

Particle size 

Particle shape 

Morphologi[®]
G3

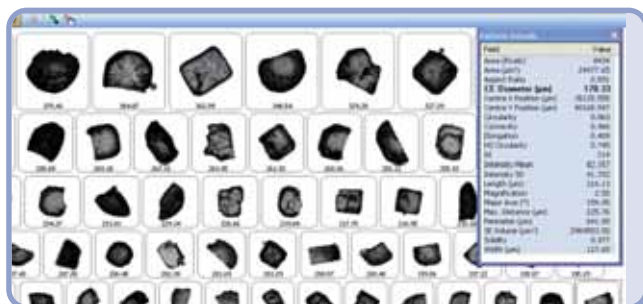


Automated Particle Characterization System

Introducing a **new concept** in particle characterization

Are you looking for?

- A fully automated and flexible solution from sample dispersion through to data analysis
- A more detailed knowledge of your particles and how they behave during processing
- A better understanding of your particulate materials from development through to production
- Statistically significant high quality size and shape information in one measurement with minimal user intervention
- A new tool for Quality by Design and PAT
- Saving time and labour automating your microscopy work



Knowledge and understanding of particle shape as well as size is now essential in the development and control of many industrial processes. The Morphologi® G3 particle characterization system from Malvern® Instruments provides high quality, statistically significant particle size and shape information. We have brought together the very best hardware and software in a single integrated package to provide the very highest level of automation and validation of results. Whether you work in R&D, process analysis or quality control, the Morphologi G3 delivers reliable, repeatable and validated results in minutes.

- Analyze hundreds of thousands of particles at the push of a button
- Particle shape and count as well as size information
- Record high resolution images of every particle
- Fully automatic
- Provides technical compliance with 21CFR Part 11
- Integrated Sample Dispersion



What Morphologi® G3 delivers

You asked for

We give you

Reliable dispersion of dry powders

A novel, fully integrated, software controlled dry powder dispersion system that reduces sample preparation times and significantly improves the repeatability of measurements. Precise control of dispersion pressure, injection time and settling time ensures highly reproducible measurements across a broad range of samples.

Meaningful data analysis

A new software tool to compare and cluster data to find differences or similarities between multiple measurements, allowing the user to make decisions quickly and with confidence.

Repeatability and automation

The tried and tested SOP (Standard Operating Procedure) methodology records all software and hardware variables in a single file. At the single click of a mouse the system then selects and calibrates the required magnification, calibrates the light intensity and focus and scans a defined area.

Sensitivity to shape

Particles are fully characterized using a number of morphological parameters such as circle equivalent diameter, circularity and convexity. This high quality information can be used to distinguish between materials that appear identical to a conventional microscope or traditional particle sizer.

High quality optics

Nikon's acclaimed CFI 60 optics. To obtain outstanding optical performance we have chosen Nikon's revolutionary CFI 60 optical system which provide longer working distances and high Numerical Apertures (NA), while producing images which are high contrast, extremely sharp and have a minimum of flare.

Statistical significance

Every particle in the sample is analyzed avoiding any sub-sampling and a statistically significant number of particles are captured in seconds or minutes. Number of particle required depends upon the standard deviation of sample but typically in range 5,000 – 500,000.

Images you can see

All images are saved for future reference including the 'xy' coordinates of each particle. If desired, you can precisely move the camera back to any position for a more detailed visual analysis.

Controlled orientation

Random orientation significantly reduces the validity of data. To avoid this common source of error, particles are dispersed onto a flat glass plate, which has the effect of consistently orientating them with their largest area facing the camera.

Regulatory compliance

The Morphologi® G3 has a full validation documentation package available and provides technical compliance with the requirements of 21CFR part 11.

A product and company with a secure future

Recognizing that most of our customers have global operations Malvern® Instruments is committed to providing a service and support structure which is present worldwide and has a high degree of applications knowledge.



Simple Operation

Access to the Morphologi® G3 powerful measurement capabilities is controlled via an equally impressive software interface that makes particle characterization by image analysis entirely straightforward.



1

Set up your Standard Operating Procedure (SOP) using the system's integrated method definition wizard. SOPs lock-down all aspects of the measurement process including the hardware configuration, analysis settings, result, filtering, classification and parameter reporting.



2

Run the measurement by selecting the desired SOP from the menu system. This automatically configures the system and ensures everything is optimally set to deliver accurate results. The system will automatically calibrate against a grating and set light intensity and focusing positions.



3

Observe each stage of the measurement via the software's measurement manager. This allows the user to monitor all aspects of the measurement and analysis process.



