

Supplementary Information

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Thermal stability of particle-phase monoethanolamine salts

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EXPERIMENTAL

Synthesis of the mono-ethanolamine (MEA) salts. The salts were synthesized by neutralization reactions between MEA and a series of mono-, di- and triprotic acids, including acetic, benzoic, oxalic, succinic, adipic, glutaric, sulfuric, and citric acids. For instance, to prepare MEA oxalate, 12 mL of 0.75 M oxalic acid in ethanol was slowly added to 24 mL of 0.75 M ethanolamine in ethanol to allow complete neutralization, yielding 2-hydroxyethan ammonium oxalate. The product was then isolated by rotary evaporation at approximately 40 °C until all ethanol was removed. ^1H and ^{13}C NMR spectra were obtained (in D_2O) using a Varian 300 MHz NMR spectrometer to confirm that the purity of the product was >98% and no free-form amine or ethanol was left in the final product. All precursor chemicals were ACS grade, obtained from Sigma Aldrich or Fisher Scientific, and used without further purification.

Table S1. Determination of the saturation vapor pressure and enthalpy of vaporization for known substances (accommodation coefficient α was set to 1.0 in all cases)

Name	Model I, full length		Model I, 1/e		Model II	
	P_{sat} (298 K), Pa	ΔH_{vap} , kJ mol ⁻¹	P_{sat} (298 K), Pa	ΔH_{vap} , kJ mol ⁻¹	P_{sat} (298 K), Pa	ΔH_{vap} , kJ mol ⁻¹
Succinic acid	1.1×10^{-4}	81.3	2.1×10^{-4}	82.2	2.4×10^{-5}	87.7
Adipic acid	3.1×10^{-5}	91.5	6.4×10^{-5}	91.7	8.2×10^{-6}	95.9

Table S2. The change in the particle size (*Gfd*) determined using TD-TDMA for all the MEA salts (See Table 1 for the definitions of the abbreviations).

Chemical		Change in the Particle Size (<i>Gfd</i>)													
EaAc	T, K	295	329	337	346	358	363	368	373	383	403	414	433	453	473
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>
	75 nm	0.991	0.920	0.903	0.877	0.833	0.813	0.775	0.756	0.741	0.708	0.683	0.640	0.597	0.555
	100 nm	0.993	0.923	0.906	0.882	0.841	0.826	0.789	0.766	0.742	0.711	0.688	0.643	0.601	0.557
	150 nm	0.993	0.927	0.906	0.885	0.848	0.835	0.800	0.782	0.746	0.713	0.693	0.646	0.602	0.558
EaBz	T, K	296	313	328	343	358	375	409	430	431	444	458	468		
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>		
	75 nm	0.964	0.942	0.937	0.893	0.883	0.837	0.823	0.777	0.683	0.609	0.586	0.570		
	100 nm	0.978	0.949	0.948	0.901	0.889	0.844	0.825	0.786	0.699	0.636	0.603	0.579		
	150 nm	0.989	0.960	0.955	0.912	0.897	0.845	0.823	0.789	0.702	0.651	0.615	0.583		
EaHOx	T, K	296	313	323	333	338	343	348	353	358					
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>					
	75 nm	1.000	0.987	0.956	0.854	0.797	0.734	0.516	0.294						
	100 nm	1.000	0.992	0.971	0.908	0.871	0.831	0.665	0.541						
	150 nm	1.000	0.996	0.985	0.950	0.920	0.901	0.813	0.718	0.545					
Ea2Ox	T, K	296	313	333	338	343	348	353	358	363	368				
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>				
	75 nm	1.000	0.998	0.961	0.953	0.923	0.871	0.805	0.667	0.465					
	100 nm	1.000	0.997	0.973	0.966	0.946	0.906	0.881	0.758	0.629	0.321				
	150 nm	1.000	0.995	0.985	0.978	0.966	0.942	0.926	0.845	0.772	0.612				
Ea2Su	T, K	295	303	309	314	318	323								
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>								
	75 nm	0.926	0.855	0.815	0.711	0.603									
	100 nm	0.950	0.899	0.870	0.795	0.759	0.529								
	150 nm	0.970	0.939	0.921	0.878	0.856	0.715								
Ea2Gl	T, K	295	303	308	313	318	323	325							
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>								
	75 nm	0.905	0.847	0.811	0.670	0.396									
	100 nm	0.935	0.898	0.860	0.780	0.610	0.418								
	150 nm	0.960	0.938	0.912	0.867	0.781	0.695	0.595							
Ea2Ad	T, K	297	303	308	313	318	323	325							
		<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>	<i>Gfd</i>							
	75 nm	0.953	0.907	0.830	0.713	0.495									
	100 nm	0.968	0.938	0.891	0.797	0.669	0.401	0.258							
	150 nm	0.978	0.960	0.932	0.876	0.806	0.699	0.646							

