Samples analysis reports

1. Chemical analyses

Samples used for analysis consisted of four representative samples of fly ash resulting from the combustion of different wastes, collected from filters of waste incinerator Pro Air Clean Timisoara, for a period of six months (June to November 2013).

Table 1 presents the AAS analyses for the significant ash samples, performed with a KONTRAA 700 spectrophotometer, revealing the metallic and total organic carbon (TOC) content of the samples. For example, the high concentration of aluminum (16,64%) in probe 0 leads to a high conductivity of the sample and sustains the hypothesis of a higher value for the CM factor at low frequencies.

Table 1: Metallic content of the ash samples

Chemical Element	**Content**							
	Probe 0		**Probe 1**		**Probe 2**		**Probe 3**	
	mg/kg	**%**	**mg/kg**	**%**	**mg/kg**	**%**	**mg/kg**	**%**
Al	166440	**16,64**	3890	**0,39**	3480	**0,35**	44890	**4,5**
Cd	328	**0,033**	198	**0,02**	198	**0,02**	248	**0,025**
Co	100	**0,01**	122	**0,012**	122	**0,012**	99	**0,01**
Cr	110	**0,01**	98	**0,01**	98	**0,01**	105	**0,01**
Cu	1450	**0,145**	4490	**0,45**	4490	**0,45**	4230	**0,42**
Fe	39670	**3,97**	13980	**1,4**	34980	**3,5**	56970	**5,7**
Mn	5390	**0,54**	148	**0,15**	159	**0,16**	890	**0,09**
Ni	500	**0,05**	390	**0,04**	190	**0,02**	328	**0.033**
Pb	9870	**0,99**	510	**0,05**	970	**0,1**	700	**0,07**
Sb	140	**0,014**	108	**0,01**	98	**0,01**	100	**0.01**
Zn	48760	**4,88**	17980	**1,8**	78980	**7,9**	5390	**0,54**
TOC[1]	31980	**3.2**	27870	**2.8**	23950	**2.4**	39980	**4.0**

[1] For proper operation of the incinerator, TOC concentration should not exceed 4%.

2. Dimensional analyses

For dimensional characterization, we prepared for each of the 4 probes; a mixture of 5 mg powder in 100 ml distilled water at room temperature, and put it to rest first for 20 minutes, and more 10 minutes then, in order to decant the microparticles. Each time we collected the remained slurry liquid and analyzed the particle size/concentration distribution by using a Nano Sight LM 10 nanoparticle visualization system. This high-performance device determines the size distribution and the number of nanoparticles in polydispersed and heterogeneous systems using nanoparticle-tracking analysis method.

Probe 0

Figure 1 illustrates the size/concentration distribution of particle for probe 0, after a time decantation of 20 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates that there were four significant groups of nanoparticles in the sample, having sizes of 59 nm, 112 nm, 165 nm, and 285 nm.

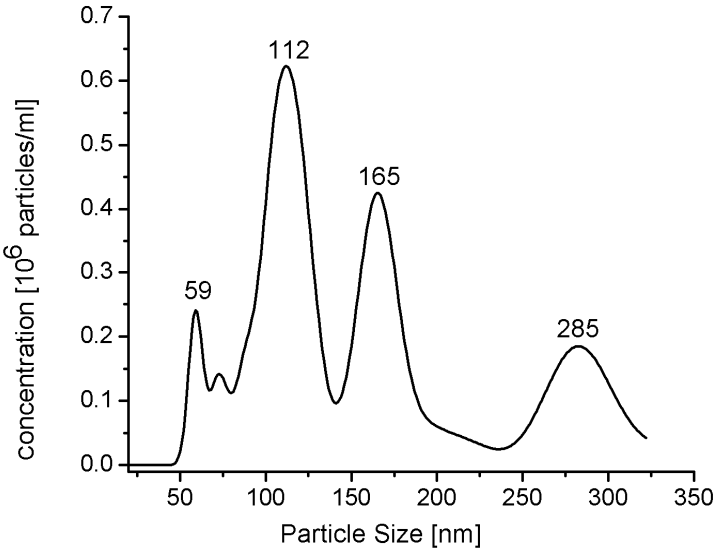


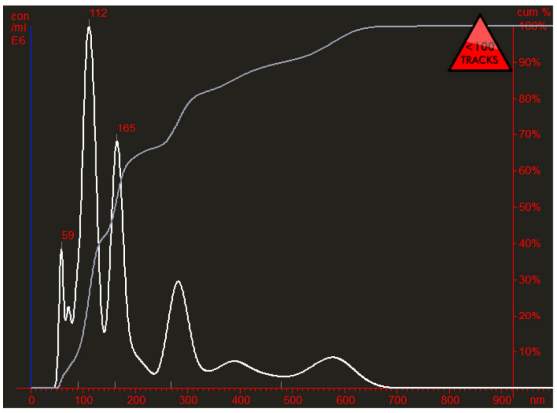
Figure 1: The size/concentration distribution of particle for probe 0, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

