



Measurements of particle size distributions

**Analysis Report
Stephen Gould Corporation**

**NO. 200 088
Created for GICC LLC
23 Countryside Court
Bluffton, SC. 29909**



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I. Summary

Introduction

This report provides the particle size distributions of the samples

Water Spray Nozzle

measured with the HELOS laser diffraction instrument.

Details of the measurement procedure and the measurement results are summarised in section I. In addition to the averaged characteristic values of the particle size distributions the averaged distribution curves are presented as volume-based cumulative distribution $Q_3(x)$ and volume-based distribution density q_{3lg} . The detailed description of the measurement conditions and the results of the individual measurements with statistical evaluation of each sample are documented in tabular and graphical form in section II. The nomenclature and the presentation of the measurement results are in accordance with ISO 9276. Please refer to section III for detailed explanations and definitions.

Measurement procedure

The following measuring ranges were selected for the analyses.

Measuring range	Focal length f / mm	x_{Mb} / μm
R6	1000	0.5/9.0 – 1750.0

Table I-1: Selected measuring ranges; f - focal length; x_{Mb} - size range of particles that can be detected by the measuring range (x_u/x_o of smallest size class, x_o of largest size class)

Evaluation

For the evaluation of the measured data the Fraunhofer theory was used with Sympatec's evaluation mode FREE. Here the diffraction of the light is assumed to be the dominant effect of the particle-light interactions. This assumption is valid for opaque particles within and above the micron range. Only in the sub-micron range or for transparent particles other optical effects i.e. refraction, reflection, absorption need to be considered. These effects are taken into account in the Mie theory where the optical parameters (i.e. the complex refractive index) of the particle material and the dispersion medium are mandatory. More details about the Mie evaluation are described in appendix B.

From the particle size analysis by laser diffraction the volume-specific surface S_v of the particles can be calculated. This calculation requires the knowledge of the Heywood shape factor f_H of the particles.

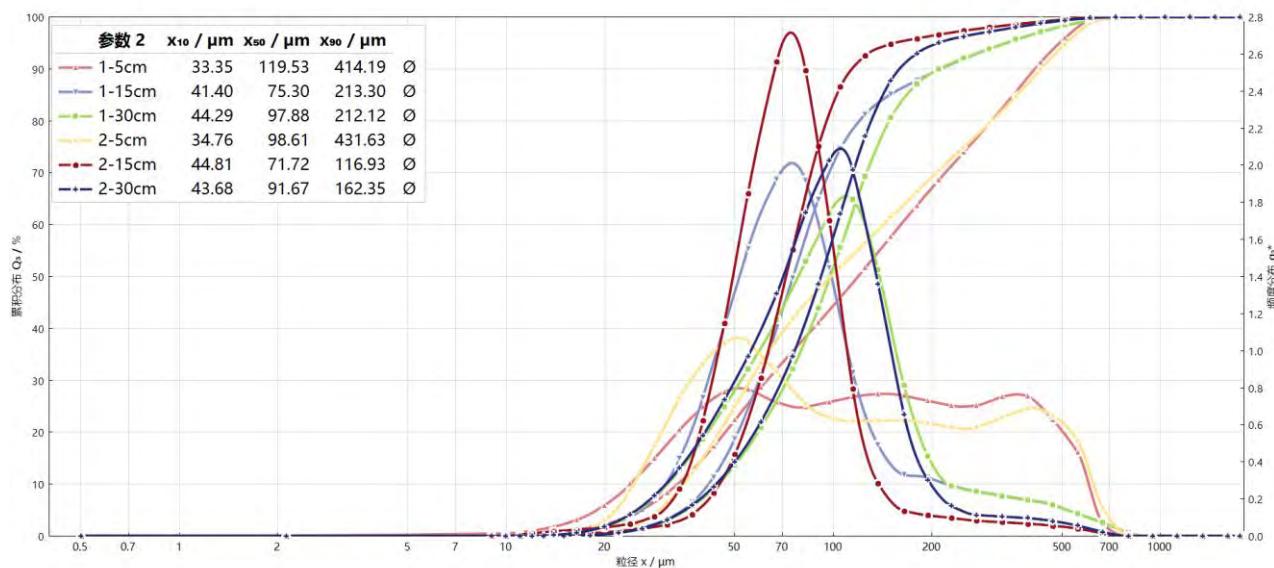
Additionally, with the density ρ of the sample material the mass specific area S_m is calculated from the volume related surface area S_v . As both factors are unknown they were set to 1.0.

Particle size distribution

Characteristic values (x_{10} , x_{50} and x_{90}) of the average cumulative distribution curves and a description of the density distribution curves k_{q3lg} are presented in table I-2.

Sample	x_{10} / μm	x_{50} / μm	x_{90} / μm
1-5cm	33.35	119.53	414.19
1-15cm	41.40	75.30	213.30
1-30cm	44.29	97.88	212.12
2-5cm	34.76	98.61	431.63
2-15cm	44.81	71.72	116.93
2-30cm	43.68	91.67	162.35

Table I-2: Characteristic values of particle size distribution; x_Q : size of Q % of total particle volume



Conclusion

The samples can be measured without any restrictions with the HELOS laser diffraction system using the above described measurement procedure.

The instrument provides with a maximum standard deviation of < x.x % in one size class **highly** reproducible and repeatable results. **The analysed sample materials showed a stable behaviour during the measurements with regard to the particle size distribution.**

[eventuelle Fragestellungen vom Kunden beantworten]

Clausthal-Zellerfeld, 24th June 2017

Stefanie Scherbarth
Head of Laboratory

Uwe Pierau
Assistant Head of Laboratory

II. Detailed documentation of results

Water spray1-5cm

Laser Diffraction Particle Size Analyser

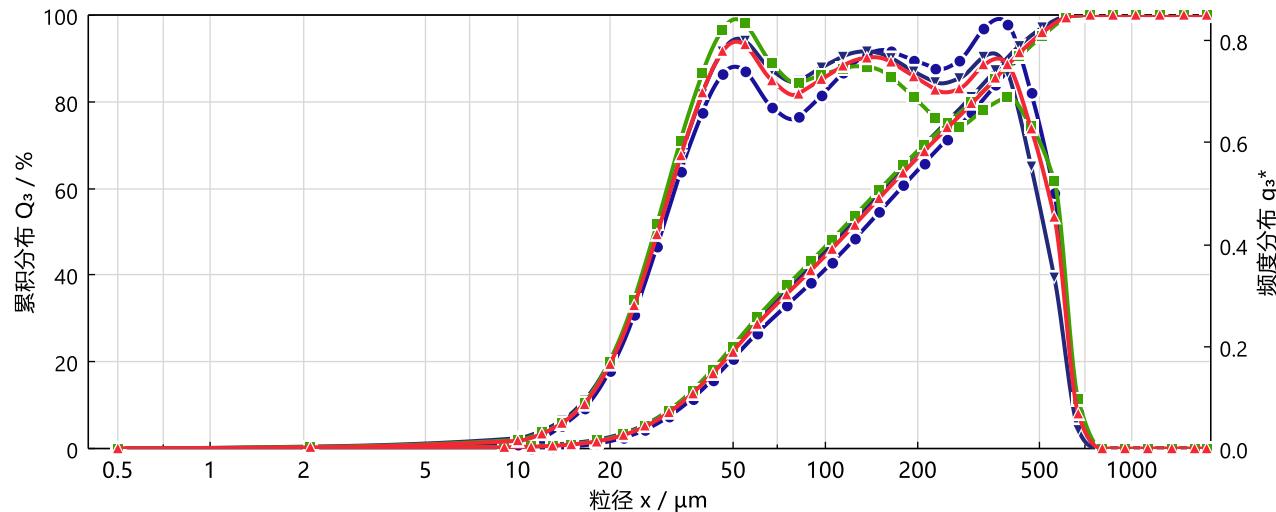
Sample Preparation	No
Sensor	HELOS (HI219)
Disperser	UNIVERSAL
Measuring Range	R6
Trigger Condition	StartCopt \geq 1 %, Stop 10 s measure time or 20 s real time
Time Base	10.00 ms
Measuring time	10.00 s (10.00 s - 10.00 s)
Optial Concentration	4.72 % (4.24 % - 5.52 %)
Measurements per partial sample	3
Calculation Mode	FREE

Details Later



Average size Distribution Data and Statistics

$x_{10,3} = 33.35 \pm 1.21 \mu\text{m}$ [3.64 %] $x_{50,3} = 119.53 \pm 10.59 \mu\text{m}$ [8.86 %] $x_{90,3} = 414.19 \pm 18.26 \mu\text{m}$ [4.41 %]
 $x_{16,3} = 41.40 \pm 1.58 \mu\text{m}$ [3.81 %] $x_{84,3} = 344.85 \pm 16.63 \mu\text{m}$ [4.82 %] $x_{99,3} = 595.04 \pm 10.98 \mu\text{m}$ [1.85 %]
 $x_{\min,3} = 3.56 \pm 4.96 \mu\text{m}$ [139.17 %] $x_{\max,3} = 727.36 \pm 1.33 \mu\text{m}$ [0.18 %] $x_{10,0} = 5.11 \pm 5.99 \mu\text{m}$ [117.34 %]



Cumulative distribution

$x_0 / \mu\text{m}$	$Q_3 / \%$	$\sigma Q_3 / \%$	$\Delta Q_3 / \%$
9.00	0.29	0.25	0.29
11.00	0.42	0.31	0.13
13.00	0.62	0.36	0.21
15.00	0.94	0.39	0.31
18.00	1.63	0.45	0.69
22.00	3.07	0.54	1.44
26.00	5.10	0.64	2.03
31.00	8.30	0.79	3.21
37.00	12.71	1.00	4.40
43.00	17.26	1.23	4.55
50.00	22.35	1.51	5.10
60.00	28.62	1.88	6.27
75.00	35.62	2.32	7.00
90.00	41.13	2.62	5.51
105.00	45.97	2.79	4.84
125.00	51.66	2.87	5.68
150.00	57.73	2.81	6.07
180.00	63.72	2.66	6.00
210.00	68.61	2.47	4.89
250.00	73.94	2.21	5.33
300.00	79.52	1.92	5.59
360.00	85.48	1.70	5.95
430.00	91.29	1.48	5.81
510.00	95.94	1.02	4.65
610.00	99.47	0.23	3.53
730.00	100.00	0.00	0.53
870.00	100.00	0.00	0.00
1030.00	100.00	0.00	0.00
1230.00	100.00	0.00	0.00
1470.00	100.00	0.00	0.00
1750.00	100.00	0.00	0.00

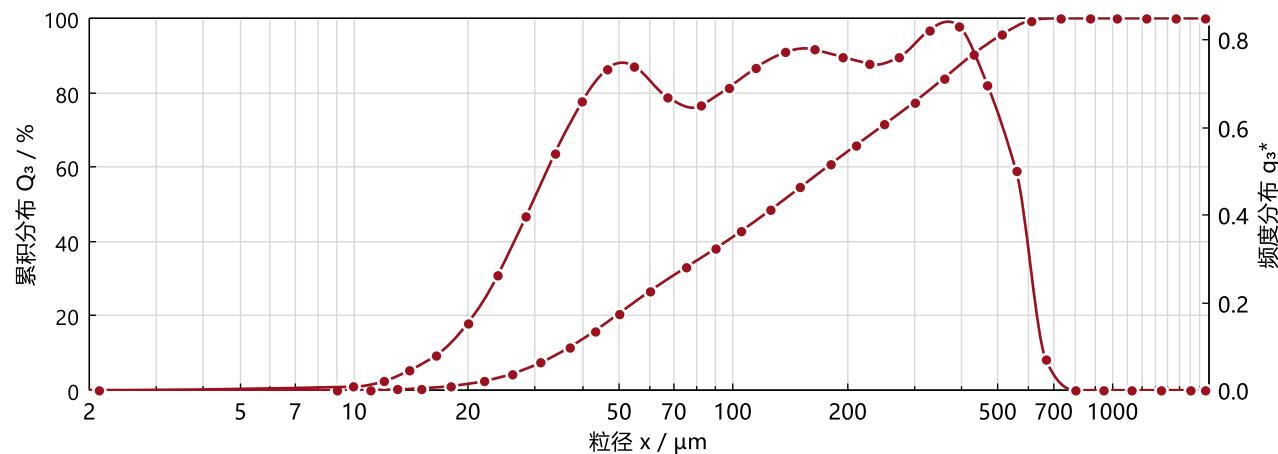
Density Distribution (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.002
9.95	0.015
11.96	0.029
13.96	0.050
16.43	0.088
19.90	0.165
23.92	0.280
28.39	0.420
33.87	0.573
39.89	0.697
46.37	0.778
54.77	0.791
67.08	0.722
82.16	0.696
97.21	0.724
114.56	0.750
136.93	0.767
164.32	0.757
194.42	0.730
229.13	0.704
273.86	0.705
328.63	0.752
393.45	0.753
468.29	0.628
557.76	0.454
667.31	0.068
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 34.75 \mu\text{m}$ $x_{50,3} = 131.60 \mu\text{m}$ $x_{90,3} = 425.90 \mu\text{m}$ SMD = $81.07 \mu\text{m}$ $C_{\text{opt}} = 5.52 \%$
 $x_{16,3} = 43.20 \mu\text{m}$ $x_{84,3} = 360.54 \mu\text{m}$ $x_{99,3} = 598.58 \mu\text{m}$ VMD = $184.73 \mu\text{m}$
 $x_{\min} = 9.29 \mu\text{m}$ $x_{\max} = 727.84 \mu\text{m}$ $x_{10,0} = 12.02 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.07
13.00	0.22
15.00	0.50
18.00	1.13
22.00	2.45
26.00	4.36
31.00	7.39
37.00	11.56
43.00	15.86
50.00	20.67
60.00	26.53
75.00	33.02
90.00	38.18
105.00	42.81
125.00	48.39

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	54.50
180.00	60.66
210.00	65.76
250.00	71.41
300.00	77.43
360.00	83.95
430.00	90.38
510.00	95.55
610.00	99.44
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.008
11.96	0.020
13.96	0.045
16.43	0.080
19.90	0.152
23.92	0.263
28.39	0.397
33.87	0.543
39.89	0.659
46.37	0.734
54.77	0.741
67.08	0.670
82.16	0.651
97.21	0.692
114.56	0.737

