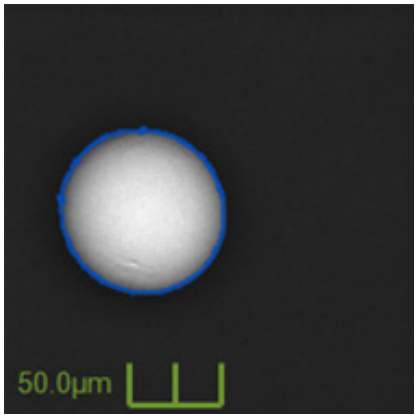
FractaLink™ for IntelliSEM™

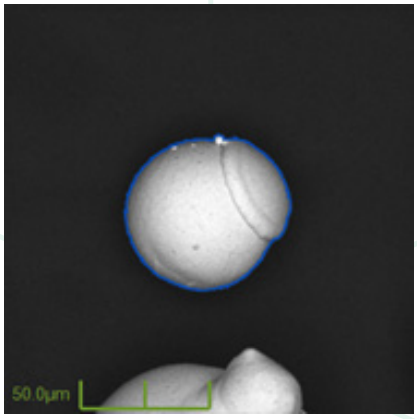
FractaLink™ is a metric available in IntelliSEM™ for characterizing the complexity of particle edges, using a fractal approach to perform analysis on zoomed-in particle images.

Surface texture is an important morphological parameter as it may impact chemical reactions and friction. The standard practice for the characterization of particles, ASTM F1877, is commonly used to describe the morphology of particles. Yet the morphological properties defined in this standard, such as Equivalent Circular Diameter, Aspect Ratio, and Elongation, do not capture the roughness or surface texture of a particle.

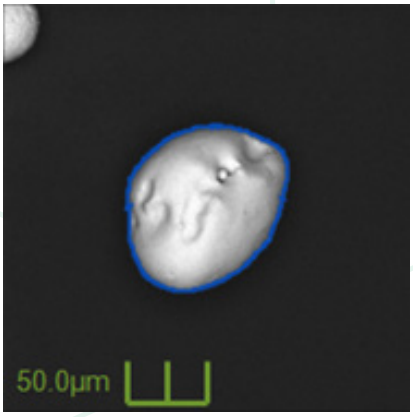
The standard introduces 2 metrics, Roundness and Form Factor, to characterize variations in the the roughness of the particle outline. However, these metrics were found to be insufficiently sensitive to variations in roughness of the particle outline for the characterization of modern powders.



