Supplementary Material

Silver Nanoparticles Stabilized with Phosphorus-Containing Heterocyclic Surfactants: Synthesis, Physico-Chemical Properties, and Biological Activity Determination

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1. Dynamic light scattering measurements and data analysis

Screenshots from DLS measurements were obtained using Brookhaven BIC analysis software ver. 6.3 for BI 9000AT digital correlator (DOS version). Five independent measurements were performed for each Ag/surfactant system and each silver-to-surfactant molar ratio value. For each Ag/surfactant system and each molar ratio, the first screenshot provides the image of the autocorrelation function, and the second screenshot provides the data analysis.
The hydrodynamic diameter values of AgNPs shown in the plots in the main article were calculated as the mean of the value Eff.Diam. shown in the second screenshot. This value is calculated from the Taylor series expansion of logarithm of autocorrelation function $g^{(1)}(t)$ in terms of cumulants as follows:

$$\ln(g^{(1)}(t)) = -\bar{\Gamma} t + \frac{1}{2!} \mu_2 t^2 + ...$$

μ_2 is the second cumulant which would be near zero for a perfect single exponential decay. The decay rate $\bar{\Gamma}$ was calculated from the expansion of the logarithm of time correlation function up to the second term using the first linear term in the series for the $\bar{\Gamma}$ calculation (Gam.Ave. in the screenshots). The diffusion coefficient D was determined from the decay rate ($\bar{\Gamma} = D q^2$) and the hydrodynamic diameter of AgNPs (Eff.Diam. in the screenshots) was calculated from the diffusion coefficient using the Stokes–Einstein formula

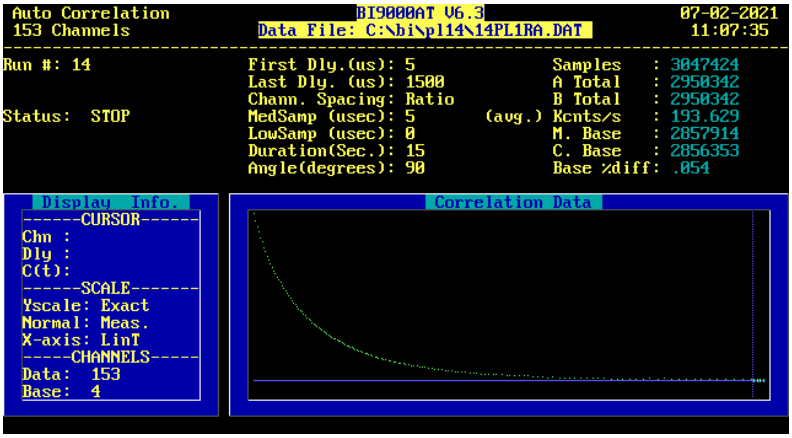
$$Eff.Diam = kT / (3\pi\eta D)$$

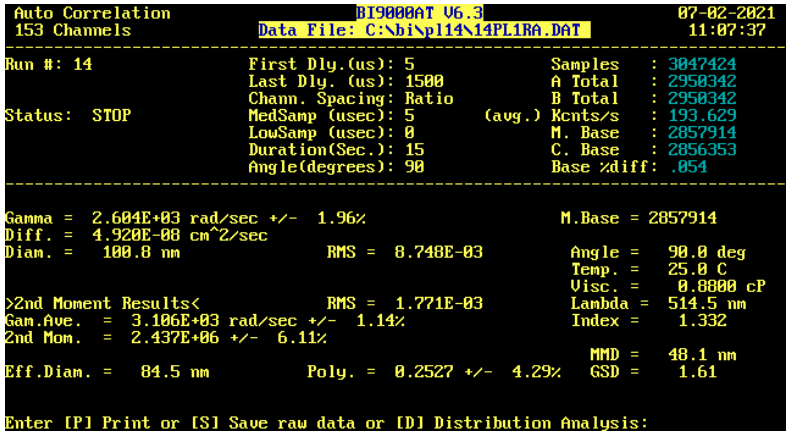
η is solvent viscosity, k is the Boltzmann constant, and T is absolute temperature. Five independent measurements and calculations of time correlation function were carried out for each Ag/surfactant system and silver-to-surfactant molar ratio investigated. The mean value and standard deviation of Eff.Diam for each sample were calculated and plotted in the graphs.

To reduce the excessive number of screenshots in this supplementary material, just one independent measurement for each Ag/surfactant system and each silver-to-surfactant molar ratio value is shown.

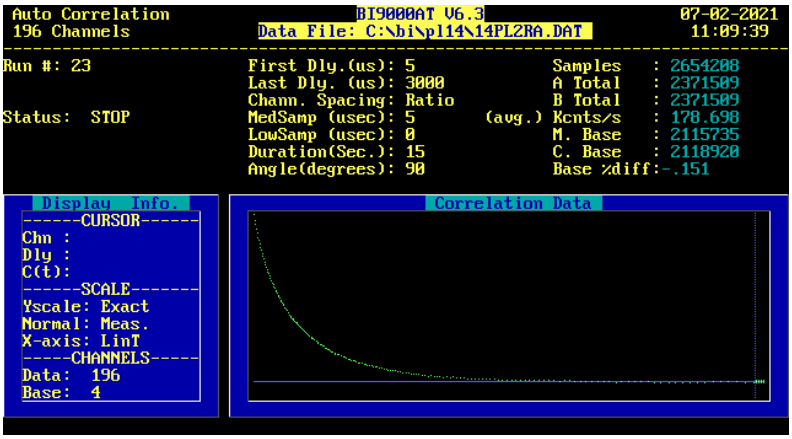
Screenshots section - DLS

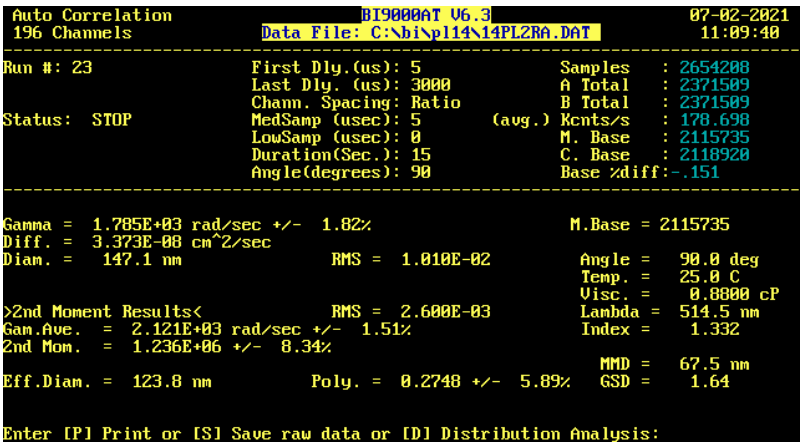
Ag/14pl, n_{Ag}/n_{Surf} = 8



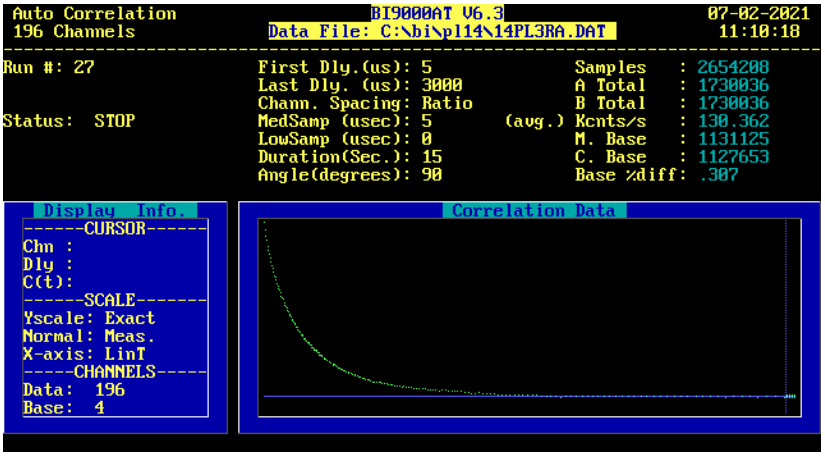


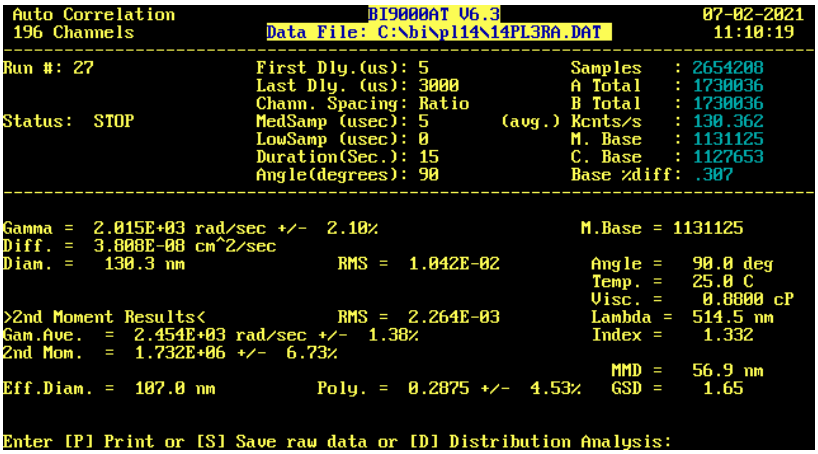
Ag/14pl, n_{Ag}/n_{Surf} = 4





Ag/14pl, n_{Ag}/n_{Surf} = 2.7





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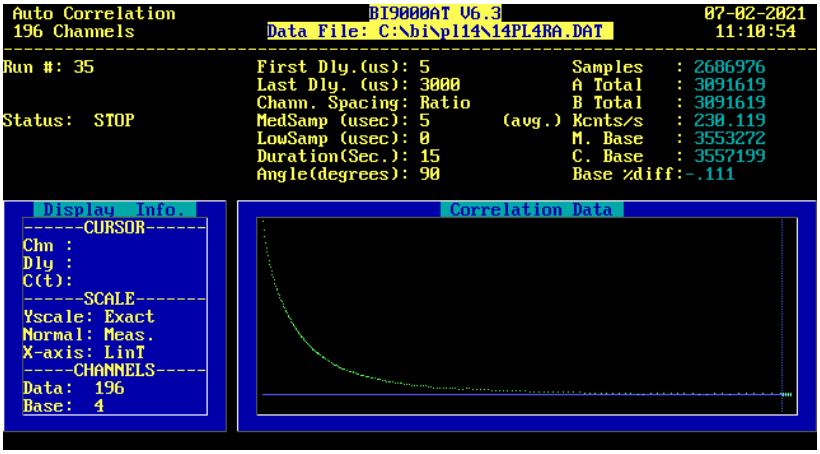
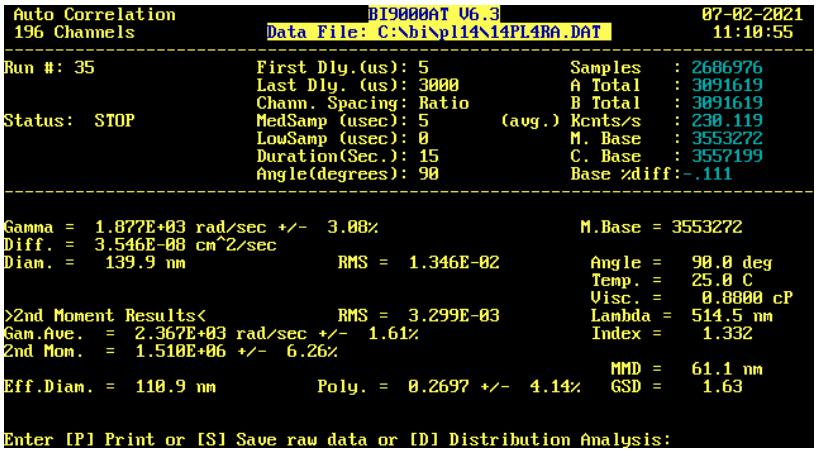
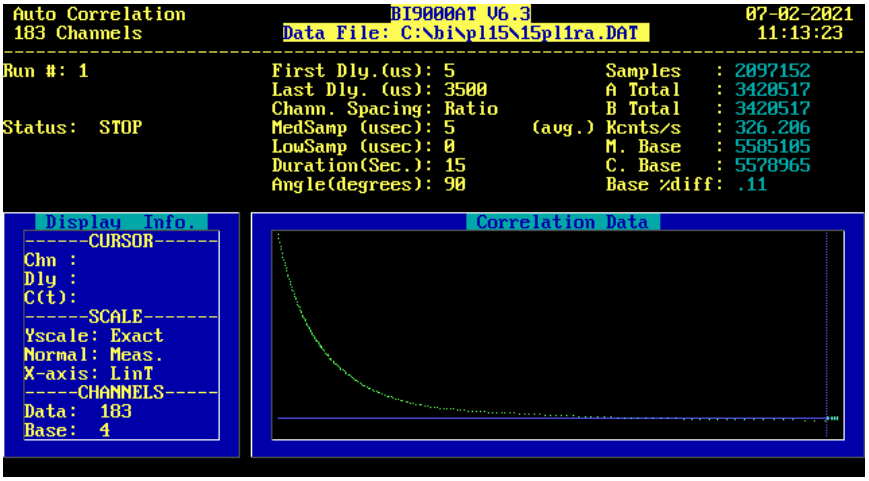
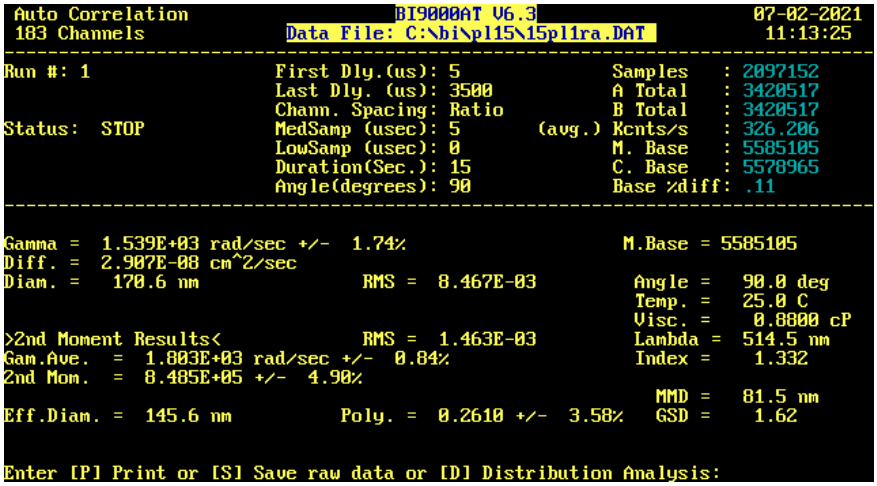


