SUPPORTING INFORMATION

Humidity effects on the detection of soluble and insoluble nanoparticles in butanol operated condensation particle counters

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TSI 3776 UCPC Cut-off Measurements

Table S1: Cut-off measurements for a TSI 3776 UCPC for (+) positively and (-) negatively charged sodium chloride (NaCl) seeds under low, standard (std) and high temperature settings. In addition the experimentally determined cut-off diameter d_{50} and the deviation of the cut-off diameter $\Delta(d_{50})$, as well as the minimum $\mathcal{N}_{min}$ and maximum number concentration $\mathcal{N}_{max}$ during the cut-off measurements.

Seed	T-Setting	RH [%]	d_{50}[nm]	$\Delta(d_{50})$ [nm]	$\mathcal{N}_{min}$ $[cm^{-3}]$	$\mathcal{N}_{max}$ $[cm^{-3}]$
NaCl(+)	low	0	2.99	0.24	500	30000
NaCl(+)	std	0	4.32	0.35	300	30000
NaCl(+)	high	0	4.76	0.39	1000	30000
NaCl(-)	low	0	3.70	0.30	300	40000
NaCl(-)	std	0	4.41	0.36	500	50000
NaCl(-)	high	0	4.72	0.39	500	12500
NaCl(+)	low	10	2.45	0.20	500	35000
NaCl(+)	std	10	3.82	0.31	300	35000
NaCl(+)	high	10	4.98	0.41	300	35000
NaCl(-)	low	10	2.82	0.23	250	30000
NaCl(-)	std	10	3.77	0.31	500	40000
NaCl(-)	high	10	4.95	0.41	200	40000
NaCl(+)	low	20	2.35	0.19	200	8000
NaCl(+)	std	20	3.14	0.26	200	12000
NaCl(+)	high	20	4.61	0.38	500	11000
NaCl(-)	low	20	2.28	0.19	100	10000
NaCl(-)	std	20	2.69	0.22	200	20000
NaCl(-)	high	20	4.11	0.34	500	15000
NaCl(+)	low	30	1.96	0.16	300	10000
NaCl(+)	std	30	2.45	0.20	500	20000
NaCl(+)	high	30	4.09	0.34	200	18000
NaCl(-)	low	30	1.50	0.12	200	15000
NaCl(-)	std	30	2.40	0.20	200	15000
NaCl(-)	high	30	4.02	0.33	250	30000
NaCl(+)	low	40	1.84	0.15	500	17500
NaCl(+)	std	40	2.04	0.17	1500	15000
NaCl(+)	high	40	3.18	0.26	800	12500
NaCl(-)	low	40	1.23	0.10	500	20000
NaCl(-)	std	40	1.84	0.15	500	25000
NaCl(-)	high	40	3.33	0.27	1000	25000

Table S2: Cut-off measurements for a TSI 3776 UCPC for (+) positively and (-) negatively charged silver (Ag) seeds under low, standard (std) and high temperature settings. In addition the experimentally determined cut-off diameter d_{50} and the deviation of the cut-off diameter $\Delta(d_{50})$, as well as the minimum $\mathcal{N}_{min}$ and maximum number concentration $\mathcal{N}_{max}$ during the cut-off measurements.