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.772
164.32	0.778
194.42	0.762
229.13	0.746
273.86	0.761
328.63	0.823
393.45	0.833
468.29	0.698
557.76	0.501
667.31	0.071
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:17:00
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

分散方法

介质种类 干法

工作距离 63 mm

用户参数

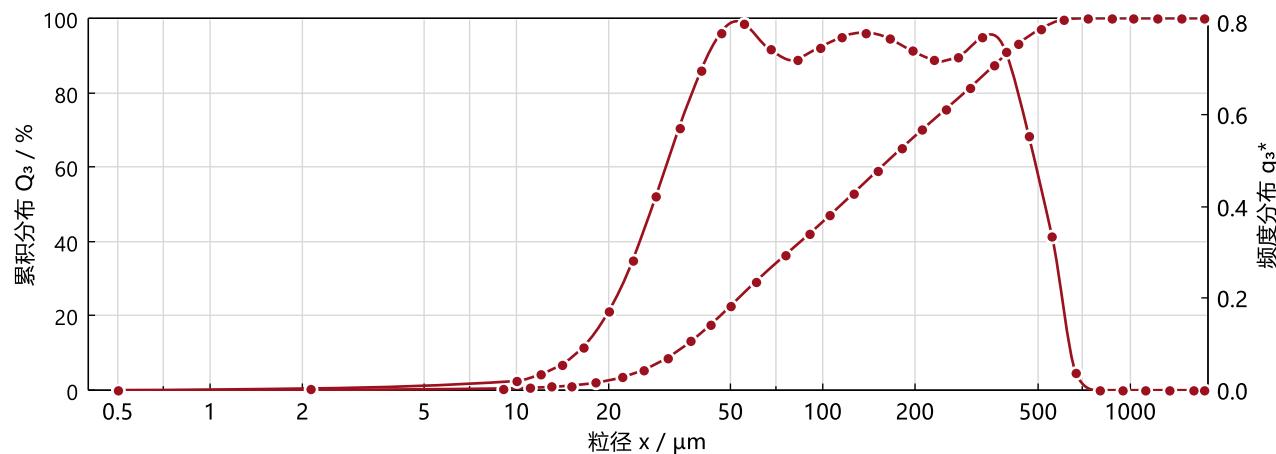
公司名称 Stephen
批号 1-5cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 32.70 \mu\text{m}$ $x_{50,3} = 115.20 \mu\text{m}$ $x_{90,3} = 393.15 \mu\text{m}$ SMD = $70.17 \mu\text{m}$ $C_{\text{opt}} = 4.39 \%$
 $x_{16,3} = 40.76 \mu\text{m}$ $x_{84,3} = 327.42 \mu\text{m}$ $x_{99,3} = 582.73 \mu\text{m}$ VMD = $167.10 \mu\text{m}$
 $x_{\min} = 0.68 \mu\text{m}$ $x_{\max} = 725.86 \mu\text{m}$ $x_{10,0} = 1.62 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.48
11.00	0.65
13.00	0.90
15.00	1.25
18.00	1.99
22.00	3.48
26.00	5.54
31.00	8.76
37.00	13.16
43.00	17.70
50.00	22.80
60.00	29.13
75.00	36.32
90.00	42.03
105.00	47.03
125.00	52.85

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	59.02
180.00	65.08
210.00	70.03
250.00	75.47
300.00	81.22
360.00	87.30
430.00	93.00
510.00	97.11
610.00	99.71
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.004
9.95	0.020
11.96	0.035
13.96	0.055
16.43	0.094
19.90	0.171
23.92	0.284
28.39	0.421
33.87	0.572
39.89	0.696
46.37	0.779
54.77	0.800
67.08	0.742
82.16	0.721
97.21	0.747
114.56	0.769

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.779
164.32	0.766
194.42	0.739
229.13	0.718
273.86	0.726
328.63	0.768
393.45	0.738
468.29	0.554
557.76	0.335
667.31	0.037
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:17:00
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

分散方法

介质种类 干法

工作距离 63 mm

用户参数

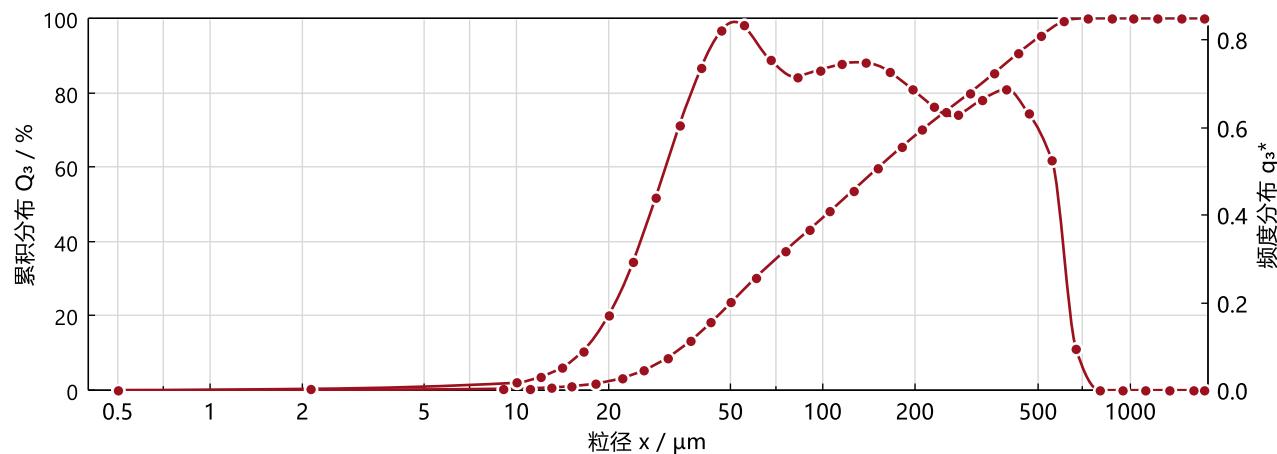
公司名称 Stephen
批号 1-5cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 32.61 \mu\text{m}$ $x_{50,3} = 111.79 \mu\text{m}$ $x_{90,3} = 423.53 \mu\text{m}$ SMD = $70.49 \mu\text{m}$ $C_{\text{opt}} = 4.24 \%$
 $x_{16,3} = 40.25 \mu\text{m}$ $x_{84,3} = 346.60 \mu\text{m}$ $x_{99,3} = 603.82 \mu\text{m}$ VMD = $172.35 \mu\text{m}$
 $x_{\min} = 0.72 \mu\text{m}$ $x_{\max} = 728.40 \mu\text{m}$ $x_{10,0} = 1.67 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.38
11.00	0.53
13.00	0.75
15.00	1.07
18.00	1.78
22.00	3.27
26.00	5.39
31.00	8.76
37.00	13.40
43.00	18.21
50.00	23.59
60.00	30.19
75.00	37.51
90.00	43.18
105.00	48.08
125.00	53.73

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	59.66
180.00	65.42
210.00	70.04
250.00	74.94
300.00	79.92
360.00	85.17
430.00	90.49
510.00	95.17
610.00	99.25
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

頻度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.003
9.95	0.017
11.96	0.031
13.96	0.051
16.43	0.090
19.90	0.171
23.92	0.292
28.39	0.441
33.87	0.605
39.89	0.736
46.37	0.821
54.77	0.834
67.08	0.755
82.16	0.717
97.21	0.732
114.56	0.746

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.749
164.32	0.728
194.42	0.689
229.13	0.647
273.86	0.629
328.63	0.664
393.45	0.689
468.29	0.632
557.76	0.525
667.31	0.096
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:17:00
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

分散方法

介质种类 干法

工作距离 63 mm

用户参数

公司名称 Stephen
批号 1-5cm
Operator Tfe

备注

Water spray1-15cm

Laser Diffraction Particle Size Analyser

Sample Preparation No

Sensor HELOS (HI219)

Disperser UNIVERSAL

Measuring Range R6

Trigger Condition StartCopt \geq 1 %, Stop 10 s measure time or 20 s real time

Time Base 10.00 ms

Measuring time 10.00 s (10.00 s - 10.00 s)

Optial Concentration 11.00 % (8.02 % - 12.83 %)

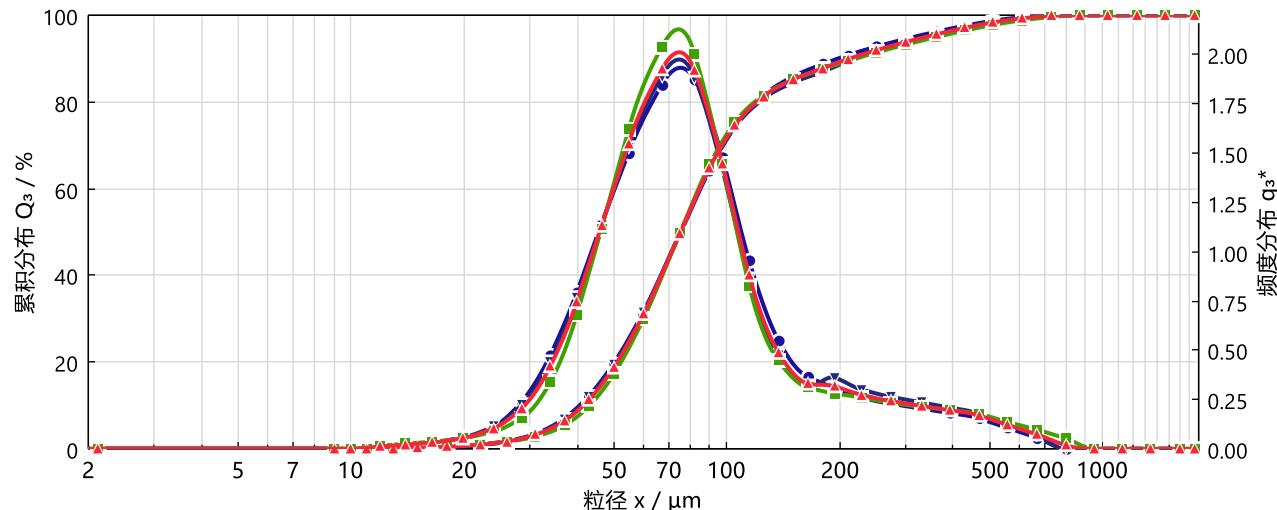
Measurements per partial sample 3

Calculation Mode FREE

Details Later

Average size Distribution Data and Statistics

$x_{10,3} = 41.40 \pm 1.50 \mu\text{m}$ [3.61 %] $x_{50,3} = 75.30 \pm 0.15 \mu\text{m}$ [0.20 %] $x_{90,3} = 213.30 \pm 13.06 \mu\text{m}$ [6.12 %]
 $x_{16,3} = 47.40 \pm 1.28 \mu\text{m}$ [2.69 %] $x_{84,3} = 142.75 \pm 3.75 \mu\text{m}$ [2.63 %] $x_{99,3} = 578.85 \pm 49.65 \mu\text{m}$ [8.58 %]
 $x_{\min,3} = 11.26 \pm 0.08 \mu\text{m}$ [0.72 %] $x_{\max,3} = 773.83 \pm 80.28 \mu\text{m}$ [10.37 %] $x_{10,0} = 14.28 \pm 0.91 \mu\text{m}$ [6.39 %]



Cumulative distribution

$x_0 / \mu\text{m}$	$Q_3 / \%$	$\sigma Q_3 / \%$	$\Delta Q_3 / \%$
9.00	0.00	0.00	0.00
11.00	0.00	0.00	0.00
13.00	0.08	0.02	0.08
15.00	0.21	0.06	0.13
18.00	0.46	0.09	0.25
22.00	0.94	0.11	0.48
26.00	1.69	0.09	0.75
31.00	3.26	0.36	1.56
37.00	6.47	0.91	3.22
43.00	11.35	1.29	4.88
50.00	18.76	1.37	7.41
60.00	31.04	0.89	12.28
75.00	49.69	0.14	18.66
90.00	64.88	0.65	15.19
105.00	74.58	0.61	9.70
125.00	81.26	0.46	6.68
150.00	85.15	0.69	3.89
180.00	87.77	0.90	2.62
210.00	89.89	0.80	2.12
250.00	91.95	0.72	2.07
300.00	93.86	0.67	1.91
360.00	95.59	0.62	1.72
430.00	97.09	0.57	1.51
510.00	98.35	0.50	1.26
610.00	99.29	0.40	0.94
730.00	99.87	0.23	0.57
870.00	100.00	0.00	0.13
1030.00	100.00	0.00	0.00
1230.00	100.00	0.00	0.00
1470.00	100.00	0.00	0.00
1750.00	100.00	0.00	0.00

