Supporting Information

Temperature Dependent Solubility Transition of Na_2SO_4 in Water and Effect of NaCl Therein: Solutions Structures and Salt water Dynamics

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Annexure 1

Gravimetric analysis of the solubility of pure Na_2SO_4 in water

(1) A known amount of Na_2SO_4 was dissolved in water in a glass beaker to a supersaturating concentration by stirring on a magnetic stirrer at variable temperature (10-70°C) for half an hour. In order to avoid evaporation of water the beaker was covered with aluminium foil.

(2) The beaker was then incubated in a water bath at working temperature say T (T=10-70°C) for half an hour to remove the extra salt dissolved at a particular temperature.

(3) The saturated solution was then filtered, kept in oven for 2 days to evaporate the water completely. Since Na_2SO_4 has strong tendency to hold the water, the $Na_2SO_4.10H_2O$ crystals were crushed to powder and again dried in oven for 1 day for complete water removal.

(4) The recovered salt was then weighed, re-dissolved in water and soluble concentration was analysed quantitatively by gravimetric method using $BaCl_2$ as precipitant.

Solubility of Na_2SO_4 in water at varying NaCl concentration (5-15%):

A known amount of NaCl (5-15%) was added in to a saturated Na_2SO_4 solution at working temperature (T) and stirred for half an hour before incubating in a water bath at working temperature for half an hour for the precipitation of extra salt.

Solubility calculation

Weight of empty beaker = X gm

Weight of Na_2SO_4 added in 100 g water to make a saturated solution at temperature, T = Ygm

Amount of NaCl added in the saturated solution of Na_2SO_4 at temperature T = Z g

Total salt in 100 mL of water in the beaker = Y+Z= O g

Beaker was then incubated in water bath at temperature T after stirring to precipitate the extra salt. The supernatant was decanted and precipitated salt in the beaker was dried in oven.

Weight of the precipitated salt = Weight of beaker with salt-X = P g

Remaining salt in the supernatant = O-P = Q g

The precipitated salt was then re-dissolved in water and chloride content of the salt was measured by volumetric method using standard $AgNO_3$ solution.

% amount of SO_4^{2-} in the solution = 100-Cl^- content = R%

Amount of Na_2SO_4 in the precipitated salt = (R/100) x P = U g

Remaining Na_2SO_4 in the supernatant solution = Y-S = V g

Final % solubility of Na_2SO_4 in the presence of NaCl = (V/100) x 100 = S%

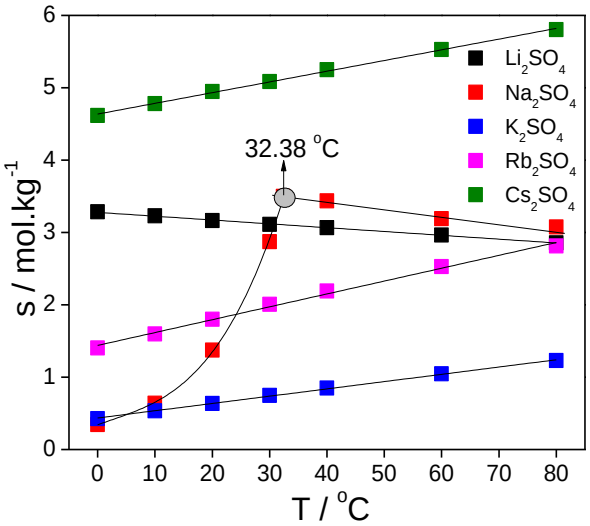

Figure S1. Temperature dependent aqueous solubility plot of alkali metal sulfates. Plot is prepared from the salt solubility chart available on Google Chrome.[1]

Table S1. Density (ρ), Speed of Sound (u), Viscosity (η) and Refractive Index (n_D) data of saturated Na_2SO_4 solution at different temperatures