NANOSIGHT

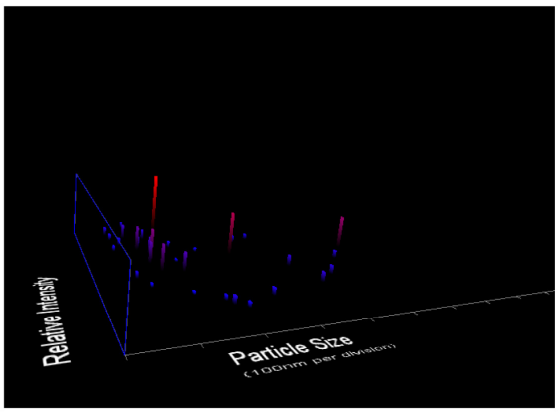
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 14 February 2013 12:03
Video File: test3.avi analysis no: 118
Operator: proba 3 mas 9
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	0.000	0.000
50	1.334	2.189
70	2.910	6.963
90	4.252	13.937
110	11.261	32.410
130	5.701	41.761
150	3.963	48.262
170	7.276	60.197
190	2.206	63.816
210	0.989	65.438
230	0.592	66.409
250	1.008	68.062
270	2.884	72.793
290	3.366	78.314
310	1.676	81.062
330	0.697	82.206
350	0.642	83.259
370	0.822	84.607
390	0.921	86.118
410	0.816	87.457
430	0.633	88.495
450	0.499	89.314
470	0.424	90.009
490	0.408	90.679
510	0.490	91.483
530	0.670	92.582
550	0.888	94.038
570	1.036	95.738
590	1.005	97.387
610	0.781	98.668
630	0.476	99.449
650	0.225	99.818
670	0.082	99.952
690	0.023	99.990

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.005	99.999
730	0.001	100.000
750	0.000	100.000
770	0.000	100.000
790	0.000	100.000
810	0.000	100.000
830	0.000	100.000
850	0.000	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**219 nm**
Mode:	**112 nm**
SD:	**149 nm**
D10:	**91 nm**
D50:	**162 nm**
D90:	**479 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.61 E8 particles/ml**
Completed Tracks:	**34**

Measurement Conditions

Temperature:	25.10 °C
Viscosity:	0.89 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	857 nm/s
Camera Shutter:	8 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto - failed

For the next three samples were performed two measurements on each sample (after 20 minutes of decantation and after another 10 minutes of decantation).

Probe 1

Figure 2 illustrates the size/concentration distribution of particle for probe 1, after a time decantation of 20 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates that there were five significant groups of nanoparticles in the sample, having sizes of 70 nm, 115 nm, 148 nm, 189 nm, and 266 nm.