Table S3. Continued (See Table 1 for the definitions of the abbreviations).

Chemical		Change in the Particle Size (Gfd)															
EaH2Ct	T, K	296	353	368	378	383	388	393	395	398	403						
		Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd						
	75 nm	1.000	0.951	0.929	0.903	0.856	0.788	0.690	0.614	0.587	0.285						
	100 nm	1.000	0.955	0.938	0.920	0.893	0.854	0.795	0.739	0.702	0.528						
	150 nm	1.000	0.960	0.947	0.932	0.912	0.896	0.861	0.832	0.804	0.711						
Ea2HCt	T, K	296	313	328	343	368	373	378	383	385	388	393	398	403			
		Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd			
	75 nm	0.979	0.962	0.942	0.927	0.885	0.864	0.825	0.801	0.779	0.761	0.692	0.535	0.395			
	100 nm	0.980	0.964	0.943	0.927	0.891	0.877	0.854	0.832	0.817	0.810	0.742	0.676	0.464			
	150 nm	0.982	0.967	0.944	0.927	0.893	0.884	0.872	0.858	0.845	0.840	0.781	0.752	0.623			
Ea3Ct	T, K	296	313	338	358	373	383	390	398	406	413						
		Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd						
	75 nm	0.980	0.963	0.928	0.908	0.893	0.819	0.737	0.508	0.308							
	100 nm	0.979	0.963	0.929	0.909	0.892	0.847	0.756	0.573	0.354							
	150 nm	0.978	0.962	0.928	0.905	0.888	0.866	0.788	0.731	0.530	0.362						
Ea2SO4	T, K	296	308	329	349	359	378	396	416	431	435	439	443	448	453	458	463
		Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd	Gfd
	75 nm	0.984	0.982	0.969	0.943	0.928	0.921	0.911	0.892	0.861	0.830	0.799	0.751	0.687	0.638	0.610	0.596
	100 nm	0.988	0.985	0.974	0.950	0.936	0.927	0.916	0.903	0.877	0.850	0.831	0.790	0.751	0.695	0.660	0.642
	150 nm	0.992	0.990	0.979	0.958	0.945	0.935	0.922	0.909	0.892	0.870	0.853	0.828	0.804	0.753	0.718	0.698