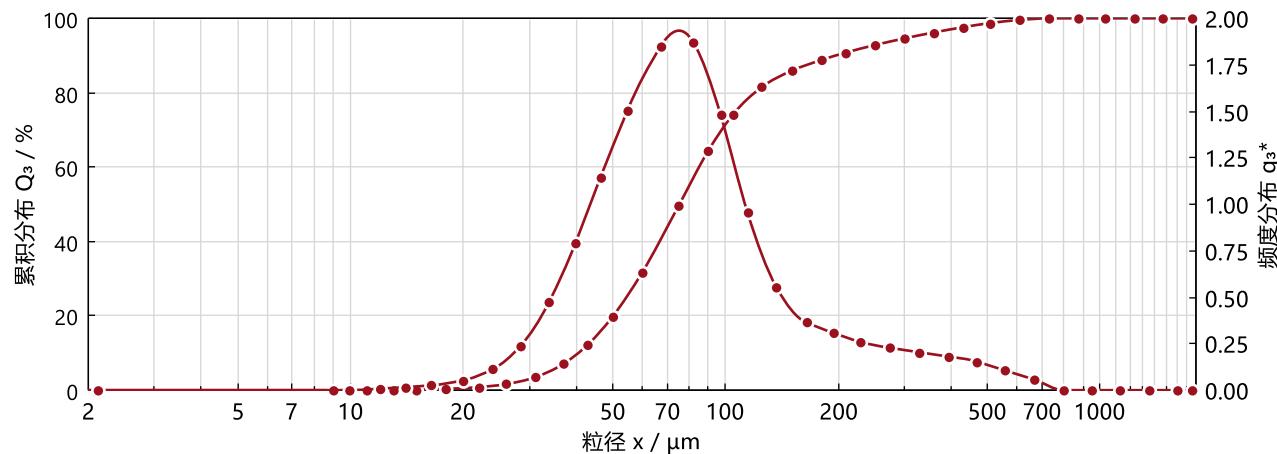
Density Distribution (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.011
13.96	0.021
16.43	0.032
19.90	0.055
23.92	0.104
28.39	0.204
33.87	0.418
39.89	0.748
46.37	1.131
54.77	1.551
67.08	1.925
82.16	1.918
97.21	1.449
114.56	0.882
136.93	0.491
164.32	0.331
194.42	0.316
229.13	0.273
273.86	0.241
328.63	0.218
393.45	0.195
468.29	0.170
557.76	0.121
667.31	0.073
796.93	0.018
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 40.38 \mu\text{m}$ $x_{50,3} = 75.48 \mu\text{m}$ $x_{90,3} = 198.22 \mu\text{m}$ SMD = $68.71 \mu\text{m}$ $C_{\text{opt}} = 8.02 \%$
 $x_{16,3} = 46.50 \mu\text{m}$ $x_{84,3} = 139.36 \mu\text{m}$ $x_{99,3} = 542.49 \mu\text{m}$ VMD = $104.54 \mu\text{m}$
 $x_{\min} = 11.35 \mu\text{m}$ $x_{\max} = 727.30 \mu\text{m}$ $x_{10,0} = 15.23 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.06
15.00	0.16
18.00	0.36
22.00	0.82
26.00	1.63
31.00	3.44
37.00	7.08
43.00	12.27
50.00	19.74
60.00	31.64
75.00	49.53
90.00	64.34
105.00	74.25
125.00	81.49

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	85.86
180.00	88.75
210.00	90.81
250.00	92.77
300.00	94.58
360.00	96.20
430.00	97.59
510.00	98.73
610.00	99.56
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$	$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000	136.93	0.553
9.95	0.000	164.32	0.365
11.96	0.008	194.42	0.308
13.96	0.016	229.13	0.260
16.43	0.026	273.86	0.228
19.90	0.052	328.63	0.204
23.92	0.112	393.45	0.181
28.39	0.237	468.29	0.154
33.87	0.474	557.76	0.106
39.89	0.794	667.31	0.057
46.37	1.141	796.93	0.000
54.77	1.503	946.63	0.000
67.08	1.846	1125.57	0.000
82.16	1.871	1344.66	0.000
97.21	1.479	1603.90	0.000
114.56	0.956		

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:23:55
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

分散方法

介质种类 干法

工作距离 63 mm

用户参数

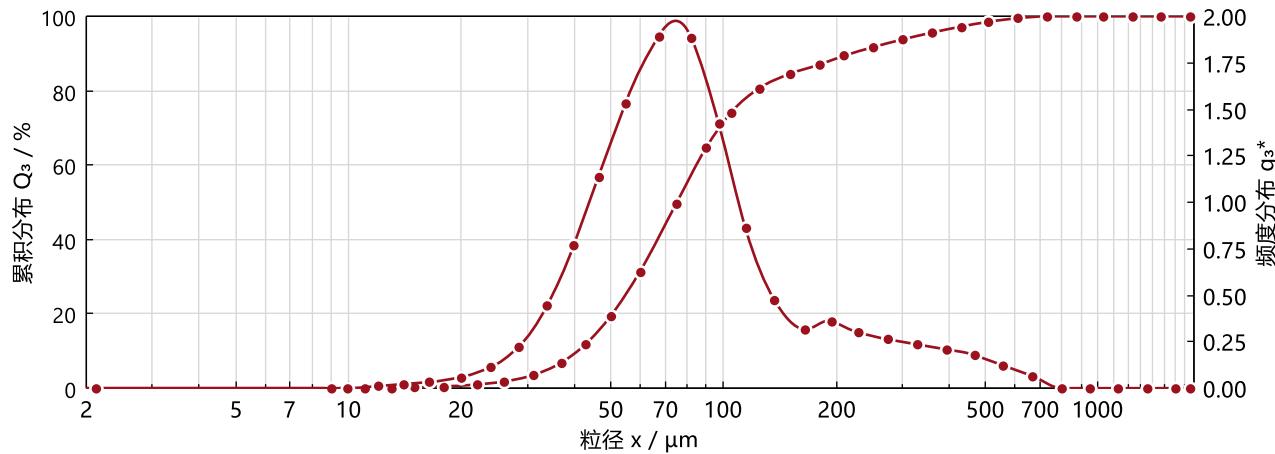
公司名称 Stephen
批号 1-15cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 40.71 \mu\text{m}$ $x_{50,3} = 75.22 \mu\text{m}$ $x_{90,3} = 220.62 \mu\text{m}$ SMD = $68.94 \mu\text{m}$ $C_{\text{opt}} = 12.16 \%$
 $x_{16,3} = 46.85 \mu\text{m}$ $x_{84,3} = 146.78 \mu\text{m}$ $x_{99,3} = 558.64 \mu\text{m}$ VMD = $107.96 \mu\text{m}$
 $x_{\min} = 11.25 \mu\text{m}$ $x_{\max} = 727.66 \mu\text{m}$ $x_{10,0} = 14.20 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.08
15.00	0.22
18.00	0.48
22.00	0.99
26.00	1.80
31.00	3.49
37.00	6.90
43.00	11.92
50.00	19.35
60.00	31.46
75.00	49.79
90.00	64.70
105.00	74.22
125.00	80.74

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	84.48
180.00	86.99
210.00	89.40
250.00	91.66
300.00	93.75
360.00	95.61
430.00	97.22
510.00	98.54
610.00	99.49
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.011
13.96	0.022
16.43	0.033
19.90	0.059
23.92	0.112
28.39	0.221
33.87	0.444
39.89	0.768
46.37	1.135
54.77	1.530
67.08	1.891
82.16	1.884
97.21	1.422
114.56	0.861

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.473
164.32	0.316
194.42	0.360
229.13	0.299
273.86	0.263
328.63	0.235
393.45	0.208
468.29	0.178
557.76	0.122
667.31	0.066
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:23:55
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

分散方法

介质种类 干法

工作距离 63 mm

用户参数

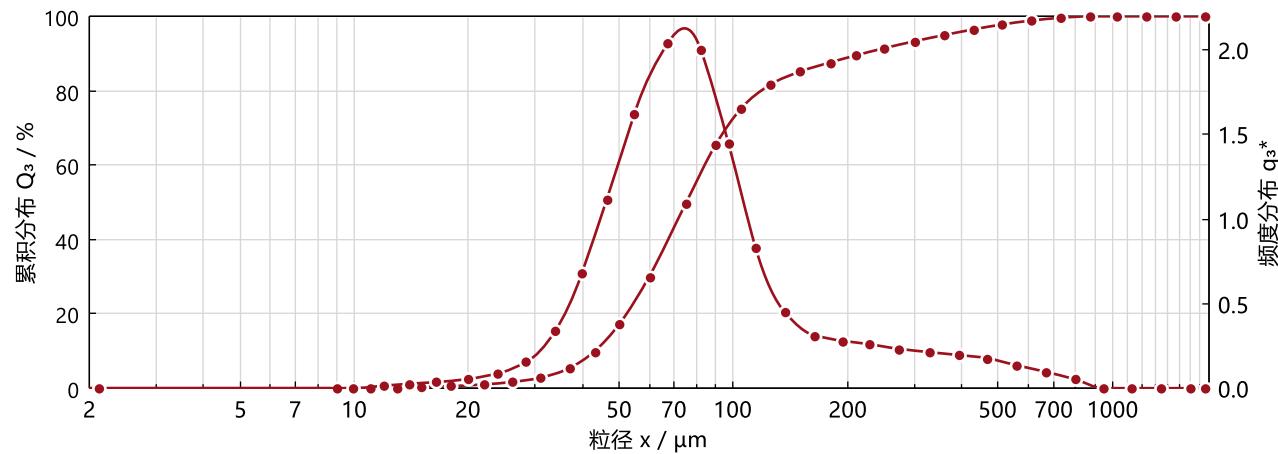
公司名称 Stephen
批号 1-15cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 43.12 \mu\text{m}$ $x_{50,3} = 75.22 \mu\text{m}$ $x_{90,3} = 221.06 \mu\text{m}$ SMD = $70.12 \mu\text{m}$ $C_{\text{opt}} = 12.83 \%$
 $x_{16,3} = 48.86 \mu\text{m}$ $x_{84,3} = 142.12 \mu\text{m}$ $x_{99,3} = 635.42 \mu\text{m}$ VMD = $110.98 \mu\text{m}$
 $x_{\min} = 11.19 \mu\text{m}$ $x_{\max} = 866.53 \mu\text{m}$ $x_{10,0} = 13.41 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.11
15.00	0.27
18.00	0.55
22.00	1.02
26.00	1.65
31.00	2.84
37.00	5.43
43.00	9.88
50.00	17.19
60.00	30.01
75.00	49.77
90.00	65.61
105.00	75.28
125.00	81.57

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	85.12
180.00	87.58
210.00	89.46
250.00	91.42
300.00	93.27
360.00	94.96
430.00	96.47
510.00	97.78
610.00	98.84
730.00	99.60
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

頻度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.015
13.96	0.026
16.43	0.036
19.90	0.054
23.92	0.087
28.39	0.155
33.87	0.337
39.89	0.682
46.37	1.116
54.77	1.620
67.08	2.038
82.16	2.000
97.21	1.445
114.56	0.830

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.448
164.32	0.311
194.42	0.280
229.13	0.260
273.86	0.233
328.63	0.213
393.45	0.196
468.29	0.177
557.76	0.136
667.31	0.097
796.93	0.053
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:23:55
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

分散方法

介质种类 干法

工作距离 63 mm

用户参数

公司名称 Stephen
批号 1-15cm
Operator Tfe

备注

Water spray1-30cm

Laser Diffraction Particle Size Analyser

Sample Preparation	No
Sensor	HELOS (HI219)
Disperser	UNIVERSAL
Measuring Range	R6
Trigger Condition	StartCopt \geq 1 %, Stop 10 s measure time or 20 s real time
Time Base	10.00 ms
Measuring time	10.00 s (10.00 s - 10.00 s)
Optial Concentration	12.42 % (11.42 % - 13.56 %)
Measurements per partial sample	3
Calculation Mode	FREE

Details Later



Average size Distribution Data and Statistics

$x_{10,3} = 44.29 \pm 0.74 \mu\text{m}$ [1.67 %]

$x_{16,3} = 53.20 \pm 0.86 \mu\text{m}$ [1.61 %]

$x_{\min,3} = 13.61 \pm 0.05 \mu\text{m}$ [0.35 %]

$x_{50,3} = 97.88 \pm 1.56 \mu\text{m}$ [1.59 %]

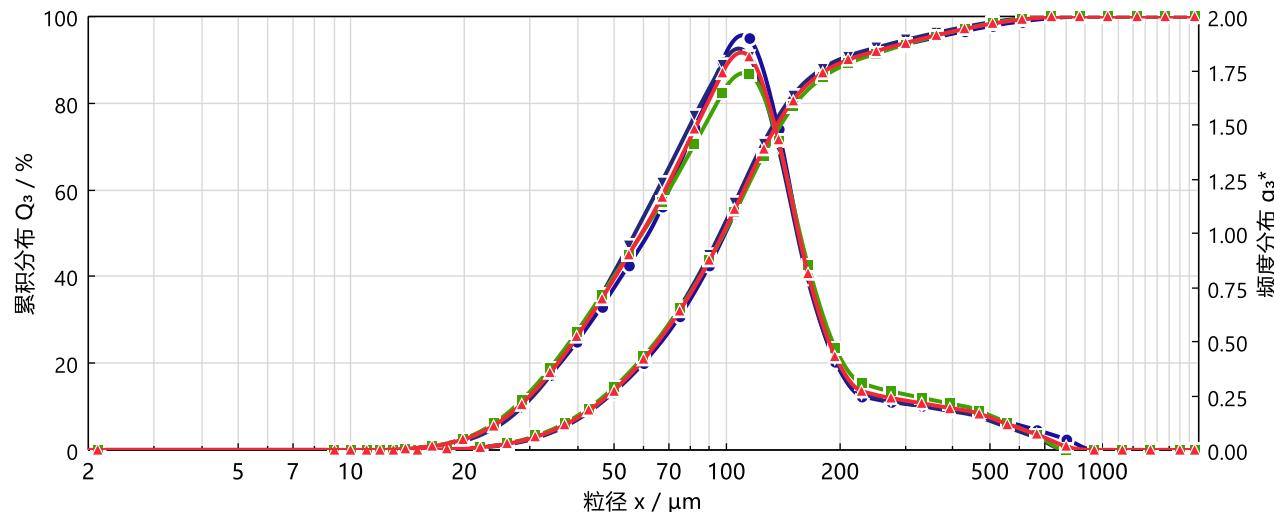
$x_{84,3} = 165.41 \pm 5.48 \mu\text{m}$ [3.31 %]

$x_{\max,3} = 773.78 \pm 80.17 \mu\text{m}$ [10.36 %]

$x_{90,3} = 212.12 \pm 12.20 \mu\text{m}$ [5.75 %]

$x_{99,3} = 576.76 \pm 44.95 \mu\text{m}$ [7.79 %]

$x_{10,0} = 18.73 \pm 0.05 \mu\text{m}$ [0.29 %]