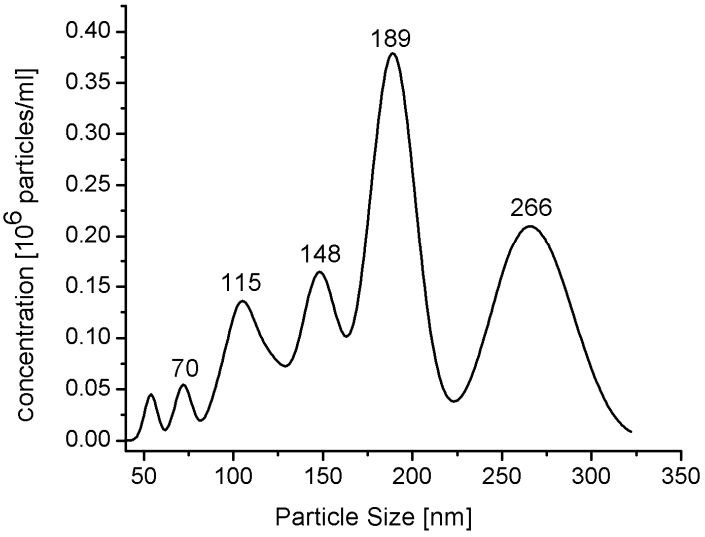


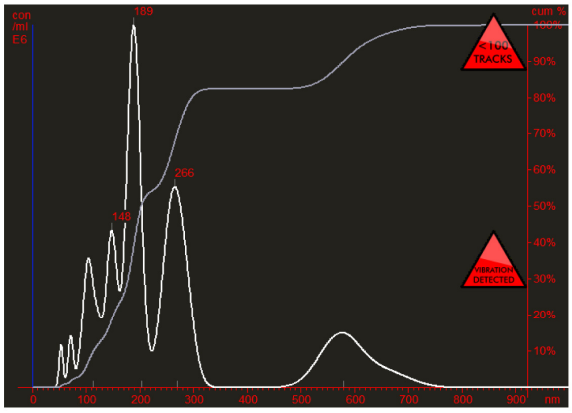
Figure 2: The size/concentration distribution of particle for probe 1, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

NANOSIGHT

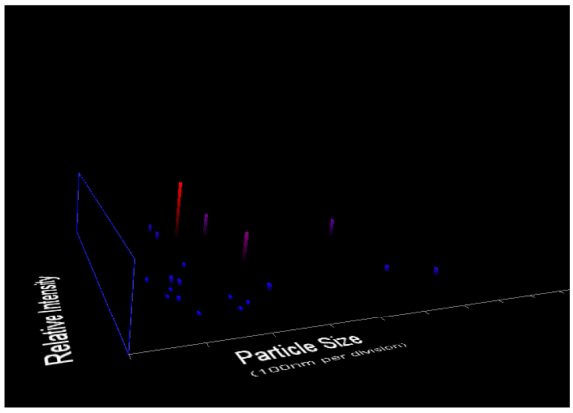
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 19 November 2013 10:54
Video File: proba 1 mas 3.avi analysis no: 003
Operator: proba 2
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	0.000	0.000
50	0.387	0.958
70	0.658	2.588
90	1.104	5.324
110	2.368	11.193
130	1.685	15.368
150	2.902	22.559
170	3.170	30.415
190	6.881	47.467
210	2.593	53.891
230	1.119	56.663
250	3.108	64.364
270	4.022	74.332
290	2.501	80.531
310	0.719	82.312
330	0.081	82.513
350	0.003	82.520
370	0.000	82.520
390	0.000	82.520
410	0.000	82.520
430	0.001	82.523
450	0.007	82.541
470	0.032	82.619
490	0.109	82.888
510	0.287	83.598
530	0.582	85.041
550	0.915	87.307
570	1.119	90.080
590	1.086	92.771
610	0.874	94.937
630	0.636	96.513
650	0.467	97.670
670	0.357	98.555
690	0.262	99.204

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.169	99.622
730	0.091	99.849
750	0.041	99.949
770	0.015	99.986
790	0.004	99.997
810	0.001	100.000
830	0.000	100.000
850	0.000	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**267 nm**
Mode:	**189 nm**
SD:	**162 nm**
D10:	**115 nm**
D50:	**204 nm**
D90:	**579 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.40 E8 particles/ml**
Completed Tracks:	**21**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	1725 nm/s
Camera Shutter:	30 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto - failed

Figure 3 illustrates the size/concentration distribution of particle for probe 1, after more 10 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates three significant groups of nanoparticles in the sample, having sizes of 45 nm, 93 nm, and 154 nm.

