-H45*				95.85
*LP(2)O47→σ*O4-H38*				117.96
ΔE_{Total}	220.33	222.59	215.10	560.62

Table S6. Analysis of the Bond Critical Points for the anhydrous trehalose species in gas and in aqueous solution phases

B3LYP/6-31G* Method									
Trehalose anhydrous/ Gas phase									
Parameter[#]	αα			αβ			ββ		
	RCP1	RCP2	H33---H38	RCP1	RCP2	O6---H42	RCP1	RCP2	O6---H42
ρ(r)	0.0187	0.0186		0.0187	0.0184	0.0183	0.0190	0.0185	0.0181
$\nabla^2\rho(r)$	0.1247	0.1235		0.1245	0.1228	0.0761	0.1257	0.1229	0.0762
λ1	-0.0138	-0.0138		-0.0138	-0.0143	-0.0197	-0.0135	-0.0143	-0.0193
λ2	0.0666	0.0664		0.0665	0.0675	-0.0075	0.0683	0.0677	-0.0066
λ3	0.0719	0.0709		0.0718	0.0696	0.1033	0.0708	0.0695	0.1022
|λ1|/λ3	0.1919	0.1946		0.1922	0.2055	0.1907	0.1907	0.2058	0.1888
Distances			2.615			2.181			2.185
Trehalose anhydrous /PCM									
Parameter[#]	αα			αβ			ββ		
	RCP1	RCP2	H33---H38	RCP1	RCP2	H32---H39	RCP1	RCP2	O6---H42
ρ(r)	0.0184	0.0184	0.0043	0.0185	0.0185	0.0044	0.0187	0.0185	
$\nabla^2\rho(r)$	0.1215	0.1216	0.0186	0.1227	0.1231	0.0189	0.1238	0.1232	
λ1	-0.0138	-0.0137	-0.0028	-0.0137	-0.0140	-0.0031	-0.0135	-0.0140	
λ2	0.0650	0.0656	-0.0003	0.0664	0.0675	-0.0013	0.0679	0.0677	
λ3	0.0702	0.0697	0.0217	0.0699	0.0695	0.0232	0.0694	0.0694	
|λ1|/λ3	0.1966	0.1966	0.1290	0.1960	0.2014	0.1336	0.1945	0.2017	
Distances			2.395			2.370			3.519

[#]The quantities are in atomics units, distances in Å

Table S7. Analysis of the Bond and Ring Critical Points for the dihydrated trehalose species in gas and in aqueous solution phases

B3LYP/6-31G* Method								
Gas phase								
Parameter[#]	RCP1	RCP2	O3---H49	O4---H33	O8---H44	O11---H51	O46---H45	O47---H38
$\rho(r)$	0.0185	0.0189	0.0329	0.0059	0.0111	0.0408	0.0424	0.0462
$\nabla^2\rho(r)$	0.1223	0.1257	0.1033	0.0210	0.0448	0.1203	0.1252	0.1355
$\lambda1$	-0.0134	-0.0138	-0.0488	-0.0055	-0.0101	-0.0660	-0.0686	-0.0779
$\lambda2$	0.0641	0.0680	-0.0465	-0.0047	-0.0056	-0.0632	-0.0665	-0.0750
$\lambda3$	0.0715	0.0715	0.1986	0.0313	0.0606	0.2496	0.2605	0.2884
$\lvert\lambda1\rvert/\lambda3$	0.1874	0.1930	0.2457	0.1757	0.1667	0.2644	0.2633	0.2701
Distances			1.853	2.736	2.407	1.765	1.759	1.719
Aqueous solution/PCM								
	RCP1	RCP2	O3---H49	O4---H33	O8---H44	O11---H51	O46---H45	O47---H38
$\rho(r)$	0.01842	0.0186	0.0301	0.0042		0.0395	0.0418	0.0455
$\nabla^2\rho(r)$	0.1217	0.1232	0.0915	0.0162		0.1138	0.1183	0.1301
$\lambda1$	-0.0135	-0.0137	-0.04307	-0.0036		-0.0629	-0.0668	-0.0759
$\lambda2$	0.0650	0.0675	-0.0414	-0.0021		-0.0603	-0.0651	-0.0735
$\lambda3$	0.0701	0.0694	0.1760	0.0219		0.2371	0.2503	0.2796
$\lvert\lambda1\rvert/\lambda3$	0.1926	0.1974	0.2447	0.1644		0.2653	0.2669	0.2715
Distances			1.900	2.895	3.139	1.786	1.778	1.735