Seed	T-Setting	RH [%]	d_{50}[nm]	$\Delta(d_{50})$ [nm]	$\mathcal{N}_{min}$ $[cm^{-3}]$	$\mathcal{N}_{max}$ $[cm^{-3}]$
Ag(+)	low	0	2.57	0.21	200	30000
Ag(+)	std	0	3.03	0.25	500	20000
Ag(+)	high	0	3.47	0.28	200	18000
Ag(-)	low	0	2.12	0.17	200	25000
Ag(-)	std	0	2.54	0.21	200	7000
Ag(-)	high	0	3.00	0.25	200	3000
Ag(+)	low	10	2.29	0.19	1000	25000
Ag(+)	std	10	2.77	0.23	2000	25000
Ag(+)	high	10	3.23	0.26	1000	12000
Ag(-)	low	10	2.15	0.18	2000	25000
Ag(-)	std	10	2.69	0.22	200	6000
Ag(-)	high	10	3.18	0.26	2000	15000
Ag(+)	low	20	2.37	0.19	100	6000
Ag(+)	std	20	2.89	0.24	1000	70000
Ag(+)	high	20	3.11	0.25	200	80000
Ag(-)	low	20	2.11	0.17	500	8000
Ag(-)	std	20	2.66	0.22	250	5000
Ag(-)	high	20	3.11	0.25	200	3000
Ag(+)	low	30	2.26	0.19	200	6000
Ag(+)	std	30	2.60	0.21	200	3000
Ag(+)	high	30	2.99	0.25	100	3000
Ag(-)	low	30	2.12	0.17	500	6000
Ag(-)	std	30	2.54	0.21	400	4000
Ag(-)	high	30	3.00	0.25	250	4000
Ag(+)	low	40	2.49	0.20	500	6000
Ag(+)	std	40	2.95	0.24	500	6000
Ag(+)	high	40	3.08	0.25	500	6000
Ag(-)	low	40	2.41	0.20	600	6000
Ag(-)	std	40	2.42	0.20	400	6000
Ag(-)	high	40	2.99	0.25	1000	18000

Table S3: Cut-off measurements for a TSI 3776 UCPC for (0+) positively and (0-) negatively neutralized sodium chloride (NaCl) seeds under low, standard (std) and high temperature settings. In addition the experimentally determined cut-off diameter d_{50} and the deviation of the cut-off diameter $\Delta(d_{50})$, as well as the minimum $\mathcal{N}_{min}$ and maximum number concentration $\mathcal{N}_{max}$ during the cut-off measurements.

Seed	T-Setting	RH [%]	d_{50}[nm]	$\Delta(d_{50})$ [nm]	$\mathcal{N}_{min}$ $[cm^{-3}]$	$\mathcal{N}_{max}$ $[cm^{-3}]$
NaCl(0+)	low	0	3.20	0.26	500	15000
NaCl(0+)	std	0	3.78	0.31	500	15000
NaCl(0+)	high	0	4.57	0.38	500	15000
NaCl(0-)	low	0	3.14	0.26	250	70000
NaCl(0-)	std	0	3.96	0.32	250	60000
NaCl(0-)	high	0	4.59	0.38	400	30000
NaCl(0+)	low	10	2.41	0.20	200	8000
NaCl(0+)	std	10	3.31	0.27	200	7500
NaCl(0+)	high	10	4.30	0.35	400	6000
NaCl(0-)	low	10	2.14	0.18	500	30000
NaCl(0-)	std	10	3.20	0.26	500	30000
NaCl(0-)	high	10	4.26	0.35	500	25000
NaCl(0+)	low	20	2.36	0.19	400	10000
NaCl(0+)	std	20	2.81	0.23	500	7500
NaCl(0+)	high	20	4.10	0.34	500	7000
NaCl(0-)	low	20	1.92	0.16	800	25000
NaCl(0-)	std	20	2.60	0.21	800	20000
NaCl(0-)	high	20	4.04	0.33	600	20000
NaCl(0+)	low	30	2.04	0.17	100	10000
NaCl(0+)	std	30	2.32	0.19	100	10000
NaCl(0+)	high	30	3.00	0.25	1000	11000
NaCl(0-)	low	30	1.54	0.13	500	25000
NaCl(0-)	std	30	1.80	0.15	500	25000
NaCl(0-)	high	30	2.86	0.23	100	15000
NaCl(0+)	low	40	1.95	0.16	100	12000
NaCl(0+)	std	40	2.20	0.18	800	13500
NaCl(0+)	high	40	2.68	0.22	100	14000
NaCl(0-)	low	40	1.63	0.13	500	15000
NaCl(0-)	std	40	1.76	0.14	500	15000
NaCl(0-)	high	40	2.49	0.20	1000	20000