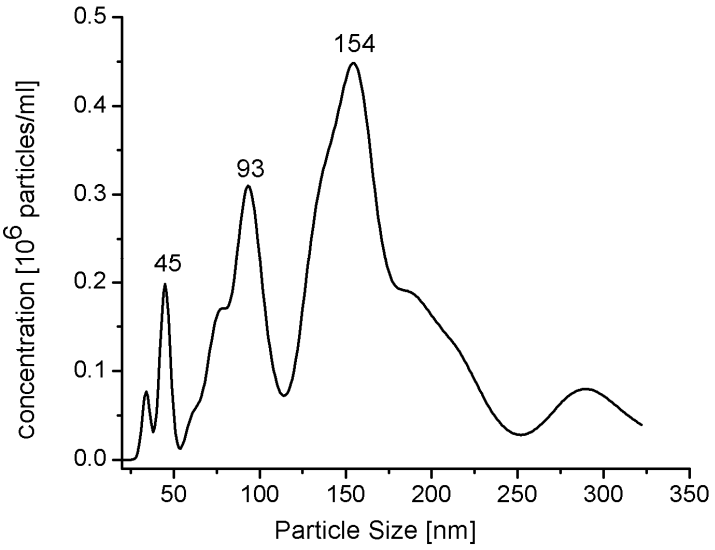


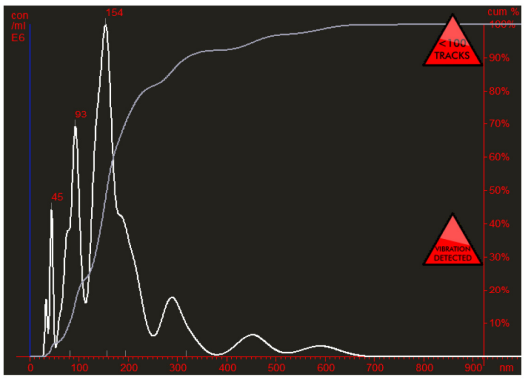
Figure 3: The size/concentration distribution of particle for probe 1, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 30 minutes time of decantation.

NANOSIGHT

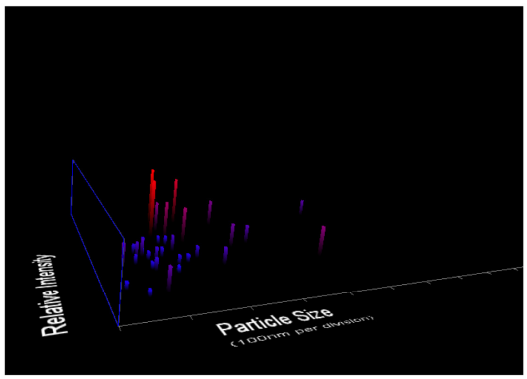
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 19 November 2013 11:08
Video File: proba 1 mas 1.avi analysis no: 003
Operator: proba 2
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	0.494	1.049
50	1.632	4.514
70	2.182	9.149
90	4.957	19.675
110	2.308	24.577
130	4.663	34.479
150	8.241	51.979
170	5.665	64.008
190	3.674	71.810
210	2.772	77.697
230	1.482	80.844
250	0.632	82.187
270	1.038	84.392
290	1.543	87.667
310	1.149	90.107
330	0.637	91.460
350	0.291	92.078
370	0.089	92.268
390	0.082	92.442
410	0.222	92.914
430	0.442	93.853
450	0.577	95.078
470	0.494	96.128
490	0.286	96.735
510	0.137	97.027
530	0.114	97.268
550	0.174	97.638
570	0.250	98.170
590	0.286	98.776
610	0.253	99.314
630	0.175	99.685
650	0.093	99.883
670	0.039	99.965
690	0.013	99.992

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.003	99.999
730	0.001	100.000
750	0.000	100.000
770	0.000	100.000
790	0.000	100.000
810	0.000	100.000
830	0.000	100.000
850	0.000	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**187 nm**
Mode:	**154 nm**
SD:	**114 nm**
D10:	**82 nm**
D50:	**157 nm**
D90:	**318 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.47 E8 particles/ml**
Completed Tracks:	**35**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	612 nm/s
Camera Shutter:	14 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto

Probe 2

Figure 4 illustrates the size/concentration distribution of particle for probe 2, after a time decantation of 20 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates four significant groups of nanoparticles in the sample, having sizes of 44 nm, 67 nm, 109 nm, and 180 nm.

