Samples analysis reports
- II -

Probes used for analysis consisted of three representative samples of fly ash resulting from the combustion of different wastes, collected from filters of waste incinerator Pro Air Clean Timisoara, bi-monthly, for a period of six months (February to August 2014). For dimensional characterization, we prepared for each of the 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 nanoparticle in polydispersed and heterogeneous systems using nanoparticle-tracking analysis method.

1. Chemical analyses

Table 1 presents the AAS analyses for the last 3 samples, performed with a KONTRAA 700 spectrophotometer, revealing the metallic and total organic carbon (TOC) content of the samples.

Table 1: Metallic content of the ash samples

Chemical Element	Content					
	Probe 4 14.03.2014		Probe 5 21.03.2014		Probe 6 28.03.2014	
	mg/kg	%	mg/kg	%	mg/kg	%
Al	21980	**2.2**	17980	**1.8**	15980	**1.6**
Cd	3000	**0.003**	6000	**0.006**	5000	**0.005**
Co	-	**-**	-	**-**	-	**-**
Cr	758	**0.076**	198	**0.02**	178	**0.18**
Cu	790	**0.8**	590	**0.6**	790	**0.8**
Fe	24460	**2.45**	15980	**1.6**	14980	**1.5**
Mn	600	**0.06**	400	**0.04**	400	**0.04**
Ni	200	**0.02**	718	**0.072**	2890	**0.29**
Pb	3390	**0.34**	159	**0.16**	290	**0.3**
Sb	-	**-**	-	**-**	-	**-**
Zn	15980	**1.6**	7890	**0.79**	16460	**1.65**
TOC[1]	32980	**3.3**	27980	**2.8**	25980	**2.6**

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

2. Dimensional 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 dimensional characterization, we prepared for the last 3 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 4

Figure 1 illustrates the size/concentration distribution of particle for probe 4, 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 23 nm, 48 nm, 196 nm.

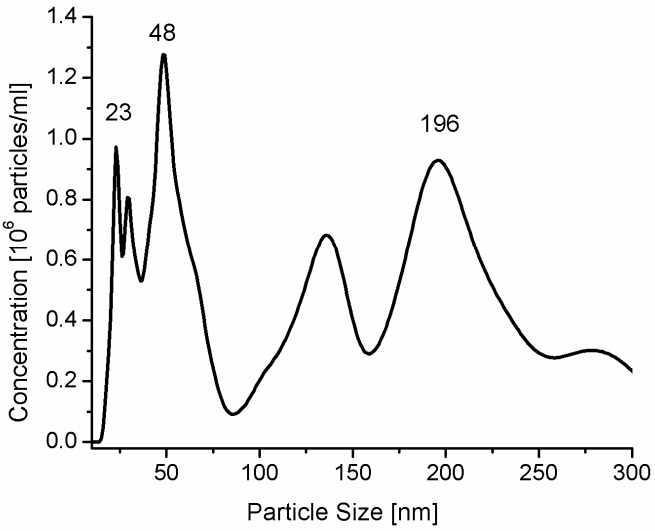


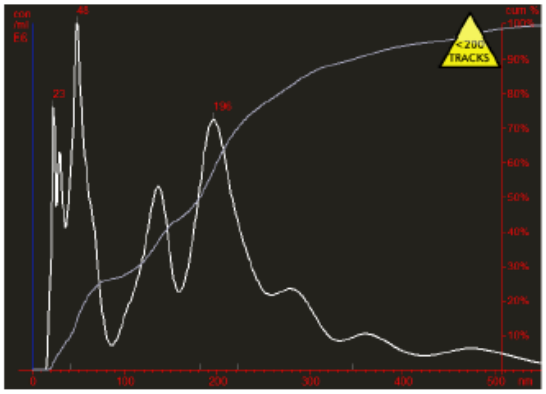
Figure 1: The size/concentration distribution of particle for probe 4, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