4

View the results using preconfigured reports. Display distributions and tables. View single particle details in the Particle View or use the Scattergram for easy visualization of measurement data.

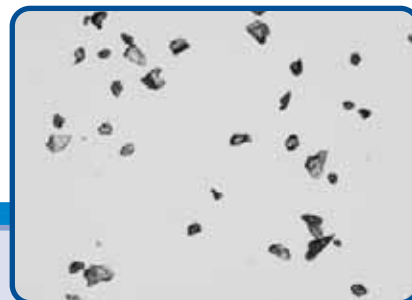
Take the **pain** out of sample dispersion

Are you looking for?

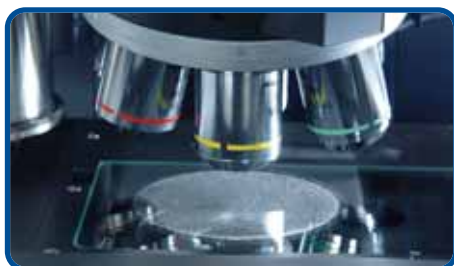
- Fully automated sample dispersion
- Reproducible results
- No more user bias
- Safer handling of hazardous substances



The sample is dispersed with an instantaneous pulse of compressed air. Precise control of dispersion pressure, injection time and settling time ensures highly reproducible measurements across a broad range of samples.



Reliable measurement of dry powders requires strict control of dispersion conditions. A novel, fully integrated, software controlled dry powder dispersion system reduces sample preparation times and significantly improves the reproducibility of measurements.

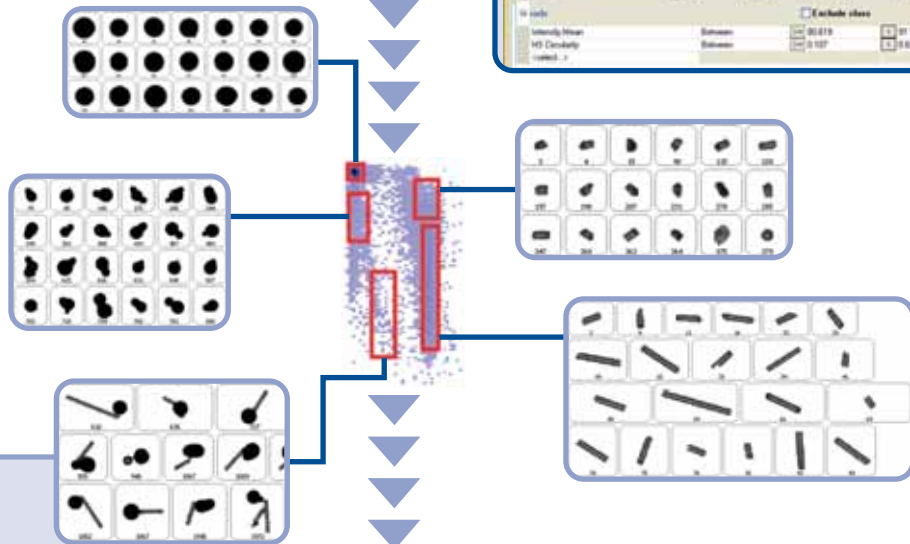
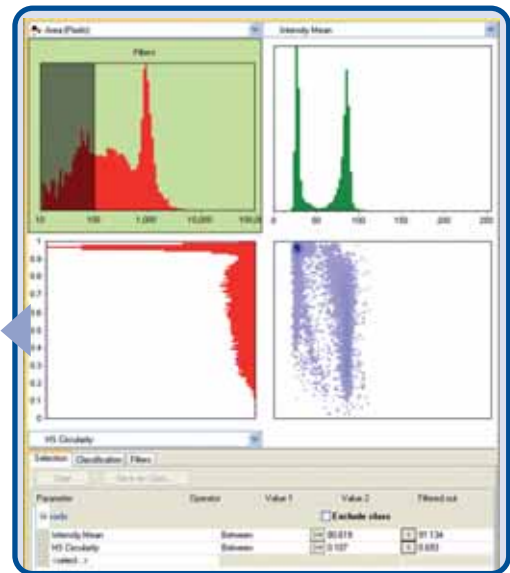


Measurements are made in an enclosed sample carrier, minimizing environmental exposure and ensuring safe material handling, especially when measuring pharmaceutical actives or toxic materials samples. Multiple aliquots can be prepared in advance, ready to use at the next measurement.