[#]The quantities are in atomics units, distances in Å

Table S8. The molecular frontier HOMO and LUMO orbitals for all the studied forms of trehalose at B3LYP/6-31G* level of theory

Gas phase											
	Trehalose[a]				Maltose[b]				Lactose[b]		
Orbital	anhydrous			Dihydrated	anhydrous		Monohydrated		anhydrous		Monohydrated
(eV)	αα	αβ	ββ	αα	α	β	α	β	α	β	α
HOMO	-7.1812	-7.1224	-7.1501	-6.9464	-6.652	-6.695	-6.693	-6.732	-6.550	-6.607	-6.816
LUMO	0.9025	0.8887	0.7849	1.0134	1.028	1.094	0.924	1.098	0.718	0.642	0.713
GAP	-8.0837	-8.0111	-7.9350	-7.9597	-7.680	-7.789	-7.617	-7.830	-7.268	-7.249	-7.529
Aqueous solution/PCM											
	Trehalose[a]				Maltose[b]				Lactose[b]		
Orbital	anhydrous			Dihydrated	anhydrous		Monohydrated		anhydrous		Monohydrated
(eV)	αα	αβ	ββ	αα	α	β	α	β	α	β	α
HOMO	-7.0268	-6.9992	-7.0700	-6.8926	-6.431	-6.666	-6.477	-6.873	-6.501	-6.667	-6.343
LUMO	0.8328	0.8534	0.7509	0.9116	1.023	1.056	0.663	0.888	0.697	0.612	0.756
GAP	-7.8596	-7.8526	-7.8209	-7.8042	-7.454	-7.722	-7.140	-7.761	-7.197	-7.279	-7.099

[a]This work, [b]From Ref. Iramain et al., 2016

Table S9. Chemical potential (μ), electronegativity (χ), global hardness (η), global softness (S), global electrophilicity index (ω) and mucleophilic index (E) descriptors for all the studied forms of trehalose at B3LYP/6-31G* level of theory

GAS PHASE											
	Trehalose[a]				maltose[b]				Lactose[b]		
Parameters	Anhydrous			Dihydrated	Anhydrous		Monohydrated		Anhydrous		Monohydrated
(eV)	αα	αβ	ββ	αα	α-	β-	α-	β-	α-	β-	α-
χ	-4.0419	-4.0056	-3.9675	-3.9799	-3.840	-3.895	-3.809	-3.915	-3.634	-3.625	-3.765
μ	-3.1394	-3.1169	-3.1826	-2.9665	-2.812	-2.801	-2.885	-2.817	-2.916	-2.982	-3.052
η	4.0419	4.0056	3.9675	3.9799	3.840	3.895	3.809	3.915	3.634	3.625	3.765
S	0.1237	0.1248	0.1260	0.1256	0.130	0.128	0.131	0.128	0.138	0.138	0.133
ω	1.2192	1.2127	1.2765	1.1056	1.030	1.007	1.092	1.013	1.170	1.227	1.237
E	-12.6888	-12.4847	-12.6270	-11.8064	-10.798	-10.907	-10.986	-11.029	-10.597	-10.810	-11.489
Aqueous solution/PCM											
χ	-3.9298	-3.9263	-3.9105	-3.9021	-3.727	-3.861	-3.570	-3.881	-3.599	-3.640	-3.550
μ	-3.0970	-3.0729	-3.1596	-2.9905	-2.704	-2.805	-2.907	-2.993	-2.902	-3.027	-2.793
η	3.9298	3.9263	3.9105	3.9021	3.727	3.861	3.570	3.881	3.599	3.640	3.550
S	0.1272	0.1273	0.1279	0.1281	0.134	0.130	0.140	0.129	0.139	0.137	0.141
ω	1.2203	1.2025	1.2764	1.1459	0.981	1.019	1.184	1.154	1.170	1.259	1.099
E	-12.1706	-12.0651	-12.3553	-11.6692	-10.078	-10.830	-10.378	-11.612	-10.444	-11.018	-9.915

[a]This work, [b]From Ref. Iramain et al., 2016

$\chi = -[E(LUMO) - E(HOMO)]/2$; $\mu = [E(LUMO) + E(HOMO)]/2$; $\eta = [E(LUMO) - E(HOMO)]/2$; $S = \frac{1}{2}\eta$; $\omega = \mu^2/2\eta$