NANOSIGHT

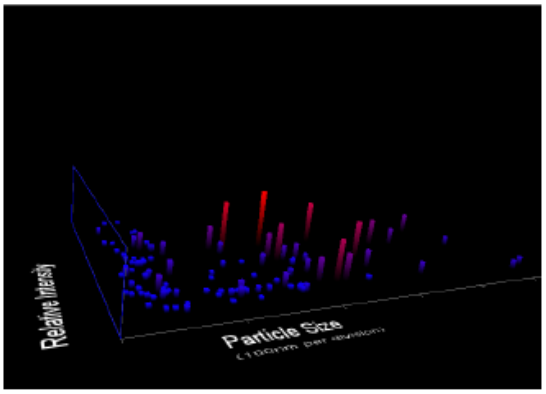
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture:
Video File: 14.03.2014 ciclon test.avi analysis no: 002
Operator: cenusa ciclon
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.702	0.438
30	13.453	8.833
50	19.039	20.713
70	8.465	25.995
90	2.484	27.545
110	5.932	31.247
130	11.762	38.586
150	8.763	44.054
170	8.509	49.363
190	16.814	59.855
210	15.083	69.266
230	9.289	75.063
250	6.076	78.854
270	5.826	82.490
290	5.566	85.963
310	3.600	88.209
330	2.257	89.617
350	2.519	91.189
370	2.526	92.765
390	1.821	93.901
410	1.214	94.659
430	1.095	95.342
450	1.366	96.195
470	1.594	97.189
490	1.496	98.123
510	1.180	98.859
530	0.832	99.378
550	0.528	99.707
570	0.286	99.886
590	0.126	99.964
610	0.043	99.991
630	0.011	99.998
650	0.002	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:	**48 nm**
SD:	**118 nm**
D10:	**42 nm**
D50:	**181 nm**
D90:	**345 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**1.60 E8 particles/ml**
Completed Tracks:	**109**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	10 of 10 s
Drift Velocity:	2076 nm/s
Camera Shutter:	14 ms

Analysis Conditions

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

Figure 2 illustrates the size/concentration distribution of particle for probe 4, 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 27 nm, 105 nm, 240 nm.

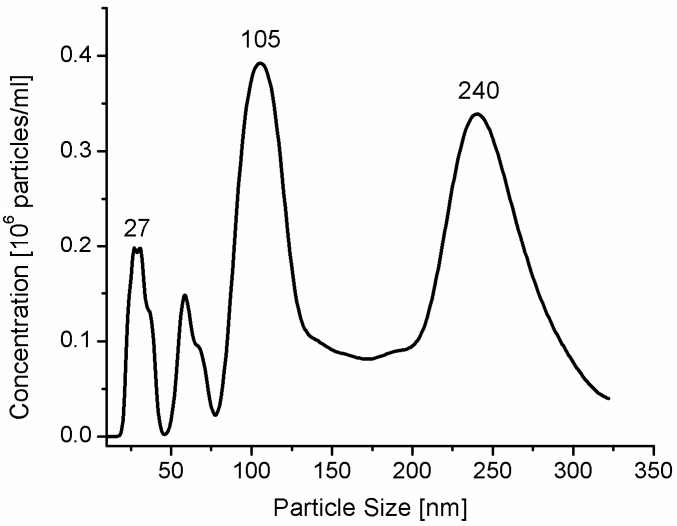


Figure 2: The size/concentration distribution of particle for probe 4, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 30 minutes time of decantation.