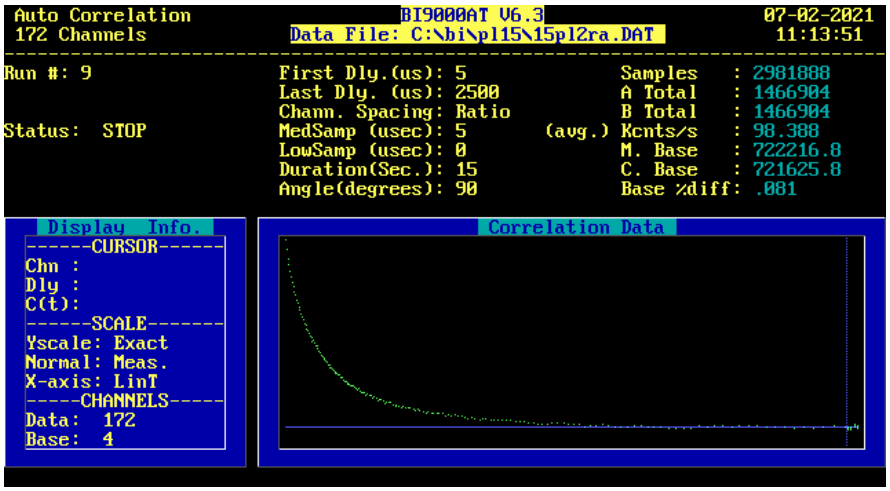


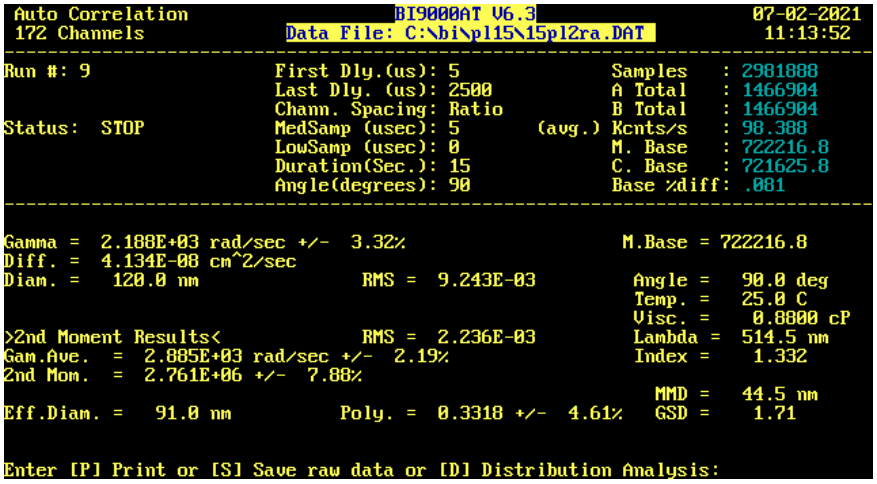
Ag/15pl, n_{Ag}/n_{Surf} = 8



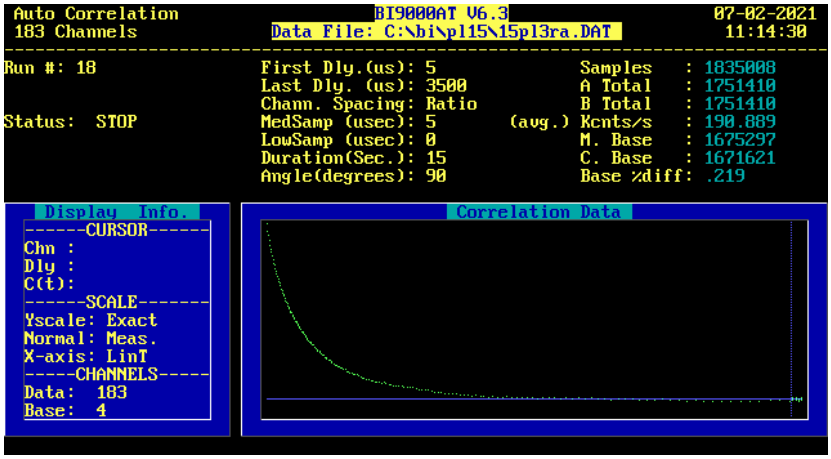


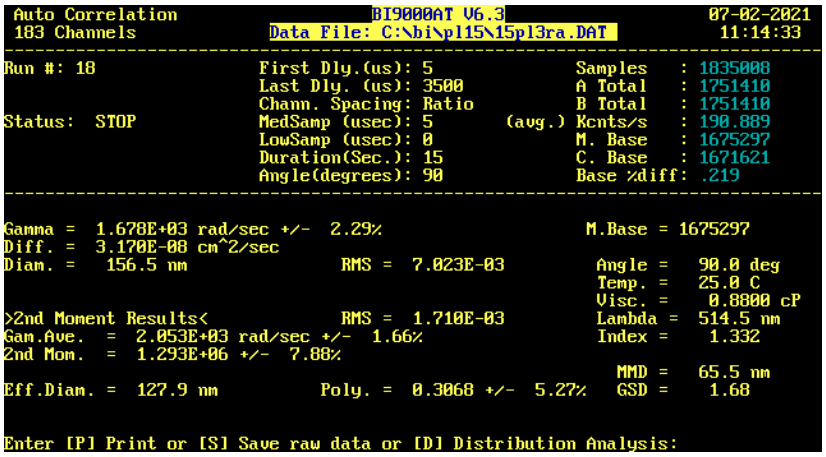
Ag/15pl, n_{Ag}/n_{Surf} = 4



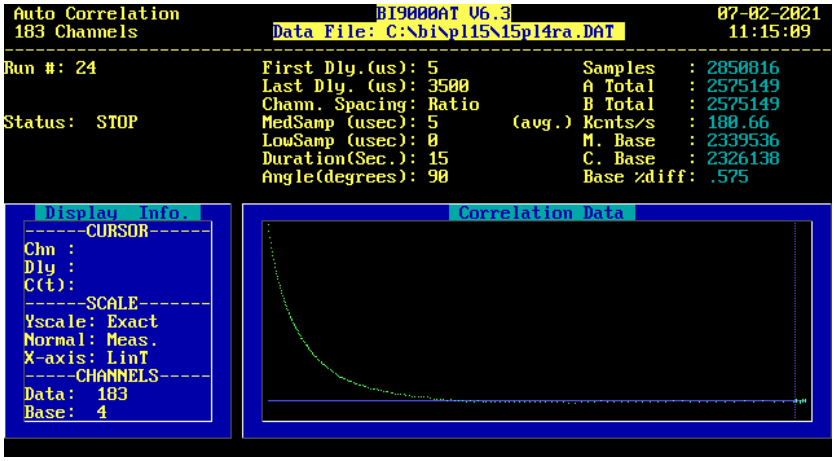

Auto Correlation
BI9000AT V6.3
07-02-2021
172 Channels
Data File: C:\bi\pl15\15pl2ra.DAT
11:13:52
Run #: 9
First Dly.(us): 5
Samples : 2981888
Last Dly. (us): 2500
A Total : 1466904
Chann. Spacing: Ratio
B Total : 1466904
Status: STOP
MedSamp (usec): 5 (avg.)
Kcnts/s : 98.388
LowSamp (usec): 0
M. Base : 722216.8
Duration(Sec.): 15
C. Base : 721625.8
Angle(degrees): 90
Base %diff: .081
Gamma = 2.188E+03 rad/sec +/- 3.32%
M.Base = 722216.8
Diff. = 4.134E-08 cm^2/sec
Diam. = 120.0 nm
RMS = 9.243E-03
Angle = 90.0 deg
Temp. = 25.0 C
Visc. = 0.8800 cP
>2nd Moment Results<
RMS = 2.236E-03
Lambda = 514.5 nm
Gam.Ave. = 2.885E+03 rad/sec +/- 2.19%
Index = 1.332
2nd Mom. = 2.761E+06 +/- 7.88%
MMD = 44.5 nm
Eff.Diam. = 91.0 nm
Poly. = 0.3318 +/- 4.61%
GSD = 1.71
Enter [P] Print or [S] Save raw data or [D] Distribution Analysis:

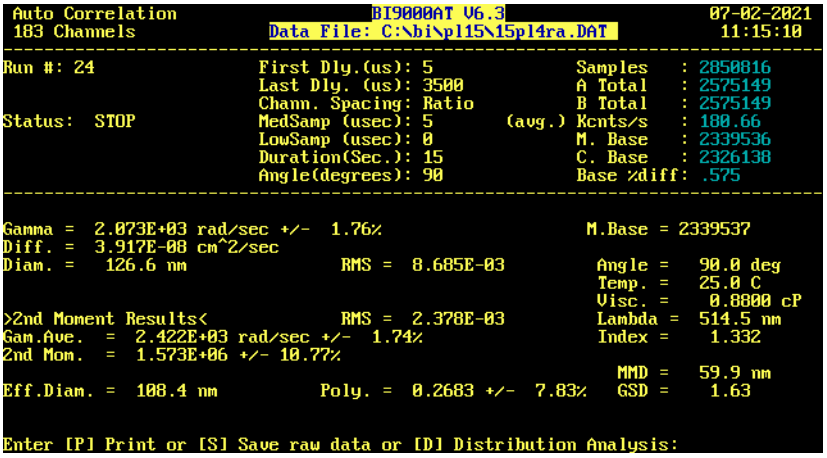
Ag/15pl, n_{Ag}/n_{Surf} = 2.7



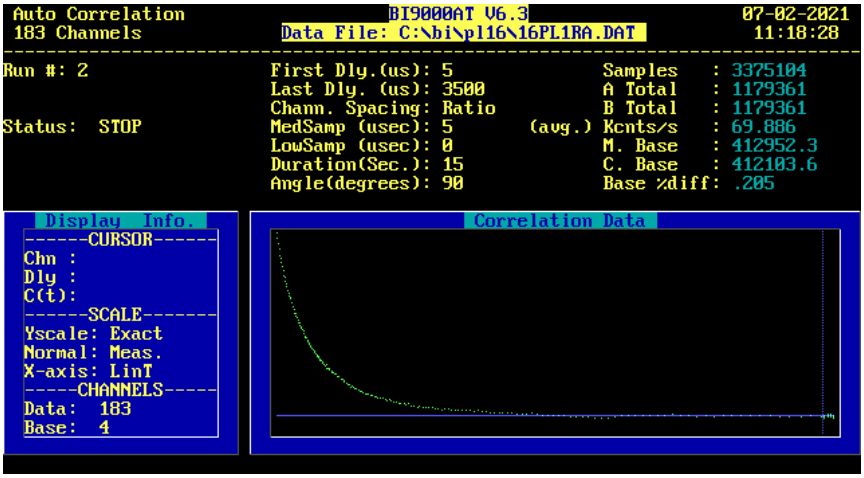


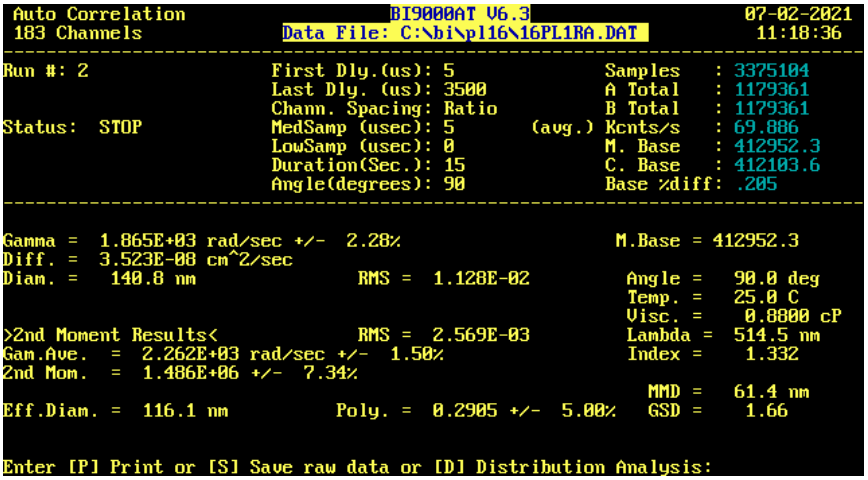
Ag/15pl, n_{Ag}/n_{Surf} = 2



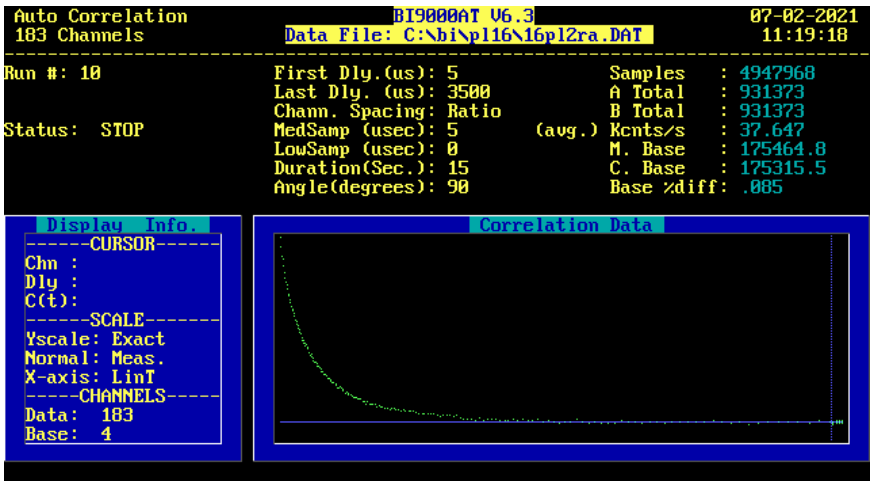


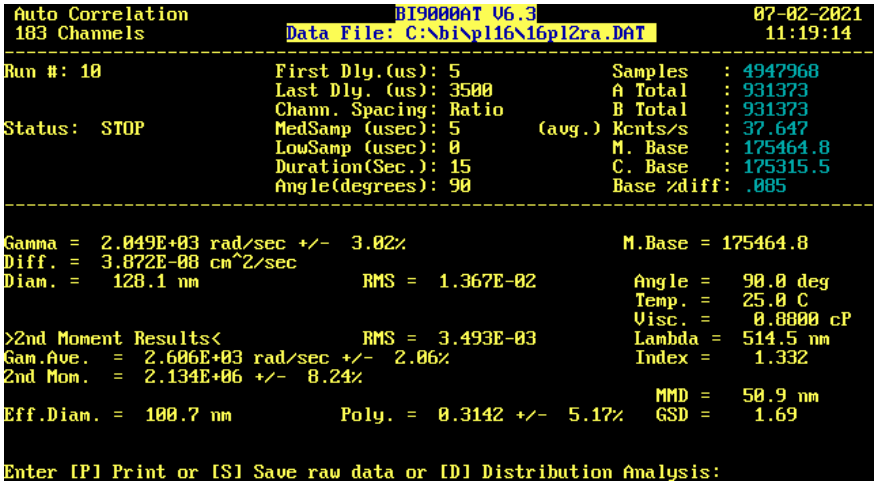
Ag/16pl, n_{Ag}/n_{Surf} = 8



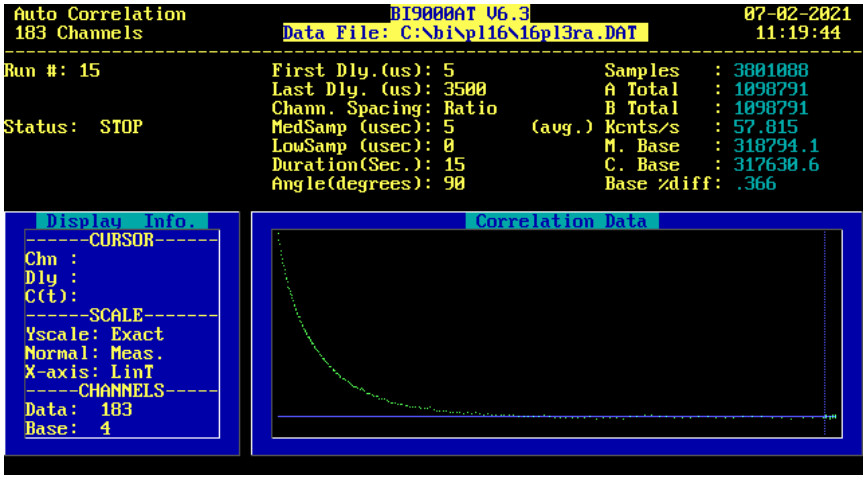


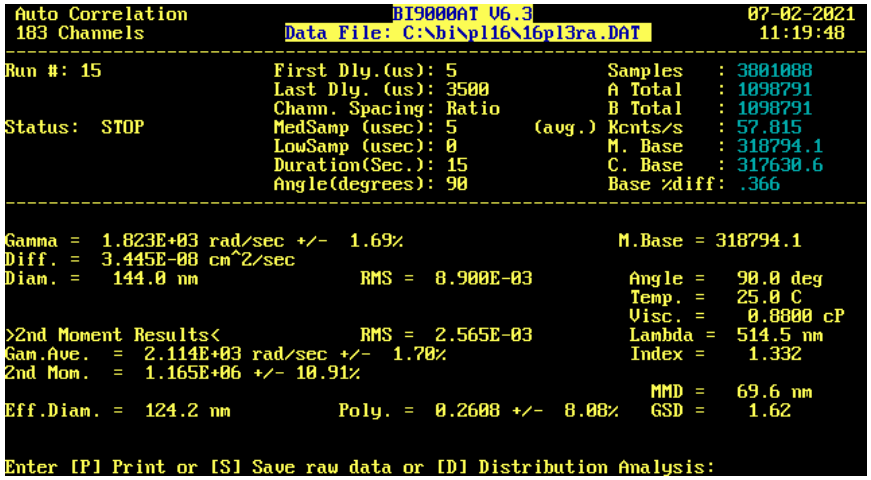
Ag/16pl, n_{Ag}/n_{Surf} = 4



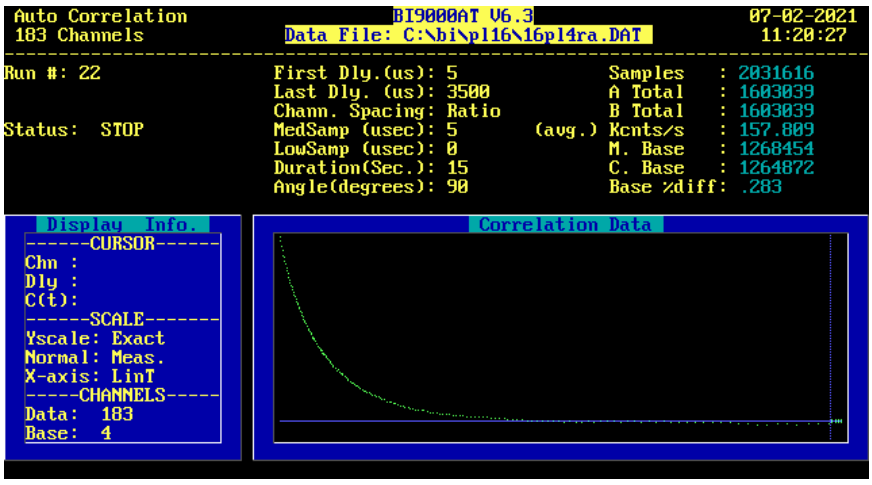

Auto Correlation
BI9000AT V6.3
07-02-2021
183 Channels
Data File: C:\bi\pl16\16pl2ra.DAT
11:19:14
Run #: 10
First Dly.(us): 5
Samples : 4947968
Last Dly. (us): 3500
A Total : 931373
Chann. Spacing: Ratio
B Total : 931373
Status: STOP
MedSamp (usec): 5 (avg.)
Kcnts/s : 37.647
LowSamp (usec): 0
M. Base : 175464.8
Duration(Sec.): 15
C. Base : 175315.5
Angle(degrees): 90
Base %diff: .085
Gamma = 2.049E+03 rad/sec +/- 3.02%
M.Base = 175464.8
Diff. = 3.872E-08 cm^2/sec
Diam. = 128.1 nm
RMS = 1.367E-02
Angle = 90.0 deg
Temp. = 25.0 C
Visc. = 0.8800 cP
>2nd Moment Results<
RMS = 3.493E-03
Lambda = 514.5 nm
Gam.Ave. = 2.606E+03 rad/sec +/- 2.06%
Index = 1.332
2nd Mom. = 2.134E+06 +/- 8.24%
MMD = 50.9 nm
Eff.Diam. = 100.7 nm
Poly. = 0.3142 +/- 5.17%
GSD = 1.69
Enter [P] Print or [S] Save raw data or [D] Distribution Analysis:

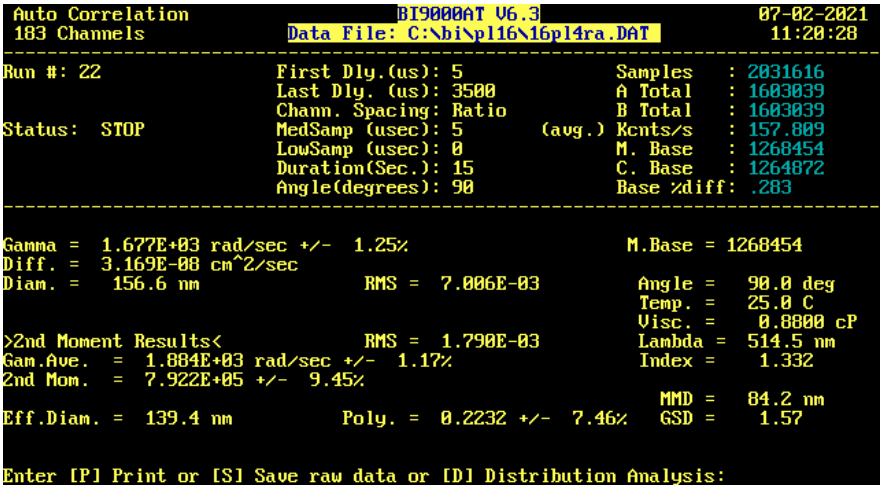
Ag/16pl, n_{Ag}/n_{Surf} = 2.7





Ag/16pl, n_{Ag}/n_{Surf} = 2




Auto Correlation
BI9000AT V6.3
07-02-2021
183 Channels
Data File: C:\bi\pl16\16pl4ra.DAT
11:20:28
Run #: 22
First Dly.(us): 5
Samples : 2031616
Last Dly. (us): 3500
A Total : 1603039
Chann. Spacing: Ratio
B Total : 1603039
Status: STOP
MedSamp (usec): 5 (avg.)
Kcnts/s : 157.809
LowSamp (usec): 0
M. Base : 1268454
Duration(Sec.): 15
C. Base : 1264872
Angle(degrees): 90
Base %diff: .283
Gamma = 1.677E+03 rad/sec +/- 1.25%
M.Base = 1268454
Diff. = 3.169E-08 cm^2/sec
Diam. = 156.6 nm
RMS = 7.006E-03
Angle = 90.0 deg
Temp. = 25.0 C
Visc. = 0.8800 cP
>2nd Moment Results<
RMS = 1.790E-03
Lambda = 514.5 nm
Gam.Ave. = 1.884E+03 rad/sec +/- 1.17%
Index = 1.332
2nd Mom. = 7.922E+05 +/- 9.45%
MMD = 84.2 nm
Eff.Diam. = 139.4 nm
Poly. = 0.2232 +/- 7.46%
GSD = 1.57
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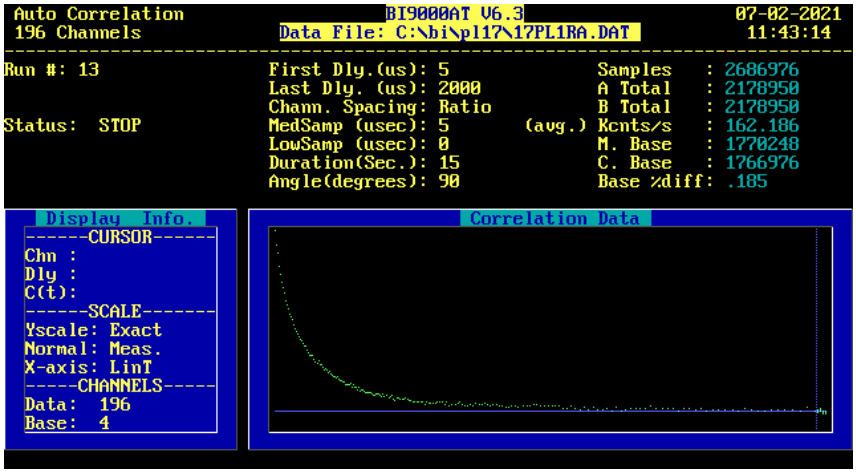
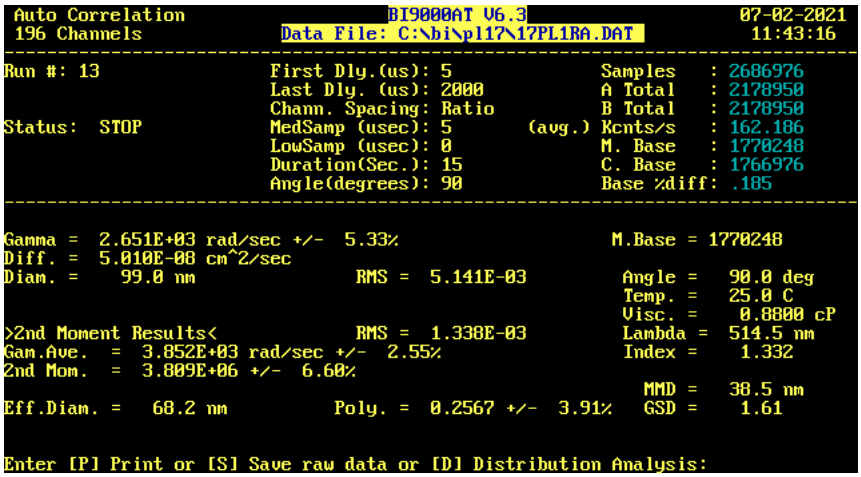
Ag/17pl, n_{Ag}/n_{Surf} = 8





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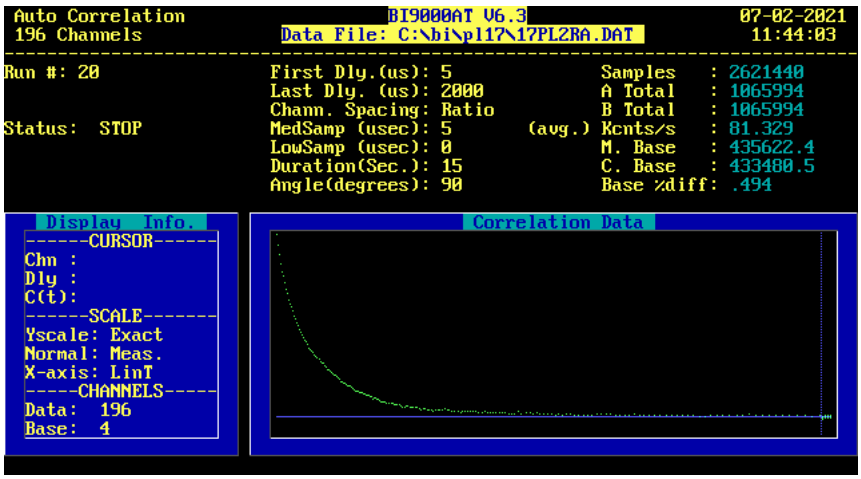
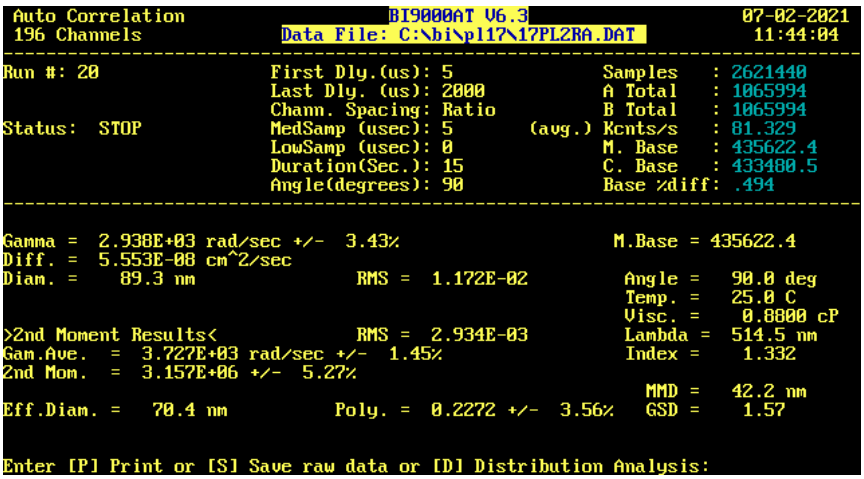
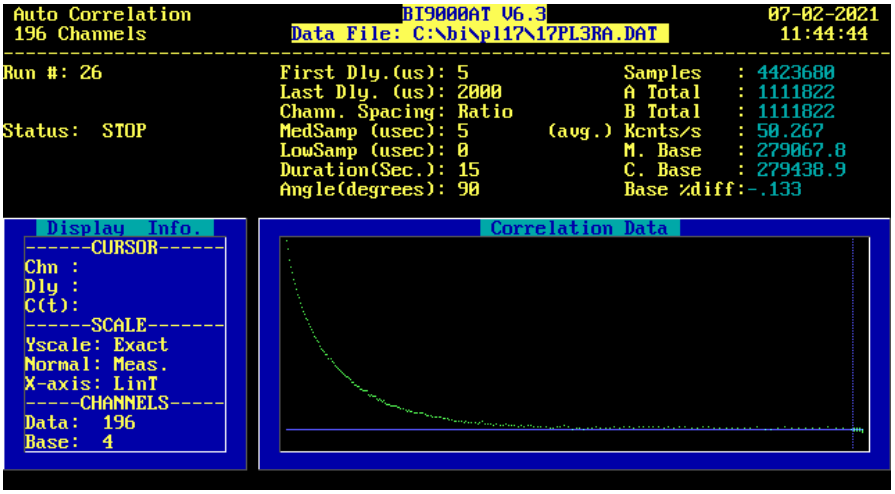
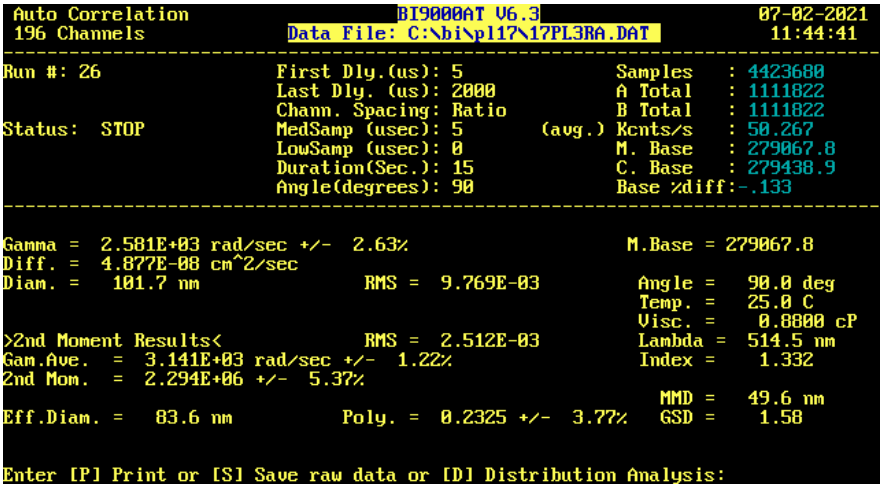