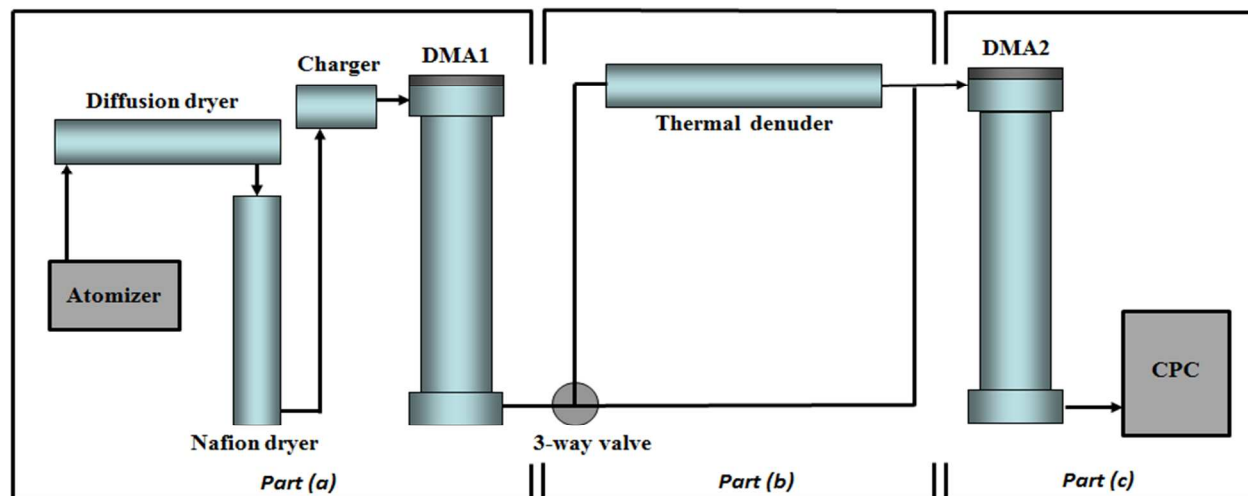


Figure S1. Schematic of the TDMA aerosol system for measurements of aerosol evaporation rates.