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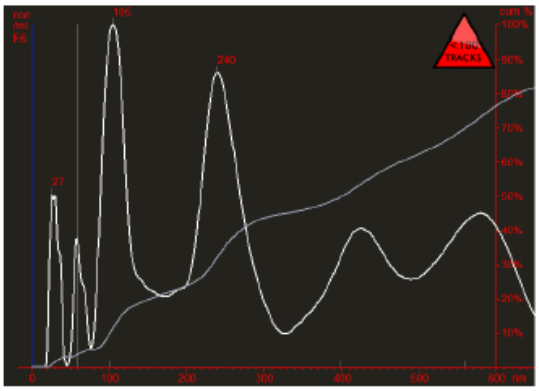
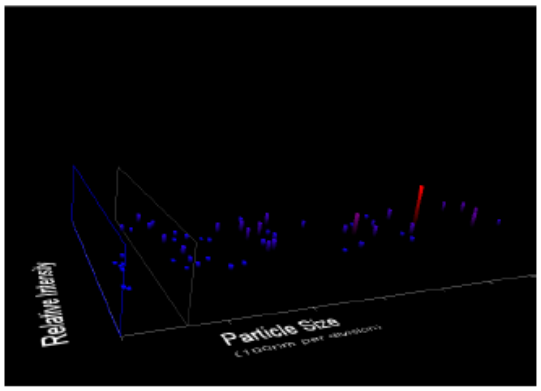
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 14 April 2014 13:05
Video File: 14.03 2014 ciclon test 3.avi analysis no: 003
Operator: oenusa ciclon
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.005	0.005
30	2.876	2.737
50	1.090	3.773
70	1.499	5.197
90	4.082	9.074
110	7.243	15.955
130	3.000	18.805
150	1.850	20.563
170	1.652	22.133
190	1.779	23.823
210	2.715	26.402
230	5.828	31.938
250	6.199	37.828
270	3.970	41.599
290	2.191	43.681
310	1.145	44.769
330	0.808	45.536
350	1.089	46.571
370	1.490	47.987
390	2.140	50.019
410	2.915	52.789
430	3.152	55.783
450	2.747	58.393
470	2.236	60.517
490	2.039	62.454
510	2.207	64.551
530	2.618	67.038
550	3.109	69.992
570	3.472	73.290
590	3.449	76.566
610	2.911	79.331
630	2.042	81.271
650	1.229	82.439
670	0.763	83.164
690	0.696	83.826

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.922	84.702
730	1.297	85.934
750	1.694	87.543
770	2.012	89.454
790	2.179	91.524
810	2.160	93.576
830	1.962	95.440
850	1.631	96.989
870	1.236	98.163
890	0.851	98.971
910	0.529	99.474
930	0.297	99.756
950	0.149	99.898
970	0.067	99.962
990	0.027	99.987
1000-2000	0.013	100.000

Results

Mean:	**408 nm**
Mode:	**105 nm**
SD:	**245 nm**
D10:	**102 nm**
D50:	**399 nm**
D90:	**785 nm**
User Lines:	**60 nm, 0 nm**
Concentration:	**1.05 E8 particles/ml**
Completed Tracks:	**59**

Measurement Conditions

Temperature:	22.00 °C
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	1211 nm/s
Camera Shutter:	30 ms

Analysis Conditions

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

Probe 5

Figure 3 illustrates the size/concentration distribution of particle for probe 5, 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 26 nm, 46 nm, 63 nm.

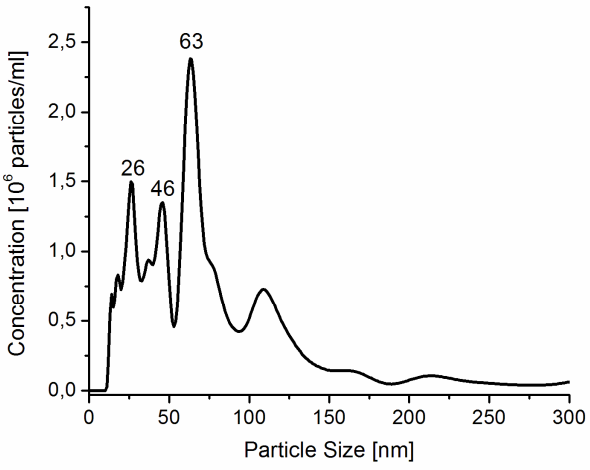


Figure 3: The size/concentration distribution of particle for probe 5, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