Cumulative distribution

$x_0 / \mu\text{m}$	$Q_3 / \%$	$\sigma Q_3 / \%$	$\Delta Q_3 / \%$
9.00	0.00	0.00	0.00
11.00	0.00	0.00	0.00
13.00	0.00	0.00	0.00
15.00	0.03	0.00	0.03
18.00	0.17	0.00	0.14
22.00	0.59	0.05	0.42
26.00	1.40	0.14	0.81
31.00	3.02	0.26	1.62
37.00	5.75	0.39	2.73
43.00	9.16	0.48	3.41
50.00	13.73	0.57	4.56
60.00	20.86	0.73	7.13
75.00	32.17	1.06	11.31
90.00	43.89	1.21	11.72
105.00	55.53	1.31	11.64
125.00	69.29	1.43	13.76
150.00	80.65	1.33	11.36
180.00	87.10	1.05	6.45
210.00	89.99	0.87	2.89
250.00	92.04	0.71	2.05
300.00	93.93	0.59	1.89
360.00	95.64	0.53	1.71
430.00	97.13	0.49	1.49
510.00	98.38	0.44	1.24
610.00	99.31	0.36	0.93
730.00	99.87	0.22	0.56
870.00	100.00	0.00	0.13
1030.00	100.00	0.00	0.00
1230.00	100.00	0.00	0.00
1470.00	100.00	0.00	0.00
1750.00	100.00	0.00	0.00

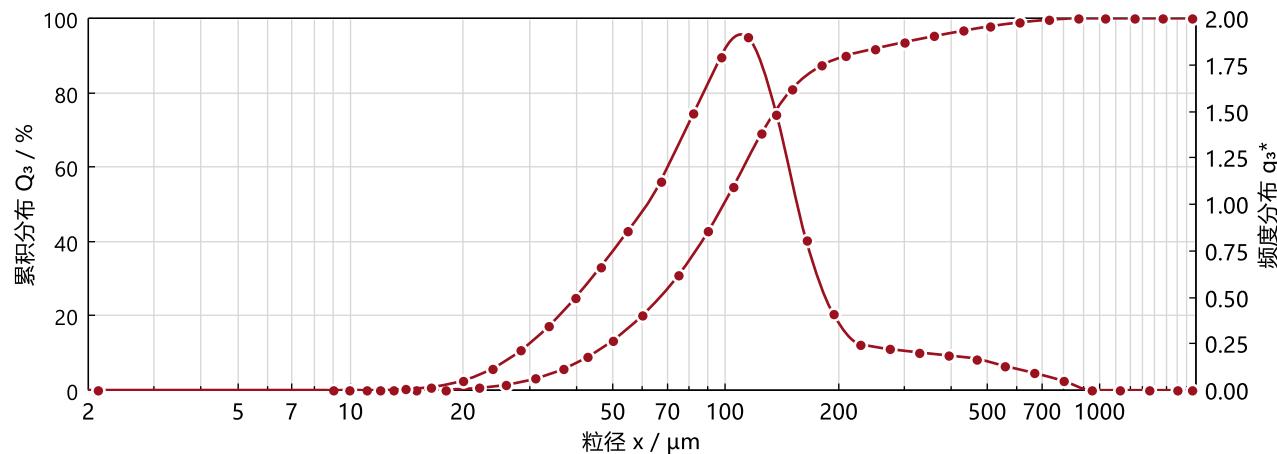
Density Distribution (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.005
16.43	0.017
19.90	0.048
23.92	0.112
28.39	0.212
33.87	0.356
39.89	0.523
46.37	0.696
54.77	0.900
67.08	1.167
82.16	1.481
97.21	1.739
114.56	1.817
136.93	1.435
164.32	0.814
194.42	0.431
229.13	0.271
273.86	0.239
328.63	0.216
393.45	0.193
468.29	0.168
557.76	0.120
667.31	0.072
796.93	0.017
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 44.61 \mu\text{m}$ $x_{50,3} = 99.08 \mu\text{m}$ $x_{90,3} = 210.79 \mu\text{m}$ SMD = $81.99 \mu\text{m}$ $C_{\text{opt}} = 11.42 \%$
 $x_{16,3} = 53.94 \mu\text{m}$ $x_{84,3} = 164.77 \mu\text{m}$ $x_{99,3} = 627.41 \mu\text{m}$ VMD = $125.54 \mu\text{m}$
 $x_{\min} = 13.65 \mu\text{m}$ $x_{\max} = 866.36 \mu\text{m}$ $x_{10,0} = 18.74 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.03
18.00	0.17
22.00	0.61
26.00	1.46
31.00	3.08
37.00	5.74
43.00	9.01
50.00	13.34
60.00	20.09
75.00	30.96
90.00	42.73
105.00	54.74
125.00	69.12

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	80.86
180.00	87.24
210.00	89.96
250.00	91.84
300.00	93.59
360.00	95.20
430.00	96.64
510.00	97.89
610.00	98.90
730.00	99.62
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.005
16.43	0.017
19.90	0.051
23.92	0.117
28.39	0.212
33.87	0.346
39.89	0.500
46.37	0.661
54.77	0.853
67.08	1.122
82.16	1.487
97.21	1.793
114.56	1.899

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	1.483
164.32	0.806
194.42	0.407
229.13	0.247
273.86	0.221
328.63	0.203
393.45	0.187
468.29	0.168
557.76	0.130
667.31	0.092
796.93	0.050
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:23:55
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

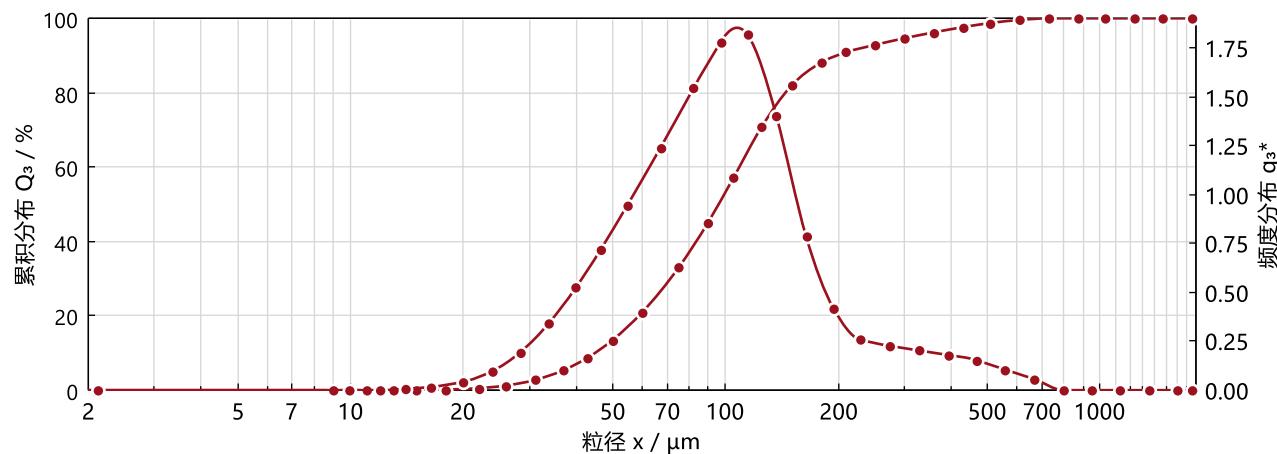
公司名称 Stephen
批号 1-30cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 44.82 \mu\text{m}$ $x_{50,3} = 96.12 \mu\text{m}$ $x_{90,3} = 200.63 \mu\text{m}$ SMD = $80.78 \mu\text{m}$ $C_{\text{opt}} = 13.56 \%$
 $x_{16,3} = 53.39 \mu\text{m}$ $x_{84,3} = 160.28 \mu\text{m}$ $x_{99,3} = 541.65 \mu\text{m}$ VMD = $118.80 \mu\text{m}$
 $x_{\min} = 13.56 \mu\text{m}$ $x_{\max} = 727.28 \mu\text{m}$ $x_{10,0} = 18.67 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.04
18.00	0.17
22.00	0.54
26.00	1.25
31.00	2.73
37.00	5.37
43.00	8.78
50.00	13.46
60.00	20.94
75.00	32.93
90.00	45.14
105.00	57.05
125.00	70.80

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	81.87
180.00	88.08
210.00	90.87
250.00	92.82
300.00	94.62
360.00	96.22
430.00	97.61
510.00	98.74
610.00	99.56
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.006
16.43	0.017
19.90	0.042
23.92	0.098
28.39	0.194
33.87	0.343
39.89	0.523
46.37	0.714
54.77	0.945
67.08	1.237
82.16	1.542
97.21	1.779
114.56	1.817

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	1.398
164.32	0.784
194.42	0.417
229.13	0.258
273.86	0.227
328.63	0.203
393.45	0.179
468.29	0.153
557.76	0.105
667.31	0.057
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:23:55
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

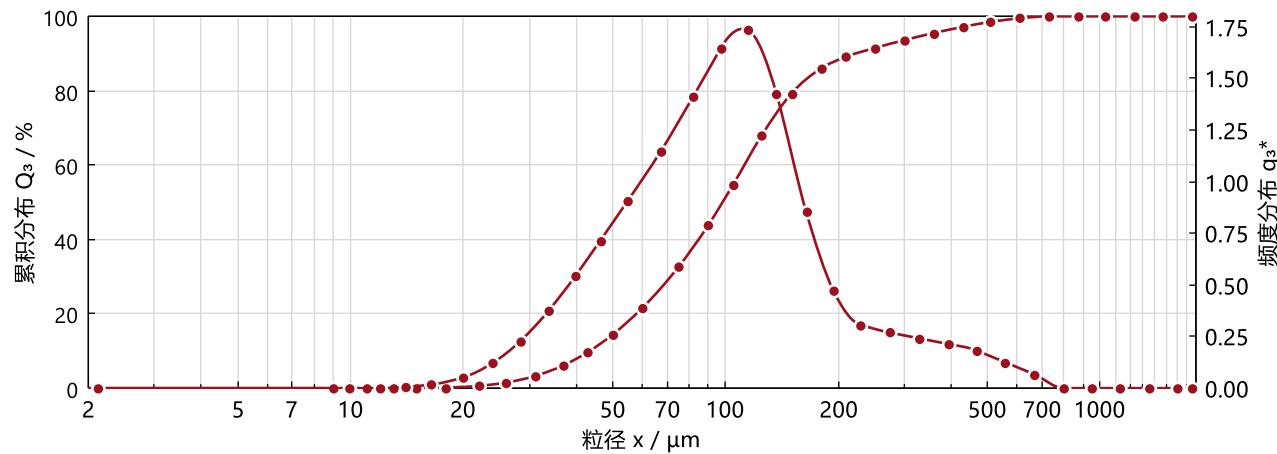
公司名称 Stephen
批号 1-30cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 43.44 \mu\text{m}$ $x_{50,3} = 98.44 \mu\text{m}$ $x_{90,3} = 224.93 \mu\text{m}$ SMD = $80.96 \mu\text{m}$ $C_{\text{opt}} = 12.27 \%$
 $x_{16,3} = 52.27 \mu\text{m}$ $x_{84,3} = 171.18 \mu\text{m}$ $x_{99,3} = 561.21 \mu\text{m}$ VMD = $124.04 \mu\text{m}$
 $x_{\min} = 13.61 \mu\text{m}$ $x_{\max} = 727.71 \mu\text{m}$ $x_{10,0} = 18.78 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.03
18.00	0.17
22.00	0.62
26.00	1.50
31.00	3.24
37.00	6.15
43.00	9.70
50.00	14.38
60.00	21.54
75.00	32.61
90.00	43.80
105.00	54.82
125.00	67.95

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	79.23
180.00	85.99
210.00	89.13
250.00	91.46
300.00	93.59
360.00	95.50
430.00	97.15
510.00	98.50
610.00	99.48
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.005
16.43	0.018
19.90	0.051
23.92	0.121
28.39	0.228
33.87	0.378
39.89	0.545
46.37	0.714
54.77	0.904
67.08	1.143
82.16	1.413
97.21	1.645
114.56	1.735

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:23:55
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

公司名称 Stephen
批号 1-30cm
Operator Tfe

备注

Water spray2-5cm

Laser Diffraction Particle Size Analyser

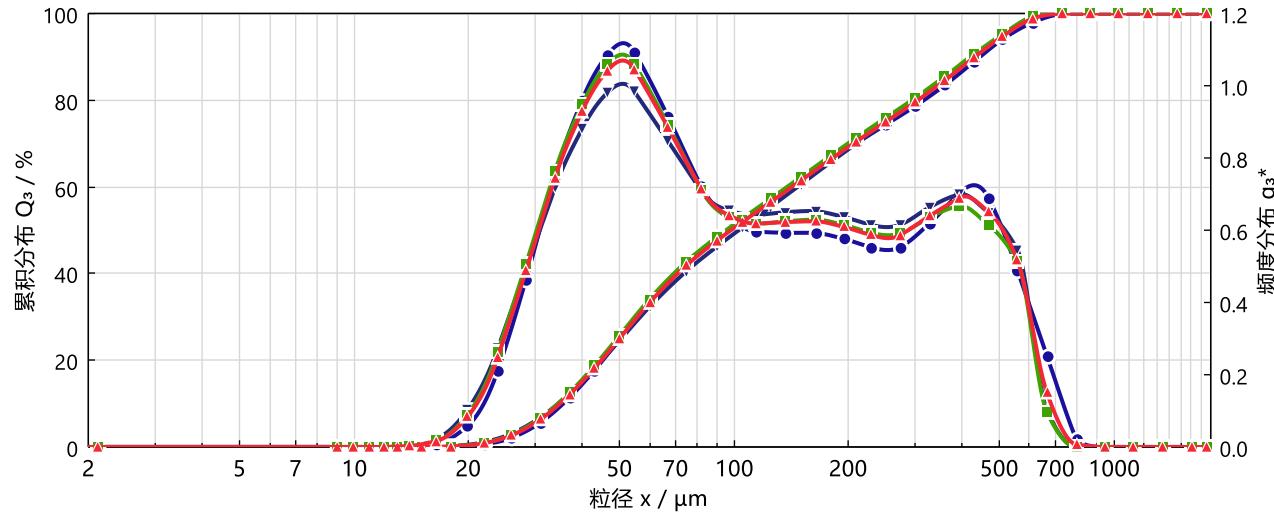
Sample Preparation	No
Sensor	HELOS (HI219)
Disperser	UNIVERSAL
Measuring Range	R6
Trigger Condition	StartCopt \geq 1 %, Stop 10 s measure time or 20 s real time
Time Base	10.00 ms
Measuring time	10.00 s (10.00 s - 10.00 s)
Optial Concentration	6.62 % (5.05 % - 7.43 %)
Measurements per partial sample	3
Calculation Mode	FREE
Details Later	