Table S4: Cut-off measurements for a TSI 3776 UCPC for (0+) positively and (0-) negatively neutralized silver (Ag) seeds under low, standard (std) and high temperature settings. In addition the experimentally determined cut-off diameter d_{50} and the deviation of the cut-off diameter $\Delta(d_{50})$, as well as the minimum $\mathcal{N}_{min}$ and maximum number concentration $\mathcal{N}_{max}$ during the cut-off measurements.

Seed	T-Setting	RH [%]	d_{50}[nm]	$\Delta(d_{50})$ [nm]	$\mathcal{N}_{min}$ $[cm^{-3}]$	$\mathcal{N}_{max}$ $[cm^{-3}]$
Ag(0+)	low	0	2.22	0.18	300	80000
Ag(0+)	std	0	3.02	0.25	300	70000
Ag(0+)	high	0	3.93	0.32	1500	35000
Ag(0-)	low	0	2.32	0.19	250	70000
Ag(0-)	std	0	2.96	0.24	250	60000
Ag(0-)	high	0	3.81	0.31	400	30000
Ag(0+)	low	10	2.52	0.21	250	35000
Ag(0+)	std	10	3.06	0.25	250	35000
Ag(0+)	high	10	3.80	0.31	300	20000
Ag(0-)	low	10	2.40	0.20	500	30000
Ag(0-)	std	10	2.98	0.24	500	30000
Ag(0-)	high	10	3.69	0.30	500	25000
Ag(0+)	low	20	2.51	0.21	250	20000
Ag(0+)	std	20	3.31	0.27	250	20000
Ag(0+)	high	20	3.73	0.31	250	20000
Ag(0-)	low	20	2.33	0.19	800	25000
Ag(0-)	std	20	3.06	0.25	800	20000
Ag(0-)	high	20	4.06	0.33	600	20000
Ag(0+)	low	30	2.46	0.20	250	12000
Ag(0+)	std	30	2.82	0.23	250	12000
Ag(0+)	high	30	3.98	0.33	100	20000
Ag(0-)	low	30	2.28	0.19	500	25000
Ag(0-)	std	30	2.74	0.22	500	25000
Ag(0-)	high	30	3.98	0.33	100	15000
Ag(0+)	low	40	2.48	0.20	250	12000
Ag(0+)	std	40	2.77	0.23	200	10000
Ag(0+)	high	40	3.37	0.28	500	15000
Ag(0-)	low	40	2.33	0.19	500	15000
Ag(0-)	std	40	2.70	0.22	500	15000
Ag(0-)	high	40	3.37	0.28	1000	20000

Size Analyzing Nuclei Counter (SANC) Measurements

Table S5: A summary of experimentally inferred onset saturation ratio S_0, nucleation temperature T_{nuc} and number of molecules in the critical cluster n^* values, as well as the selected mobility equivalent diameter d_p for neutralized silver seeds (0-/+). All measurements were conducted with a maximal relative humidity at room temperature (RH) below 2.5% or 10%.