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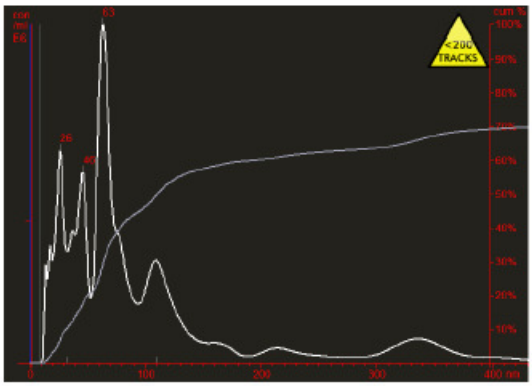
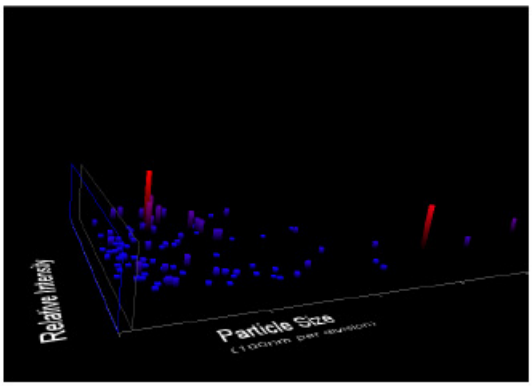
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 8 May 2014 12:33
Video File: 21.03.2014 ciclon test 1.avi analysis no: 004
Operator: cenusa ciclon
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	5.126	2.763
30	20.175	13.636
50	19.580	24.189
70	30.492	40.623
90	10.461	46.261
110	12.845	53.184
130	6.575	56.727
150	3.109	58.403
170	2.381	59.686
190	1.142	60.302
210	1.957	61.356
230	1.620	62.230
250	1.090	62.817
270	0.842	63.271
290	0.945	63.781
310	1.942	64.827
330	3.273	66.591
350	2.862	68.133
370	1.476	68.929
390	0.884	69.405
410	0.726	69.797
430	0.444	70.036
450	0.214	70.151
470	0.243	70.282
490	0.569	70.589
510	1.154	71.211
530	1.825	72.195
550	2.333	73.452
570	2.620	74.864
590	2.897	76.426
610	3.336	78.224
630	3.788	80.265
650	3.941	82.389
670	3.687	84.376
690	3.235	86.120

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	2.883	87.674
730	2.774	89.169
750	2.840	90.699
770	2.916	92.271
790	2.875	93.820
810	2.679	95.264
830	2.361	96.537
850	1.972	97.600
870	1.556	98.438
890	1.147	99.056
910	0.778	99.476
930	0.480	99.735
950	0.267	99.878
970	0.133	99.950
990	0.059	99.981
1000-2000	0.034	100.000

Results

Mean:	**282 nm**
Mode:	**63 nm**
SD:	**287 nm**
D10:	**32 nm**
D50:	**110 nm**
D90:	**751 nm**
User Lines:	**8 nm, 0 nm**
Concentration:	**1.86 E8 particles/ml**
Completed Tracks:	**108**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	0 of 10 s
Drift Velocity:	823 nm/s
Camera Shutter:	30 ms

Analysis Conditions

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

Figure 4 illustrates the size/concentration distribution of particle for probe 5, 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 73 nm, 128 nm, 220 nm.

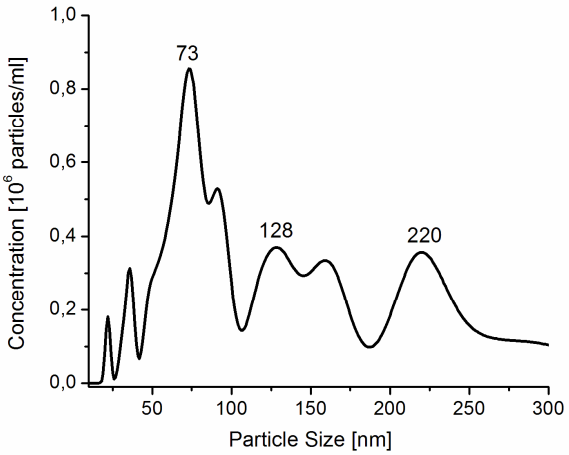


Figure 4: The size/concentration distribution of particle for probe 5, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 30 minutes time of decantation.