Average size Distribution Data and Statistics

PAQXOS 4.1 FREE

$$\begin{aligned}x_{10,3} &= 34.76 \pm 0.63 \mu\text{m} [1.82 \%] &x_{50,3} &= 98.61 \pm 3.99 \mu\text{m} [4.05 \%] &x_{90,3} &= 431.63 \pm 13.28 \mu\text{m} [3.08 \%] \\x_{16,3} &= 40.82 \pm 0.51 \mu\text{m} [1.26 \%] &x_{84,3} &= 353.00 \pm 12.36 \mu\text{m} [3.50 \%] &x_{99,3} &= 629.26 \pm 42.97 \mu\text{m} [6.83 \%] \\x_{\min,3} &= 14.31 \pm 0.72 \mu\text{m} [5.03 \%] &x_{\max,3} &= 772.76 \pm 76.75 \mu\text{m} [9.93 \%] &x_{10,0} &= 20.31 \pm 1.24 \mu\text{m} [6.10 \%]\end{aligned}$$



Cumulative distribution

x_0 / μm	Q_3 / %	σQ_3 / %	ΔQ_3 / %
9.00	0.00	0.00	0.00
11.00	0.00	0.00	0.00
13.00	0.00	0.00	0.00
15.00	0.02	0.01	0.02
18.00	0.15	0.07	0.13
22.00	0.87	0.27	0.73
26.00	2.68	0.50	1.81
31.00	6.41	0.65	3.73
37.00	12.14	0.60	5.73
43.00	18.21	0.52	6.07
50.00	25.02	0.60	6.82
60.00	33.30	0.89	8.28
75.00	41.87	1.17	8.57
90.00	47.52	1.20	5.65
105.00	51.82	1.12	4.29
125.00	56.50	0.98	4.68
150.00	61.43	0.85	4.93
180.00	66.37	0.77	4.95
210.00	70.45	0.77	4.08
250.00	74.90	0.83	4.45
300.00	79.54	0.95	4.64
360.00	84.61	1.02	5.07
430.00	89.94	0.89	5.32
510.00	94.76	0.62	4.82
610.00	98.78	0.78	4.02
730.00	99.95	0.09	1.17
870.00	100.00	0.00	0.05
1030.00	100.00	0.00	0.00
1230.00	100.00	0.00	0.00
1470.00	100.00	0.00	0.00
1750.00	100.00	0.00	0.00

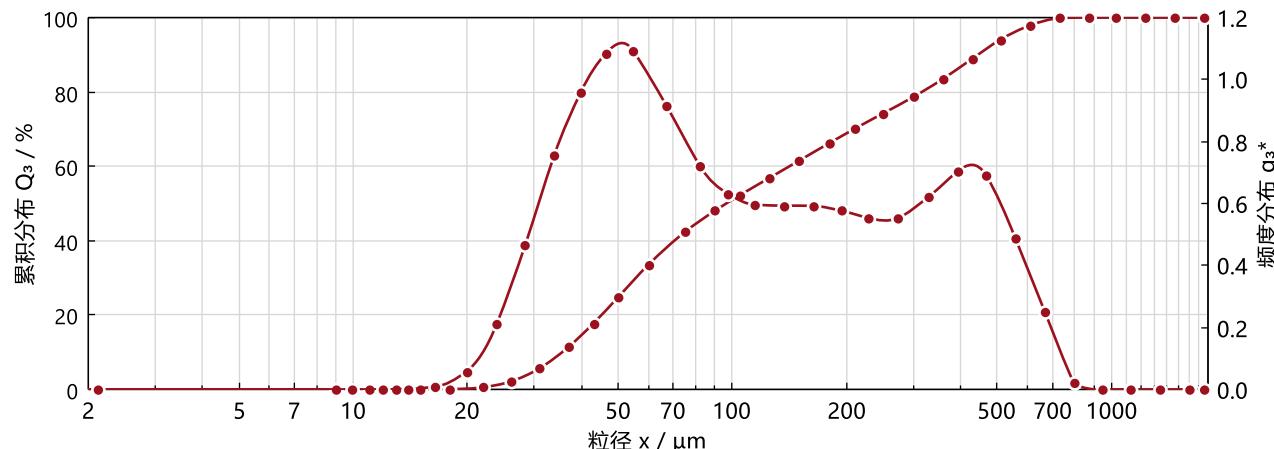
Density Distribution (LOG.)

x_m / μm	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.003
16.43	0.016
19.90	0.083
23.92	0.249
28.39	0.488
33.87	0.746
39.89	0.929
46.37	1.041
54.77	1.045
67.08	0.885
82.16	0.714
97.21	0.641
114.56	0.618
136.93	0.622
164.32	0.625
194.42	0.609
229.13	0.587
273.86	0.586
328.63	0.640
393.45	0.690
468.29	0.651
557.76	0.517
667.31	0.150
796.93	0.007
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 35.49 \mu\text{m}$ $x_{50,3} = 96.88 \mu\text{m}$ $x_{90,3} = 446.36 \mu\text{m}$ SMD = $76.64 \mu\text{m}$ $C_{\text{opt}} = 5.05 \%$
 $x_{16,3} = 41.35 \mu\text{m}$ $x_{84,3} = 366.12 \mu\text{m}$ $x_{99,3} = 678.87 \mu\text{m}$ VMD = $174.90 \mu\text{m}$
 $x_{\min} = 15.10 \mu\text{m}$ $x_{\max} = 861.38 \mu\text{m}$ $x_{10,0} = 21.67 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.01
18.00	0.08
22.00	0.58
26.00	2.12
31.00	5.67
37.00	11.46
43.00	17.73
50.00	24.83
60.00	33.48
75.00	42.35
90.00	48.06
105.00	52.29
125.00	56.81

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$	$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000	136.93	0.593
9.95	0.000	164.32	0.592
11.96	0.000	194.42	0.576
13.96	0.001	229.13	0.553
16.43	0.009	273.86	0.553
19.90	0.058	328.63	0.620
23.92	0.212	393.45	0.704
28.39	0.464	468.29	0.689
33.87	0.754	557.76	0.490
39.89	0.960	667.31	0.252
46.37	1.084	796.93	0.021
54.77	1.093	946.63	0.000
67.08	0.915	1125.57	0.000
82.16	0.721	1344.66	0.000
97.21	0.632	1603.90	0.000
114.56	0.596		

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

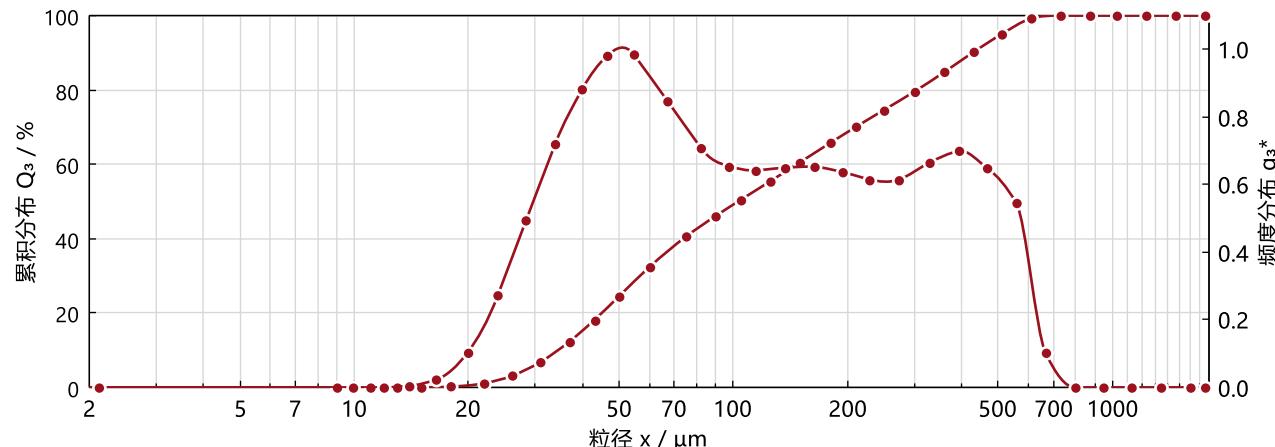
公司名称 Stephen
批号 2-5cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 34.42 \mu\text{m}$ $x_{50,3} = 103.17 \mu\text{m}$ $x_{90,3} = 427.96 \mu\text{m}$ SMD = $76.20 \mu\text{m}$ $C_{\text{opt}} = 7.43 \%$
 $x_{16,3} = 40.78 \mu\text{m}$ $x_{84,3} = 351.32 \mu\text{m}$ $x_{99,3} = 605.11 \mu\text{m}$ VMD = $171.60 \mu\text{m}$
 $x_{\min} = 13.70 \mu\text{m}$ $x_{\max} = 728.49 \mu\text{m}$ $x_{10,0} = 19.24 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.03
18.00	0.21
22.00	1.11
26.00	3.08
31.00	6.85
37.00	12.38
43.00	18.13
50.00	24.55
60.00	32.33
75.00	40.54
90.00	46.15
105.00	50.54
125.00	55.40

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$	$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000	136.93	0.650
9.95	0.000	164.32	0.653
11.96	0.000	194.42	0.637
13.96	0.005	229.13	0.615
16.43	0.023	273.86	0.615
19.90	0.103	328.63	0.664
23.92	0.272	393.45	0.699
28.39	0.494	468.29	0.648
33.87	0.719	557.76	0.546
39.89	0.881	667.31	0.102
46.37	0.980	796.93	0.000
54.77	0.983	946.63	0.000
67.08	0.847	1125.57	0.000
82.16	0.709	1344.66	0.000
97.21	0.655	1603.90	0.000
114.56	0.642		

System

Instrument HELOS (HI219) & UNIVERSAL, R6
 Reference Mea. 2020-11-09 11:41:17
 Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
 Valid Always
 Stop 10 s measure time or 20 s real time

用户参数

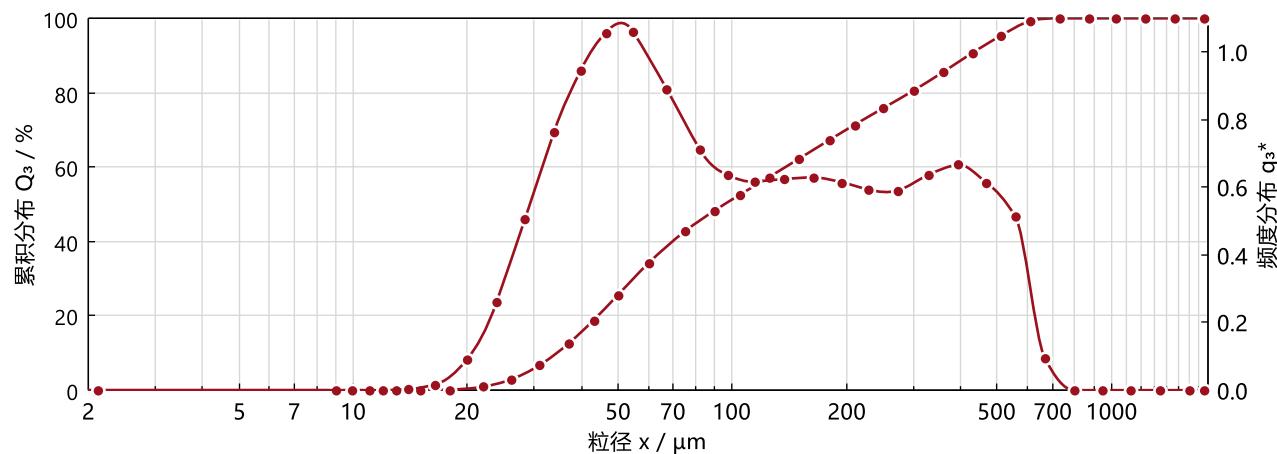
公司名称 Stephen
 批号 2-5cm
 Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 34.37 \mu\text{m}$ $x_{50,3} = 95.77 \mu\text{m}$ $x_{90,3} = 420.57 \mu\text{m}$ SMD = $74.45 \mu\text{m}$ $C_{\text{opt}} = 7.39 \%$
 $x_{16,3} = 40.32 \mu\text{m}$ $x_{84,3} = 341.58 \mu\text{m}$ $x_{99,3} = 603.81 \mu\text{m}$ VMD = $166.11 \mu\text{m}$
 $x_{\min} = 14.12 \mu\text{m}$ $x_{\max} = 728.40 \mu\text{m}$ $x_{10,0} = 20.03 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.02
18.00	0.15
22.00	0.93
26.00	2.83
31.00	6.71
37.00	12.58
43.00	18.76
50.00	25.69
60.00	34.09
75.00	42.73
90.00	48.36
105.00	52.62
125.00	57.29

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	62.24
180.00	67.22
210.00	71.34
250.00	75.83
300.00	80.51
360.00	85.55
430.00	90.69
510.00	95.25
610.00	99.25
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.003
16.43	0.017
19.90	0.089
23.92	0.263
28.39	0.507
33.87	0.764
39.89	0.947
46.37	1.058
54.77	1.060
67.08	0.892
82.16	0.711
97.21	0.636
114.56	0.617

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.625
164.32	0.629
194.42	0.615
229.13	0.593
273.86	0.591
328.63	0.637
393.45	0.667
468.29	0.614
557.76	0.515
667.31	0.096
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

公司名称 Stephen
批号 2-5cm
Operator Tfe

备注

Water spray2-15cm

Laser Diffraction Particle Size Analyser

Sample Preparation	No
Sensor	HELOS (HI219)
Disperser	UNIVERSAL
Measuring Range	R6
Trigger Condition	StartCopt \geq 1 %, Stop 10 s measure time or 20 s real time
Time Base	10.00 ms
Measuring time	10.00 s (10.00 s - 10.00 s)
Optial Concentration	8.05 % (7.49 % - 8.86 %)
Measurements per partial sample	3
Calculation Mode	FREE
<hr/>	
Details Later	