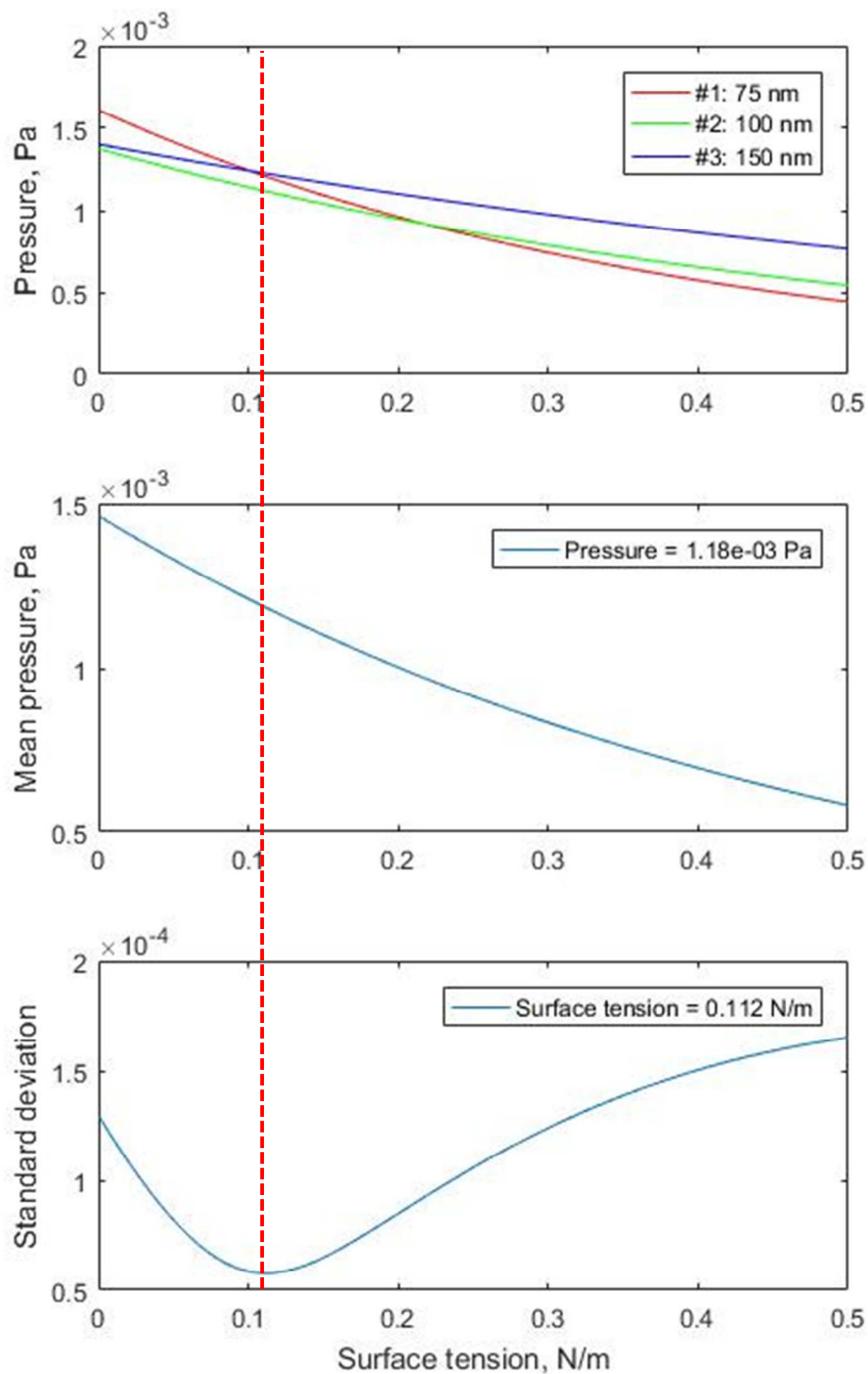


Figure S2. Derivation of the saturation vapor pressure and surface tension from evaporation rate experiments performed on aerosol of different initial particle sizes at a single temperature.

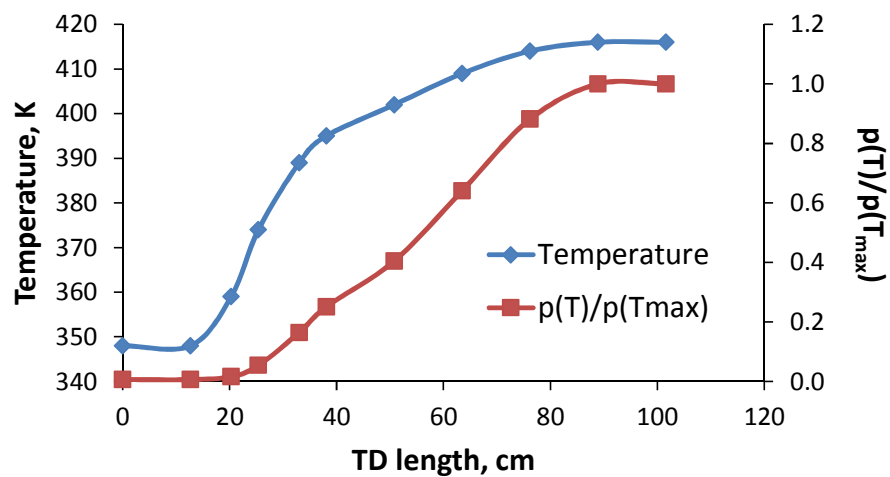


Figure S3. Profiles of the gas temperature and normalized saturation vapor pressure of salt along the length of the thermal denuder