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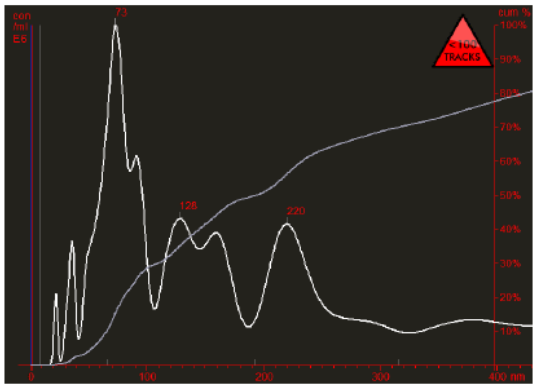
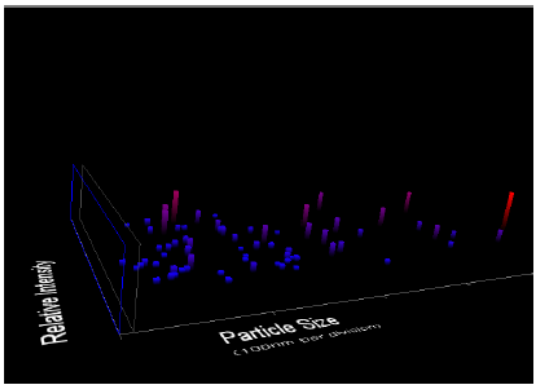
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 8 May 2014 12:37
Video File: 21.03.2014 ciclon test 8.avi analysis no: 002
Operator: cenusa ciclon
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.033	0.030
30	2.982	2.715
50	4.989	7.208
70	13.783	19.619
90	9.852	28.491
110	4.217	32.289
130	7.003	38.595
150	6.205	44.183
170	5.040	48.721
190	2.397	50.879
210	5.739	56.047
230	6.117	61.556
250	3.318	64.543
270	2.406	66.710
290	2.222	68.711
310	1.856	70.383
330	1.699	71.913
350	2.008	73.721
370	2.263	75.759
390	2.267	77.800
410	2.095	79.686
430	1.989	81.477
450	1.876	83.166
470	1.674	84.674
490	1.600	86.115
510	1.741	87.683
530	1.828	89.329
550	1.625	90.792
570	1.264	91.930
590	1.043	92.870
610	1.043	93.809
630	1.096	94.796
650	1.026	95.720
670	0.803	96.443
690	0.518	96.910

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.275	97.157
730	0.120	97.265
750	0.044	97.305
770	0.014	97.317
790	0.006	97.322
810	0.007	97.328
830	0.014	97.341
850	0.029	97.368
870	0.054	97.417
890	0.093	97.500
910	0.145	97.631
930	0.207	97.817
950	0.270	98.061
970	0.322	98.351
990	0.352	98.668
1000-2000	1.480	100.000

Results

Mean:	**257 nm**
Mode:	**73 nm**
SD:	**210 nm**
D10:	**66 nm**
D50:	**193 nm**
D90:	**548 nm**
User Lines:	**8 nm, 0 nm**
Concentration:	**1.11 E8 particles/ml**
Completed Tracks:	**75**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	10 of 10 s
Drift Velocity:	221 nm/s
Camera Shutter:	17 ms

Analysis Conditions

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

Probe 6

Figure 5 illustrates the size/concentration distribution of particle for probe 6, 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 36 nm, 47 nm, 177 nm.

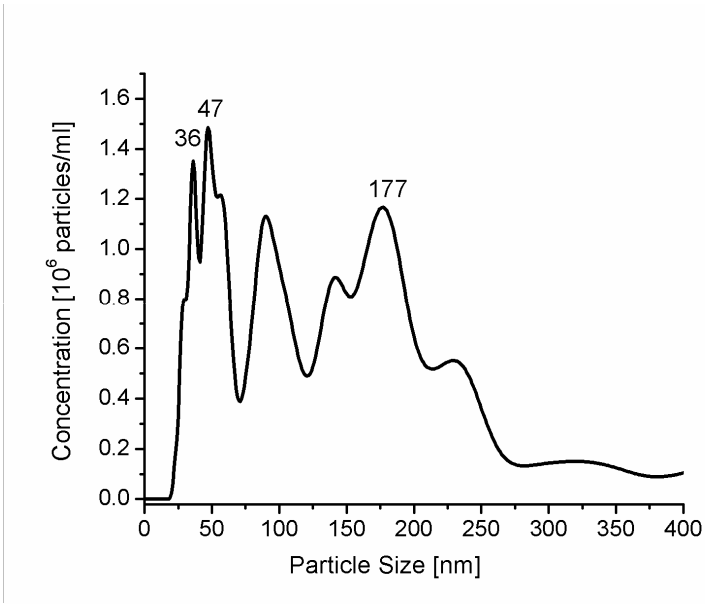


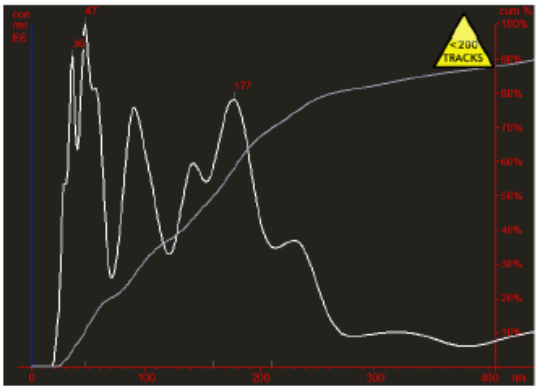
Figure 5: The size/concentration distribution of particle for probe 6, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 20 minutes time of decantation.