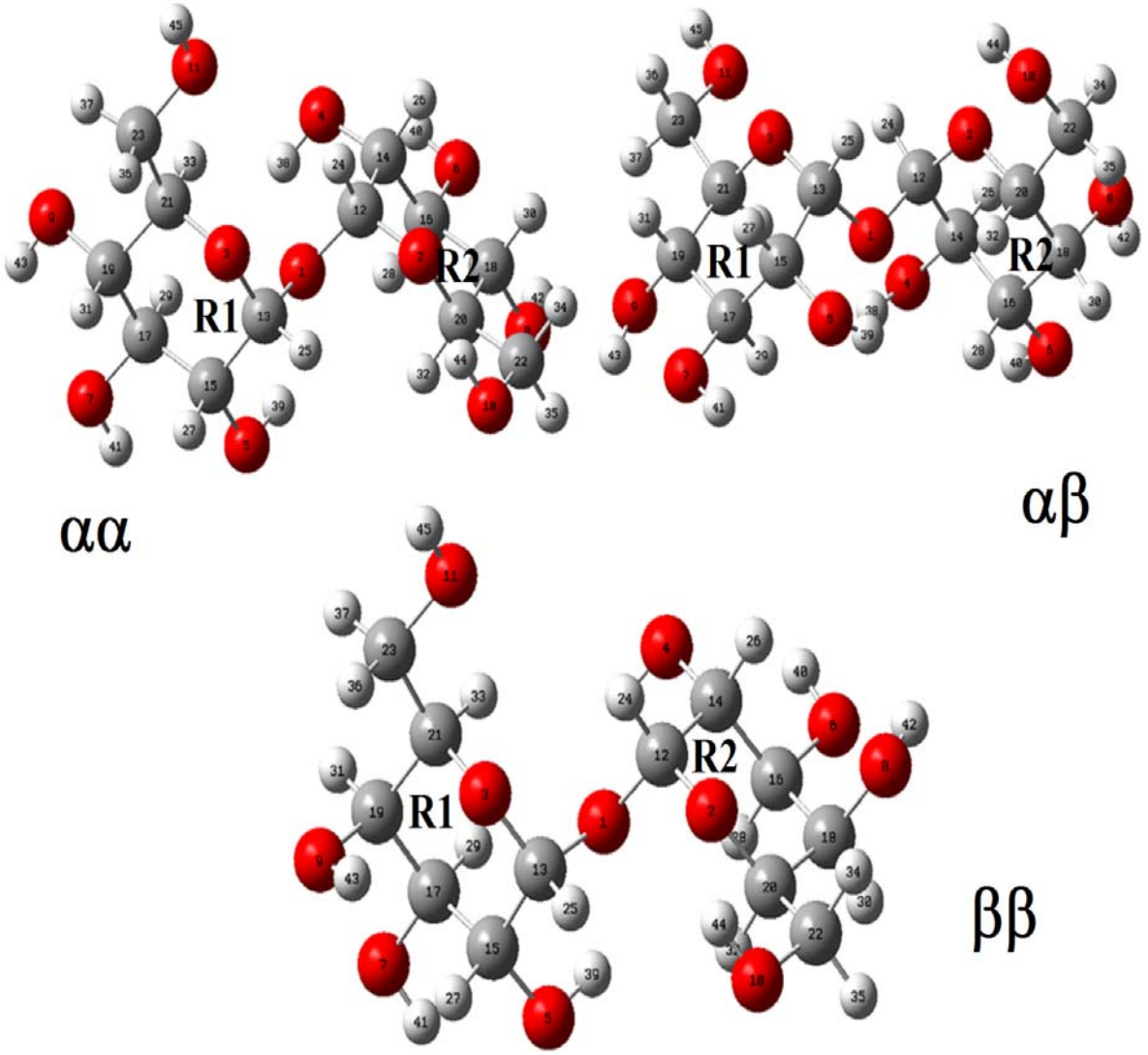

Figure S1. Detailed theoretical structures of αα- (upper), αβ- (medium) and ββ-trehalose (bottom) anhydrous species showing the identifications of the R1 and R2 glucopyranose rings.