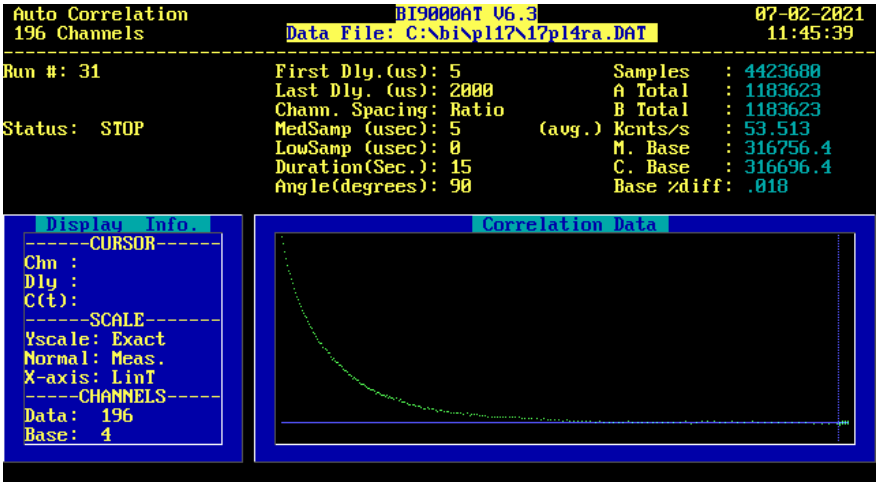


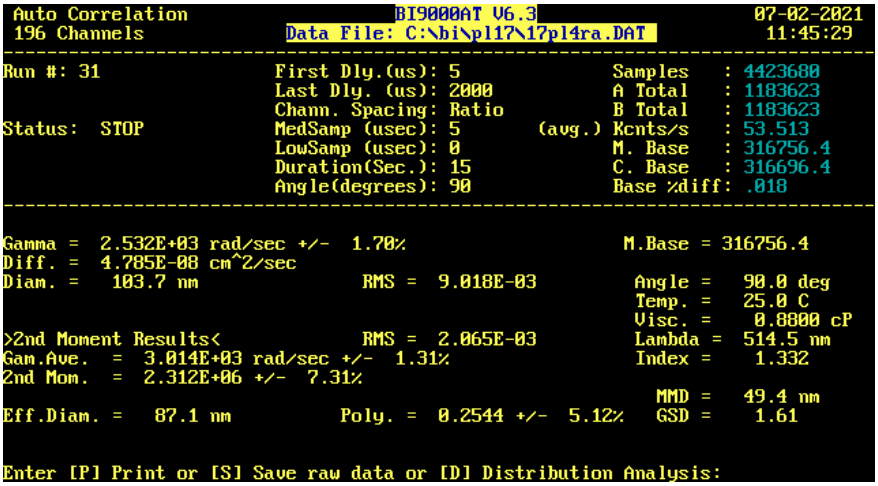
Ag/17pl, n_{Ag}/n_{Surf} = 2.7



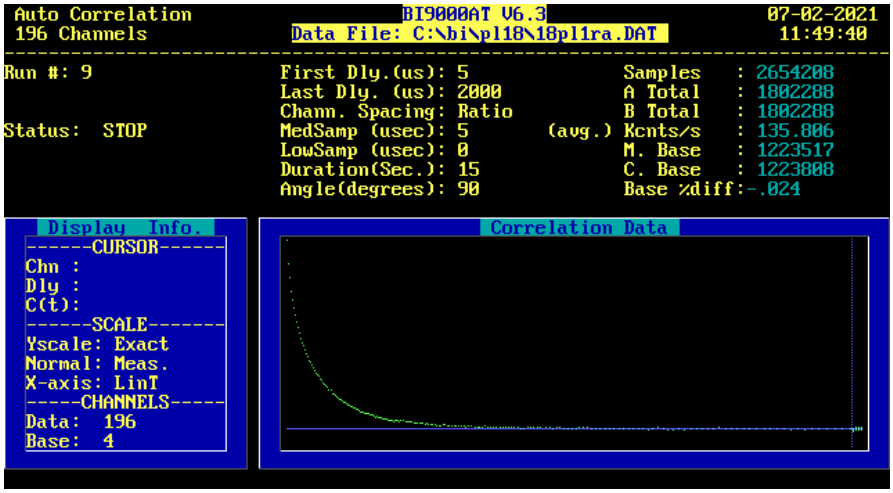


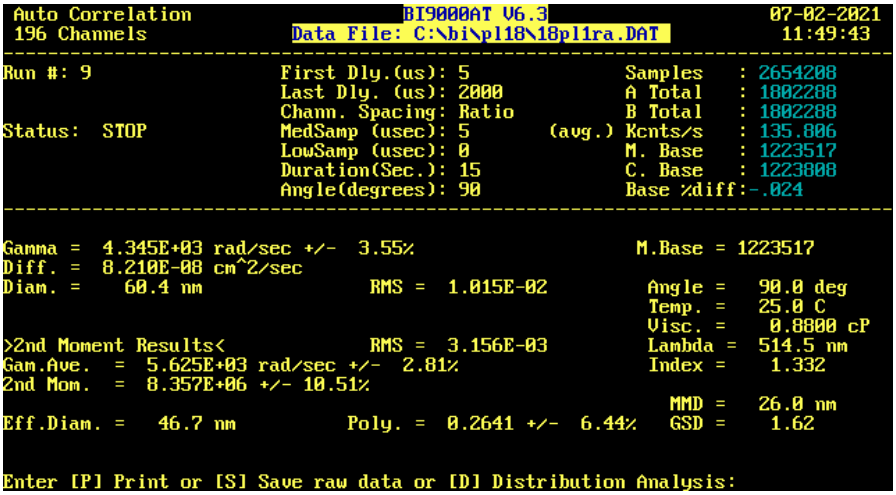
Ag/17pl, n_{Ag}/n_{Surf} = 2



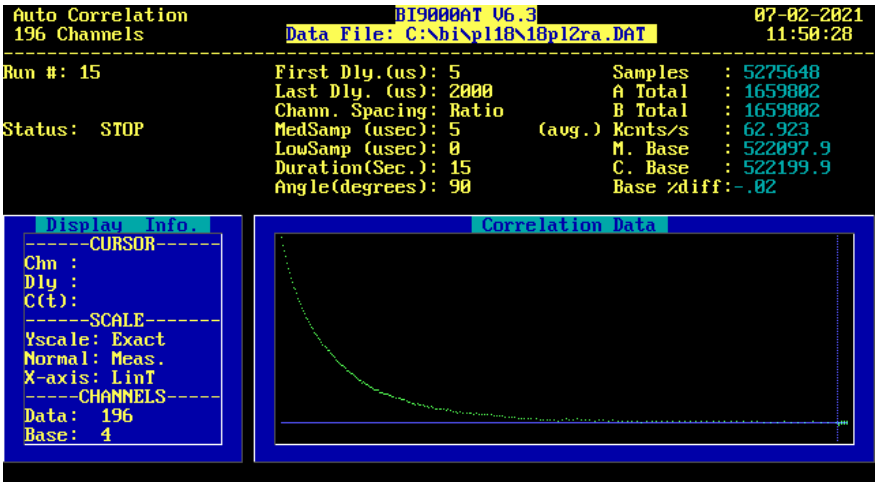

Auto Correlation
BI9000AT V6.3
07-02-2021
196 Channels
Data File: C:\bi\pl17\17pl4ra.DAT
11:45:29
Run #: 31
First Dly.(us): 5
Samples : 4423680
Last Dly. (us): 2000
A Total : 1183623
Chann. Spacing: Ratio
B Total : 1183623
Status: STOP
MedSamp (usec): 5 (avg.)
Kcnts/s : 53.513
LowSamp (usec): 0
M. Base : 316756.4
Duration(Sec.): 15
C. Base : 316696.4
Angle(degrees): 90
Base %diff: .018
Gamma = 2.532E+03 rad/sec +/- 1.70%
M.Base = 316756.4
Diff. = 4.785E-08 cm^2/sec
Diam. = 103.7 nm
RMS = 9.018E-03
Angle = 90.0 deg
Temp. = 25.0 C
Visc. = 0.8800 cP
>2nd Moment Results<
RMS = 2.065E-03
Lambda = 514.5 nm
Gam.Ave. = 3.014E+03 rad/sec +/- 1.31%
Index = 1.332
2nd Mom. = 2.312E+06 +/- 7.31%
MMD = 49.4 nm
Eff.Diam. = 87.1 nm
Poly. = 0.2544 +/- 5.12%
GSD = 1.61
Enter [P] Print or [S] Save raw data or [D] Distribution Analysis:

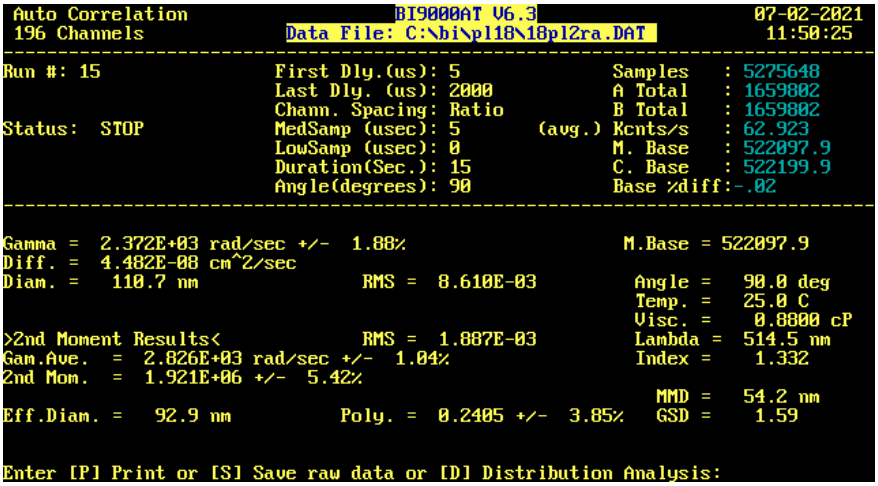
Ag/18pl, n_{Ag}/n_{Surf} = 8



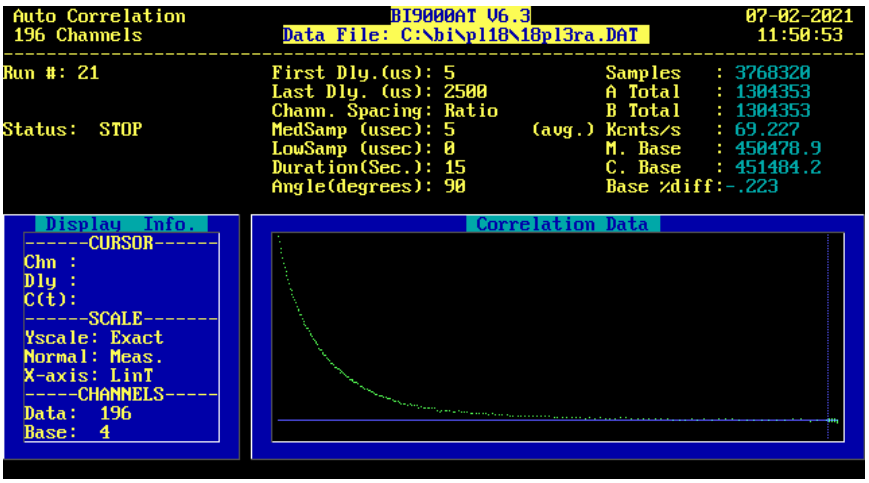


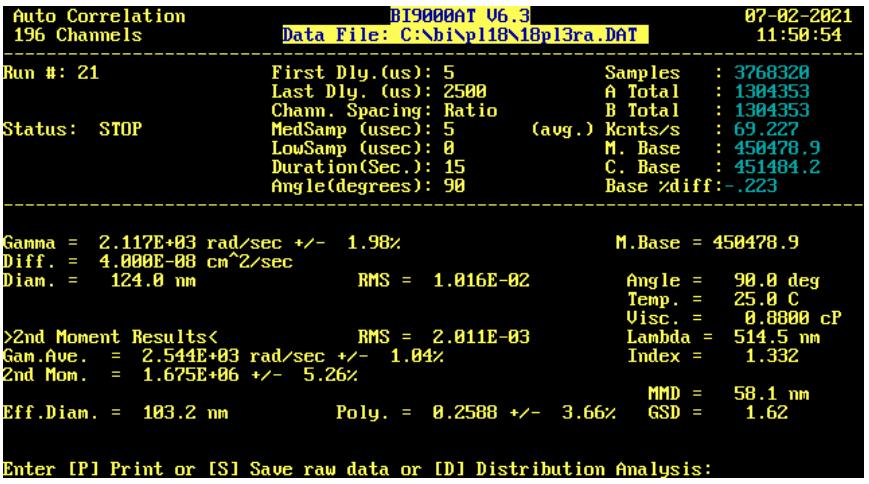
Ag/18pl, n_{Ag}/n_{Surf} = 4



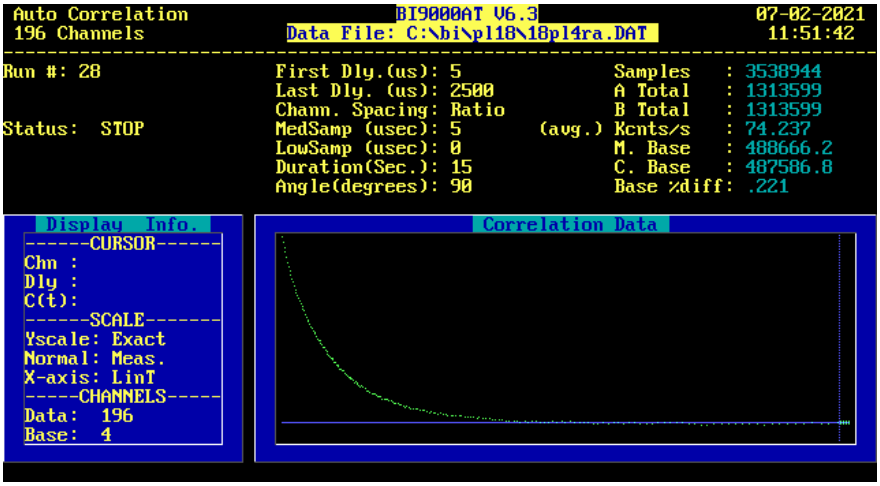

Auto Correlation
BI9000AT V6.3
07-02-2021
196 Channels
Data File: C:\bi\pl18\18pl2ra.DAT
11:50:25
Run #: 15
First Dly.(us): 5
Samples : 5275648
Last Dly. (us): 2000
A Total : 1659802
Chann. Spacing: Ratio
B Total : 1659802
Status: STOP
MedSamp (usec): 5 (avg.)
Kcnts/s : 62.923
LowSamp (usec): 0
M. Base : 522097.9
Duration(Sec.): 15
C. Base : 522199.9
Angle(degrees): 90
Base %diff:-.02
Gamma = 2.372E+03 rad/sec +/- 1.88%
M.Base = 522097.9
Diff. = 4.482E-08 cm^2/sec
Diam. = 110.7 nm
RMS = 8.610E-03
Angle = 90.0 deg
Temp. = 25.0 C
Visc. = 0.8800 cP
>2nd Moment Results<
RMS = 1.887E-03
Lambda = 514.5 nm
Gam.Ave. = 2.826E+03 rad/sec +/- 1.04%
Index = 1.332
2nd Mom. = 1.921E+06 +/- 5.42%
MMD = 54.2 nm
Eff.Diam. = 92.9 nm
Poly. = 0.2405 +/- 3.85%
GSD = 1.59
Enter [P] Print or [S] Save raw data or [D] Distribution Analysis:

Ag/18pl, n_{Ag}/n_{Surf} = 2.7





Ag/18pl, n_{Ag}/n_{Surf} = 2



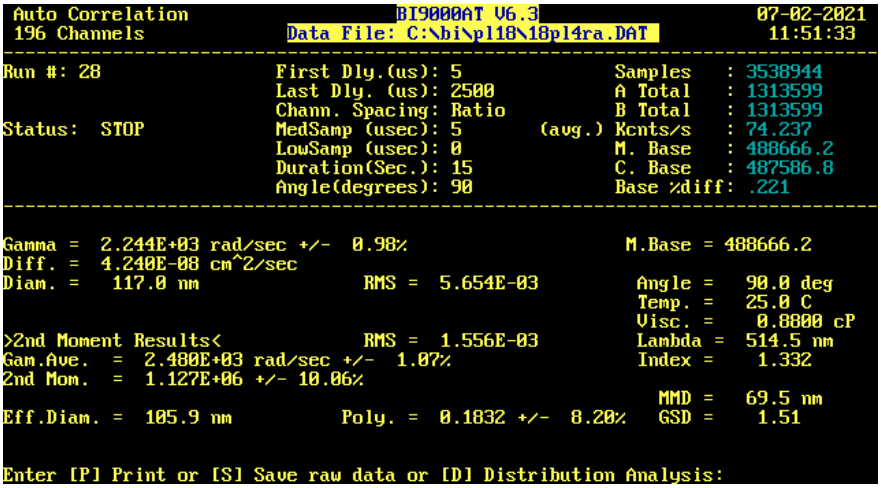


Image of the used DLS experimental setup:

2. Zeta potential measurements

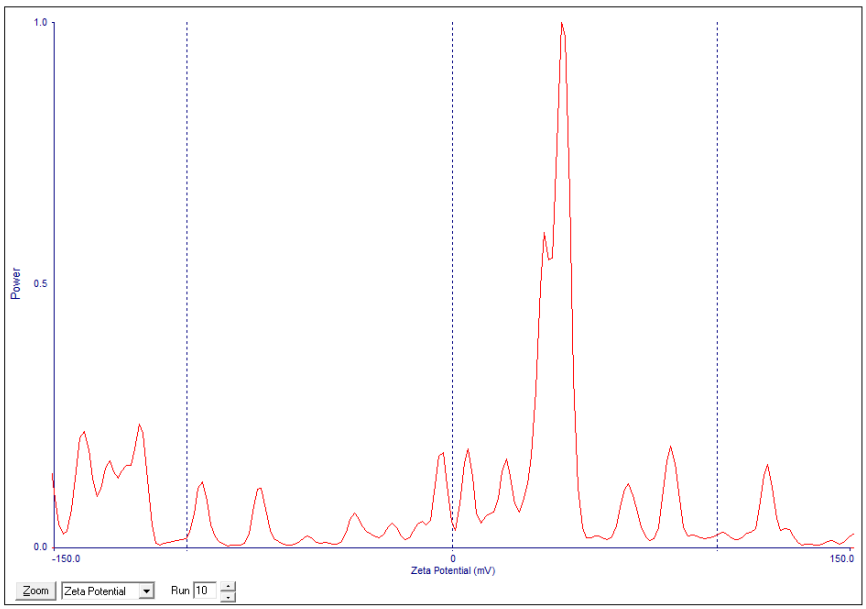
Screenshots of zeta potential peaks and the set of 10 repeated measurements are shown for each Ag/surfactant system and each silver-to-surfactant molar ratio value. The screenshots were obtained from the Broohkaven Instruments Zeta Potential Analyzer Software ver. 5.68. To reduce the excessive number of screenshots in the supplementary material, just single set of 10 independent readings of zeta potential for each Ag/surfactant system and each silver-to-surfactant molar ratio value is shown.