NANOSIGHT

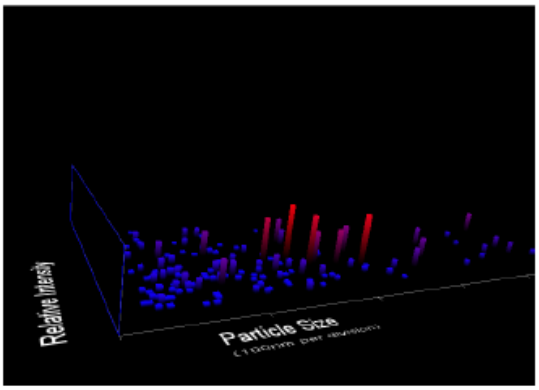
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 15 May 2014 10:34
Video File: 28.03.2014 ciclon test 3.avi analysis no: 002
Operator: oenusa ciclon
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.007	0.003
30	14.446	6.255
50	24.774	16.977
70	12.028	22.182
90	20.165	30.909
110	13.882	36.917
130	13.095	42.585
150	16.917	49.906
170	21.315	59.131
190	18.627	67.193
210	10.983	71.946
230	10.789	76.615
250	7.365	79.803
270	3.276	81.220
290	2.740	82.406
310	2.964	83.689
330	2.947	84.964
350	2.511	86.051
370	1.934	86.888
390	1.885	87.704
410	2.356	88.724
430	2.858	89.961
450	3.143	91.321
470	2.999	92.619
490	2.343	93.633
510	1.491	94.278
530	0.855	94.648
550	0.525	94.875
570	0.348	95.026
590	0.209	95.116
610	0.100	95.160
630	0.036	95.175
650	0.010	95.180
670	0.002	95.181
690	0.000	95.181

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.001	95.181
730	0.004	95.183
750	0.012	95.188
770	0.030	95.201
790	0.069	95.231
810	0.142	95.293
830	0.266	95.408
850	0.450	95.602
870	0.689	95.900
890	0.956	96.314
910	1.199	96.833
930	1.362	97.423
950	1.400	98.029
970	1.302	98.592
990	1.096	99.067
1000-2000	2.156	100.000

Results

Mean:	**210 nm**
Mode:	**47 nm**
SD:	**202 nm**
D10:	**47 nm**
D50:	**160 nm**
D90:	**440 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**2.31 E8 particles/ml**
Completed Tracks:	**138**

Measurement Conditions

Temperature:	22.00 °C
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	10 of 10 s
Drift Velocity:	4178 nm/s
Camera Shutter:	30 ms

Analysis Conditions

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

Figure 6 illustrates the size/concentration distribution of particle for probe 6, 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 28 nm, 54 nm, 251 nm.

