Particle Technology

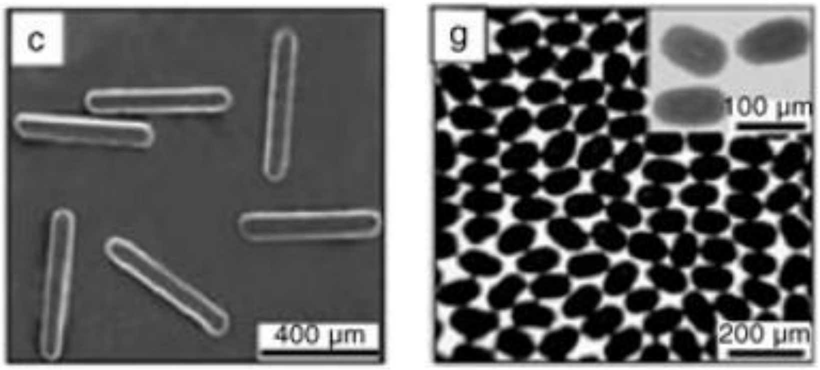
- A liquid does not have any definite shape, it takes the shape of the container. But solid particles have specific shape.
- Thus, handling any solid particle in any chemical process industry, we have to specify both of shape and size of the particle.
- If the particle conforms itself to any of the standard configurations such as spherical, cubical, cylindrical, then it is easy to define the size of the particle.
- For example, the size of spherical particle is defined through its diameter, that for a cubical particle is the length of the side.
- However, many of the particles commonly encountered in industrial practices donot conform to any of these standard configurations. These are irregular shaped particles.
- To define the size of the irregular particles is a real challenge to us.

Regular Shaped Particles

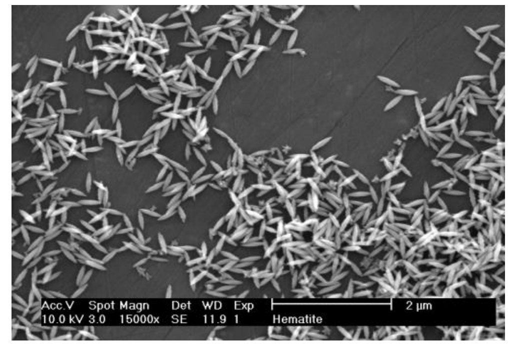
Table 1.1 Regular-shaped particles

Shape	Sphere	Cube	Cylinder	Cuboid	Cone
Dimensions	Radius	Side length	Radius and height	Three side lengths	Radius and height

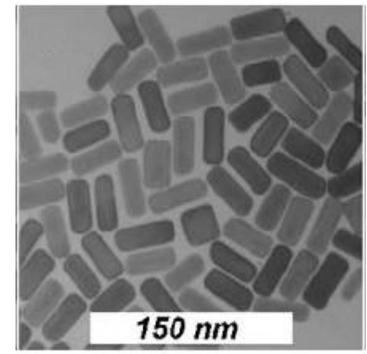
Particles of different shapes synthesized by various routes



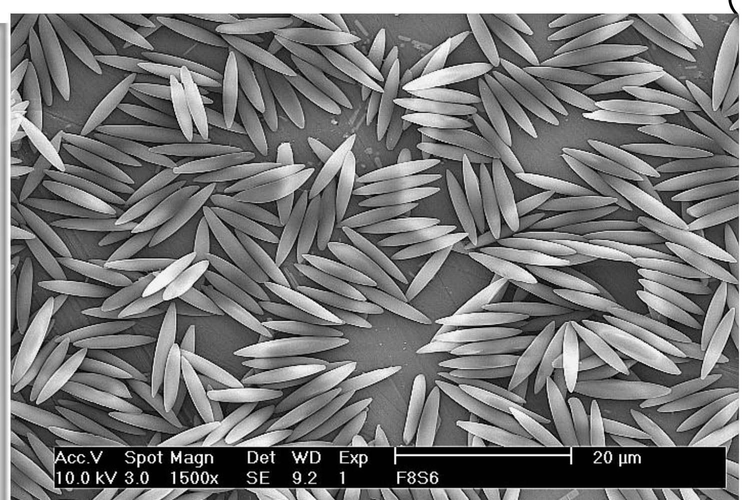
Xu et al.
Angew Chem.
2005

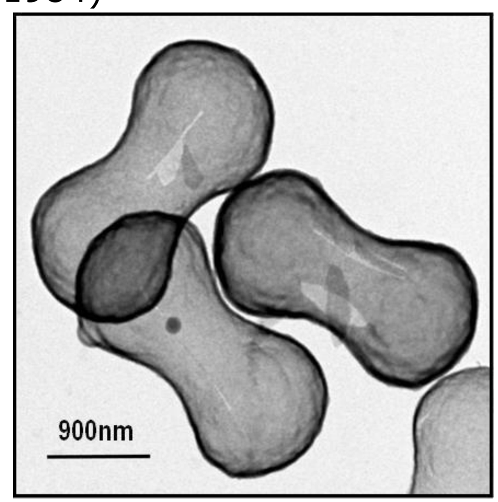


Ozaki et al.
J Colloid Int. Sci.
(1984)



Pérez-Juste et al.
Appl. Surf. Sci.
(2004)