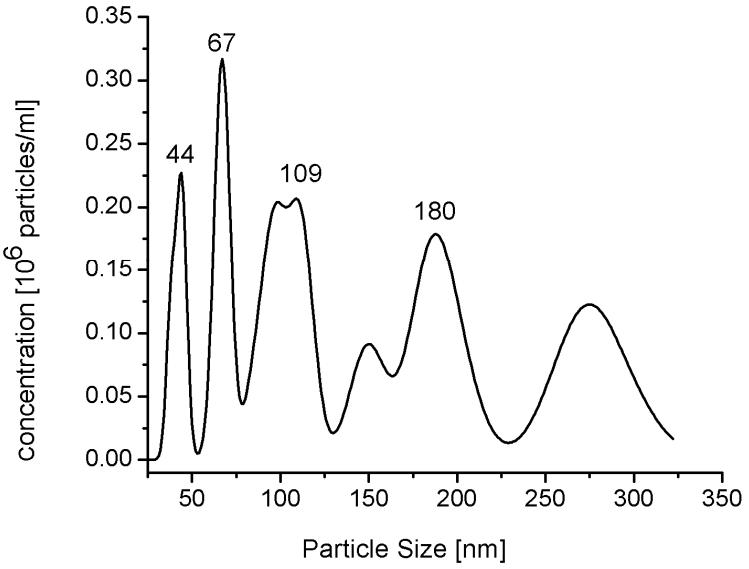


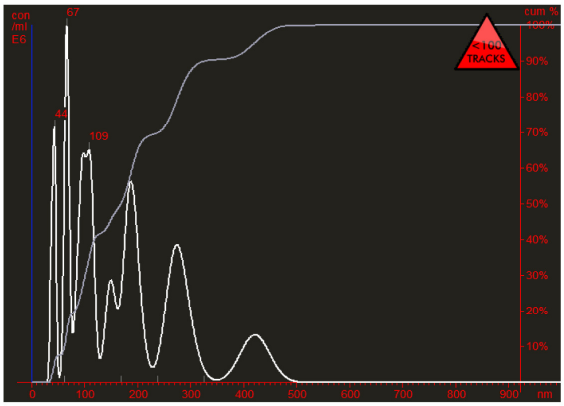
Figure 4: The size/concentration distribution of particle for probe 2, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

NANOSIGHT

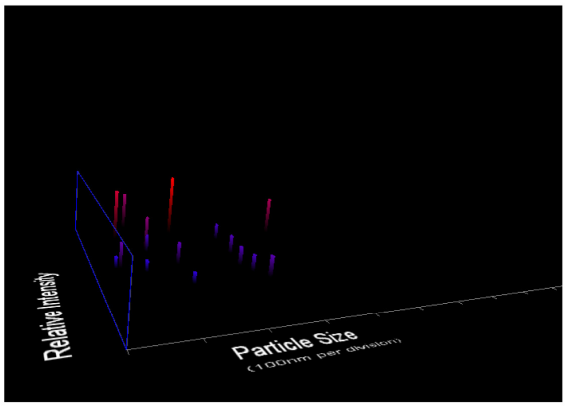
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 19 November 2013 12:07
Video File: proba 2 mas 6.avi analysis no: 003
Operator: proba 2
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	0.643	2.064
50	1.912	8.204
70	3.534	19.552
90	2.726	28.305
110	3.700	40.185
130	0.815	42.801
150	1.612	47.976
170	1.843	53.895
190	3.286	64.446
210	1.396	68.929
230	0.346	70.040
250	1.116	73.623
270	2.281	80.946
290	1.921	87.114
310	0.813	89.725
330	0.200	90.368
350	0.058	90.553
370	0.157	91.059
390	0.437	92.461
410	0.752	94.877
430	0.799	97.443
450	0.524	99.124
470	0.211	99.803
490	0.053	99.972
510	0.008	99.998
530	0.001	100.000
550	0.000	100.000
570	0.000	100.000
590	0.000	100.000
610	0.000	100.000
630	0.000	100.000
650	0.000	100.000
670	0.000	100.000
690	0.000	100.000

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.000	100.000
730	0.000	100.000
750	0.000	100.000
770	0.000	100.000
790	0.000	100.000
810	0.000	100.000
830	0.000	100.000
850	0.000	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**183 nm**
Mode:	**67 nm**
SD:	**110 nm**
D10:	**63 nm**
D50:	**169 nm**
D90:	**325 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.31 E8 particles/ml**
Completed Tracks:	**17**

Measurement Conditions

Temperature:	22.00 °C
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	1872 nm/s
Camera Shutter:	14 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto - failed

Figure 5 illustrates the size/concentration distribution of particle for probe 2, after more 10 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates three significant groups of nanoparticles in the sample, having sizes of 37 nm, 56 nm, and 95 nm.