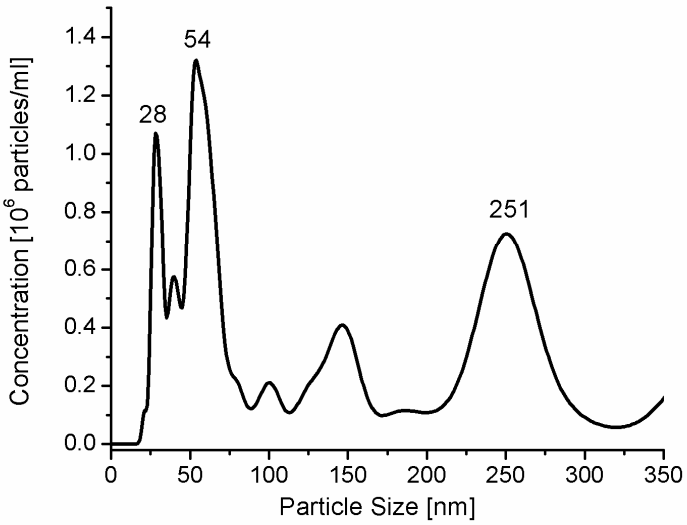


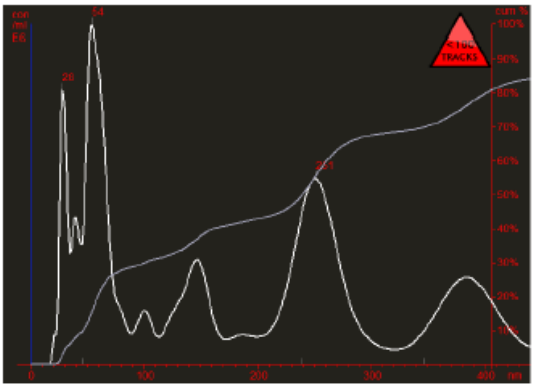
Figure 6: The size/concentration distribution of particle for probe 6, obtained with the visualization system of nanoparticles, Nano Sight LM10, after 30 minutes time of decantation.

NANOSIGHT

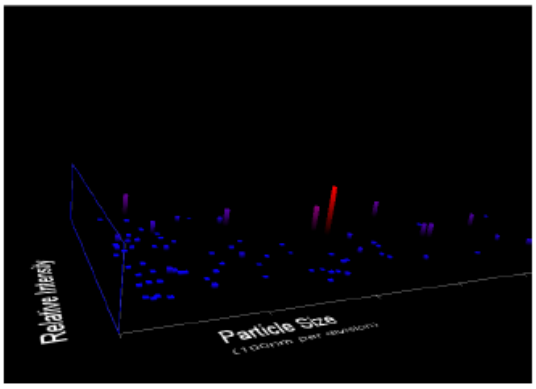
Nanoparticle Tracking Analysis (NTA) Version 2.3 Build 0025

ANALYSIS REPORT

Sample:
Date/Time of Capture: 15 May 2014 10:34
Video File: 28.03.2014 oenusa ciclon test 5.avi analysis no: 002
Operator: oenusa ciclon
Comments:



Particle Size / Concentration



Particle Size / Relative Intensity 3D plot

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
10	0.060	0.040
30	11.343	7.664
50	18.075	19.814
70	11.768	27.723
90	3.250	29.908
110	2.977	31.908
130	4.816	35.146
150	7.027	39.869
170	2.414	41.492
190	2.247	43.002
210	2.764	44.860
230	7.907	50.174
250	13.814	59.459
270	8.981	65.496
290	3.176	67.631
310	1.397	68.569
330	1.401	69.511
350	3.125	71.612
370	5.802	75.512
390	6.492	79.876
410	4.361	82.807
430	2.052	84.186
450	1.319	85.073
470	1.812	86.291
490	2.594	88.034
510	2.872	89.965
530	2.394	91.574
550	1.549	92.615
570	0.849	93.186
590	0.463	93.497
610	0.276	93.682
630	0.163	93.792
650	0.082	93.847
670	0.033	93.869
690	0.011	93.877

Bin Centre (nm)	Concentration (E6 particles/ml)	Percentile Undersize (%)
710	0.003	93.878
730	0.000	93.879
750	0.000	93.879
770	0.000	93.879
790	0.001	93.880
810	0.003	93.882
830	0.008	93.887
850	0.018	93.899
870	0.039	93.926
890	0.078	93.978
910	0.142	94.074
930	0.238	94.234
950	0.370	94.483
970	0.531	94.839
990	0.702	95.311
1000-2000	6.975	100.000

Results

Mean:	**274 nm**
Mode:	**54 nm**
SD:	**248 nm**
D10:	**46 nm**
D50:	**239 nm**
D90:	**520 nm**
User Lines:	**0 nm, 0 nm**
Concentration:	**1.49 E8 particles/ml**
Completed Tracks:	**84**

Measurement Conditions

Temperature:	22.00 ºC
Viscosity:	0.95 cP
Frames Per Second:	30.00
Measurement Time:	10 of 10 s
Drift Velocity:	1231 nm/s
Camera Shutter:	30 ms

Analysis Conditions

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