Average size Distribution Data and Statistics

$$x_{10,3} = 44.81 \pm 3.18 \mu\text{m} [7.10 \%]$$

$$x_{16,3} = 50.04 \pm 3.32 \mu\text{m} [6.64 \%]$$

$$x_{\min,3} = 11.18 \pm 0.01 \mu\text{m} [0.10 \%]$$

$$x_{50,3} = 71.72 \pm 2.37 \mu\text{m} [3.30 \%]$$

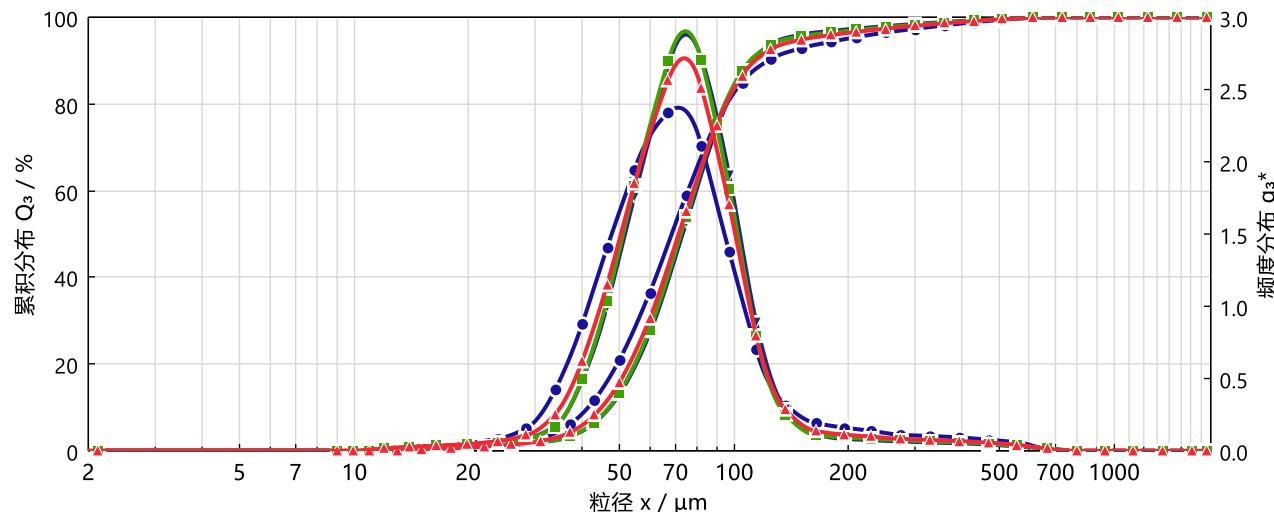
$$x_{84,3} = 101.81 \pm 1.40 \mu\text{m} [1.37 \%]$$

$$x_{\max,3} = 719.69 \pm 2.32 \mu\text{m} [0.32 \%]$$

$$x_{90,3} = 116.93 \pm 5.97 \mu\text{m} [5.10 \%]$$

$$x_{99,3} = 404.90 \pm 38.04 \mu\text{m} [9.39 \%]$$

$$x_{10,0} = 13.19 \pm 0.36 \mu\text{m} [2.73 \%]$$



Cumulative distribution

$x_0 / \mu\text{m}$	$Q_3 / \%$	$\sigma Q_3 / \%$	$\Delta Q_3 / \%$
9.00	0.00	0.00	0.00
11.00	0.00	0.00	0.00
13.00	0.11	0.01	0.11
15.00	0.28	0.02	0.17
18.00	0.55	0.03	0.27
22.00	0.96	0.06	0.41
26.00	1.44	0.17	0.48
31.00	2.26	0.48	0.82
37.00	4.21	1.59	1.95
43.00	8.27	3.04	4.06
50.00	15.80	4.48	7.53
60.00	30.43	5.18	14.63
75.00	55.24	3.36	24.81
90.00	75.13	0.83	19.89
105.00	86.53	1.34	11.40
125.00	92.55	1.93	6.02
150.00	94.80	1.71	2.25
180.00	95.88	1.34	1.08
210.00	96.63	1.05	0.75
250.00	97.38	0.79	0.74
300.00	98.03	0.59	0.66
360.00	98.62	0.41	0.59
430.00	99.14	0.23	0.52
510.00	99.56	0.10	0.42
610.00	99.88	0.02	0.32
730.00	100.00	0.00	0.12
870.00	100.00	0.00	0.00
1030.00	100.00	0.00	0.00
1230.00	100.00	0.00	0.00
1470.00	100.00	0.00	0.00
1750.00	100.00	0.00	0.00

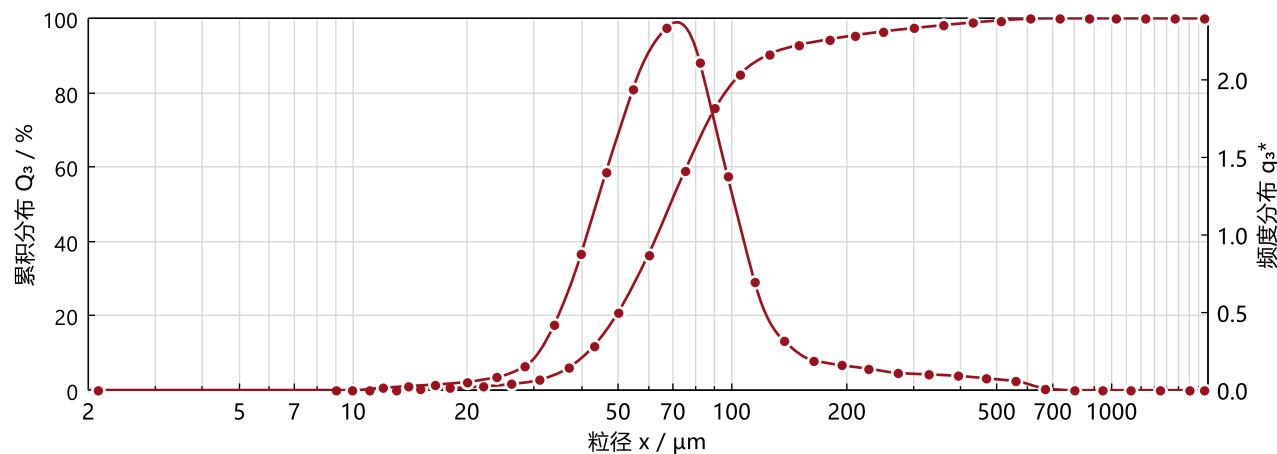
Density Distribution (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.016
13.96	0.027
16.43	0.034
19.90	0.047
23.92	0.067
28.39	0.107
33.87	0.254
39.89	0.622
46.37	1.149
54.77	1.847
67.08	2.560
82.16	2.512
97.21	1.703
114.56	0.795
136.93	0.284
164.32	0.137
194.42	0.112
229.13	0.098
273.86	0.083
328.63	0.075
393.45	0.067
468.29	0.056
557.76	0.041
667.31	0.015
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 41.14 \mu\text{m}$ $x_{50,3} = 69.02 \mu\text{m}$ $x_{90,3} = 123.79 \mu\text{m}$ SMD = $63.65 \mu\text{m}$ $C_{\text{opt}} = 8.86 \%$
 $x_{16,3} = 46.21 \mu\text{m}$ $x_{84,3} = 103.34 \mu\text{m}$ $x_{99,3} = 447.40 \mu\text{m}$ VMD = $85.26 \mu\text{m}$
 $x_{\min} = 11.18 \mu\text{m}$ $x_{\max} = 717.08 \mu\text{m}$ $x_{10,0} = 13.60 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.11
15.00	0.28
18.00	0.56
22.00	1.02
26.00	1.63
31.00	2.81
37.00	6.05
43.00	11.78
50.00	20.97
60.00	36.38
75.00	59.04
90.00	75.79
105.00	85.02
125.00	90.32

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	92.84
180.00	94.35
210.00	95.43
250.00	96.48
300.00	97.35
360.00	98.16
430.00	98.88
510.00	99.44
610.00	99.91
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.015
13.96	0.027
16.43	0.036
19.90	0.053
23.92	0.084
28.39	0.155
33.87	0.422
39.89	0.877
46.37	1.403
54.77	1.946
67.08	2.338
82.16	2.115
97.21	1.380
114.56	0.699

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.318
164.32	0.191
194.42	0.161
229.13	0.138
273.86	0.111
328.63	0.102
393.45	0.093
468.29	0.077
557.76	0.060
667.31	0.012
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

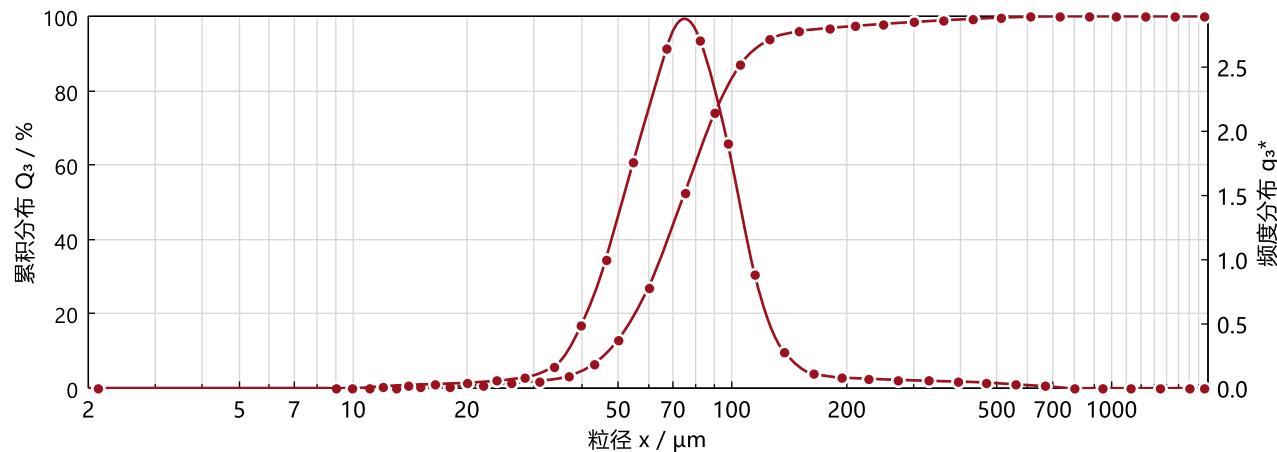
公司名称 Stephen
批号 2-15cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 46.76 \mu\text{m}$ $x_{50,3} = 73.43 \mu\text{m}$ $x_{90,3} = 113.96 \mu\text{m}$ SMD = $67.95 \mu\text{m}$ $C_{\text{opt}} = 7.81 \%$
 $x_{16,3} = 52.12 \mu\text{m}$ $x_{84,3} = 101.50 \mu\text{m}$ $x_{99,3} = 374.07 \mu\text{m}$ VMD = $83.25 \mu\text{m}$
 $x_{\min} = 11.18 \mu\text{m}$ $x_{\max} = 720.48 \mu\text{m}$ $x_{10,0} = 13.07 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.11
15.00	0.27
18.00	0.52
22.00	0.89
26.00	1.31
31.00	1.96
37.00	3.28
43.00	6.46
50.00	13.04
60.00	26.99
75.00	52.69
90.00	74.20
105.00	86.99
125.00	93.71

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	95.97
180.00	96.84
210.00	97.39
250.00	97.95
300.00	98.46
360.00	98.92
430.00	99.32
510.00	99.64
610.00	99.87
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.015
13.96	0.026
16.43	0.032
19.90	0.042
23.92	0.058
28.39	0.085
33.87	0.171
39.89	0.488
46.37	1.004
54.77	1.762
67.08	2.651
82.16	2.717
97.21	1.910
114.56	0.888

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	0.285
164.32	0.110
194.42	0.083
229.13	0.074
273.86	0.065
328.63	0.058
393.45	0.051
468.29	0.044
557.76	0.030
667.31	0.016
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

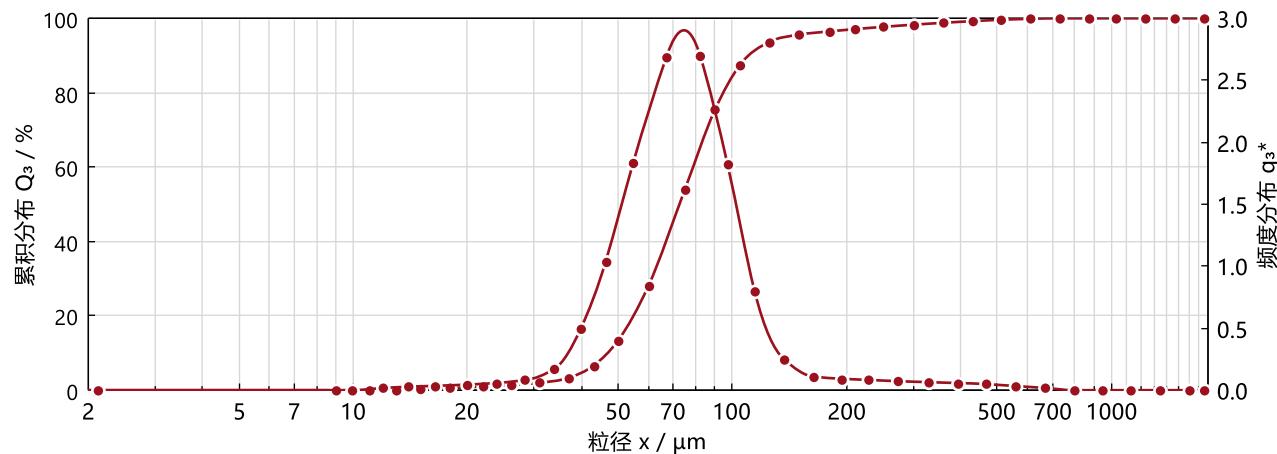
公司名称 Stephen
批号 2-15cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 46.52 \mu\text{m}$ $x_{50,3} = 72.70 \mu\text{m}$ $x_{90,3} = 113.02 \mu\text{m}$ SMD = $67.39 \mu\text{m}$ $C_{\text{opt}} = 7.49 \%$
 $x_{16,3} = 51.80 \mu\text{m}$ $x_{84,3} = 100.60 \mu\text{m}$ $x_{99,3} = 393.21 \mu\text{m}$ VMD = $83.37 \mu\text{m}$
 $x_{\min} = 11.16 \mu\text{m}$ $x_{\max} = 721.50 \mu\text{m}$ $x_{10,0} = 12.91 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.12
15.00	0.30
18.00	0.57
22.00	0.96
26.00	1.38
31.00	2.00
37.00	3.31
43.00	6.58
50.00	13.39
60.00	27.91
75.00	53.99
90.00	75.39
105.00	87.58
125.00	93.62