Pure Aqueous Saturated Na_2SO_4 Solutions				
Temp. (°C)	ρ (g. cm^{-3})	u (m.s^{-1})	η (cP)	n_D
10 °C	1.07689	1550.46	2.04	1.3464
15 °C	1.10639	1608.09	2.28	1.3520
20 °C	1.14466	1673.35	2.55	1.3557
25 °C	1.20243	1763.95	2.91	1.3633
27 °C	1.24442	1823.43	3.18	1.3685
29.5 °C	1.28663	1902.07	3.66	1.3735
32.38 °C	1.33557	1963.19	3.99	1.3786
40 °C	1.32852	1955.62	3.54	1.3746
50 °C	1.32812	1942.72	2.82	1.3727
60 °C	1.31691	1929.24	2.46	1.3707
70 °C	1.30634	1912.18	2.10	1.3693

Table S2. Density (ρ), and speed of sound (u) data of saturated Na_2SO_4 solutions in 5%, 10% and 15% aqueous NaCl at different temperatures

Temp. (^oC)	Saturated Na_2SO_4 in 5% NaCl Solution		Saturated Na_2SO_4 in 10% NaCl Solution		Saturated Na_2SO_4 in 15% NaCl Solution	
	ρ ($g.cm^{-3}$)	u ($m.s^{-1}$)	ρ ($g.cm^{-3}$)	u ($m.s^{-1}$)	ρ ($g.cm^{-3}$)	u ($m.s^{-1}$)
10 ^oC	1.10947	1605.04	1.13663	1652.23	1.16752	1706.33
15 ^oC	1.13399	1654.23	1.16401	1700.89	1.18671	1742.34
20 ^oC	1.17207	1715.36	1.19472	1757.97	1.21261	1792.18
25 ^oC	1.22704	1797.22	1.24279	1832.06	1.25291	1839.13
27 ^oC	1.26606	1870.62	1.27013	1878.37	1.24869	1837.51
29.5 ^oC	1.29901	1914.32	1.27206	1861.14	1.24626	1833.94
32.38 ^oC	1.28747	1902.22	1.26057	1871.67	1.23956	1829.80
40 ^oC	1.28766	1899.34	1.25340	1867.23	1.23802	1827.46
50 ^oC	1.27844	1887.99	1.26326	1846.82	1.23067	1825.01
60 ^oC	1.27040	1875.91	1.24888	1847.69	1.22610	1816.76
70 ^oC	1.26217	1863.40	1.25352	1809.21	1.21324	1802.40

Table S3. Density (ρ), and speed of sound (u) data of 15^oC and 32.38^oC saturated Na_2SO_4 solutions at different temperatures

Aqueous 15^oC Saturated Na_2SO_4 Solution				
Temperature (^oC)	ρ (g. cm^{-3})	u ($m.s^{-1}$)	η (cP)	n_D
15^oC	1.11015	1611.42	2.28	1.3520
20^oC	1.10827	1622.53	1.83	1.3505
25^oC	1.10602	1633.33	1.65	1.3498
30^oC	1.10411	1640.34	1.56	1.3491
Aqueous 32.38^oC Saturated Na_2SO_4 Solution				
32.38 ^oC	1.33172	1962.71	3.99	1.3786
40 ^oC	1.32796	1957.38	3.54	1.3768
50 ^oC	1.32030	1941.80	2.94	1.3751
60 ^oC	1.31156	1926.82	2.55	1.3735