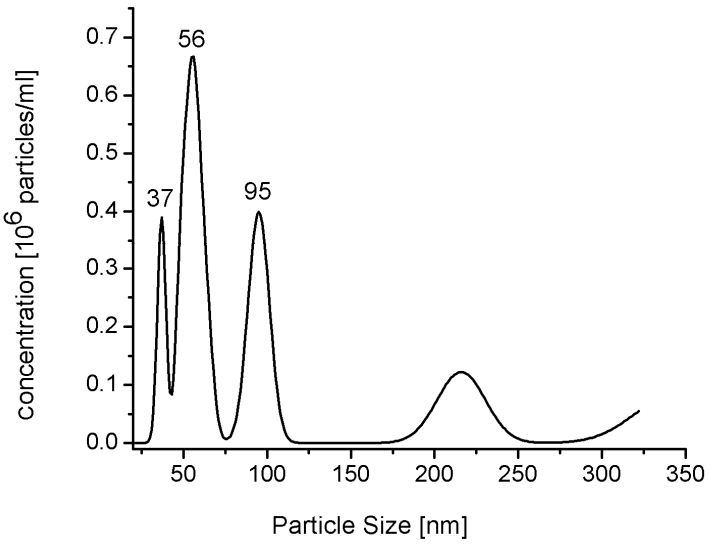


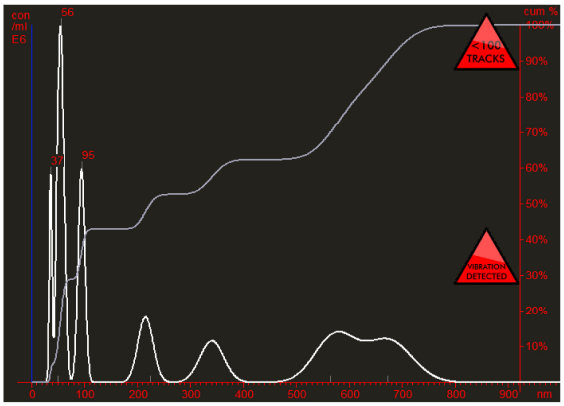
Figure 5: The size/concentration distribution of particle for sample 2, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 30 minutes time of decantation.

NANOSIGHT

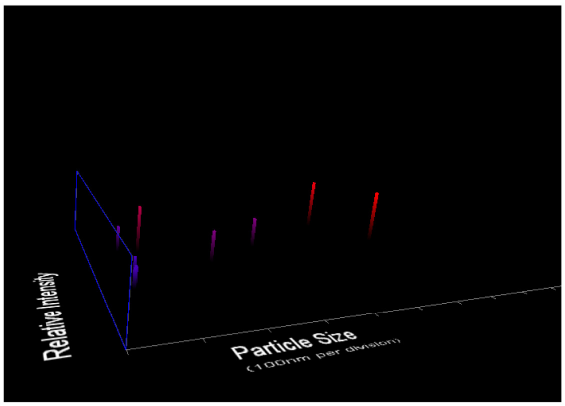
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 19 November 2013 11:55
Video File: proba 2 mas 2.avi analysis no: 003
Operator: proba 2
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	2.069	4.534
50	8.183	22.465
70	3.044	29.136
90	4.802	39.658
110	1.530	43.011
130	0.000	43.011
150	0.000	43.011
170	0.025	43.066
190	0.533	44.235
210	2.073	48.777
230	1.557	52.188
250	0.223	52.678
270	0.020	52.721
290	0.136	53.019
310	0.611	54.357
330	1.330	57.273
350	1.405	60.351
370	0.719	61.927
390	0.178	62.317
410	0.021	62.363
430	0.003	62.370
450	0.010	62.392
470	0.048	62.497
490	0.167	62.864
510	0.449	63.848
530	0.924	65.873
550	1.467	69.088
570	1.823	73.083
590	1.845	77.127
610	1.668	80.781
630	1.552	84.183
650	1.587	87.659
670	1.623	91.217
690	1.485	94.470
710	1.147	96.984
730	0.735	98.595
750	0.389	99.447
770	0.169	99.817
790	0.061	99.950
810	0.018	99.989
830	0.004	99.998
850	0.001	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**318 nm**
Mode:	**56 nm**
SD:	**255 nm**
D10:	**50 nm**
D50:	**225 nm**
D90:	**673 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.46 E8 particles/ml**
Completed Tracks:	**10**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	349 nm/s
Camera Shutter:	14 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto - failed

Probe 3

Figure 6 illustrates the size/concentration distribution of particle for probe 3, after a time decantation of 20 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates five significant groups of nanoparticles in the sample, having sizes of 40 nm, 60 nm, 102 nm, 138 nm, and 175 nm.