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	95.60
180.00	96.46
210.00	97.07
250.00	97.70
300.00	98.27
360.00	98.79
430.00	99.23
510.00	99.60
610.00	99.86
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.017
13.96	0.028
16.43	0.035
19.90	0.045
23.92	0.058
28.39	0.081
33.87	0.170
39.89	0.500
46.37	1.040
54.77	1.833
67.08	2.692
82.16	2.703
97.21	1.819
114.56	0.798

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

公司名称 Stephen
批号 2-15cm
Operator Tfe

备注

Water spray2-30cm

Laser Diffraction Particle Size Analyser

Sample Preparation	No
Sensor	HELOS (HI219)
Disperser	UNIVERSAL
Measuring Range	R6
Trigger Condition	StartCopt \geq 1 %, Stop 10 s measure time or 20 s real time
Time Base	10.00 ms
Measuring time	10.00 s (10.00 s - 10.00 s)
Optial Concentration	8.51 % (8.26 % - 8.93 %)
Measurements per partial sample	3
Calculation Mode	FREE

Details Later



Average size Distribution Data and Statistics

$x_{10,3} = 43.68 \pm 0.13 \mu\text{m}$ [0.29 %]

$x_{50,3} = 91.67 \pm 2.54 \mu\text{m}$ [2.77 %]

$x_{90,3} = 162.35 \pm 3.05 \mu\text{m}$ [1.88 %]

$x_{16,3} = 52.18 \pm 0.49 \mu\text{m}$ [0.93 %]

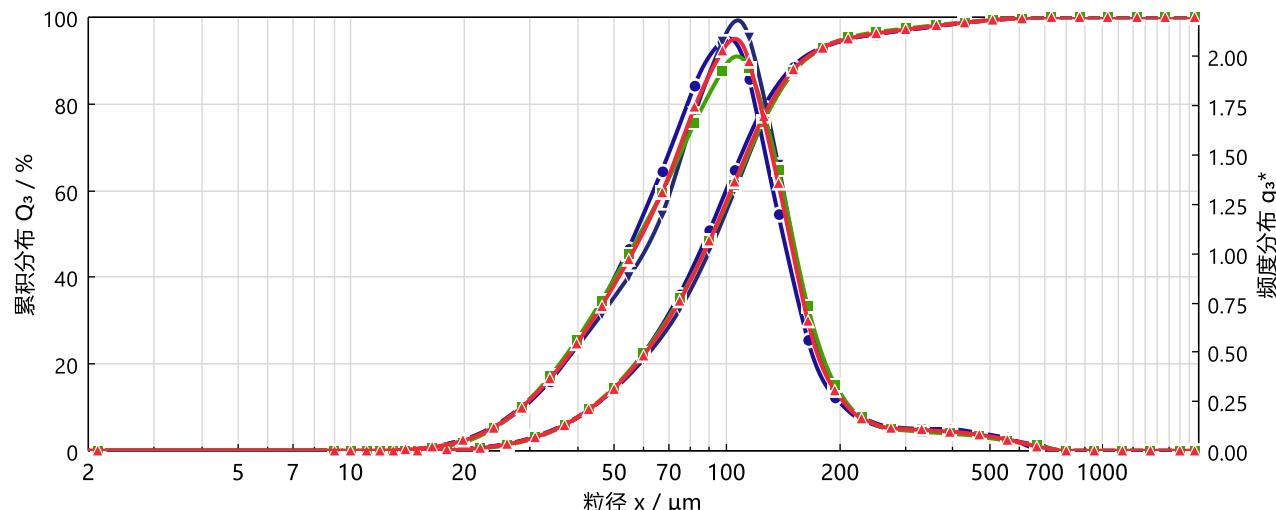
$x_{84,3} = 140.96 \pm 2.85 \mu\text{m}$ [2.02 %]

$x_{99,3} = 459.53 \pm 7.34 \mu\text{m}$ [1.60 %]

$x_{\min,3} = 13.64 \pm 0.31 \mu\text{m}$ [2.26 %]

$x_{\max,3} = 721.53 \pm 5.34 \mu\text{m}$ [0.74 %]

$x_{10,0} = 18.81 \pm 1.03 \mu\text{m}$ [5.48 %]



Cumulative distribution

$x_0 / \mu\text{m}$	$Q_3 / \%$	$\sigma Q_3 / \%$	$\Delta Q_3 / \%$
9.00	0.00	0.00	0.00
11.00	0.00	0.00	0.00
13.00	0.00	0.00	0.00
15.00	0.04	0.01	0.04
18.00	0.18	0.05	0.15
22.00	0.63	0.12	0.45
26.00	1.49	0.15	0.86
31.00	3.17	0.16	1.68
37.00	5.99	0.12	2.82
43.00	9.53	0.09	3.54
50.00	14.34	0.25	4.81
60.00	22.02	0.81	7.68
75.00	34.70	1.85	12.68
90.00	48.51	2.38	13.82
105.00	62.09	2.49	13.57
125.00	77.04	1.85	14.95
150.00	87.81	0.77	10.77
180.00	93.02	0.14	5.20
210.00	95.05	0.21	2.03
250.00	96.29	0.24	1.24
300.00	97.19	0.21	0.90
360.00	98.03	0.15	0.84
430.00	98.77	0.07	0.75
510.00	99.38	0.04	0.61
610.00	99.82	0.08	0.44
730.00	100.00	0.00	0.18
870.00	100.00	0.00	0.00
1030.00	100.00	0.00	0.00
1230.00	100.00	0.00	0.00
1470.00	100.00	0.00	0.00
1750.00	100.00	0.00	0.00

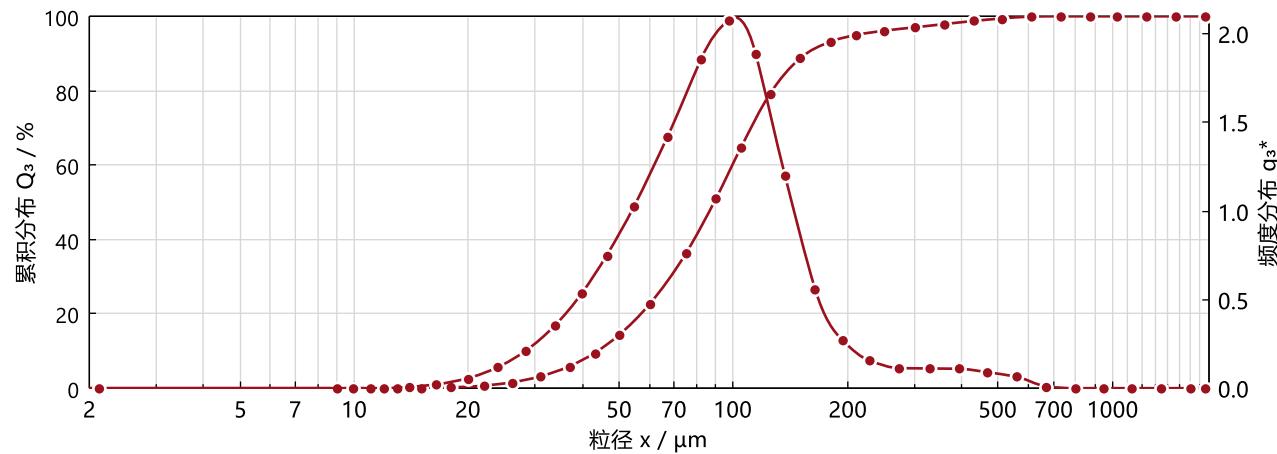
Density Distribution (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.006
16.43	0.018
19.90	0.052
23.92	0.118
28.39	0.220
33.87	0.367
39.89	0.543
46.37	0.735
54.77	0.969
67.08	1.308
82.16	1.745
97.21	2.028
114.56	1.975
136.93	1.360
164.32	0.657
194.42	0.303
229.13	0.163
273.86	0.114
328.63	0.105
393.45	0.097
468.29	0.082
557.76	0.057
667.31	0.023
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 43.81 \mu\text{m}$ $x_{50,3} = 89.02 \mu\text{m}$ $x_{90,3} = 158.83 \mu\text{m}$ SMD = $75.59 \mu\text{m}$ $C_{\text{opt}} = 8.93 \%$
 $x_{16,3} = 52.03 \mu\text{m}$ $x_{84,3} = 137.67 \mu\text{m}$ $x_{99,3} = 460.73 \mu\text{m}$ VMD = $103.22 \mu\text{m}$
 $x_{\min} = 13.46 \mu\text{m}$ $x_{\max} = 715.37 \mu\text{m}$ $x_{10,0} = 18.21 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.04
18.00	0.21
22.00	0.70
26.00	1.56
31.00	3.19
37.00	5.92
43.00	9.43
50.00	14.35
60.00	22.49
75.00	36.26
90.00	50.96
105.00	64.88
125.00	79.18

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	88.69
180.00	93.14
210.00	94.94
250.00	96.12
300.00	97.01
360.00	97.90
430.00	98.74
510.00	99.41
610.00	99.92
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

頻度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.007
16.43	0.021
19.90	0.056
23.92	0.119
28.39	0.213
33.87	0.355
39.89	0.538
46.37	0.751
54.77	1.028
67.08	1.421
82.16	1.857
97.21	2.079
114.56	1.889

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	1.201
164.32	0.562
194.42	0.269
229.13	0.155
273.86	0.113
328.63	0.111
393.45	0.110
468.29	0.090
557.76	0.065
667.31	0.011
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

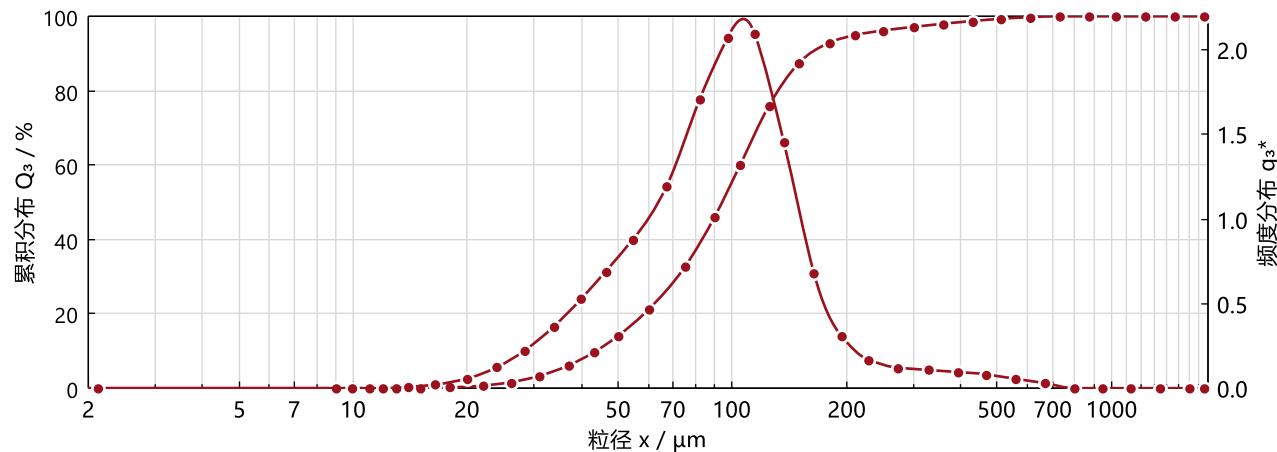
公司名称 Stephen
批号 2-30cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 43.66 \mu\text{m}$ $x_{50,3} = 94.09 \mu\text{m}$ $x_{90,3} = 164.05 \mu\text{m}$ SMD = 77.67 μm $C_{\text{opt}} = 8.26 \%$
 $x_{16,3} = 52.72 \mu\text{m}$ $x_{84,3} = 142.43 \mu\text{m}$ $x_{99,3} = 466.19 \mu\text{m}$ VMD = 106.72 μm
 $x_{\min} = 13.48 \mu\text{m}$ $x_{\max} = 724.88 \mu\text{m}$ $x_{10,0} = 18.21 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.04
18.00	0.21
22.00	0.70
26.00	1.60
31.00	3.32
37.00	6.13
43.00	9.57
50.00	14.10
60.00	21.08
75.00	32.66
90.00	46.21
105.00	60.10
125.00	75.98

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	87.48
180.00	92.86
210.00	94.91
250.00	96.18
300.00	97.14
360.00	97.99
430.00	98.73
510.00	99.33
610.00	99.77
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

频度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.007
16.43	0.021
19.90	0.056
23.92	0.124
28.39	0.225
33.87	0.366
39.89	0.527
46.37	0.691
54.77	0.882
67.08	1.194
82.16	1.712
97.21	2.075
114.56	2.097

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	1.453
164.32	0.679
194.42	0.307
229.13	0.168
273.86	0.121
328.63	0.108
393.45	0.095
468.29	0.081
557.76	0.056
667.31	0.030
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