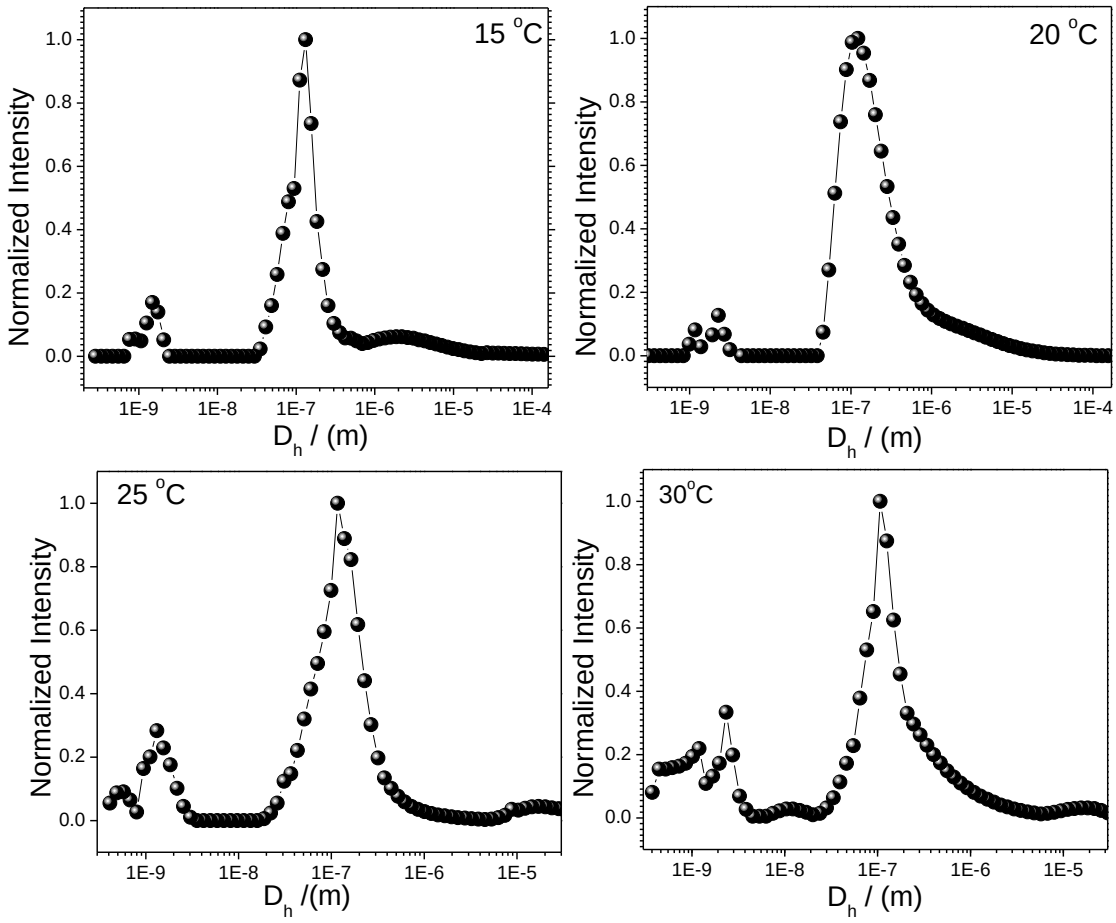

Figure S2. DLS CONTIN Plots of 15 degree saturated samples at different temperatures.