Form Factor = 0.835
Roundness = 0.949
FractaLink = 2.2

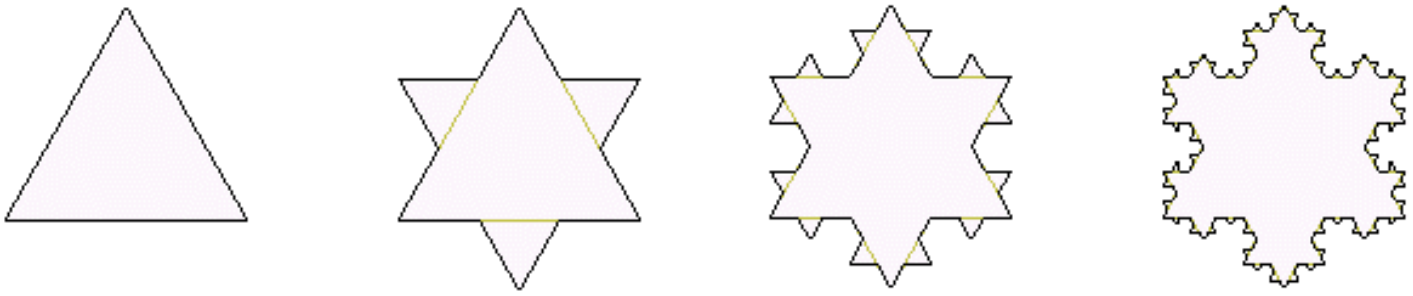


Form Factor = 0.835
Roundness = 0.890
FractaLink = 2.8



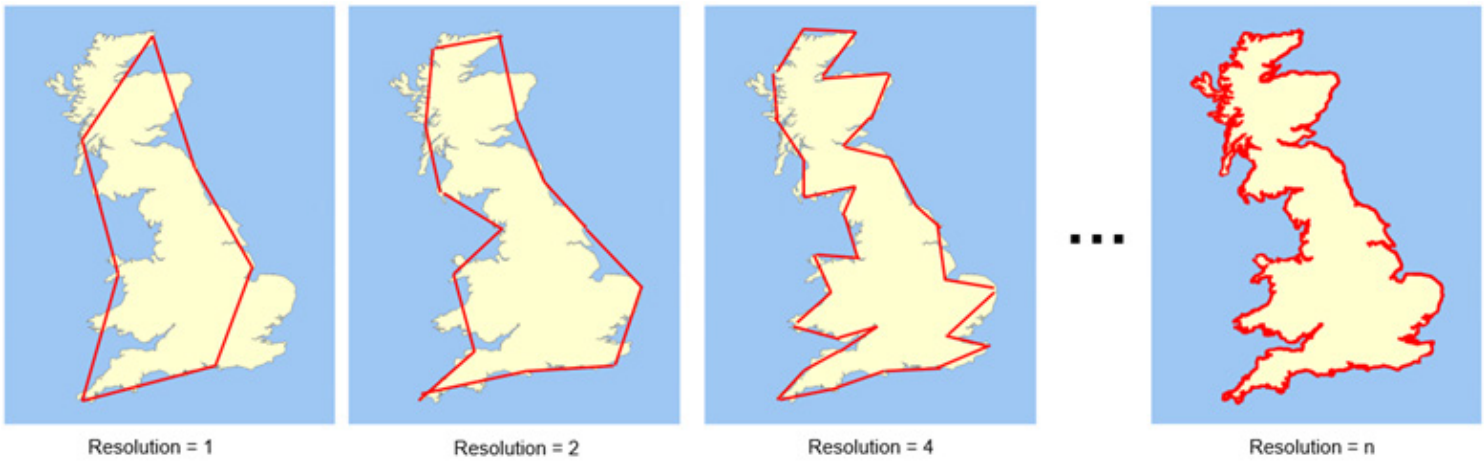
Form Factor = 0.834
Roundness = 0.762
FractaLink = 3.9

The underlying principle of fractal dimensions is that the measured length of a perimeter changes with increasing resolution. High fractality is evident in self-repeating shapes – geometrical shapes where edge detail replicates at ever-smaller scale as resolution is increased – such as the Koch Snowflake:



adapted from https://commons.wikimedia.org/wiki/File:KochFlake.png

Many examples of fractal- and fractal-like behavior can be found in nature. B.B. Mandelbrot, building on the earlier work of L.F. Richardson, provided the classic example by posing the question, “How long is the coastline of Britain?” The answer is, “It depends on the size of the measuring stick”. A 100-mile long measurement resolution will give one length; a 1-mile resolution will yield a longer length; a 1-meter resolution will be longer yet, and so on. The following images illustrate this effect:



underlying map of Britain adapted from https://commons.wikimedia.org/wiki/File:Britain-fractal-coastline-combined.jpg.

Studies of various countries have shown that a complex coastline such as Norway has a substantially higher fractal dimension than Britain, which in turn has a higher dimension than a smoother coastline such as South Africa.

A similar approach, applied to microscopic particles, is embodied in IntelliSEM’s FractaLink measurement. FractaLink produces a single number, between 0 and 100, that describes the fractality of the particle, or how quickly the perimeter length increases with increasing pixel resolution. A perfectly smooth perimeter will approach FractaLink = 0.0, while this number will increase for more complex perimeters. The image below shows computed FractaLink values for SEM images of a variety of pollen grains.

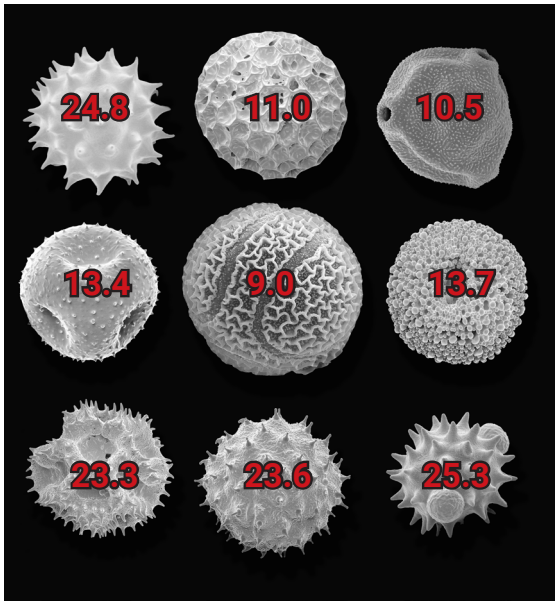


Photo: Steve Gschmeissner
Science Photo Library

FractaLink Measurements
Generated by IntelliSEM

The FractaLink value will typically be a function of the shape and complexity of perimeter features, as well as the size of these features relative to the overall size of the particle. Not all particles exhibit fractality, but FractaLink can provide a useful measure of particle morphology, along with more conventional metrics such as Form Factor, Aspect Ratio, Roundness, and Elongation.