Seed	d_p[nm]	RH [%]	S_0[ ]	T_{nuc} [$^\circ C$]	n^*
Ag(0-)	2.5	< 10.0	3.16	-4.0	13.64
Ag(0-)	2.5	< 10.0	3.13	-3.0	10.70
Ag(0-)	2.5	< 10.0	3.06	0.0	16.16
Ag(0-)	2.5	< 10.0	3.07	1.0	9.55
Ag(0-)	2.5	< 10.0	2.90	4.0	11.78
Ag(0-)	2.5	< 10.0	2.92	5.0	12.75
Ag(0-)	3.0	< 2.5	2.59	-4.0	15.58
Ag(0-)	3.0	< 2.5	2.61	0.0	11.58
Ag(0-)	3.0	< 2.5	2.45	5.0	11.74
Ag(0-)	3.0	< 2.5	2.43	6.0	11.58
Ag(0-)	3.0	< 2.5	2.44	10.0	11.24
Ag(0+)	3.5	< 2.5	2.36	3.0	15.69
Ag(0+)	3.5	< 2.5	2.33	10.0	10.98
Ag(0-)	5.0	< 2.5	1.83	0.0	25.57
Ag(0-)	5.0	< 10.0	1.72	4.0	25.53
Ag(0-)	5.0	< 10.0	1.70	5.0	25.52
Ag(0-)	5.0	< 10.0	1.67	8.0	27.68
Ag(0-)	5.0	< 10.0	1.67	12.0	27.56
Ag(0-)	5.0	< 10.0	1.67	13.0	29.00
Ag(0-)	6.5	< 10.0	1.56	2.0	45.90
Ag(0-)	6.5	< 10.0	1.57	5.0	50.41
Ag(0-)	6.5	< 10.0	1.46	10.0	49.18
Ag(0-)	6.5	< 10.0	1.49	15.0	53.93
Ag(0-)	9.0	< 10.0	1.36	4.0	62.43
Ag(0-)	9.0	< 10.0	1.29	7.0	70.79
Ag(0-)	9.0	< 10.0	1.30	8.0	47.39
Ag(0-)	9.0	< 10.0	1.30	12.0	75.85
Ag(0-)	9.0	< 10.0	1.29	15.0	74.18
Ag(0-)	9.0	< 10.0	1.29	16.0	81.21

Table S6: A summary of experimentally inferred onset saturation ratio S_0, nucleation temperature T_{nuc} and number of molecules in the critical cluster n^* values, as well as the selected mobility equivalent diameter d_p for neutralized NaCl seeds (0-/+). All measurements were conducted with a maximal relative humidity at room temperature (RH) below 10%.

Seed	d_p[nm]	RH [%]	S_0[ ]	T_{nuc} [$^\circ C$]	n^*
NaCl(0-)	2.5	< 10.0	3.28	-4.0	12.51
NaCl(0-)	2.5	< 10.0	3.18	-1.0	15.61
NaCl(0-)	2.5	< 10.0	3.14	1.0	19.71
NaCl(0-)	2.5	< 10.0	3.15	3.0	13.13
NaCl(0-)	2.5	< 10.0	3.13	4.0	11.25
NaCl(0-)	2.5	< 10.0	3.11	6.0	14.99
NaCl(0-)	3.0	< 10.0	2.79	-1.0	10.87
NaCl(0-)	3.0	< 10.0	2.79	1.0	10.40
NaCl(0-)	3.0	< 10.0	2.86	5.0	10.13
NaCl(0-)	3.0	< 10.0	2.89	7.0	13.51
NaCl(0-)	3.0	< 10.0	2.89	8.0	13.49
NaCl(0-)	5.5	< 10.0	1.92	-1.0	20.33
NaCl(0-)	5.5	< 10.0	1.97	0.0	18.34
NaCl(0-)	5.5	< 10.0	1.99	1.0	12.84
NaCl(0-)	5.5	< 10.0	2.02	2.0	12.74
NaCl(0-)	5.5	< 10.0	2.11	5.0	8.12
NaCl(0-)	5.5	< 10.0	2.12	6.0	9.80
NaCl(0-)	5.5	< 10.0	2.16	10.0	6.9
NaCl(0-)	7.5	< 10.0	1.64	1.0	16.22
NaCl(0-)	7.5	< 10.0	1.69	3.0	11.57
NaCl(0-)	7.5	< 10.0	1.68	4.0	13.63
NaCl(0-)	7.5	< 10.0	1.72	8.0	10.61
NaCl(0-)	7.5	< 10.0	1.72	9.0	9.09
NaCl(0-)	7.5	< 10.0	1.81	12.0	9.08
NaCl(0-)	7.5	< 10.0	1.83	13.0	9.34
NaCl(0-)	10.5	< 10.0	1.40	2.0	23.89
NaCl(0-)	10.5	< 10.0	1.49	6.0	23.06
NaCl(0-)	10.5	< 10.0	1.51	7.0	21.47
NaCl(0-)	10.5	< 10.0	1.52	11.0	14.80
NaCl(0-)	10.5	< 10.0	1.53	12.0	12.22
NaCl(0-)	10.5	< 10.0	1.52	14.0	17.13