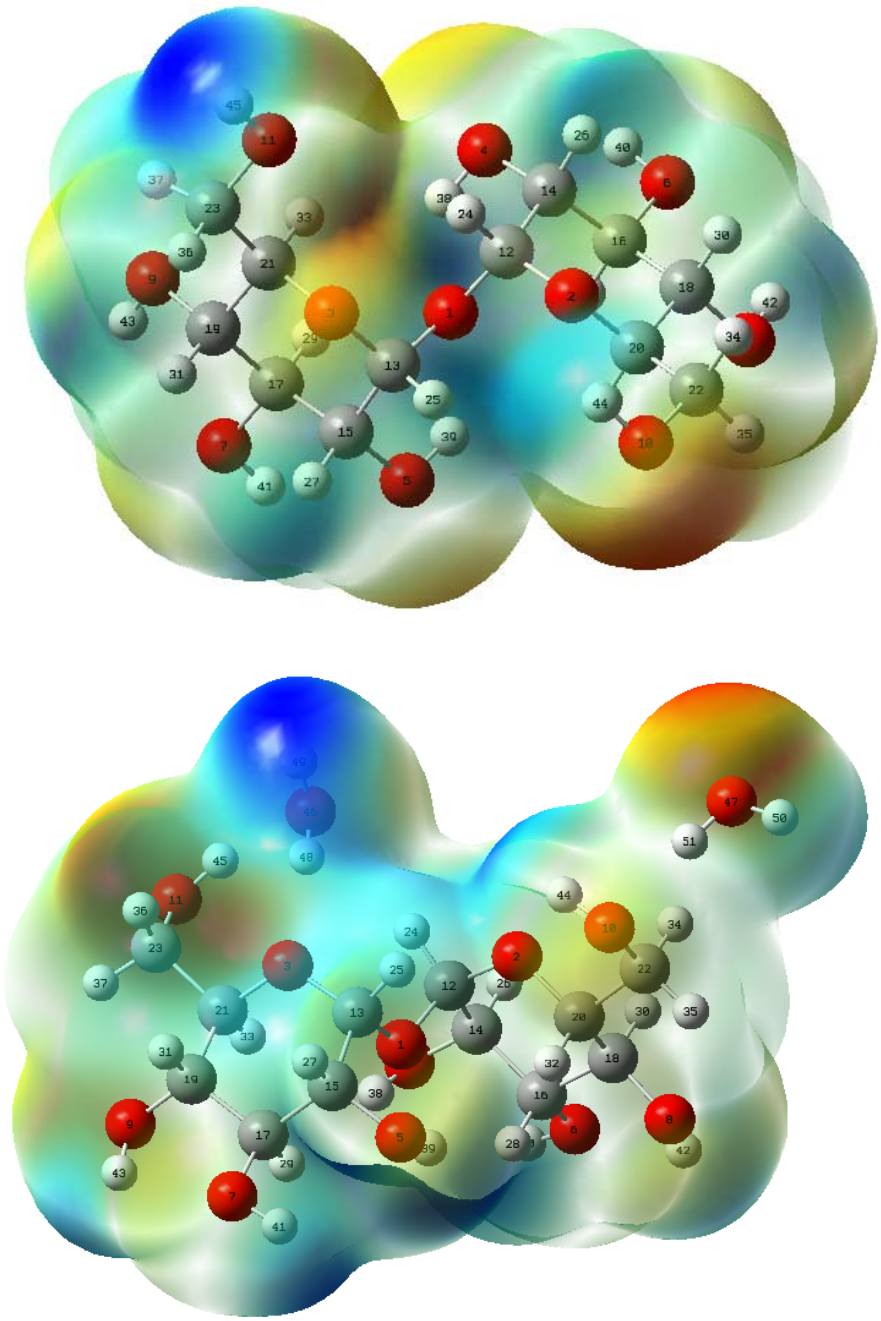

Figure S2. Calculated electrostatic potential surfaces on the molecular surfaces of the α-trehalose anhydrous (upper) and dihydrated (botomm) species in gas phase. Color ranges, in au: from red -0.060 to blue + 0.060. B3LYP functional and 6-31G* basis set. Isodensity value of 0.004.