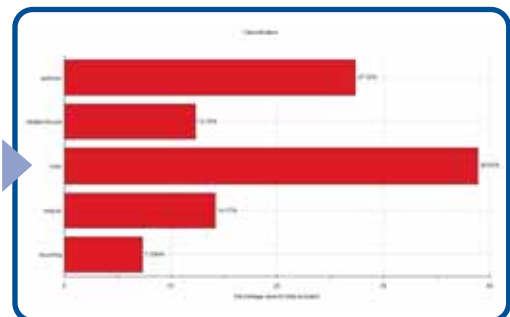
Software to make it happen - Scattergram

Are you looking for?

- Easy access to the most valuable information contained in a measurement.
- Clear visualisation of measurement data
- Easy classification saving time in SOP development



- Visualisation of measurement data
- Plot Scattergrams using any Size/Shape parameter
- Filter on any parameter
- Group and Classify



Apply classifications and filters in order to group or exclude certain values based on any size or shape parameter.

Software to make it happen – Analyzing data

Are you looking for?

- Quickly and easily identify the most important morphological parameters for differentiating a set of samples such as good and bad batches
- An objective and fast characterization of changes in your product.
- Making the most of the morphological information in every measurement made
- Quantify subtle changes in your product or process as part of Quality by Design



With the Morphologi® G3, lack of data is never a problem, for every particle measured there is a choice of 20 different parameters to describe size and shape. The Morphologi G3 offers a new software tool to compare and cluster data to find differences or similarities between multiple measurements, allowing the user to make decisions quickly and with confidence.

With just a few clicks of the mouse, your data is transformed into useful information, allowing you to make decisions quickly and with confidence.

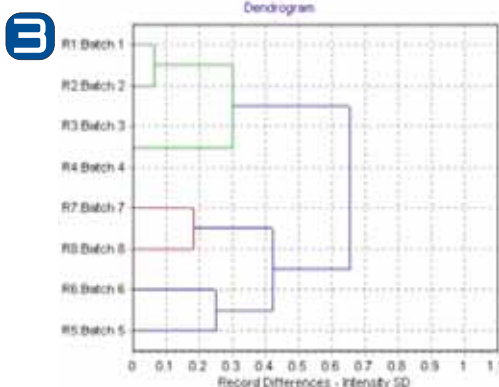
1 Select the data to compare.

Record	Sample Name	CE Diameter Mean (µm)	Circularity Mean	HS Circularity	Convexity Mean	Elongation Mean	Length Mean (µm)	Mean Intensity
1	Batch 1	56.98	0.936	0.890	0.982	0.125	66.54	60
2	Batch 2	57.64	0.905	0.971	0.993	0.028	59.40	60
3	Batch 3	49.92	0.987	0.973	0.994	0.022	51.41	61
4	Batch 4	49.92	0.987	0.973	0.994	0.022	51.41	61
5	Batch 5	48.67	0.976	0.962	0.984	0.019	50.11	56
6	Batch 6	47.91	0.981	0.962	0.990	0.023	49.40	56
7	Batch 7	57.42	0.906	0.973	0.993	0.022	59.09	57
8	Batch 8	49.57	0.984	0.968	0.992	0.022	51.10	56

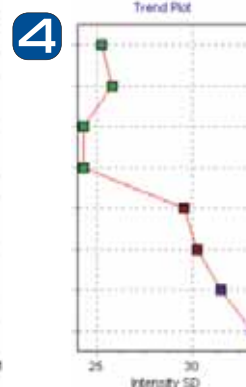
2

- ☐ CE Diameter (µm)
- ☐ Length (µm)
- ☐ Width (µm)
- ☐ Max. Distance (µm)
- ☐ Perimeter (µm)
- ☐ Area (µm²)
- ☐ SE Volume (µm³)
- ☐ Circularity
- ☐ HS Circularity
- ☐ Convexity
- ☐ Solidity
- ☐ Aspect Ratio
- ☐ Elongation
- ☐ Intensity Mean
- ☒ Intensity SD

The software will automatically calculate the difference for each parameter, highlighting the most significant one.



Measurements can then be clustered into different groups based on the parameter showing the biggest difference.