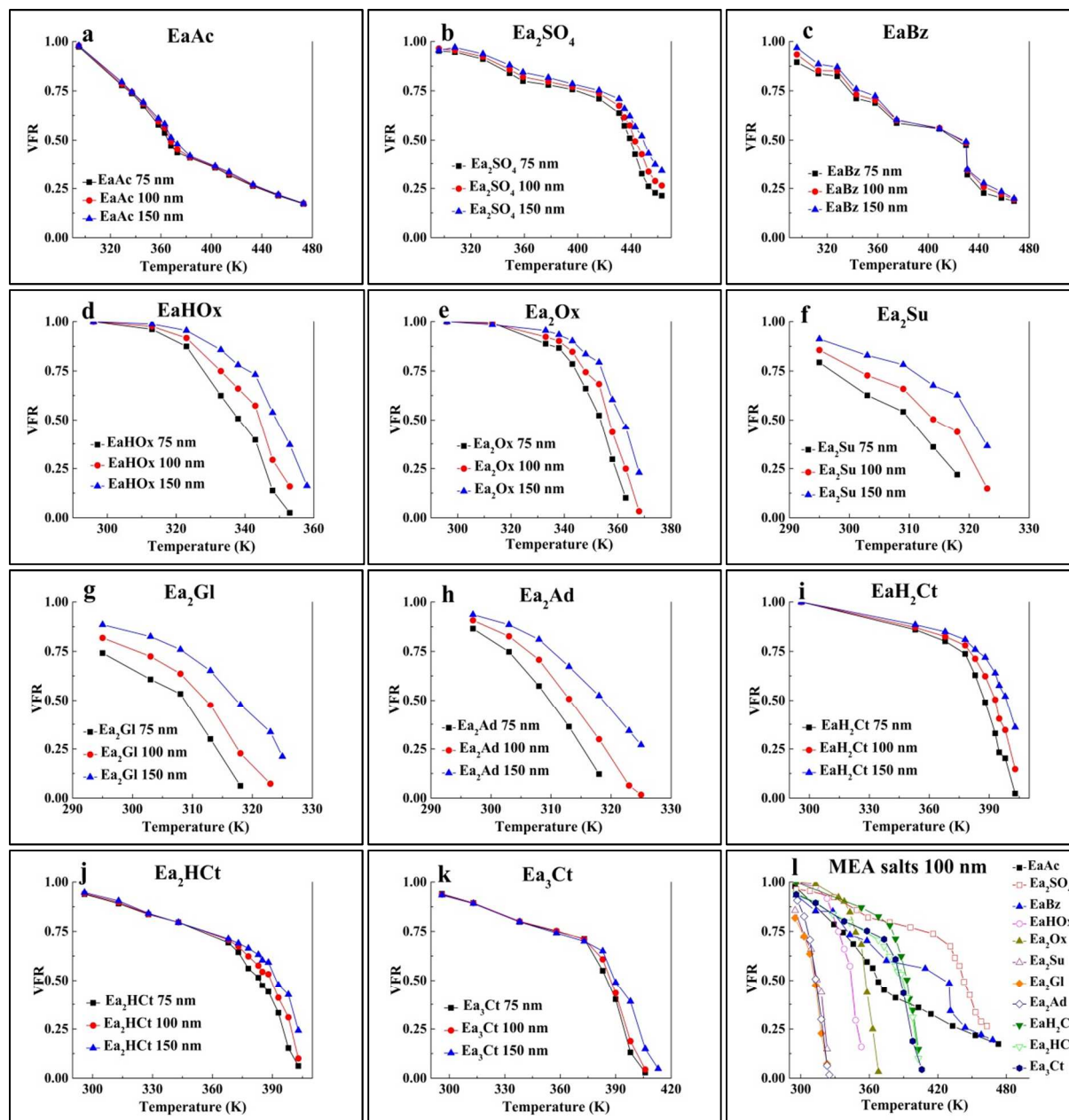


Figure S4. The measured volume fraction remaining for the size-classified aerosol composed of ethanolammonium acetate (EaAc), hydrogen oxalate (EaHOx), oxalate (Ea₂Ox), succinate (Ea₂Su), glutarate (EaGl), adipate (Ea₂Ad), dihydrogen citrate (EaH₂Ct), hydrogen citrate (Ea₂HCt), citrate (Ea₃Ct), sulfate (Ea₂SO₄), and benzoate (EaBz). Black squares, red circles, blue triangles, and purple diamonds correspond to particles with initial mobility diameters of 75, 100, and 150 nm, respectively.