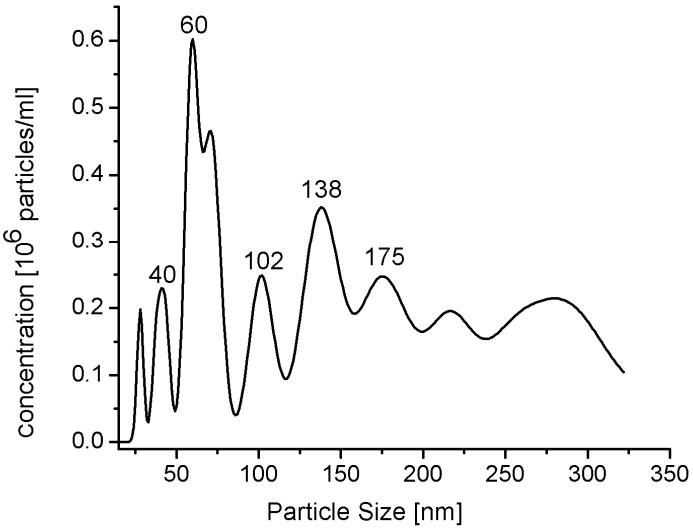


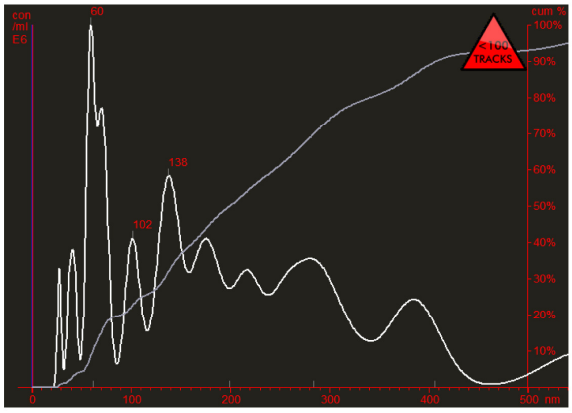
Figure 6: The size/concentration distribution of particle for sample 3, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

NANOSIGHT

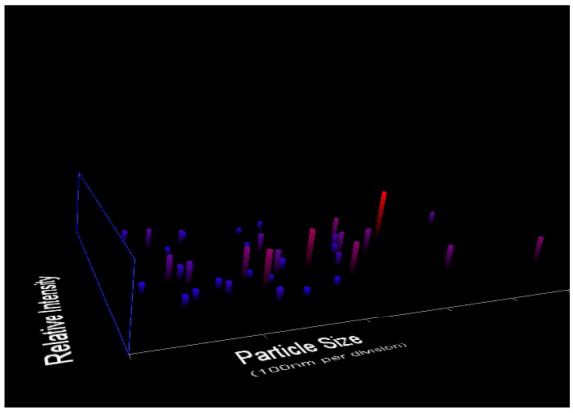
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 19 November 2013 12:07
Video File: proba 3 mas 2.avi analysis no: 002
Operator: proba 3 mas 2
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	1.803	2.302
50	4.630	8.214
70	8.504	19.071
90	2.220	21.906
110	3.319	26.143
130	5.053	32.594
150	5.161	39.184
170	4.556	45.001
190	3.941	50.033
210	3.660	54.705
230	3.396	59.042
250	3.469	63.471
270	4.156	68.778
290	4.083	73.991
310	2.920	77.719
330	1.793	80.008
350	1.710	82.191
370	2.526	85.417
390	2.816	89.012
410	1.854	91.379
430	0.709	92.284
450	0.187	92.522
470	0.136	92.696
490	0.310	93.092
510	0.620	93.884
530	0.960	95.110
550	1.154	96.583
570	1.086	97.970
590	0.805	98.997
610	0.469	99.596
630	0.214	99.870
650	0.076	99.967
670	0.021	99.994
690	0.004	99.999

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.001	100.000
730	0.000	100.000
750	0.000	100.000
770	0.000	100.000
790	0.000	100.000
810	0.000	100.000
830	0.000	100.000
850	0.000	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**225 nm**
Mode:	**60 nm**
SD:	**141 nm**
D10:	**62 nm**
D50:	**199 nm**
D90:	**406 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.78 E8 particles/ml**
Completed Tracks:	**40**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	10 of 10 s
Drift Velocity:	682 nm/s
Camera Shutter:	14 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto - failed

Figure 7 illustrates the size/concentration distribution of particle for probe 3, after more 10 minutes, followed by the analysis report generated by the LM 10 software. The distribution diagram indicates three significant groups of nanoparticles in the sample, having sizes of 42 nm, 95 nm, and 175 nm.