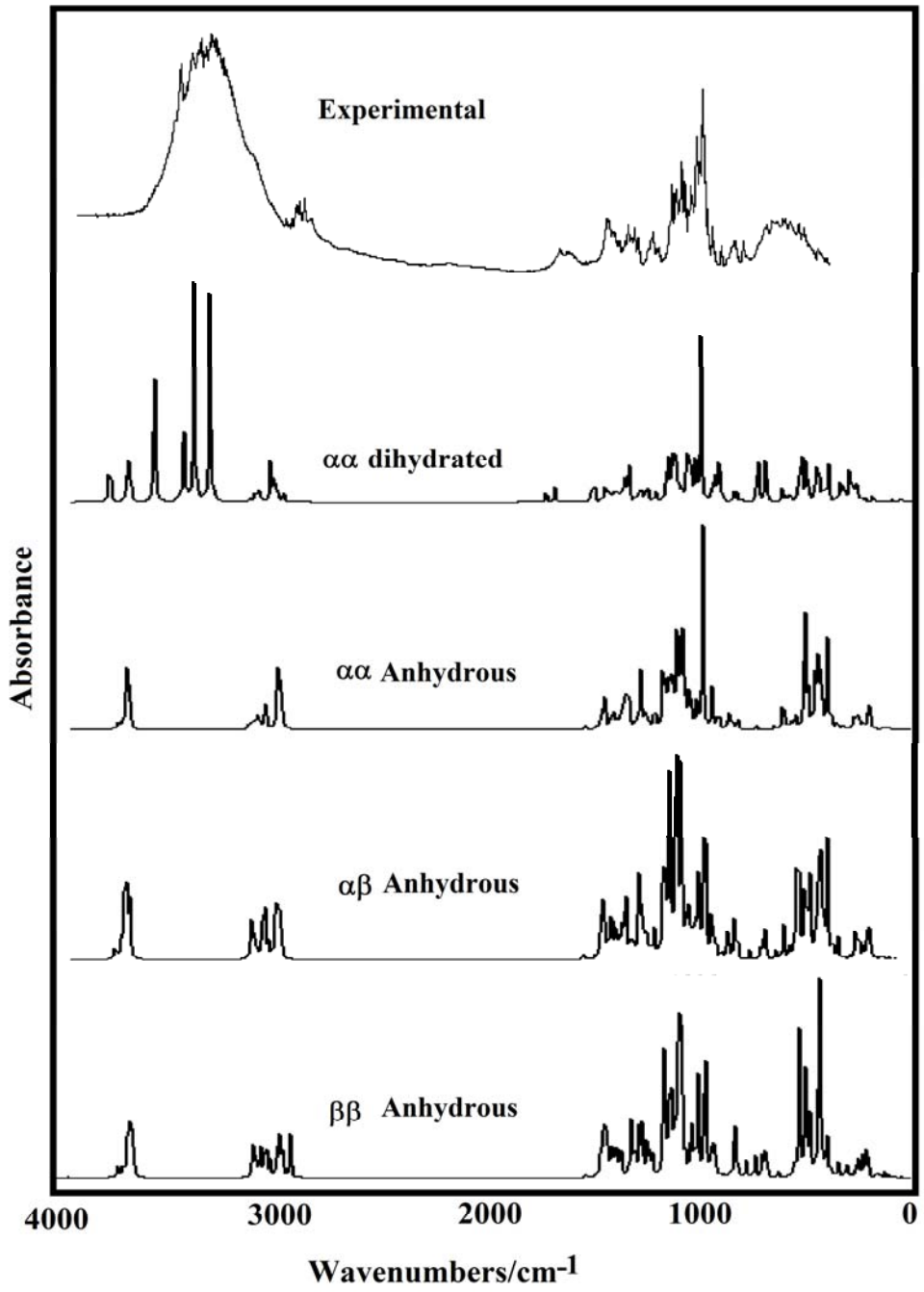

Figure S3. Comparisons among the experimental infrared spectrum of dihydrated trehalose in solid phase with the corresponding predicted for the three anhydrous species in gas phase at the B3LYP/6-31G* level of theory.