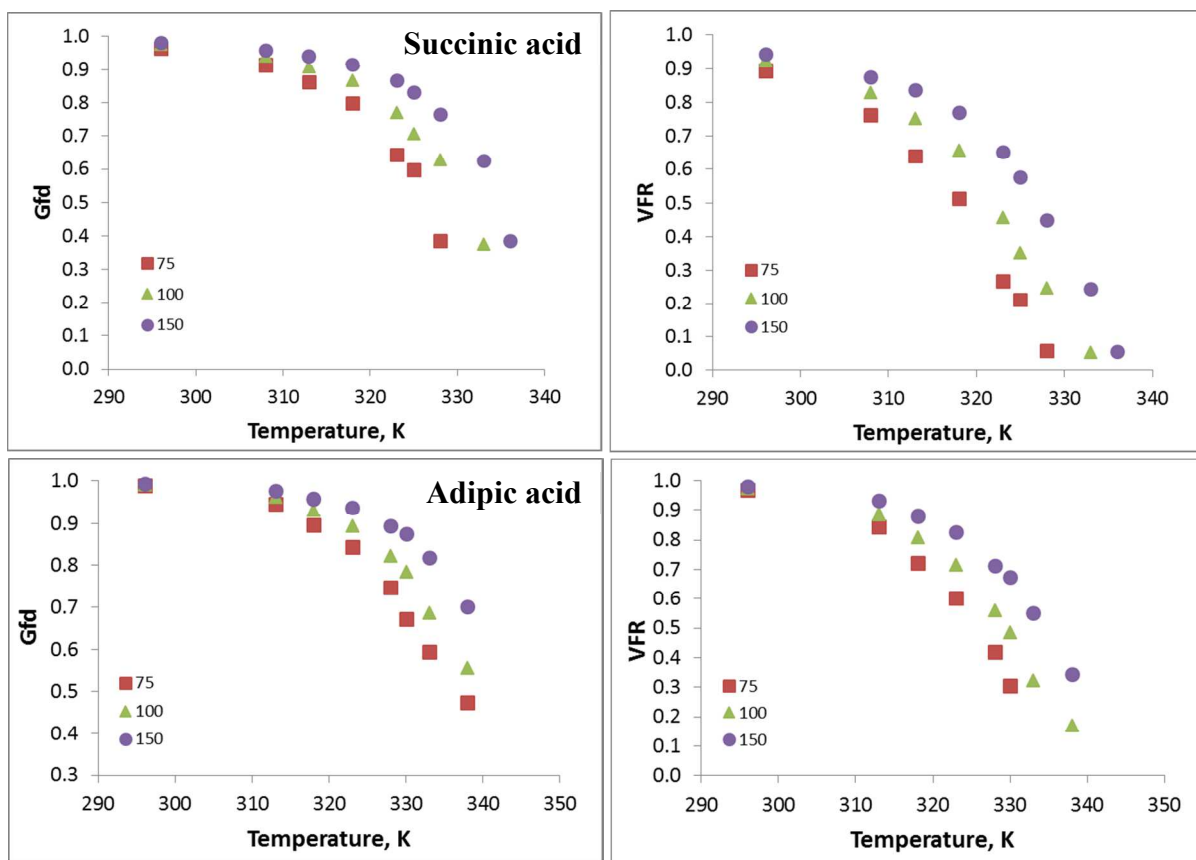


Figure S5. *Gfd* and *VFR* of the size-classified succinic and adipic acid aerosols

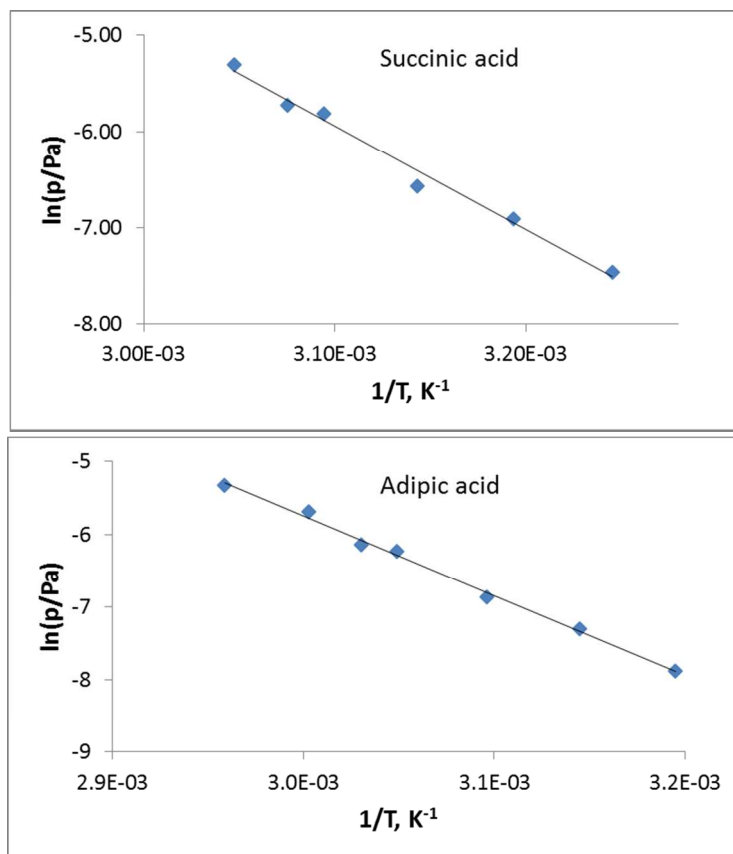


Figure S6. Temperature dependence of the saturation vapor pressure of the size-classified succinic and adipic acid aerosols.