Screenshots section – zeta potential

Ag/14pl

Ag/14pl nAg/nSurf = 8 (Run 10)

Measurement Completed



Zeta Potential

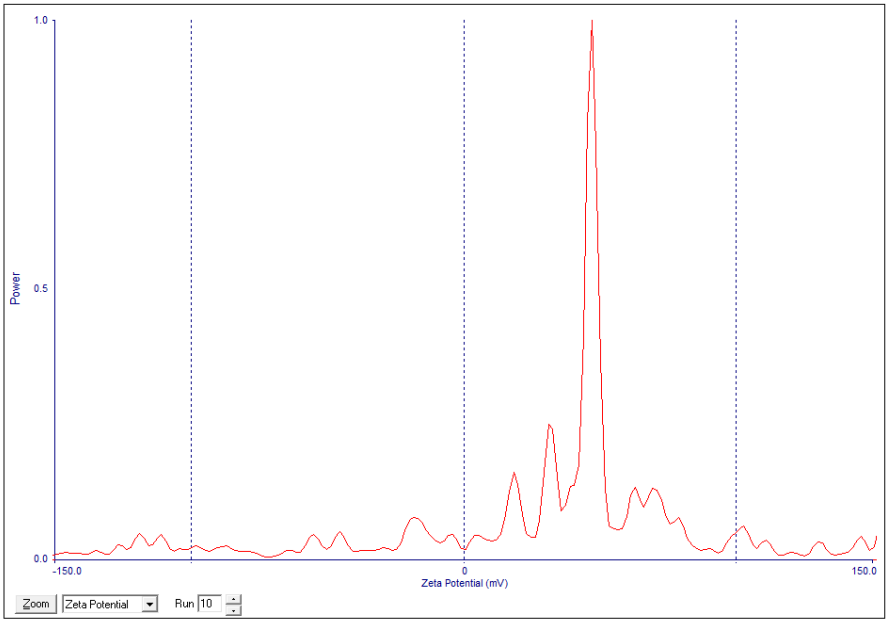
Run	Zeta Potential (mV)	Half Width (mV)
1	34.74	3.02
2	50.29	3.27
3	47.75	2.84
4	66.64	2.67
5	37.96	2.67
6	55.81	7.26
7	42.88	2.88
8	20.69	2.92
9	-19.35	2.78
10	41.14	5.92
Mean	44.21	3.72
Std. Error	4.38	0.56

Measurement Parameters:

Conductance	= 1147 µ S
Current	= 6.31 mA
Electric Field	= 14.87 V/cm
Sample Count Rate	= 441 kcps
Ref. Count Rate	= 1151 kcps

Ag/14pl nAg/nSurf = 4 (Run 10)

Measurement Completed



Zeta Potential

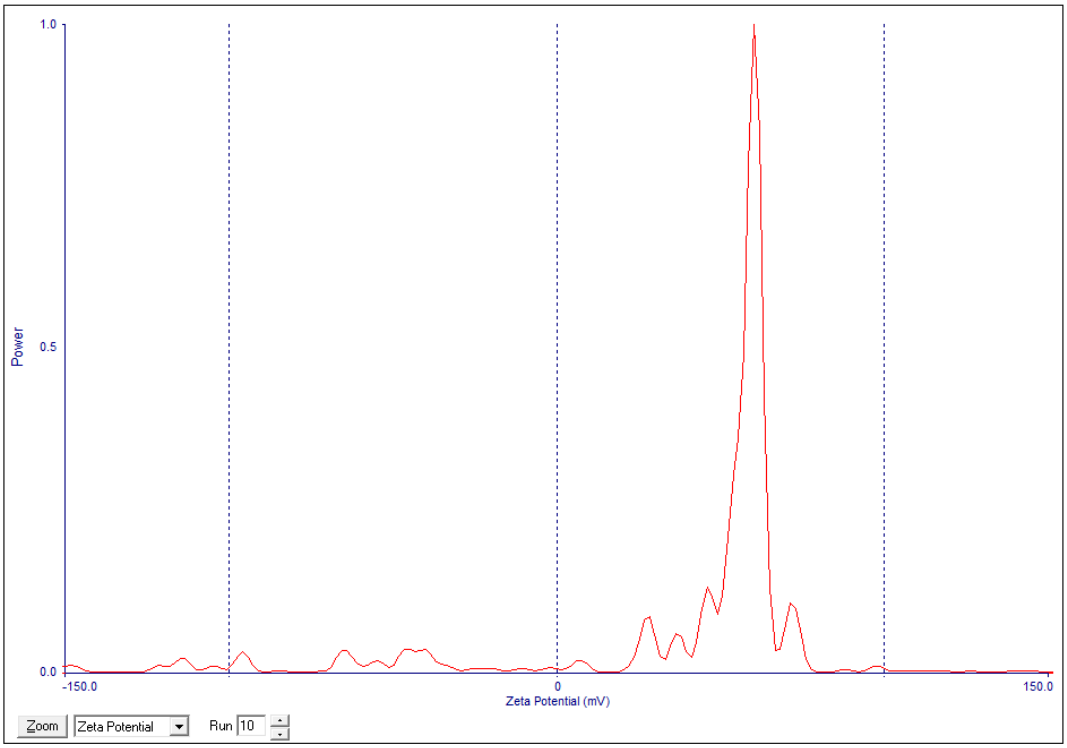
Run	Zeta Potential (mV)	Half Width (mV)
1	47.77	3.07
2	60.76	6.61
3	46.27	2.89
4	63.43	5.40
5	57.08	3.21
6	59.99	3.17
7	39.17	3.40
8	50.59	2.68
9	39.95	2.89
10	47.05	2.75
Mean	51.21	3.61
Std. Error	2.74	0.42

Measurement Parameters:

Conductance	= 1037 µ S
Current	= 5.72 mA
Electric Field	= 14.91 V/cm
Sample Count Rate	= 485 kcps
Ref. Count Rate	= 974 kcps

Ag/14pl nAg/nSurf = 2.7 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

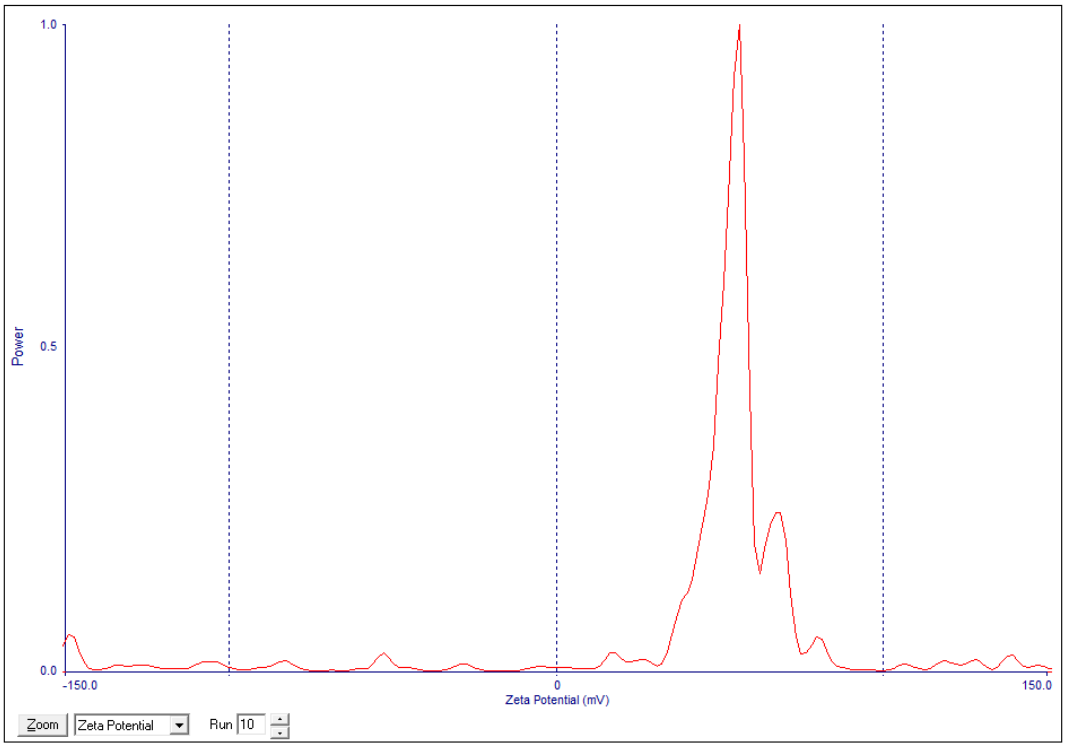
Run	Zeta Potential (mV)	Half Width (mV)
1	57.07	3.26
2	54.98	3.04
3	50.11	3.75
4	52.58	2.69
5	54.81	3.97
6	56.83	2.76
7	47.26	2.67
8	56.92	3.80
9	51.60	2.75
10	60.26	3.02
Mean	54.24	3.17
Std. Error	1.22	0.16

Measurement Parameters:

Conductance	= 831 µ S
Current	= 4.60 mA
Electric Field	= 15.08 V/cm
Sample Count Rate	= 391 kcps
Ref. Count Rate	= 916 kcps

Ag/14pl nAg/nSurf = 2 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

Run	Zeta Potential (mV)	Half Width (mV)
1	64.62	2.84
2	52.84	4.50
3	61.96	4.96
4	52.86	3.34
5	50.74	2.70
6	51.32	3.17
7	51.32	3.27
8	41.83	2.70
9	51.69	3.24
10	55.96	4.43
Mean	53.52	3.52
Std. Error	2.00	0.26

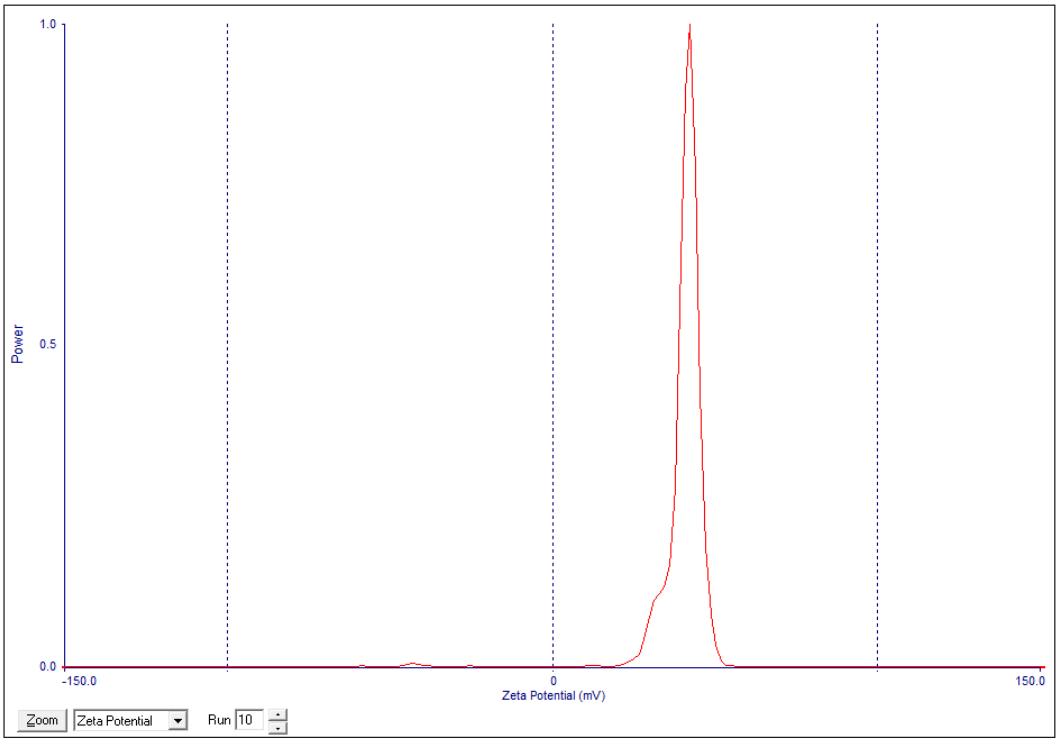
Measurement Parameters:

Conductance	= 753 µ S
Current	= 4.18 mA
Electric Field	= 15.27 V/cm
Sample Count Rate	= 319 kcps
Ref. Count Rate	= 897 kcps

Ag/15pl

Ag/15pl nAg/nSurf = 8 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

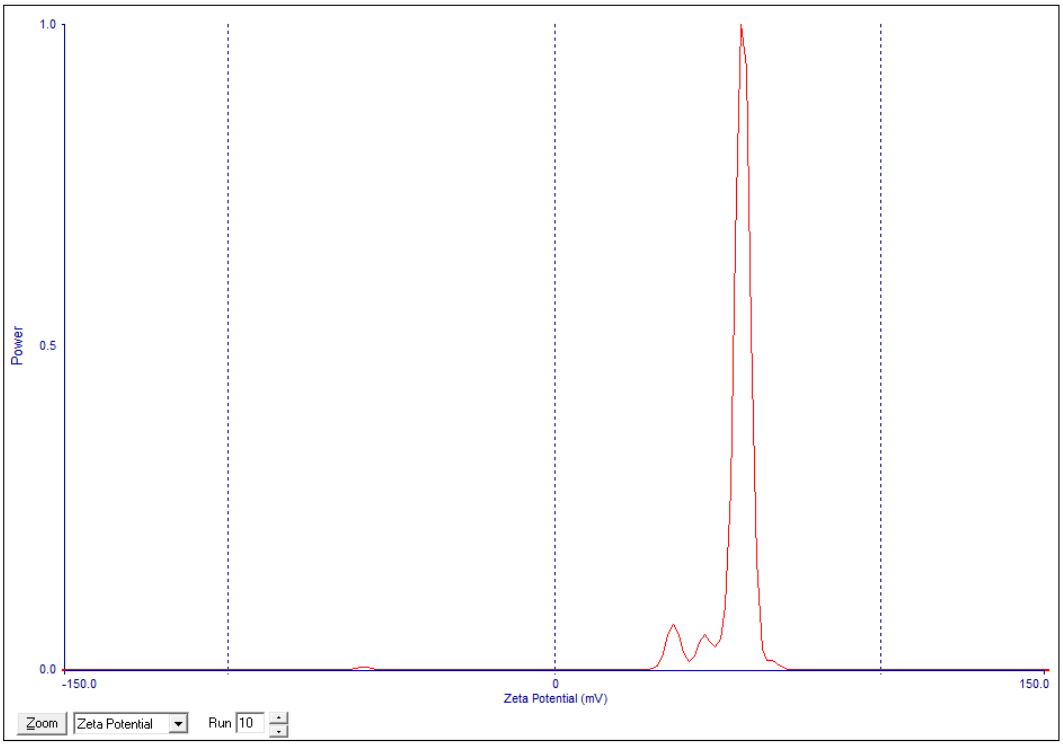
Run	Zeta Potential (mV)	Half Width (mV)
1	36.29	2.76
2	18.20	2.68
3	37.19	2.78
4	36.16	2.80
5	37.16	2.82
6	33.05	3.03
7	34.63	3.87
8	31.57	2.97
9	30.95	2.95
10	42.39	3.16
Mean	33.76	2.98
Std. Error	2.02	0.11

Measurement Parameters:

Conductance	= 917 µ S
Current	= 5.06 mA
Electric Field	= 15.01 V/cm
Sample Count Rate	= 375 kcps
Ref. Count Rate	= 1049 kcps

Ag/15pl nAg/nSurf = 4 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

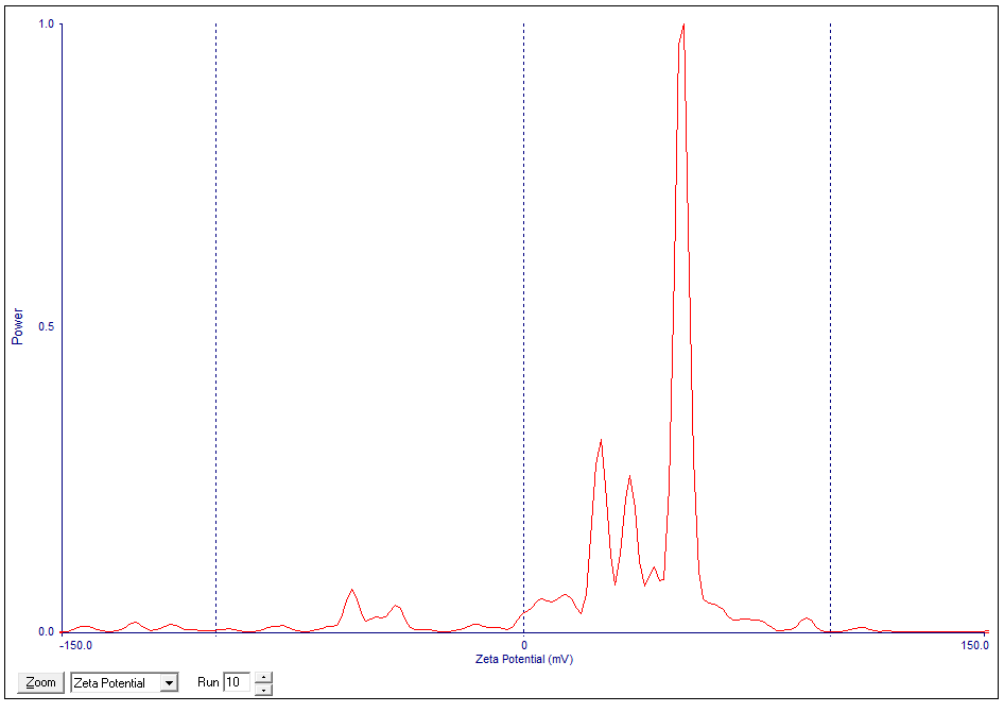
Run	Zeta Potential (mV)	Half Width (mV)
1	32.79	2.85
2	37.51	2.92
3	39.86	3.04
4	40.01	2.97
5	44.28	7.38
6	47.47	3.55
7	46.03	3.22
8	39.76	4.19
9	43.02	2.87
10	57.15	2.79
Mean	42.79	3.58
Std. Error	2.09	0.44

Measurement Parameters:

Conductance	= 1075 µ S
Current	= 5.92 mA
Electric Field	= 14.86 V/cm
Sample Count Rate	= 312 kcps
Ref. Count Rate	= 896 kcps