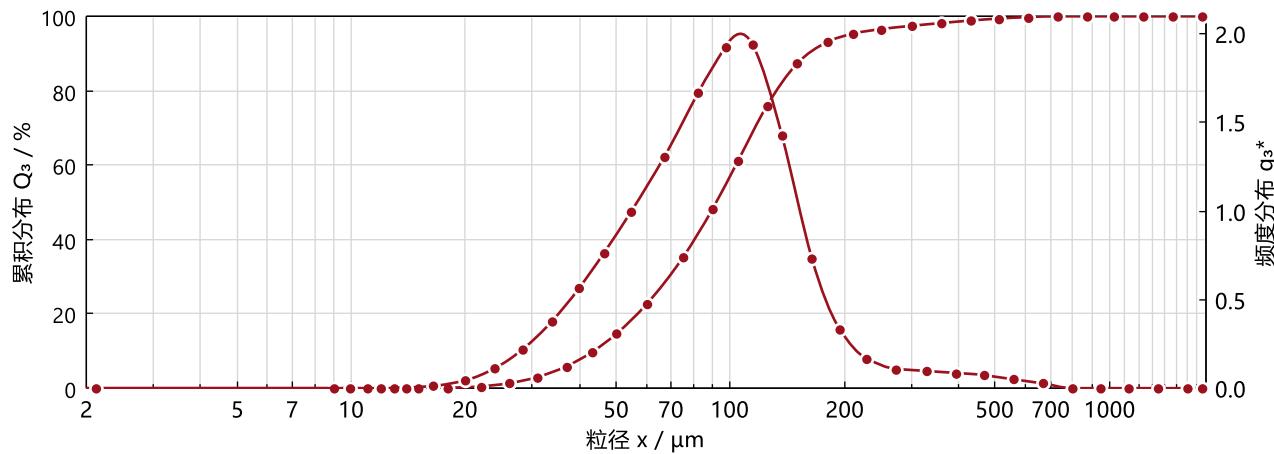
公司名称 Stephen
批号 2-30cm
Operator Tfe

备注

Measurement

PAQXOS 4.1 FREE

$x_{10,3} = 43.56 \mu\text{m}$ $x_{50,3} = 91.89 \mu\text{m}$ $x_{90,3} = 164.16 \mu\text{m}$ SMD = $76.93 \mu\text{m}$ $C_{\text{opt}} = 8.34 \%$
 $x_{16,3} = 51.79 \mu\text{m}$ $x_{84,3} = 142.77 \mu\text{m}$ $x_{99,3} = 451.66 \mu\text{m}$ VMD = $104.88 \mu\text{m}$
 $x_{\min} = 14.00 \mu\text{m}$ $x_{\max} = 724.32 \mu\text{m}$ $x_{10,0} = 20.00 \mu\text{m}$



累积分布

$x_o / \mu\text{m}$	$Q_3 / \%$
9.00	0.00
11.00	0.00
13.00	0.00
15.00	0.02
18.00	0.12
22.00	0.50
26.00	1.31
31.00	3.01
37.00	5.92
43.00	9.60
50.00	14.59
60.00	22.49
75.00	35.17
90.00	48.37
105.00	61.29
125.00	75.97

$x_o / \mu\text{m}$	$Q_3 / \%$
150.00	87.27
180.00	93.05
210.00	95.29
250.00	96.56
300.00	97.42
360.00	98.19
430.00	98.85
510.00	99.40
610.00	99.79
730.00	100.00
870.00	100.00
1030.00	100.00
1230.00	100.00
1470.00	100.00
1750.00	100.00

頻度分布 (LOG.)

$x_m / \mu\text{m}$	$q_3 \lg$
2.12	0.000
9.95	0.000
11.96	0.000
13.96	0.003
16.43	0.013
19.90	0.043
23.92	0.113
28.39	0.221
33.87	0.379
39.89	0.564
46.37	0.762
54.77	0.998
67.08	1.309
82.16	1.666
97.21	1.930
114.56	1.939

$x_m / \mu\text{m}$	$q_3 \lg$
136.93	1.426
164.32	0.731
194.42	0.334
229.13	0.167
273.86	0.109
328.63	0.097
393.45	0.086
468.29	0.073
557.76	0.050
667.31	0.027
796.93	0.000
946.63	0.000
1125.57	0.000
1344.66	0.000
1603.90	0.000

System

Instrument HELOS (HI219) & UNIVERSAL, R6
Reference Mea. 2020-11-09 11:41:17
Software PAQXOS 4.1

Condition

Start $C_{\text{opt}} \geq 1 \%$
Valid Always
Stop 10 s measure time or 20 s real time

用户参数

公司名称 Stephen
批号 2-30cm
Operator Tfe

备注

III. Appendix

A. General terms

Details regarding particle size analysis using laser diffraction are given in ISO 13320:2009 “Particle Size Analysis - Laser Diffraction Methods”.

The symbols and indices employed in the tabular print-outs and graphical representation, as well as the type and form of the plotted results are in accordance with the following ISO standards:

ISO	Title
9276-1:1998	Representation of results of particle size analysis Part 1: Graphical representation
9276-2:2014	Representation of results of particle size analysis Part 2: Calculation of average particle sizes/diameters and moments from particle size distributions
9276-3:2008	Representation of results of particle size analysis Part 3: Adjustment of an experimental curve to a reference model
9276-5:2005	Representation of results of particle size analysis Part 5: Methods of calculation relating to particle size analyses using logarithmic normal probability distribution

Table III-1: List of relevant ISO standards

The variables used in the Sympatec printouts are briefly described in the following.

The dimension x denotes the equivalent diameter achieved from the evaluation. It is usually described as “particle size” or “grain size”.

Upper Band Limit x_o

Particle diameter (upper band limit), as referred to the upper limit of the particle size interval under consideration.

Unit: Micrometres (μm)

Lower Band Limit x_u

Particle diameter (lower band limit), as referred to the lower limit of the particle size interval under consideration.

Unit: Micrometres (μm)

Average for Band x_m

Particle diameter (average for band), as referred to the middle of the particle size interval under consideration.

Unit: Micrometres (μm)

Two different types of average values are employed:

$$\text{Arithmetic average: } x_{m_{lin},i} = \frac{x_{o,i} + x_{u,i}}{2}$$

The arithmetic average is used for graphics presented in a linear scale.

$$\text{Geometric average: } x_{m_{lg},i} = \sqrt{x_{o,i} \cdot x_{u,i}}$$

The presentation in a logarithmic scale is based on the geometric average.

Minimum Particle Diameter x_{min}

The minimum diameter of particles with respect to the entire particle size distribution.

Unit: Micrometres (μm)

Maximum Particle Diameter x_{max}

The maximum diameter of particles with respect to the entire particle size distribution.

Unit: Micrometres (μm)

Cumulative Distribution $Q_r(x)$

Cumulative distribution, as given by the defining equation:

$$Q_r(x_i) = \frac{\text{Fraction of quantity of particles in interval } (x_{min} - x_i)}{\text{Total quantity of the particles } (x_{min} - x_{max})}$$

Four different types of quantities r have to be distinguished:

$r = 0$: number

$r = 1$: length

$r = 2$: area

$r = 3$: volume

$r = 3$: mass, if density of the material $\rho = \text{const}$

The cumulative distribution $Q_r(x)$ indicates the normalised fraction of particles which are smaller than the particle diameter x .

Usually in the graphical presentation of the results for the particle size analysis the value of the cumulative distribution Q_r is plotted along the linearly subdivided ordinate whilst the particle diameter x is plotted in μm along the logarithmically subdivided abscissa.

Unit: Number (percentage)

Residue Distribution $R_r(x)$

Residue distribution, which indicates the normalised fraction of particles being coarser than the particle diameter.

$$R_r(x_i) = \frac{\text{Fraction of quantity of particles in interval } (x_i - x_{max})}{\text{Total quantity of the particles } (x_{min} - x_{max})} = 1 - Q_r(x_i)$$

For the meaning of r refer to the explanation of $Q_r(x)$.

Unit: Number (percentage)

Fraction $dQ_r(x_m)$

Fraction of quantity for the distribution in a particular particle size interval, i.e. class, expressed as a percentage to the total quantity. For plotting the average particle size x_m of the interval (x_u, x_o) is used.

$$dQ_r(x_{m,i}) = Q_r(x_{o,i}) - Q_r(x_{u,i})$$

Unit: Number (percentage)

Density of the Distribution Curve $q_r(x_{m,i})$

Density distribution curve and frequency distribution curve respectively, indicating the ratio of a class, that is, the fraction for a particle size interval, to its class width:

$$q_r(x_{m,i}) = \frac{dQ_e(x_{m,i})}{dx_i} = \frac{Q_r(x_{o,i}) - Q_r(x_{u,i})}{x_{o,i} - x_{u,i}}$$

Unit: mm⁻¹

The graphical presentation of the q_r curves is often executed on a double linear grid, that means both the ordinate and the abscissa are subdivided linearly.

The infinitesimal relationship between the cumulative and density distribution curves is defined by the following equation:

$$Q_r(x') = \int_{x_{min}}^{x'} q_r(x) dx$$

In practice a rather normal relationship is:

$$Q_r(x_i) = \sum_{j=0}^i q_r(x_{m,j}) \cdot (x_{o,j} - x_{u,j})$$

Logarithmic Density Distribution $q_r^*(x_{m,lg})$

The graphical presentation of the logarithmic density distribution curve q_r^* (often denoted as $q_{r,lg}$) is usually executed on a linear-logarithmic grid, that is a linear subdivision along the ordinate and with a logarithmic subdivision along the abscissa.

The mathematical relationship between q_r and q_r^* is expressed by the following equation with the use of a transformation on the abscissa:

$$q_r^*(x_{m,lg}) = x_{m,lg} \cdot q_r(x) \cdot \ln 10 = q_{r,lg}(x_{m,lg})$$

In contrast to the plot of the distribution density curve on a linearly subdivided abscissa, the distribution density curve is without unit dimension for a logarithmically subdivided abscissa.

Unit: Number

With the following dimension x_Q size information is given, which depend on the measured distribution.

Characteristic Particle Diameter x_Q

Characteristic particle diameter (characteristic of fineness), for which the cumulative distribution Q assumes the specified value (in percent), e.g. x_{50} denotes the size x for which 50 % of all particles are finer.

Unit: Micrometres (μm)

Span

A value for the width of a particle size distribution can be calculated from characteristic particle diameters. Commonly used is the following formula:

$$\text{Span} = \frac{(x_{90} - x_{10})}{x_{50}}$$

Unit: Number

Some special dimensions are employed in particle technology. They are listed below:

k^{th} Moment of the Distribution $M_{k,r}$

Complete k^{th} moment of a $q_r(x)$ -distribution, it is represented by integrals as defined in the following equation:

$$M_{k,r} = \int_{x_{\min}}^{x_{\max}} x^k q_r(x) dx$$

M stands for moment. The first subscript k of M indicates the power of x , the second subscript r of M describes the type of quantity of the density distribution.

Unit: Depends on the power of x (subscript k)

SMD

The weighted surface mean diameter, also known as **Sauter Mean Diameter**, is calculated as the moment $M_{1,2}$. It represents the average particle size that corresponds to the specific surface area of the entire particle collective.

$$\text{SMD} = M_{1,2} = D[3,2] = \frac{M_{3,0}}{M_{2,0}} = \sum_{i=1}^n x_{m,i} \cdot q_2(x_{m,i}) \cdot (x_{o,i} - x_{u,i})$$

Unit: Micrometres (μm)

VMD

The moment $M_{1,3}$ is called **Volume Mean Diameter**, also known as De Brouckere mean diameter or $D[4,3]$.

$$\text{VMD} = M_{1,3} = D[4,3] = \frac{M_{4,0}}{M_{3,0}} = \sum_{i=1}^n x_{m,i} \cdot q_3(x_{m,i}) \cdot (x_{o,i} - x_{u,i})$$

Unit: Micrometres (μm)

Heywood Shape Factor f_H

The Heywood shape factor is the ratio of the measured specific surface area of the particle to the specific surface area of a sphere with a diameter x .

$$f_H = \frac{6 \cdot x_s^2}{x_v^3} \cdot \frac{x}{6}$$

x_s : diameter of the sphere with the same surface area

x_v : diameter of the sphere with the same volume

Unit: Number

Heywood shape factor for some kind of particles:

Solid	Heywood shape factor
Spheres	1.0
Sand	1.3 – 1.4
Cement	1.8
Coal dust	1.8 – 2.1
Flying dust, sugar	1.2 – 2.3
Quartz	1.8 – 4.0
Mica flakes	9.3

Source: http://www.ipat.tu-bs.de/wp-content/uploads/2012/05/lehre_praktikum_skript_pga.pdf

Volume Related Surface Area S_v

Volume related specific surface area, description of the ratio between the surface area of all particles for the distribution and the volume of all particles for the distribution, and thus proportional to the specific surface area, S_v , as referred to the volume, calculated from the measured particle size distribution:

$$S_V = 6 \cdot f_H \cdot M_{-1,3}$$

where 6 is the proportionality factor with respect to the volume of spherical particles and f_H denotes the Heywood shape factor:

$f_H = 1$ for spheres

$f_H > 1$ for irregularly shaped particles (see item above)

Unit: m^2/cm^3

Mass Related Specific Area S_m

The mass related specific area, description of the ratio between the surface area and the mass. It can be derived with the knowledge of the physical density ρ from the volume related surface area S_v with the help of the following equation:

$$S_m = S_v / \rho$$

Unit: cm^2/g

RRSB-Distribution

RRSB distribution (named by Rosin, Rammler, Sperling, Bennett)

The definition of the RRSB-function is as follows:

$$R(x) = 1 - Q(x) = \exp(-(x/x')^n)$$

It is a function with two parameters:

x' = position parameter

n = scatter parameter

For the particle size $x = x'$:

$$R(x') = e^{-1} = 0.368 = 36.8\% \text{ and with it } Q(x) = 0.632 = 63.2\%.$$

n is the slope of a straight line in the RRSB grid ($\lg(\lg(1/R))$).

Unit: Number (percentage)

B. HELOS terms

Optical Concentration C_{opt}

The optical concentration is an indicator for the volume flow of the particles. For the HELOS the optical concentration is the drop of light intensity (extinction) in the centre of the detector, with respect to the intensity measured without particles

$$C_{opt} = \frac{I_0 - I_p}{I_0}$$

Whereas I_0 denotes the intensity measured without particles and I_p the intensity measured with particles.

Unit: Number (percentage)

MIEE Evaluation

The basis for applying the Mie theory is the publication by Gustav Mie in 1908, in which an exact analytical solution of Maxwell's equations was formulated for the scattering of electromagnetic waves by spherical particles in a non-absorbing medium. This solution is known as the Mie theory. For the application of Mie theory, the complex refractive index, n (refraction and absorption) of the particles and the refractive index n_m of the fluid must be known.

Additional information on the used sensors and dispersing systems such as technical data or pictures can be found on the website of the Sympatec GmbH at www.sympatec.com.