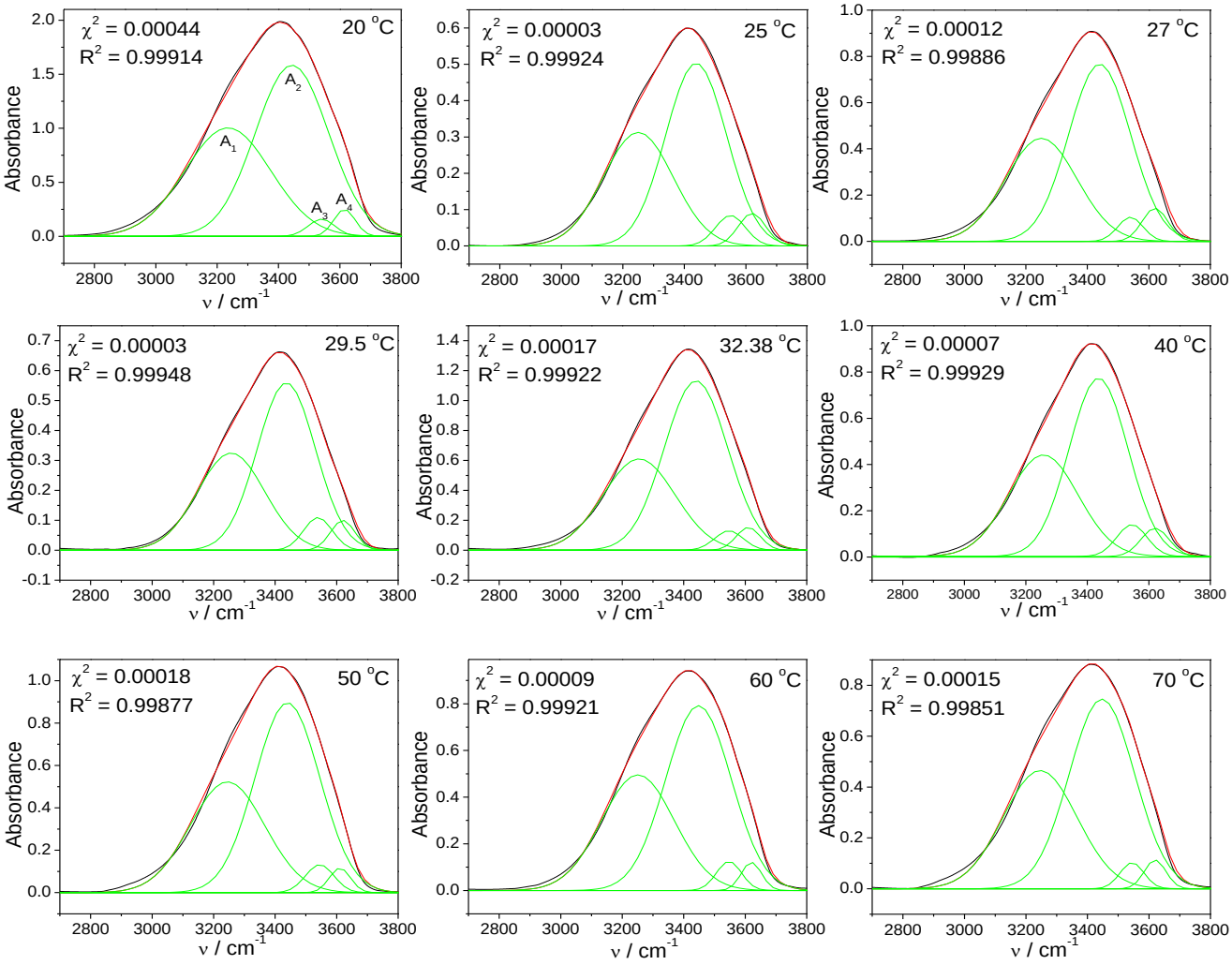

Figure S3. De-convoluted FT-IR spectra of water structural peaks in pure aqueous saturated solution of Na_2SO_4 at different temperatures.