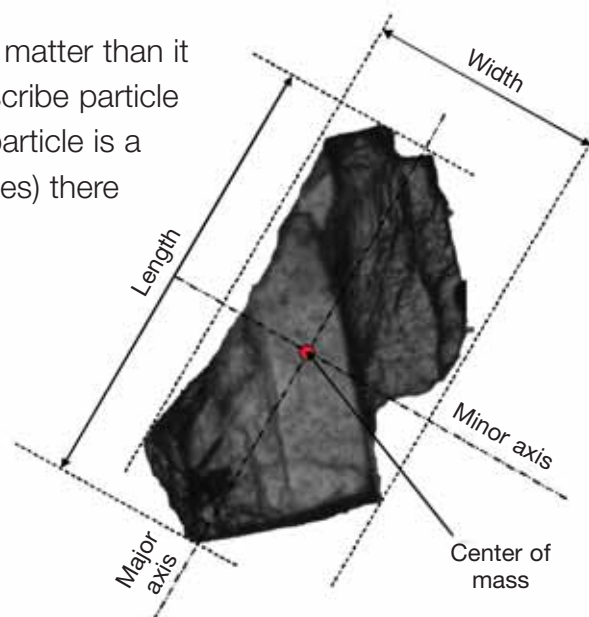


The trend plot will indicate a suitable QC parameter to distinguish between good and bad batches.

What is particle size and particle shape?

Describing a 3D particle is often a more complex matter than it first appears. For simplicity it is convenient to describe particle size as one single number. However, unless the particle is a perfect sphere (which is rare in 'real-world' samples) there are many ways to describe the size of a particle.

Image analysis systems capture a 2-dimensional image of the 3D particle and calculate various particle size and particle shape parameters from this 2D image. Calculating size and shape parameters like the ones shown in the list below allow even the most subtle differences to be identified and quantified.



Parameter	Example value	Definition
CE diameter (μm)	904.14	The diameter of a circle with the same area as the particle
Length (μm)	1306.35	All possible lines from one point of the perimeter to another point on the perimeter are projected on the major axis (axis of minimum rotational energy). The maximum length of these projections is the length of the object
Width (μm)	678.54	All possible lines from one point of the perimeter to another point on the perimeter are projected on the minor axis. The maximum length of these projections is the width of the object
Max. Distance (μm)	1318.07	Largest distance between any two pixels in particle
Perimeter (μm)	3619.42	Actual perimeter of particle
Major axis°	105.52	Axis of minimum rotational energy
Area (μm²)	371550.78	Actual area of particle in sq. microns
Area (pixels)	215018	Number of pixels in particle
Circularity	0.785	Circumference of equivalent area circle divided by the actual perimeter of the particle $= 2\sqrt{(\pi \text{ Area})/\text{Perimeter}}$
HS Circularity	0.616	High sensitivity circularity (circularity squared) $= 4 \pi \text{ Area}/\text{perimeter}^2$
Convexity	0.919	Convex hull perimeter divided by actual particle perimeter
Solidity	0.905	Actual particle area divided by convex hull area
Aspect ratio	0.519	Width divided by length
Elongation	0.461	1 - aspect ratio
Intensity mean	61.310	Average of all the greyscale values of every pixel in the particle
Intensity standard deviation	29.841	Standard deviation of all the greyscale values of every pixel in the particle
Center x position (μm)	6898271.5	x co-ordinate of center of mass of particle
Center y position (μm)	1797186.3	y co-ordinate of center of mass of particle

Why is shape analysis important?

Shape parameters such as Circularity, Convexity and Elongation provide the user with a series of highly sensitive tools in order to identify and quantify subtle variations in particle shape and provide a “fingerprint” of each sample. Each parameter is usually normalized between 0 and 1 in order to provide quick and easy comparability. Traditional qualitative human descriptions such as “jagged”, “smooth” or “needlelike” can be accurately quantified and hence correlated against important process or end-product variables such as flowability, active area and grinding efficiency.



						
Circularity is a measure of the closeness to a perfect circle. Circularity is sensitive to both changes in overall form and surface roughness.	Circularity = 1	Circularity = 0.47	Circularity = 0.89	Circularity = 0.52	Circularity = 0.47	Circularity = 0.21
Convexity is a measure of the surface roughness of a particle. Convexity is sensitive to changes in surface roughness but not overall form.	Convexity = 1	Convexity = 1	Convexity = 1	Convexity = 1	Convexity = 0.70	Convexity = 0.73
Elongation is a measure of the length-width relationship. Elongation is unaffected by surface roughness – a smooth ellipse has a similar elongation as a spiky ellipse of similar aspect ratio.	Elongation = 0	Elongation = 0.82	Elongation = 0	Elongation = 0.79	Elongation = 0.24	Elongation = 0.83

Applications and case-studies

At any point in your manufacturing process from early research and development, through process-analysis, manufacturing trouble-shooting and root-cause analysis to final product quality control, this instrument gives you an unprecedented level of product and process understanding.