Table S7: A summary of experimentally inferred onset saturation ratio S_0, nucleation temperature T_{nuc} and number of molecules in the critical cluster n^* values, as well as the selected mobility equivalent diameter d_p for neutralized NaCl seeds (0-/+). All measurements were conducted with a maximal relative humidity at room temperature (RH) below 2.5%.

Seed	d_p[nm]	RH [%]	S_0[ ]	T_{nuc} [$^\circ C$]	n^*
NaCl(0+)	2.5	< 2.5	3.19	0.0	10.71
NaCl(0-)	2.5	< 2.5	3.18	4.0	16.38
NaCl(0+)	3.0	< 2.5	2.83	1.0	9.26
NaCl(0+)	3.0	< 2.5	2.80	2.3	10.65
NaCl(0+)	3.0	< 2.5	2.82	7.5	21.22
NaCl(0+)	3.5	< 2.5	2.65	1.6	10.43
NaCl(0+)	3.5	< 2.5	2.60	8.0	16.57
NaCl(0+)	5.5	< 2.5	2.15	5.0	16.45
NaCl(0+)	5.5	< 2.5	2.21	11.8	11.59
NaCl(0+)	10.5	< 2.5	1.63	16.3	9.19
NaCl(0-)	10.5	< 2.5	1.66	17.2	12.12

Table S8: A summary of experimentally inferred onset saturation ratio S_0, nucleation temperature T_{nuc} and number of molecules in the critical cluster n^* values, as well as the selected mobility equivalent diameter d_p for positively (+) and negatively (-) charged silver seeds. All measurements were conducted with a maximal relative humidity at room temperature (RH) below 2.5% or 10%.

Seed	d_p[nm]	RH [%]	S_0[ ]	T_{nuc} [$^\circ C$]	n^*
Ag(+)	2.5	< 2.5	3.07	0.0	17.48
Ag(+)	2.5	< 2.5	3.03	6.0	14.10
Ag(+)	3.0	< 2.5	2.68	2.0	13.67
Ag(+)	3.0	< 2.5	2.48	8.0	11.65
Ag(+)	3.5	< 2.5	2.32	3.0	18.15
Ag(+)	3.5	< 2.5	2.33	10.0	11.74
Ag(-)	5.0	< 2.5	1.83	6.0	24.99
Ag(+)	5.0	< 2.5	1.85	7.0	20.55
Ag(+)	5.0	< 2.5	1.83	14.0	22.24
Ag(+)	9.0	< 2.5	1.36	11.0	33.67
Ag(+)	9.0	< 2.5	1.32	19.0	44.22

Table S9: A summary of experimentally inferred onset saturation ratio S_0, nucleation temperature T_{nuc} and number of molecules in the critical cluster n^* values, as well as the selected mobility equivalent diameter d_p for positively (+) and negatively (-) charged sodium chloride seeds. All measurements were conducted with a maximal relative humidity at room temperature (RH) below 2.5% or 10%.