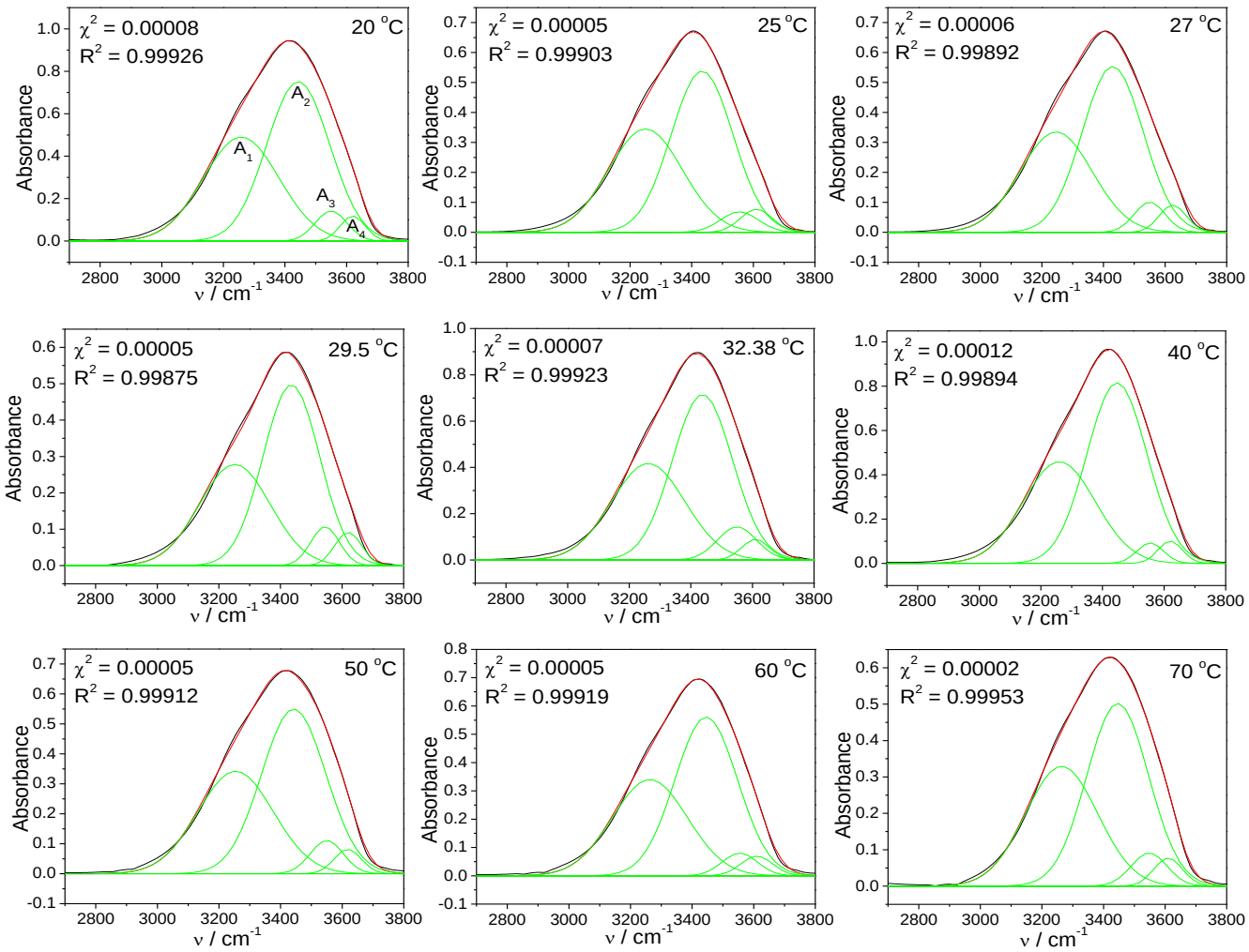

Figure S4. De-convoluted FT-IR spectra of water structural peaks in aqueous saturated solution of Na_2SO_4 + 5% NaCl at different temperatures.