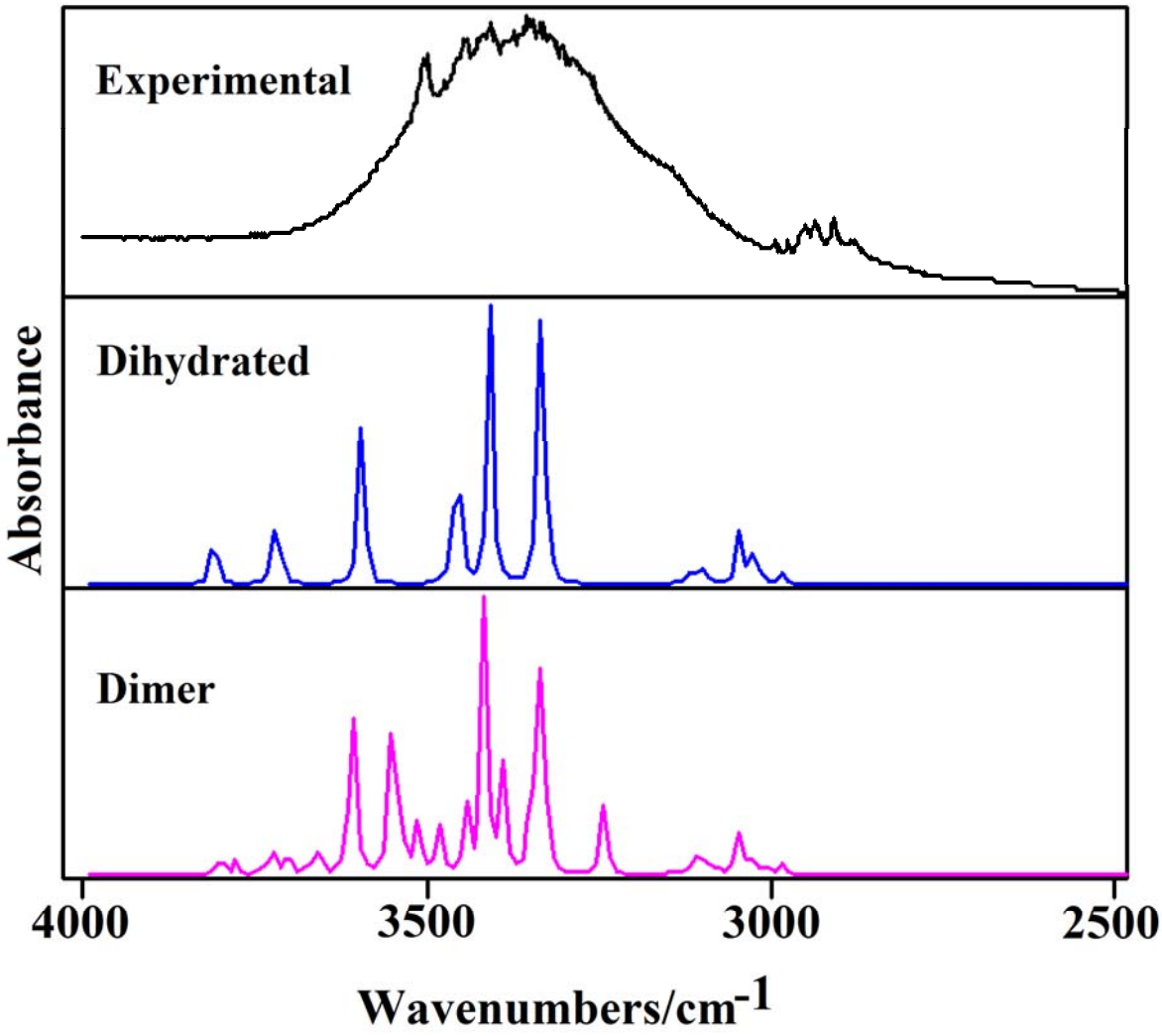

Figure S4. Comparisons among the experimental infrared spectrum of dihydrated trehalose in solid phase in the 4000-2500 cm^{-1} region with the predicted for this species and their corresponding dimer in gas phase at the B3LYP/6-31G* level of theory.