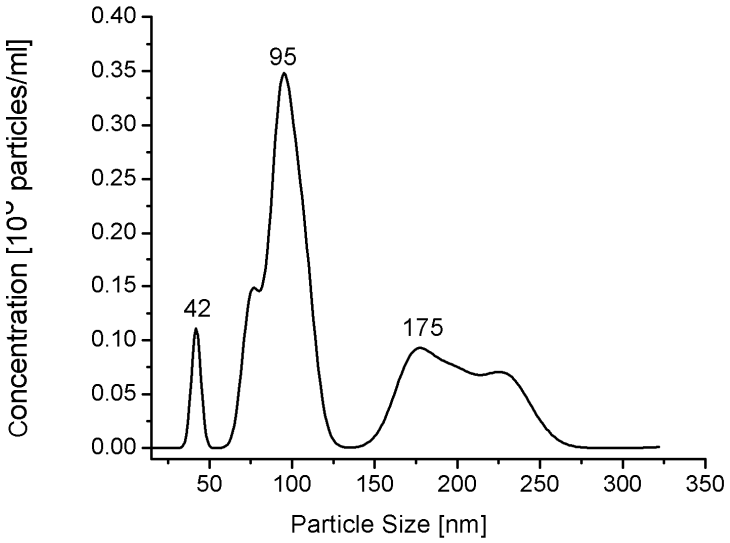


Figure 7: The size/concentration distribution of particle for sample 3, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 30 minutes time of decantation.

Conclusions

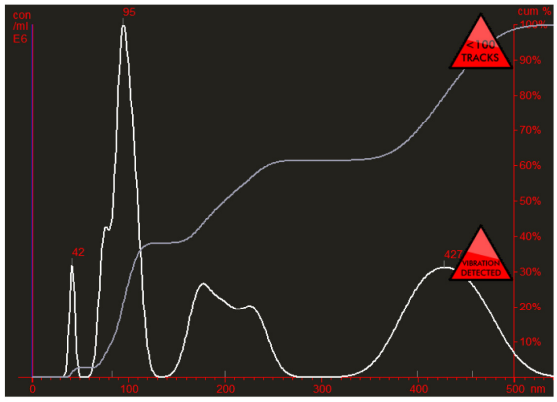
These analyses show that the gas resulting from the combustion of waste contain nanoparticles. Recall that these nanoparticles are only those that probably were attached to larger particles, and stocked during the mechanical filtering process. They are, however, relevant to our study because the result indicates the existence of a much larger quantity of nanoparticles in the combustion waste gases than originally detected. Our study will focus mainly on the particles with radii < 200nm, potentially harmful for human health.

NANOSIGHT

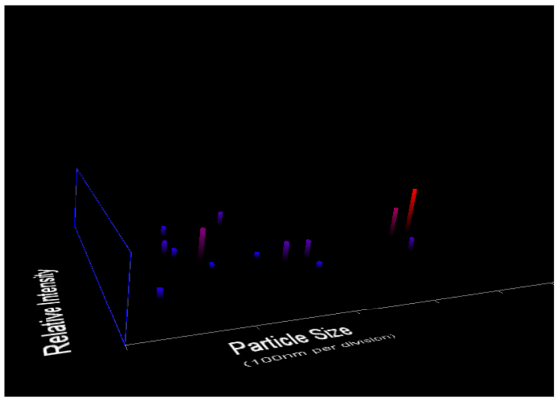
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 19 November 2013 12:07
Video File: proba 3 mas 6.avi analysis no: 002
Operator: proba 3 mas 6
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.000	0.000
30	0.149	0.510
50	0.644	2.710
70	1.557	8.033
90	5.179	25.739
110	3.515	37.757
130	0.127	38.190
150	0.272	39.120
170	1.510	44.282
190	1.668	49.984
210	1.404	54.783
230	1.328	59.322
250	0.572	61.279
270	0.059	61.482
290	0.002	61.488
310	0.006	61.507
330	0.048	61.672
350	0.243	62.502
370	0.745	65.050
390	1.471	70.078
410	2.017	76.975
430	2.165	84.379
450	1.969	91.112
470	1.450	96.069
490	0.780	98.737
510	0.287	99.719
530	0.070	99.958
550	0.011	99.996
570	0.001	100.000
590	0.000	100.000
610	0.000	100.000
630	0.000	100.000
650	0.000	100.000
670	0.000	100.000
690	0.000	100.000

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.000	100.000
730	0.000	100.000
750	0.000	100.000
770	0.000	100.000
790	0.000	100.000
810	0.000	100.000
830	0.000	100.000
850	0.000	100.000
870	0.000	100.000
890	0.000	100.000
910	0.000	100.000
930	0.000	100.000
950	0.000	100.000
970	0.000	100.000
990	0.000	100.000
1000-2000	0.000	100.000

Results

Mean:	**247 nm**
Mode:	**95 nm**
SD:	**152 nm**
D10:	**83 nm**
D50:	**200 nm**
D90:	**456 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**0.29 E8 particles/ml**
Completed Tracks:	**15**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	10 of 10 s
Drift Velocity:	1336 nm/s
Camera Shutter:	14 ms

Analysis Conditions

Blur:	Auto
Detection Threshold:	10 Multi
Min Track Length:	Auto
Min Expected Size:	Auto - failed