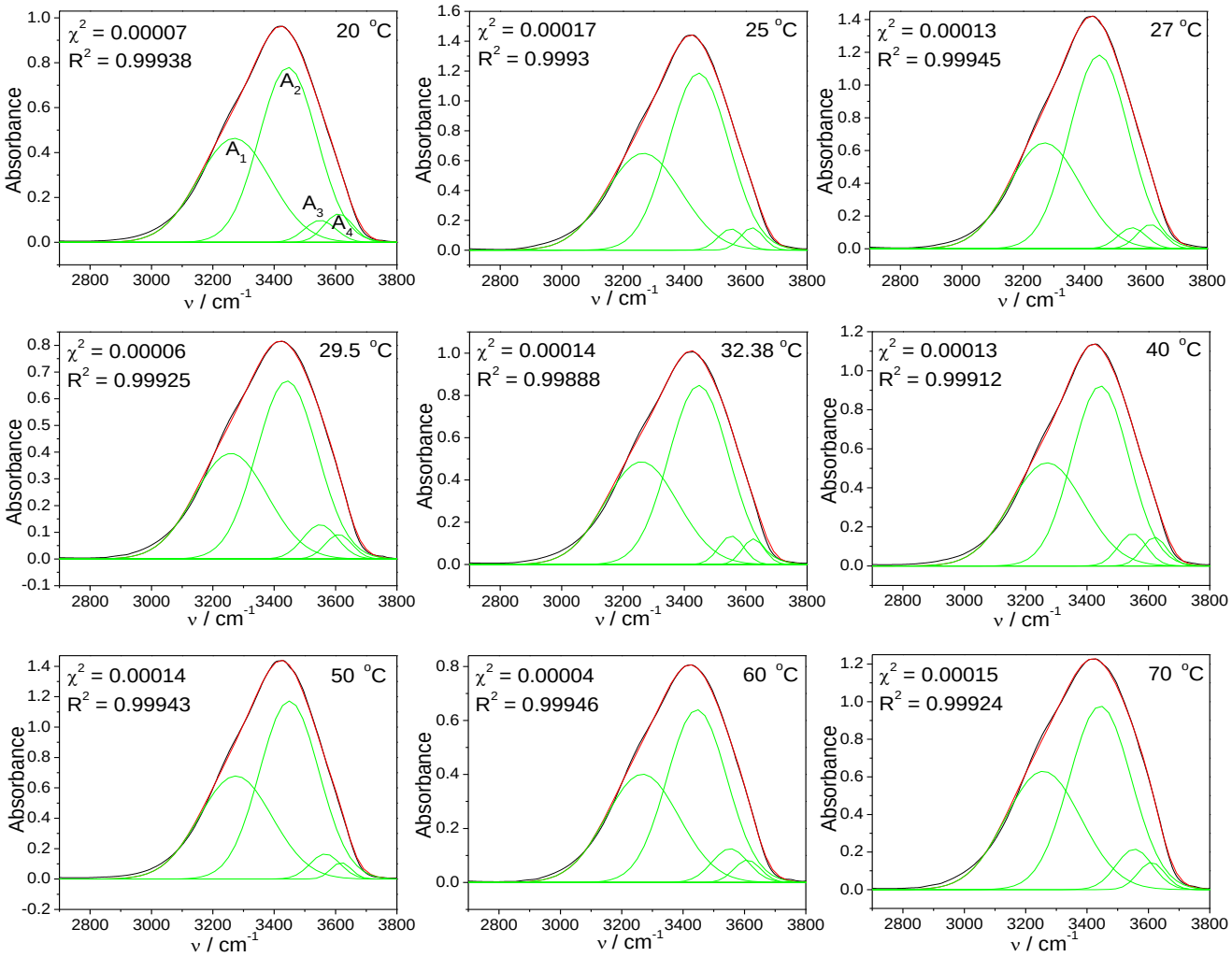

Figure S5. De-convoluted FT-IR spectra of water structural peaks in aqueous saturated solution of Na_2SO_4 + 10 % NaCl at different temperatures