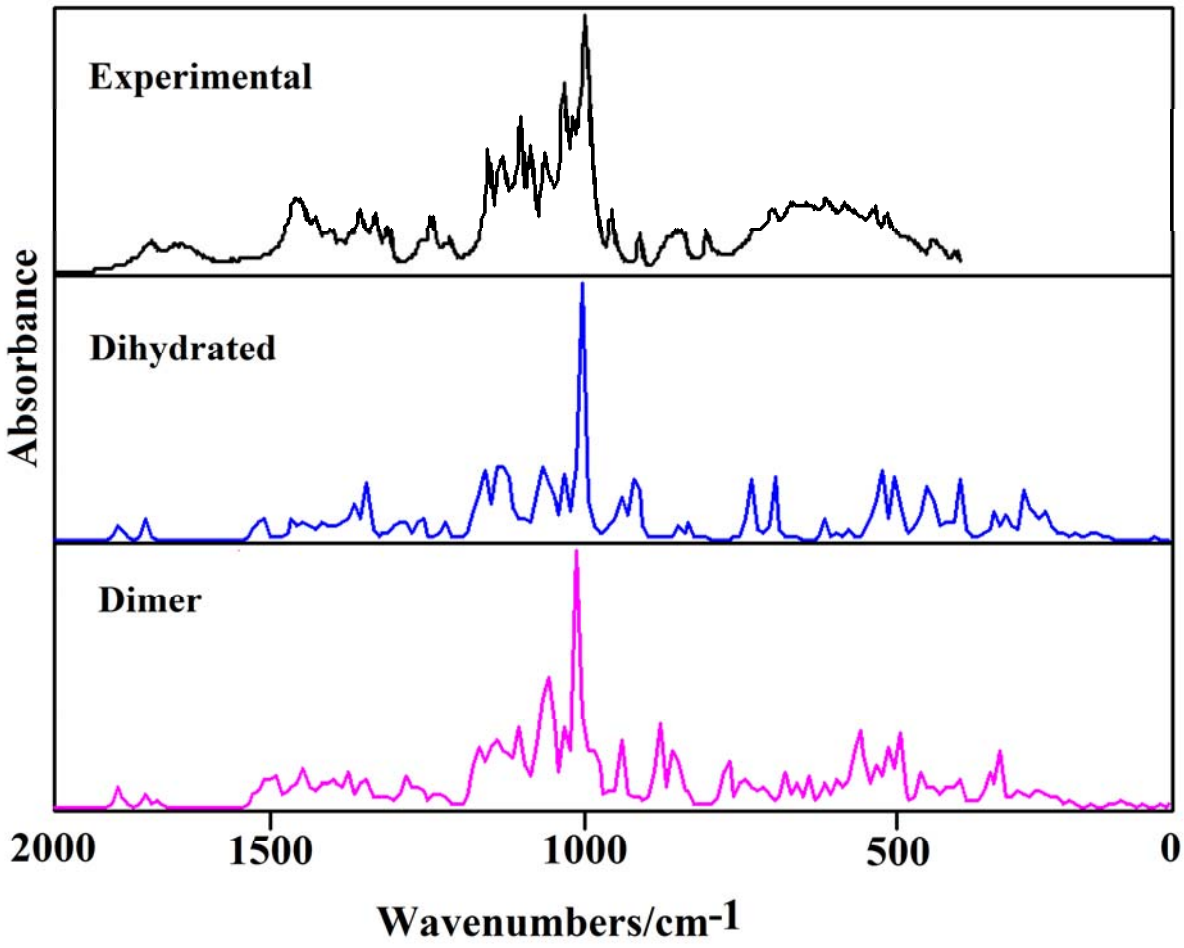

Figure S5. Comparisons among the experimental infrared spectrum of dihydrated trehalose in solid phase in the 2000-0 cm^{-1} region with the predicted for this species and their corresponding dimer in gas phase at the B3LYP/6-31G* level of theory.