Ag/15pl nAg/nSurf = 2.7 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

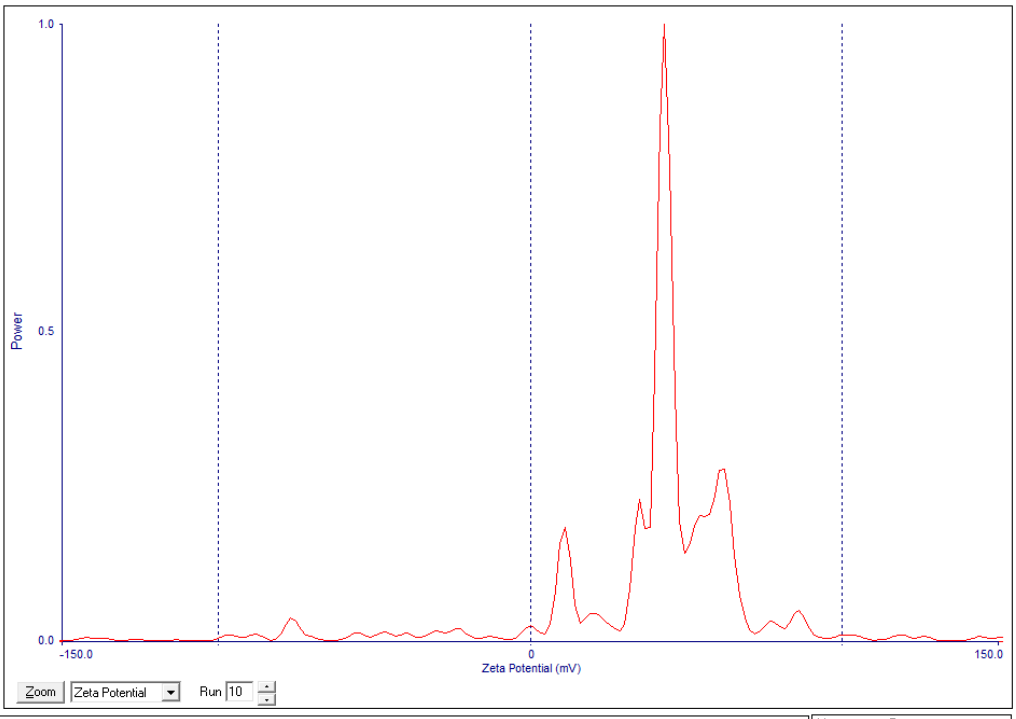
Run	Zeta Potential (mV)	Half Width (mV)
1	41.15	3.27
2	53.80	5.08
3	49.93	3.19
4	52.17	3.05
5	64.98	3.37
6	59.88	2.76
7	55.28	3.44
8	56.98	3.76
9	53.22	3.19
10	52.26	2.94
Mean	53.97	3.40
Std. Error	1.98	0.21

Measurement Parameters:

Conductance	= 1015 µ S
Current	= 5.60 mA
Electric Field	= 14.93 V/cm
Sample Count Rate	= 408 kcps
Ref. Count Rate	= 950 kcps

Ag/15pl nAg/nSurf = 2 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

Run	Zeta Potential (mV)	Half Width (mV)
1	51.75	3.85
2	64.53	3.70
3	65.82	3.34
4	62.23	3.38
5	55.34	2.67
6	66.79	2.80
7	57.07	2.80
8	55.42	3.10
9	58.34	3.68
10	43.15	2.84
Mean	58.04	3.22
Std. Error	2.29	0.14

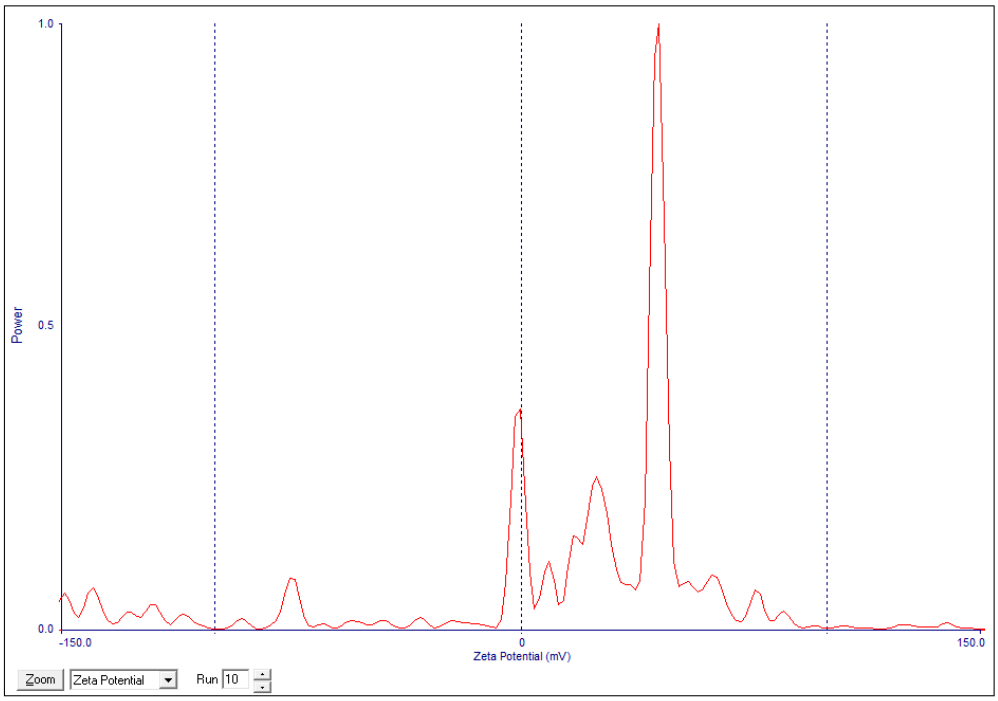
Measurement Parameters:

Conductance	= 632 µ S
Current	= 3.53 mA
Electric Field	= 15.08 V/cm
Sample Count Rate	= 440 kcps
Ref. Count Rate	= 937 kcps

Ag16/pl

Ag/16pl nAg/nSurf = 8 (Run 10)

Measurement Completed



Zeta Potential

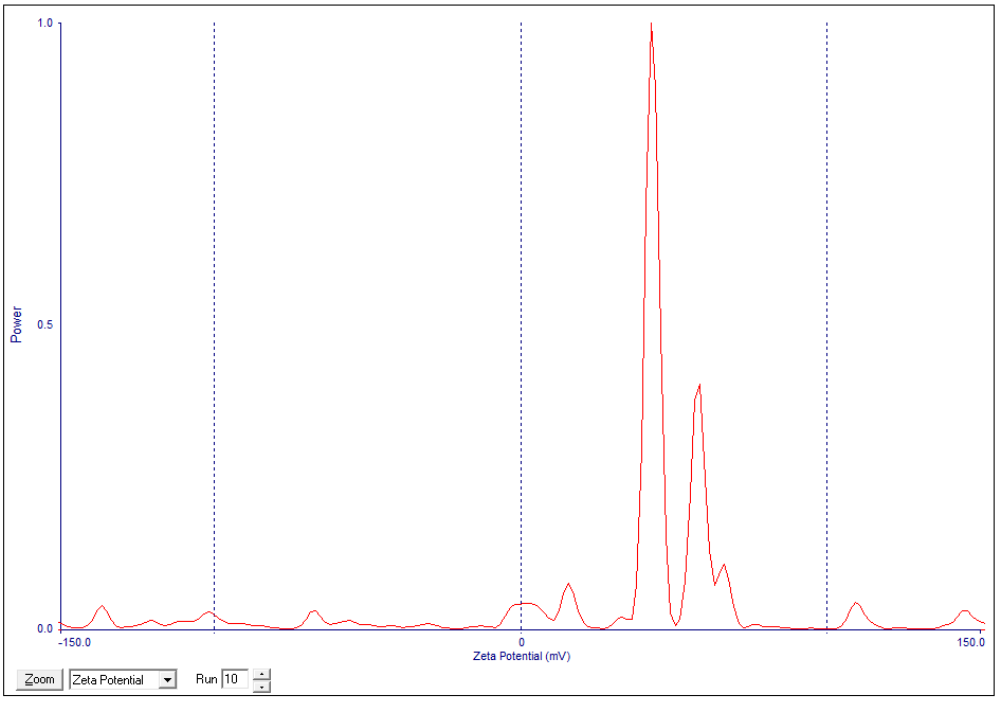
Run	Zeta Potential (mV)	Half Width (mV)
1	32.92	3.88
2	23.63	3.08
3	48.33	2.77
4	31.23	3.06
5	53.43	3.17
6	45.86	3.80
7	46.99	2.83
8	43.97	3.72
9	35.98	6.16
10	45.21	2.85
Mean	40.76	3.53
Std. Error	2.95	0.32

Measurement Parameters:

Conductance	= 1206 µ S
Current	= 6.63 mA
Electric Field	= 14.92 V/cm
Sample Count Rate	= 422 kcps
Ref. Count Rate	= 1140 kcps

Ag/16pl nAg/nSurf = 4 (Run 10)

Measurement Completed



Zeta Potential

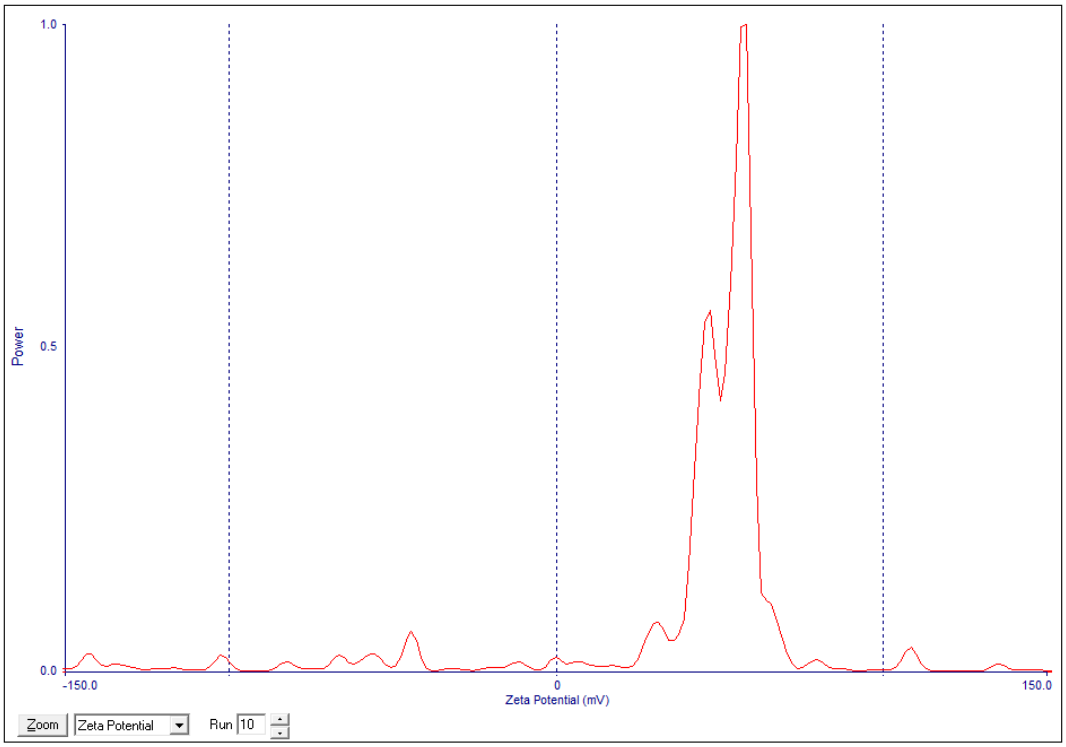
Run	Zeta Potential (mV)	Half Width (mV)
1	46.81	2.83
2	36.33	2.88
3	51.98	3.20
4	45.97	3.00
5	68.15	2.90
6	63.42	2.65
7	63.13	2.93
8	45.95	2.92
9	61.36	3.29
10	42.59	2.75
Mean	52.57	2.94
Std. Error	3.39	0.06

Measurement Parameters:

Conductance	= 1360 µ S
Current	= 7.46 mA
Electric Field	= 14.86 V/cm
Sample Count Rate	= 395 kcps
Ref. Count Rate	= 972 kcps

Ag/16pl nAg/nSurf = 2.7 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

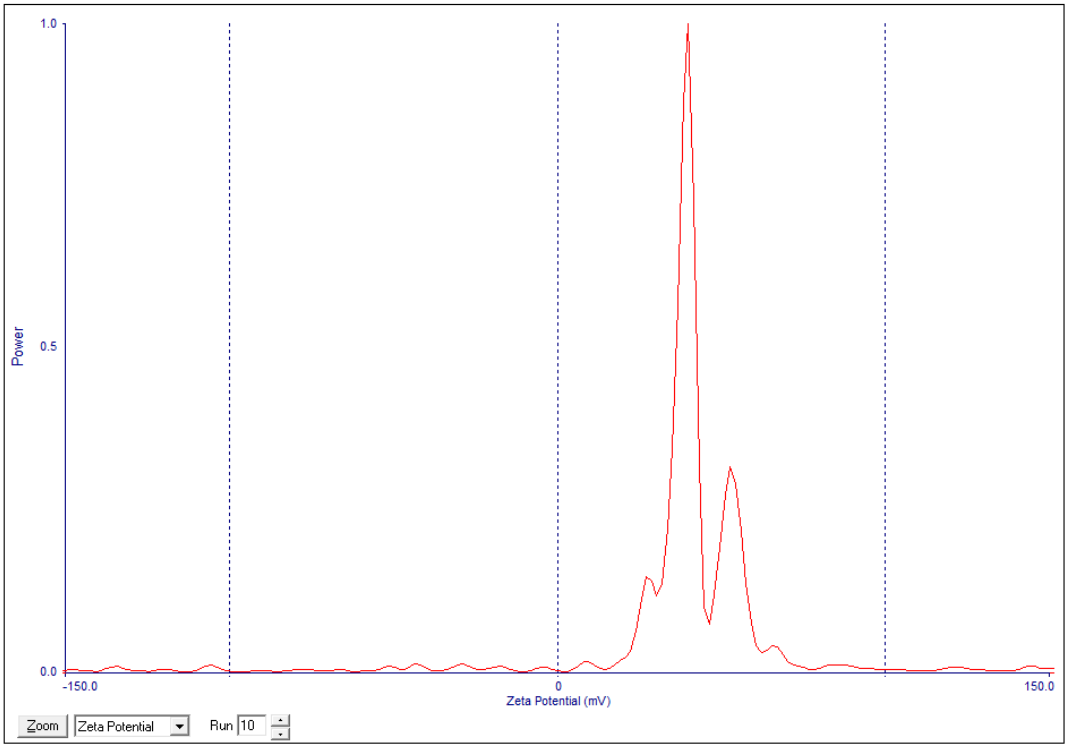
Run	Zeta Potential (mV)	Half Width (mV)
1	55.28	2.95
2	59.73	3.06
3	35.57	2.77
4	-44.54	3.20
5	-122.16	3.38
6	50.10	3.01
7	48.08	3.74
8	61.42	4.77
9	47.14	3.21
10	58.04	4.08
Mean	54.26	3.55
Std. Error	2.20	0.26

Measurement Parameters:

Conductance	= 990 µ S
Current	= 5.46 mA
Electric Field	= 15.02 V/cm
Sample Count Rate	= 360 kcps
Ref. Count Rate	= 909 kcps

Ag/16pl nAg/nSurf = 2 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

Run	Zeta Potential (mV)	Half Width (mV)
1	47.22	2.78
2	48.71	5.48
3	55.26	4.60
4	46.64	2.98
5	42.53	2.87
6	51.99	3.36
7	48.78	5.37
8	43.14	3.40
9	42.25	4.91
10	39.96	3.08
Mean	46.65	3.88
Std. Error	1.51	0.34

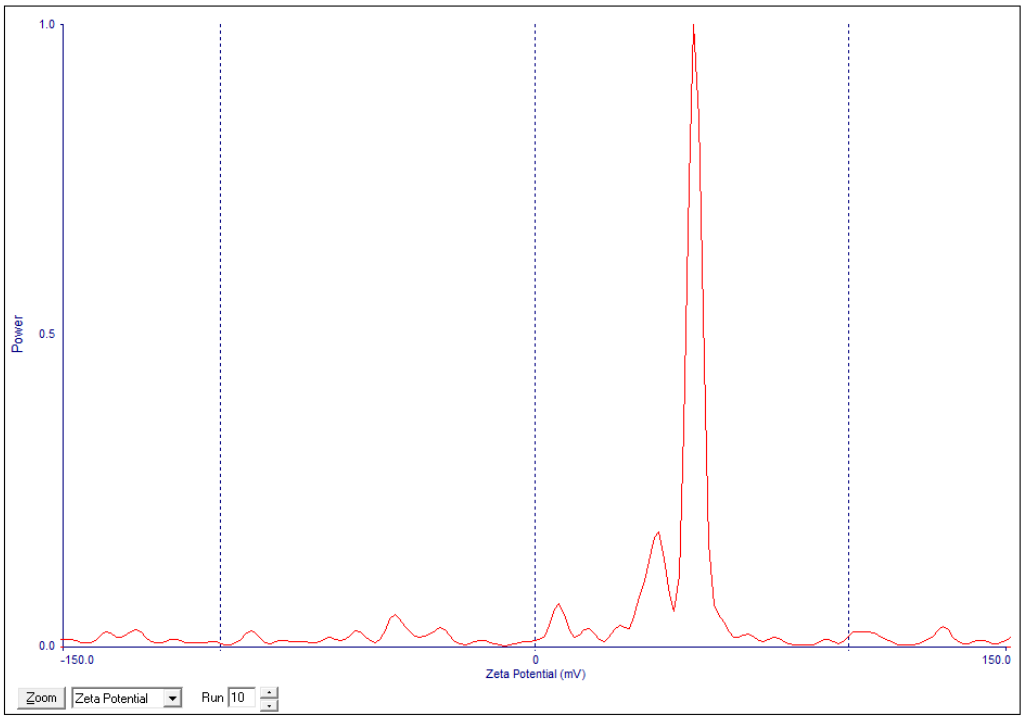
Measurement Parameters:

Conductance	= 672 µ S
Current	= 3.74 mA
Electric Field	= 15.00 V/cm
Sample Count Rate	= 351 kcps
Ref. Count Rate	= 947 kcps

Ag/17pl

Ag/17pl nAg/nSurf = 8 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

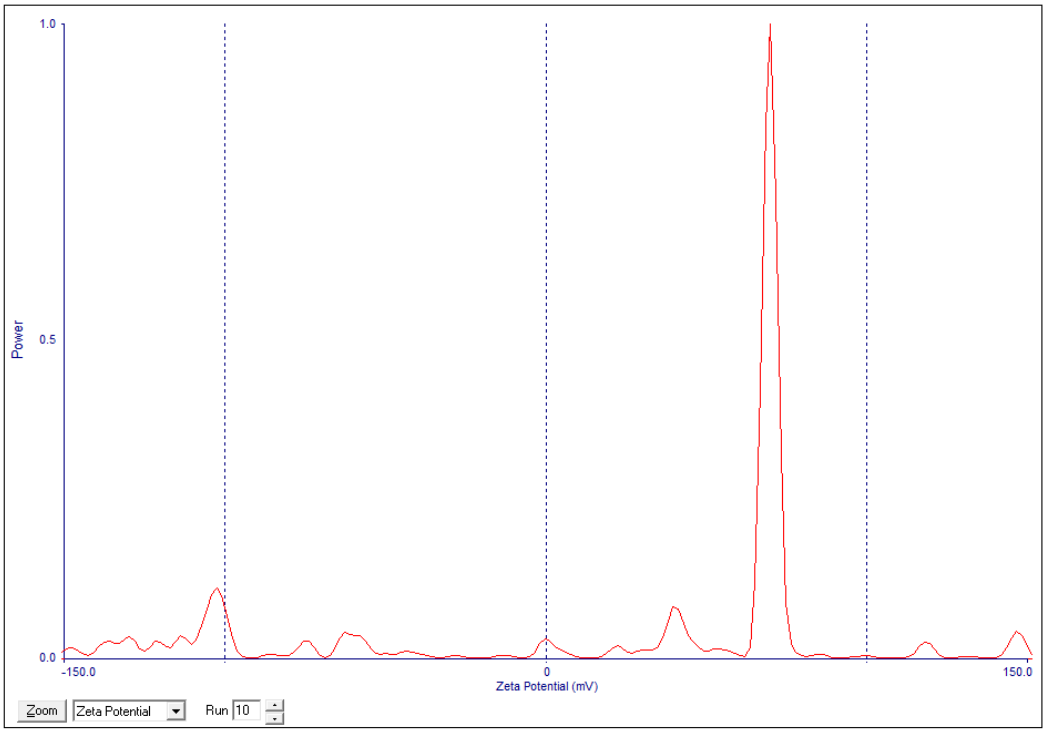
Run	Zeta Potential (mV)	Half Width (mV)
1	40.40	4.33
2	58.64	2.85
3	45.87	3.32
4	54.58	3.11
5	40.91	2.72
6	59.43	2.78
7	44.24	2.71
8	52.03	4.10
9	46.76	3.99
10	50.74	2.78
Mean	49.36	3.27
Std. Error	2.16	0.20

Measurement Parameters:

Conductance	= 920 µ S
Current	= 5.08 mA
Electric Field	= 14.93 V/cm
Sample Count Rate	= 251 kcps
Ref. Count Rate	= 1266 kcps

Ag/17pl nAg/nSurf = 4 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

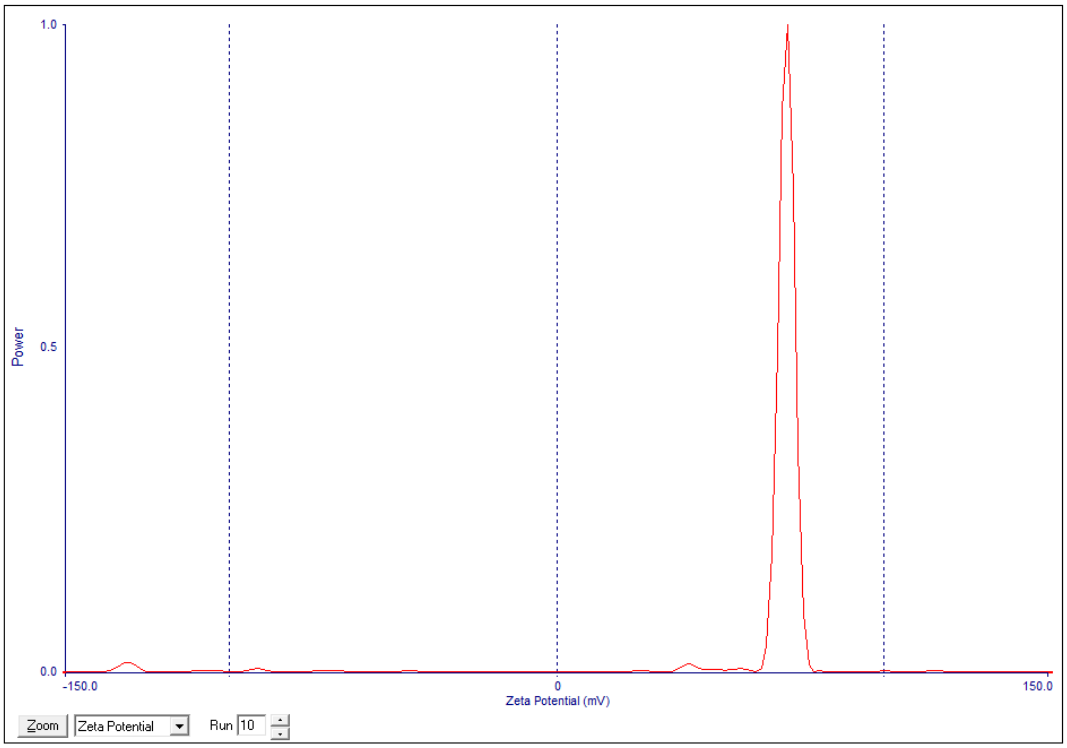
Run	Zeta Potential (mV)	Half Width (mV)
1	65.20	2.71
2	45.93	3.00
3	53.73	3.20
4	58.87	3.11
5	57.04	5.43
6	-165.80	1.88
7	56.63	4.39
8	49.13	2.63
9	-124.47	2.82
10	70.03	2.70
Mean	57.07	3.40
Std. Error	2.79	0.35

Measurement Parameters:

Conductance	= 998 µ S
Current	= 5.50 mA
Electric Field	= 14.92 V/cm
Sample Count Rate	= 492 kcps
Ref. Count Rate	= 1086 kcps

Ag/17pl nAg/nSurf = 2.7 (Run 10)

Measurement Completed



Zeta Potential

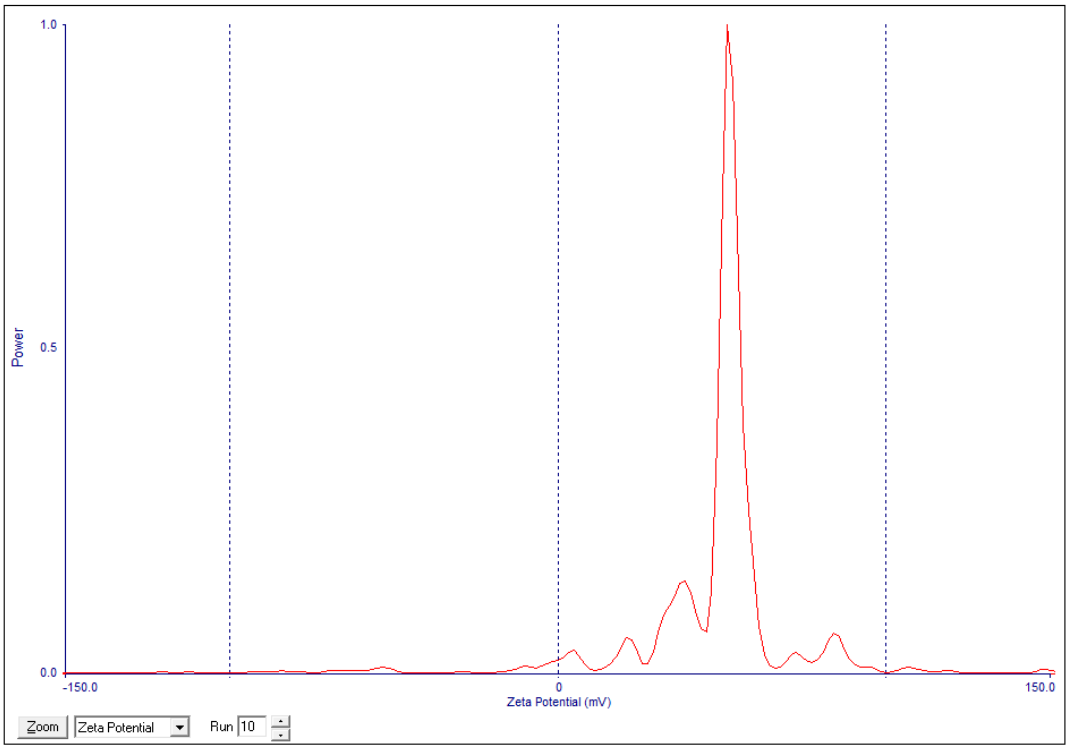
Run	Zeta Potential (mV)	Half Width (mV)
1	43.05	2.86
2	50.82	6.15
3	50.31	2.97
4	46.63	2.80
5	54.49	3.14
6	60.56	3.05
7	61.21	2.60
8	62.74	2.96
9	55.73	3.18
10	70.59	2.88
Mean	55.61	3.26
Std. Error	2.63	0.33

Measurement Parameters:

Conductance	= 804 µ S
Current	= 4.46 mA
Electric Field	= 14.84 V/cm
Sample Count Rate	= 399 kcps
Ref. Count Rate	= 900 kcps

Ag/17pl nAg/nSurf = 2 (Run 10)

Measurement Completed



Zeta Potential

Run	Zeta Potential (mV)	Half Width (mV)
1	57.28	7.36
2	81.68	2.61
3	47.92	3.47
4	51.66	4.38
5	50.67	2.99
6	62.78	3.04
7	55.83	4.07
8	61.10	5.93
9	55.85	2.90
10	51.74	3.33
Mean	57.65	4.01
Std. Error	3.05	0.48

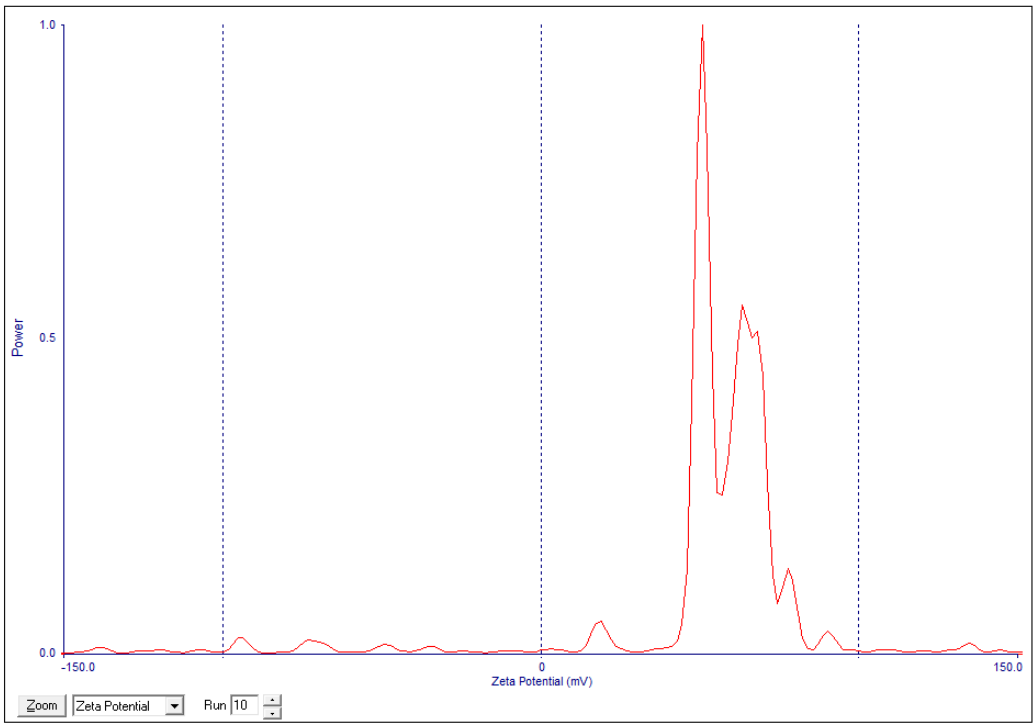
Measurement Parameters:

Conductance	= 730 µ S
Current	= 4.06 mA
Electric Field	= 14.86 V/cm
Sample Count Rate	= 318 kcps
Ref. Count Rate	= 886 kcps

Ag/18pl

Ag/18pl nAg/nSurf = 8 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

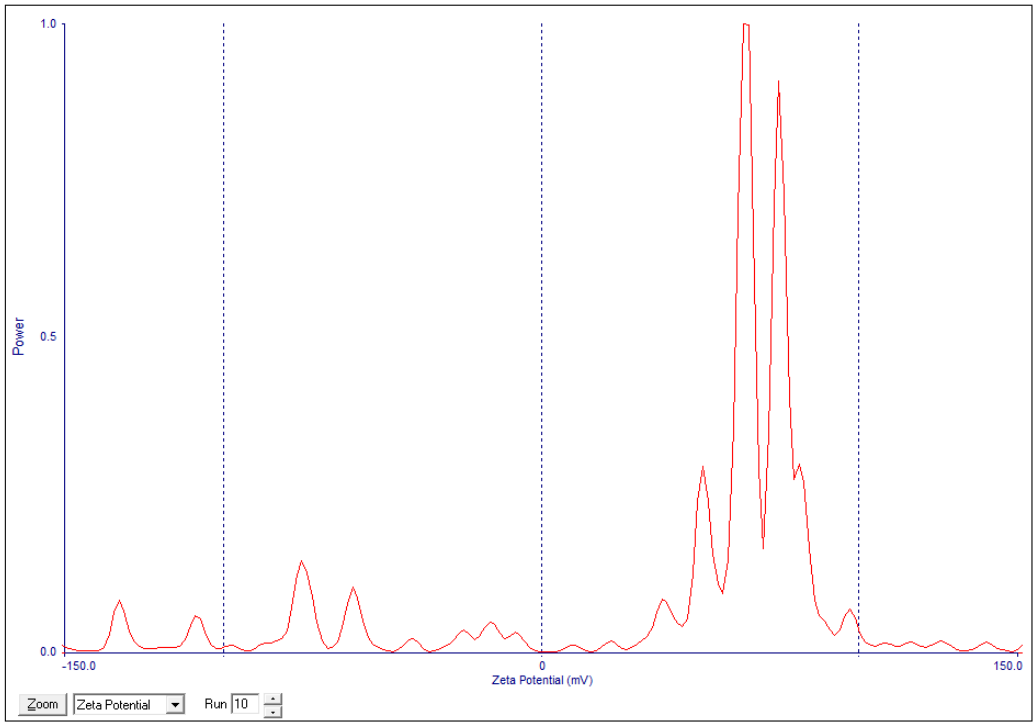
Run	Zeta Potential (mV)	Half Width (mV)
1	61.40	3.14
2	66.90	3.05
3	35.99	6.50
4	45.51	2.56
5	69.75	3.00
6	70.90	3.22
7	64.01	2.71
8	68.66	3.05
9	62.99	3.24
10	50.76	2.84
Mean	62.32	2.98
Std. Error	2.91	0.08

Measurement Parameters:

Conductance	= 1207 µ S
Current	= 6.63 mA
Electric Field	= 15.03 V/cm
Sample Count Rate	= 452 kcps
Ref. Count Rate	= 906 kcps