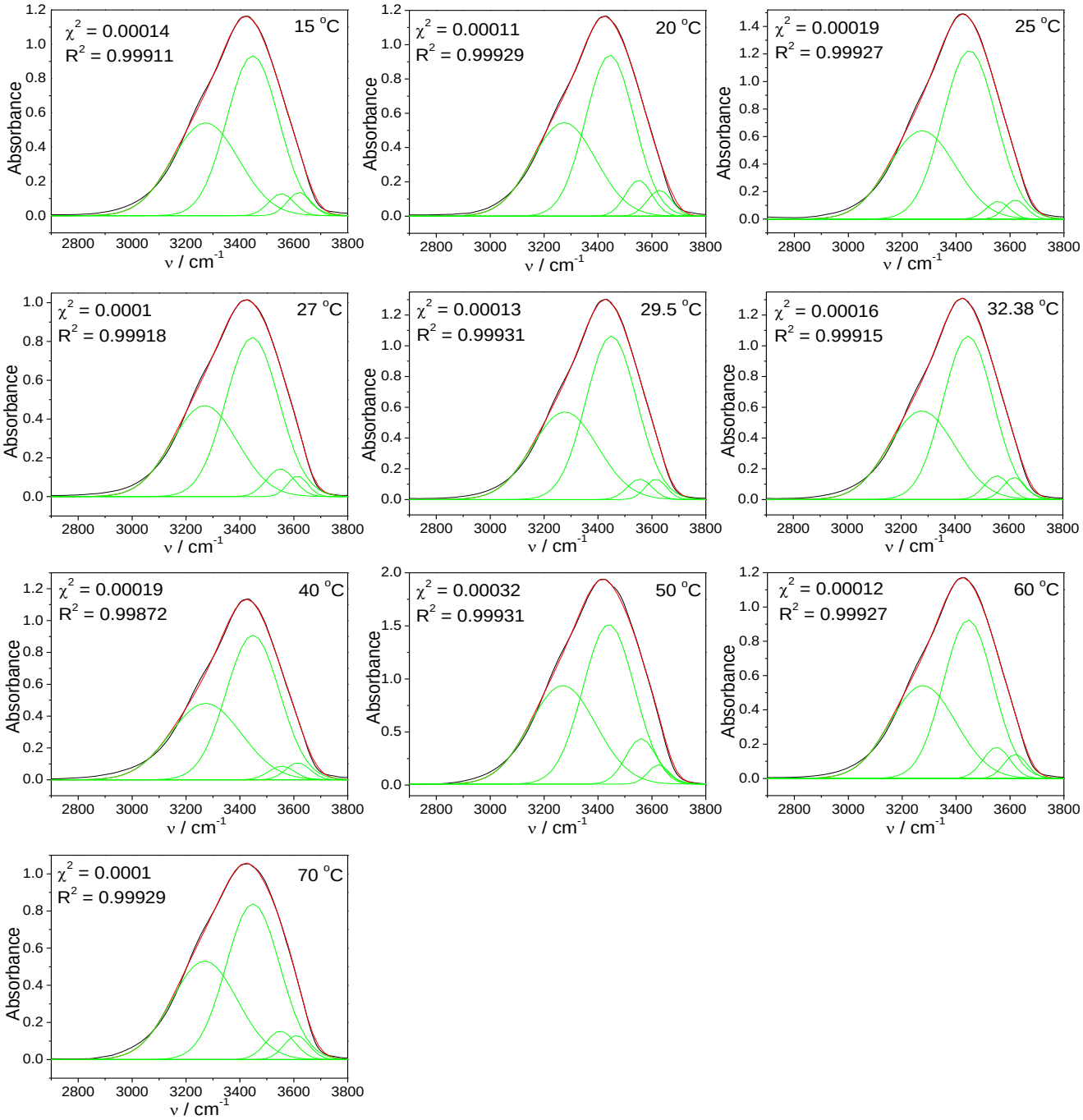

Figure S6. De-convoluted FT-IR spectra of Na_2SO_4 + 15% NaCl at different temperature

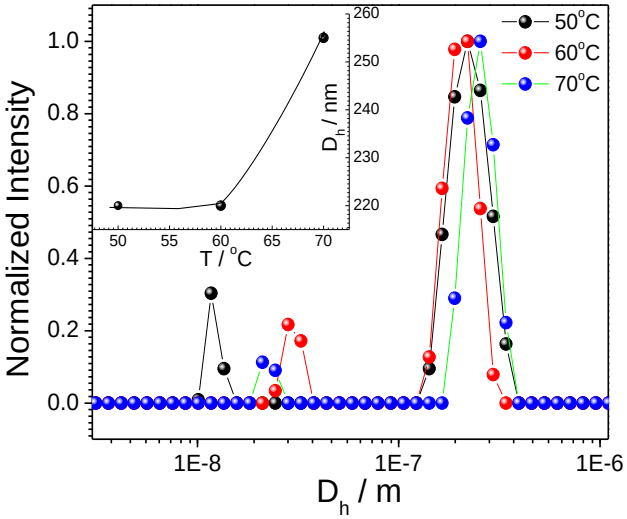

Figure S7. Temperature dependent hydrodynamic diameter (D_h) profiles of 50°C aqueous Na_2SO_4 saturated solutions.