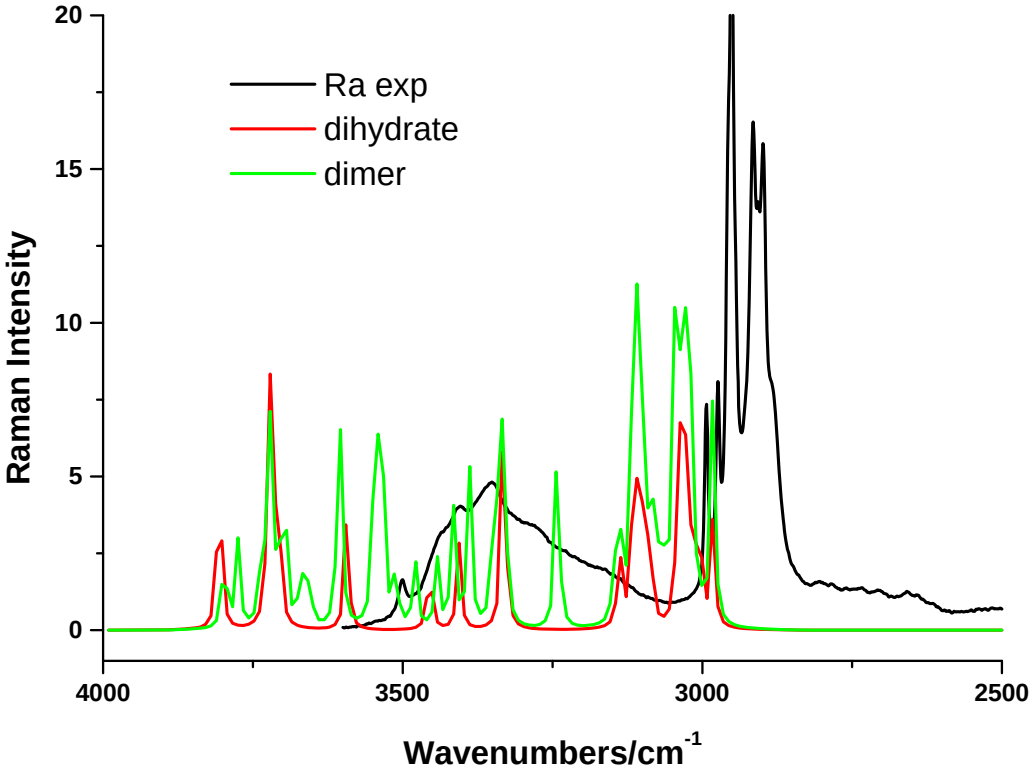

Figure S6. Comparisons among the experimental Raman spectrum of dihydrated trehalose in solid phase in the 4000-2500 cm^{-1} region with the predicted for this species and their corresponding dimer in gas phase at the B3LYP/6-31G* level of theory.

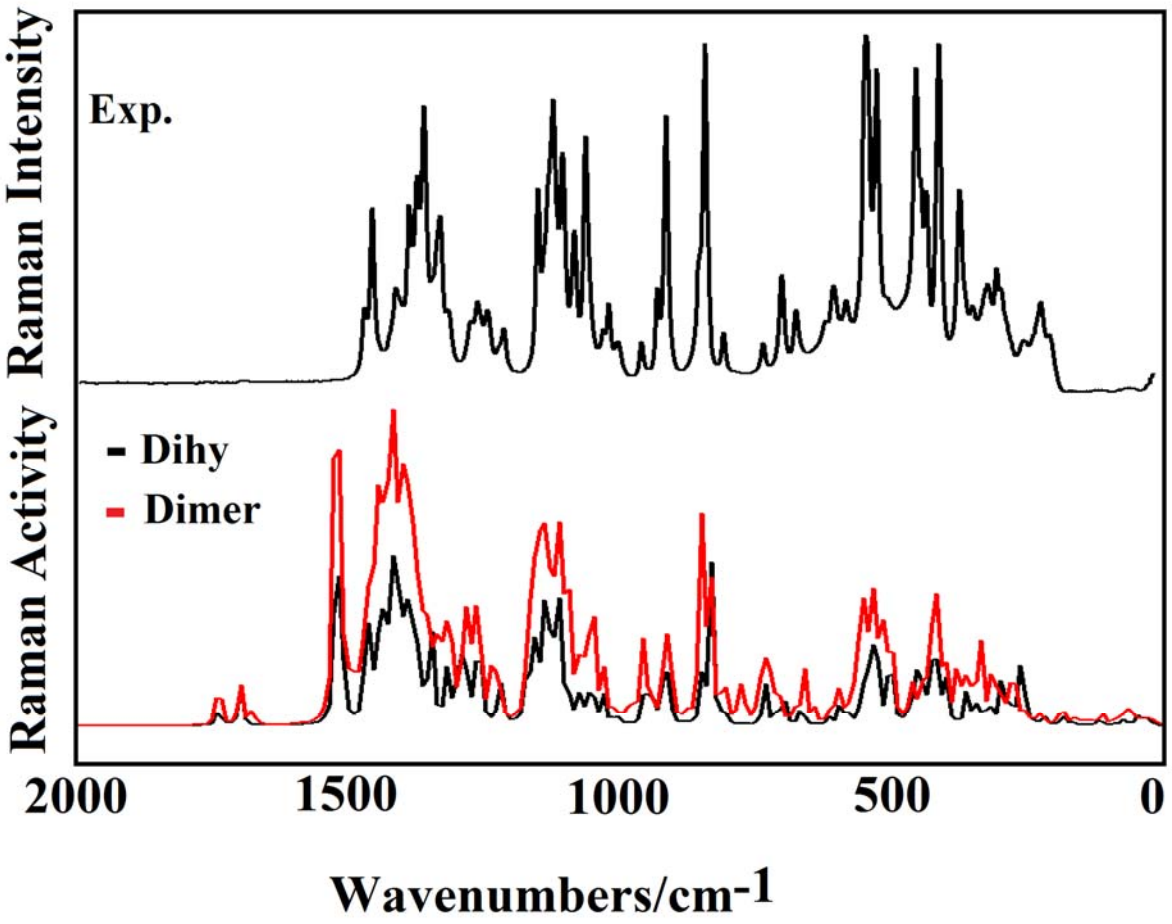

Figure S7. Comparisons among the experimental Raman spectrum of dihydrated trehalose in solid phase in the 2000-0 cm^{-1} region with the predicted for this species and their corresponding dimer in gas phase at the B3LYP/6-31G* level of theory.