Seed	d_p[nm]	RH [%]	S_0[ ]	T_{nuc} [$^\circ C$]	n^*
NaCl(+)	2.5	< 2.5	3.20	0.0	15.20
NaCl(-)	2.5	< 2.5	3.04	0.0	15.11
NaCl(-)	2.5	< 2.5	3.08	7.0	26.46
NaCl(+)	2.5	< 2.5	3.14	7.0	11.86
NaCl(-)	3.0	< 2.5	2.81	1.0	25.91
NaCl(+)	3.0	< 2.5	2.87	1.0	18.86
NaCl(-)	3.0	< 2.5	2.64	8.0	6.87
NaCl(+)	3.0	< 2.5	2.72	8.0	12.57
NaCl(+)	3.5	< 2.5	2.73	2.0	16.96
NaCl(-)	3.5	< 2.5	2.64	2.0	13.14
NaCl(-)	3.5	< 2.5	2.48	9.0	12.91
NaCl(+)	3.5	< 2.5	2.54	9.0	16.31
NaCl(+)	5.5	< 2.5	2.22	4.0	15.40
NaCl(-)	5.5	< 2.5	2.17	4.0	14.25
NaCl(+)	5.5	< 2.5	2.12	11.0	22.31
NaCl(+)	10.5	< 2.5	1.66	9.0	10.57
NaCl(-)	10.5	< 2.5	1.63	9.0	7.07
NaCl(+)	10.5	< 2.5	1.64	17.0	10.07
NaCl(-)	10.5	< 2.5	1.63	14.0	10.59

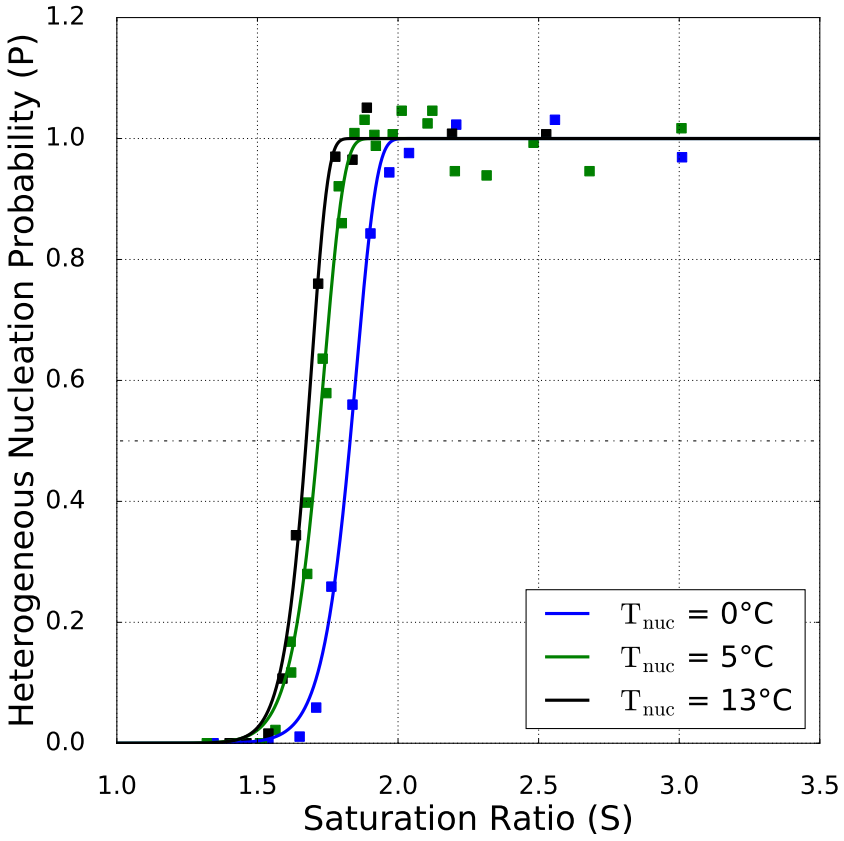

Figure S1: Heterogeneous nucleation probability measurements of n-butanol on neutral silver seeds with a mobility equivalent diameter of 5 nm at different nucleation temperatures as a function of saturation ratio. In this case lower nucleation temperature coincides with higher saturation ratios needed for particle activation. The horizontal dotted line represents the activation probability of 0.5.