Ag/18pl nAg/nSurf = 4 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

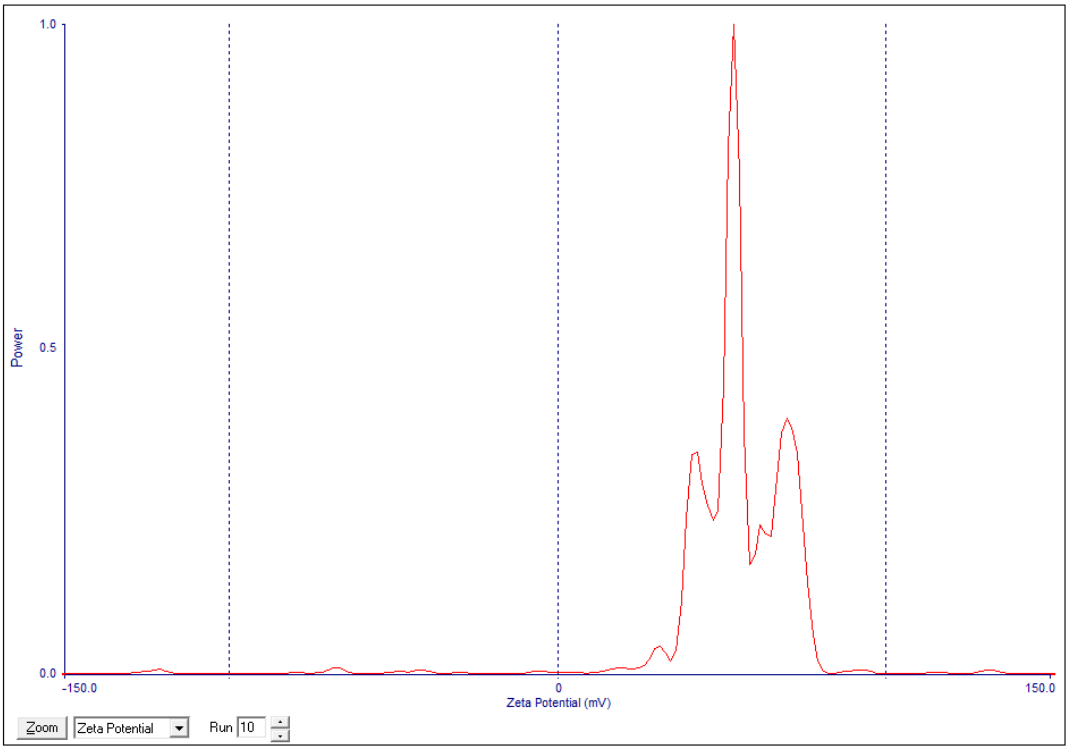
Run	Zeta Potential (mV)	Half Width (mV)
1	71.83	2.79
2	76.46	6.07
3	76.04	3.56
4	55.73	2.71
5	64.67	2.86
6	65.59	3.16
7	69.71	4.04
8	75.16	2.63
9	72.64	5.87
10	63.66	3.21
Mean	69.15	3.69
Std. Error	2.11	0.40

Measurement Parameters:

Conductance	= 1113 µ S
Current	= 6.12 mA
Electric Field	= 14.90 V/cm
Sample Count Rate	= 190 kcps
Ref. Count Rate	= 876 kcps

Ag/18pl nAg/nSurf = 2.7 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

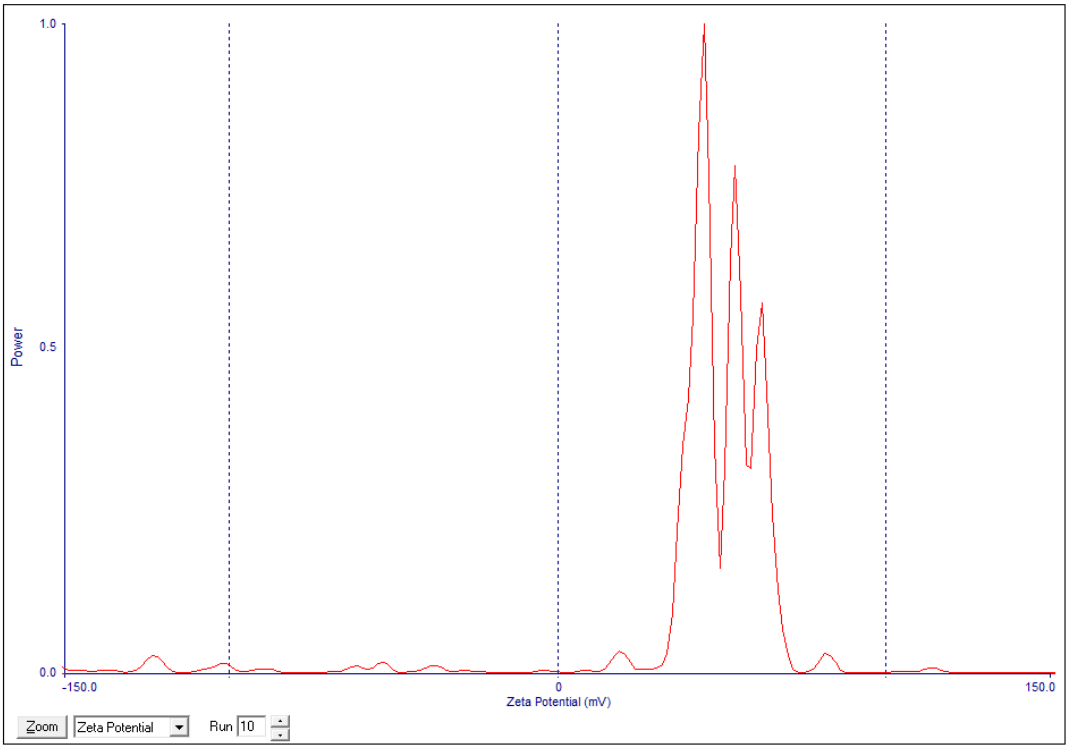
Run	Zeta Potential (mV)	Half Width (mV)
1	66.58	3.41
2	49.34	3.03
3	73.27	3.29
4	75.01	2.86
5	76.89	2.88
6	68.64	5.15
7	63.98	2.76
8	53.55	3.04
9	67.32	3.28
10	53.71	2.82
Mean	66.55	3.28
Std. Error	2.81	0.25

Measurement Parameters:

Conductance	= 931 µ S
Current	= 5.14 mA
Electric Field	= 14.90 V/cm
Sample Count Rate	= 202 kcps
Ref. Count Rate	= 895 kcps

Ag/18pl nAg/nSurf = 2 (Run 10)

Measurement Completed



Zeta Potential | Zoom | Zeta Potential | Run 10

Run	Zeta Potential (mV)	Half Width (mV)
1	68.01	3.05
2	64.01	2.89
3	51.95	2.96
4	61.71	4.22
5	79.43	2.77
6	44.71	5.04
7	62.38	3.03
8	50.96	5.87
9	62.53	3.43
10	44.58	3.22
Mean	62.62	3.53
Std. Error	3.17	0.37

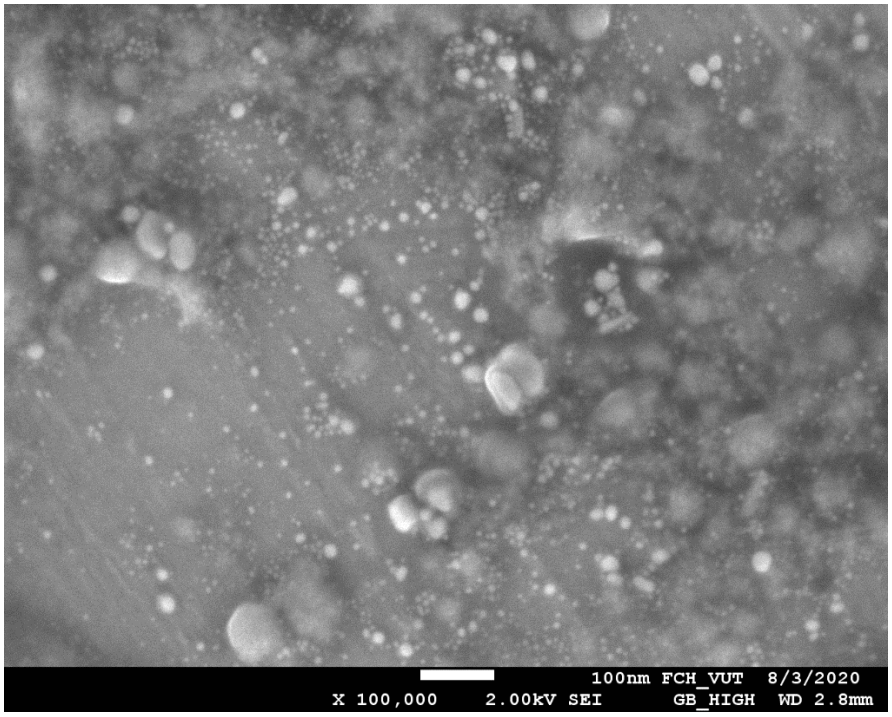
Measurement Parameters:

Conductance	= 635 µ S
Current	= 3.54 mA
Electric Field	= 14.98 V/cm
Sample Count Rate	= 336 kcps
Ref. Count Rate	= 880 kcps

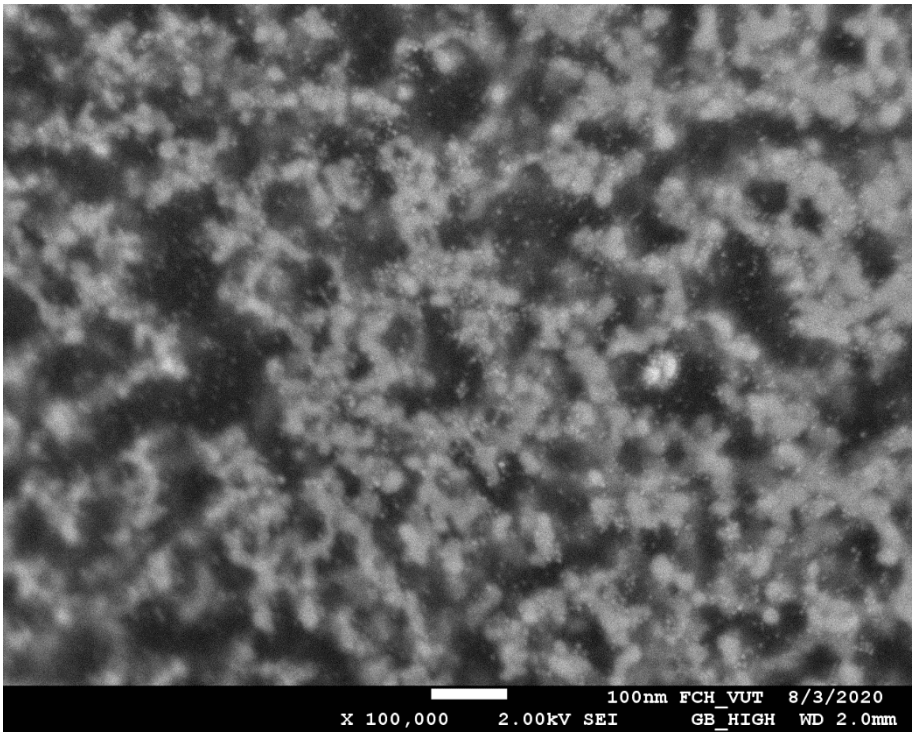
Image of the used Zeta potential analyser:

3. SEM high resolution images

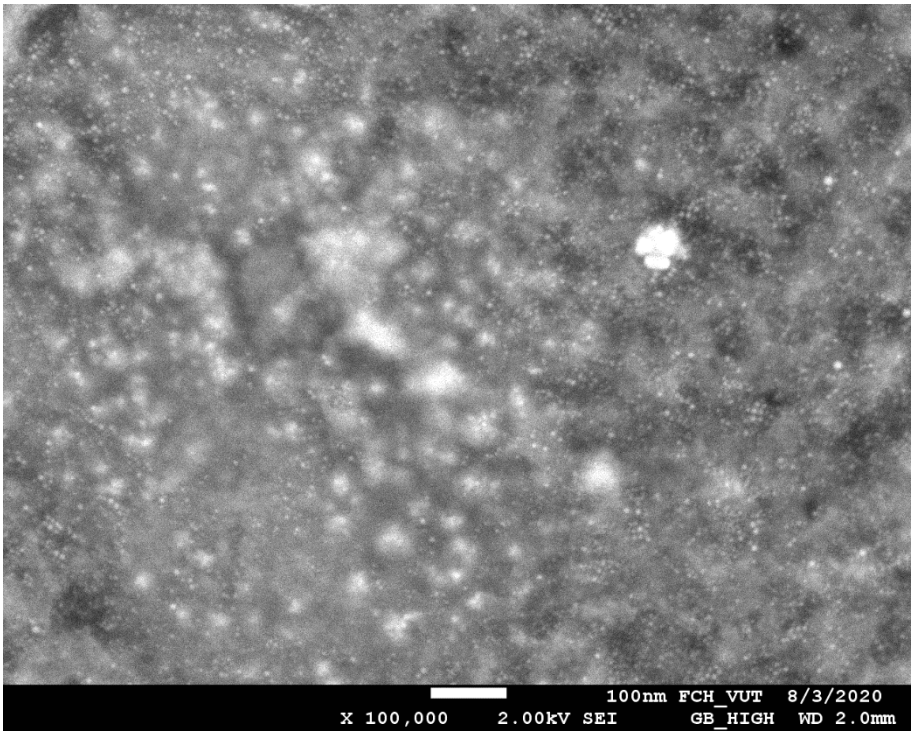
Ag/14pl



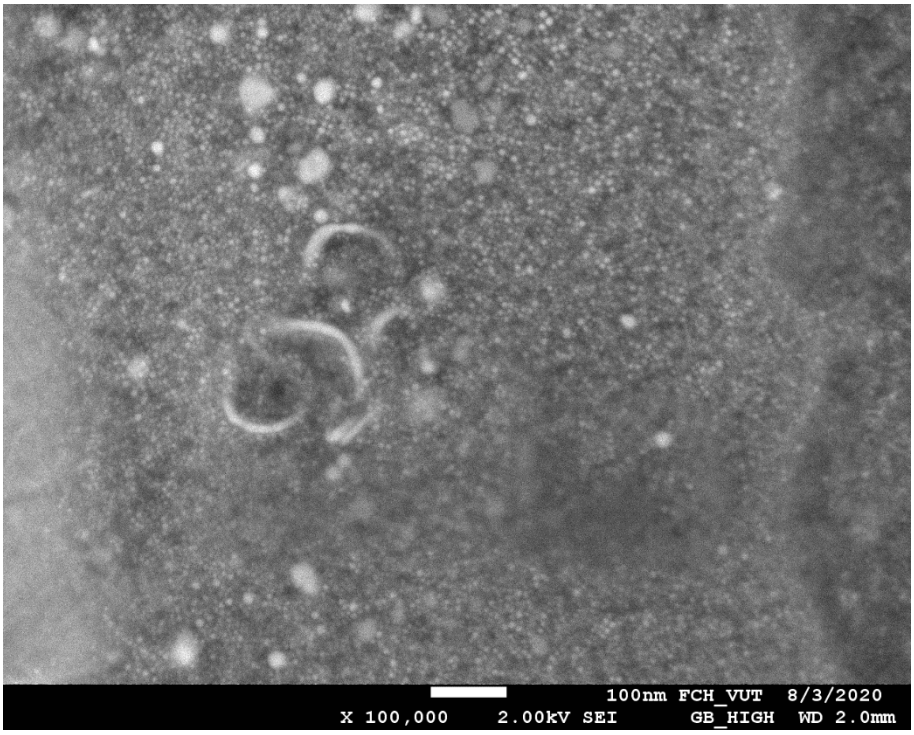
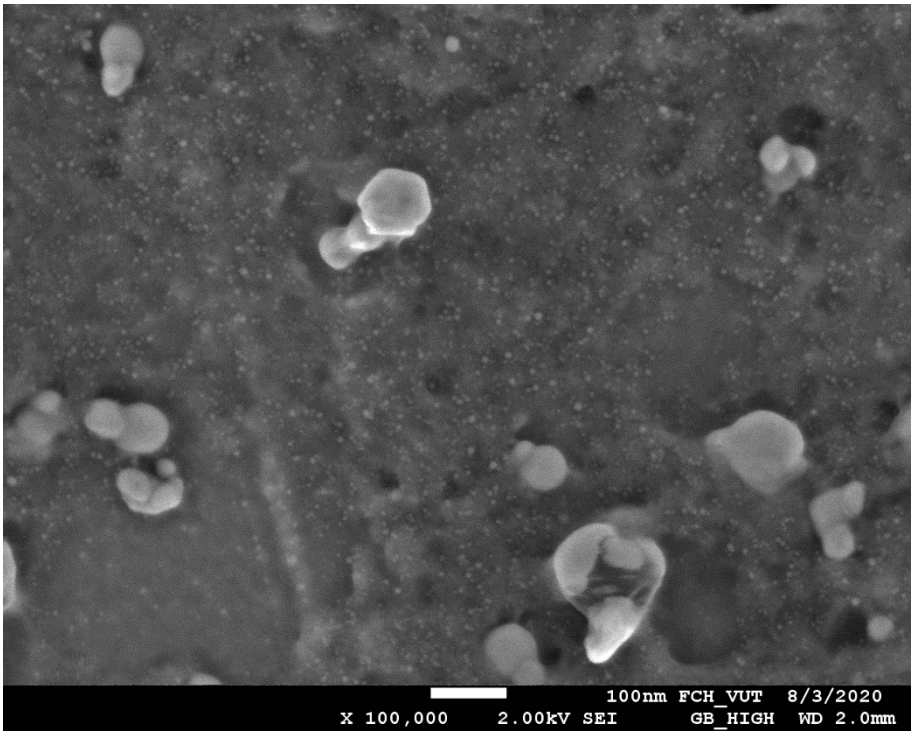
Ag/15pl



Ag/16pl



Ag/17pl



Ag/18pl