Pharmaceuticals

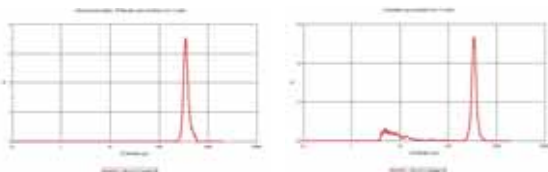
Even subtle differences in particle size or shape can significantly affect bioavailability, flowability, stability, blending and tableting efficiency.

Manufacturing processing steps including crystallization, drying, milling, blending, filtering can all introduce variability into the product and have to be precisely controlled. The extra sensitivity and resolution available in the Morphologi® G3 instrument provides users with the ability to identify, measure and monitor those process variables which are critical to product quality.



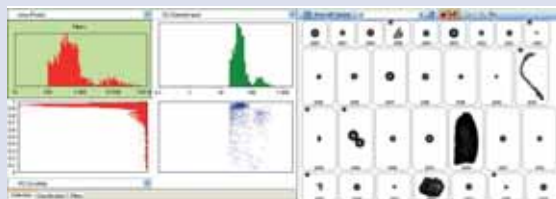
Sensitivity to fines

Image analysis proceeds on a 'number-basis' where the contribution each particle makes to the distribution is the same - a very small particle has exactly the same weighting as a very large particle. For diagnostic or trouble-shooting purposes the presence of fines could be critical to understand any given manufacturing process.



Foreign particle detection

Image analysis is an ideal technology for detecting the presence of very small numbers of foreign particles or confirming phenomena such as agglomeration. Using single parameters or combinations of parameters, foreign particles can be detected and quantified. For example – needles or fibres can be detected using the circularity shape descriptor.



High quality hardware means high quality images

The Morphologi® G3 is built upon the acclaimed Nikon® CFI 60 optical system which achieves both higher Numerical Apertures (NA) and longer working distances than ever before.

A precision XY stage and calibration grating ensure that data is precise, accurate and validated at all times.

In these revolutionary optics, both axial and lateral chromatic aberration have been corrected independently in the objective and the tube lens. This geometry produces images that are crisp and clear with high contrast and minimal flare.



The precision engineered XY stage uses high accuracy, ground ball-screws to provide smooth and maintenance free motion with zero-backlash. The quiet and precise stepper motors ensure accurate positioning of the stage while the use of micro-stepping provides smooth motion at low speeds.



Precision etched chrome-on-glass gratings are built into the XY stage for calibration purposes. The gratings are certified and traceable to the National Physical Laboratory. The system automatically calibrates before every measurement to guarantee validated, accurate data.



Plate tracking allows the surface of a non-horizontal plate or slide to be tracked, enabling large areas to be scanned and kept in-focus with high magnifications.



Overview

Morphologi® G3/G3S

Size, shape and count measurement of particulate samples

Size measurement

Size range 0.5µm - 3000µm
(depending upon material properties and dispersion conditions)

Shape measurement

Multiple shape parameters calculated for each particle and distributions generated on each parameter. Parameters include: Circle equivalent diameter, Length, Width, Perimeter, Area, Aspect ratio, Circularity, Convexity, Solidity, Elongation, Intensity.

Optical configurations

Optical system	Nikon® CFI 60 Brightfield/Darkfield system					
Magnification (at camera)	1x	2.5X	5X	10X	20X	50X
Approximate total magnification (at 17" screen)	(optional)					
	49x	123X	247X	494X	987X	2468X
Min particle size (µm)	32	13	6.5	3.5	1.75	0.5
Max particle size (µm)	3000	1000	420	210	100	40
Numerical aperture	0.040	0.075	0.15	0.30	0.40	0.55
Focal depth (total) (µm)	343.75	97.78	24.44	6.11	3.44	1.82
Working distance (mm)	3.2	8.80	18.00	15.00	13.00	9.80

Camera system

Camera type	1/1.8" Global shutter progressive scan CCD
Connection protocol type	IEEE 1394a (Firewire™)
Number of pixels	2592 x 1944 (5 MegaPixel)
Pixel size	2.7µm x 2.7µm
Sensor size	7.20mm x 5.40mm

Sample Dispersion Unit

Morphologi® G3S
Integrated Sample Dispersion Unit for the analysis of dry powders.
With software control of dispersion pressure, injection time and settling time.
Automatic operation via standard operating procedures, manual operation via computer on-screen operating dialogue. Requires, but does not include, a clean dry compressed air supply.

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