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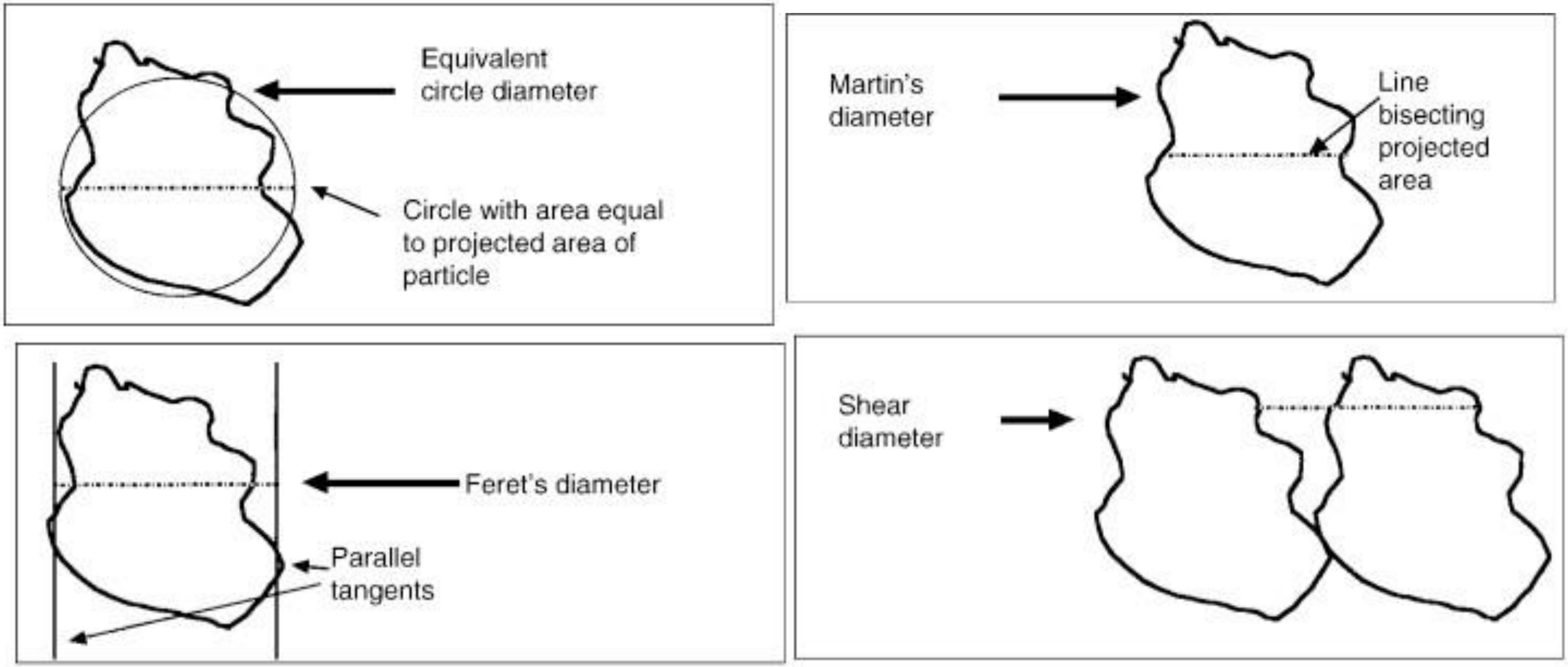
http://cohengroup.ccmr.cornell.edu/

Irregular Shaped Particles

- Early method: Obtain projected particle shape by microscopy



- There are limitations in measuring the particle shape through ordinary microscopy.
- For instance, if the distance between the farthest edges on the particle surface remains the same but the rest of configuration changes, its Ferret's diameter shall remain unaltered.
- Thus, such a definition cannot describe the actual size or shape of an irregular particle.
- The latest system of defining particle size is obtained by its comparison to a standard configuration.
- Thus, the concept of equivalent size or equivalent diameter of irregular shaped particles was developed.

Equivalent Diameter

- Equivalent diameter is defined as the size of a spherical particle having the same controlling characteristics as the particle under consideration.
- The controlling characteristics depends on the system and the process in which the particle is involved.
- For example, for catalyst particles, the surface area is the most controlling parameter.
- Thus, for defining the size of catalyst particles, the surface area is the most important parameter.
- So, for catalyst particles, surface diameter is used. This is defined as the diameter of a spherical particle having the same surface area as the particle.
- If S_p is the surface area of the particle, then,

$$S_p = \pi d_s^2$$

$$\text{or, } d_s = \sqrt{(\frac{S_p}{\pi})} \quad \text{-----(1)}$$

- The gravitational free velocity of a particle in a liquid is very much controlled by the mass of a particle or for a given density, by the volume of a particle.
- So, for this system, volumetric diameter is important for the measurement of the size of the particle.
- Volumetric diameter is defined as the diameter of a spherical particle having the same volume as the particle under consideration.
- Thus, if V_p is the volume of the particle, then

$$V_p = \frac{\pi d_v^3}{6}$$

Or,

$$d_v = (\frac{6V_p}{\pi})^{1/3} \quad \text{---- (2)}$$

Equivalent Diameter

- The dynamics of gas bubbles in a liquid or that of liquid drops in a liquid or gas depend not only on the bubble or drop volume but also on the interfacial tension at gas-liquid or liquid-liquid interface.
- Thus, both the volume as well as the surface area of the bubble or drop are the controlling parameter.
- In this case, the bubble size or drop size is defined using the volume –surface diameter or more commonly called Sauter diameter (d_{vs}).
- This is defined as the diameter of a spherical particle having the same specific surface area (surface area per unit volume) as the particle (bubble or drop) under consideration.
- Thus,

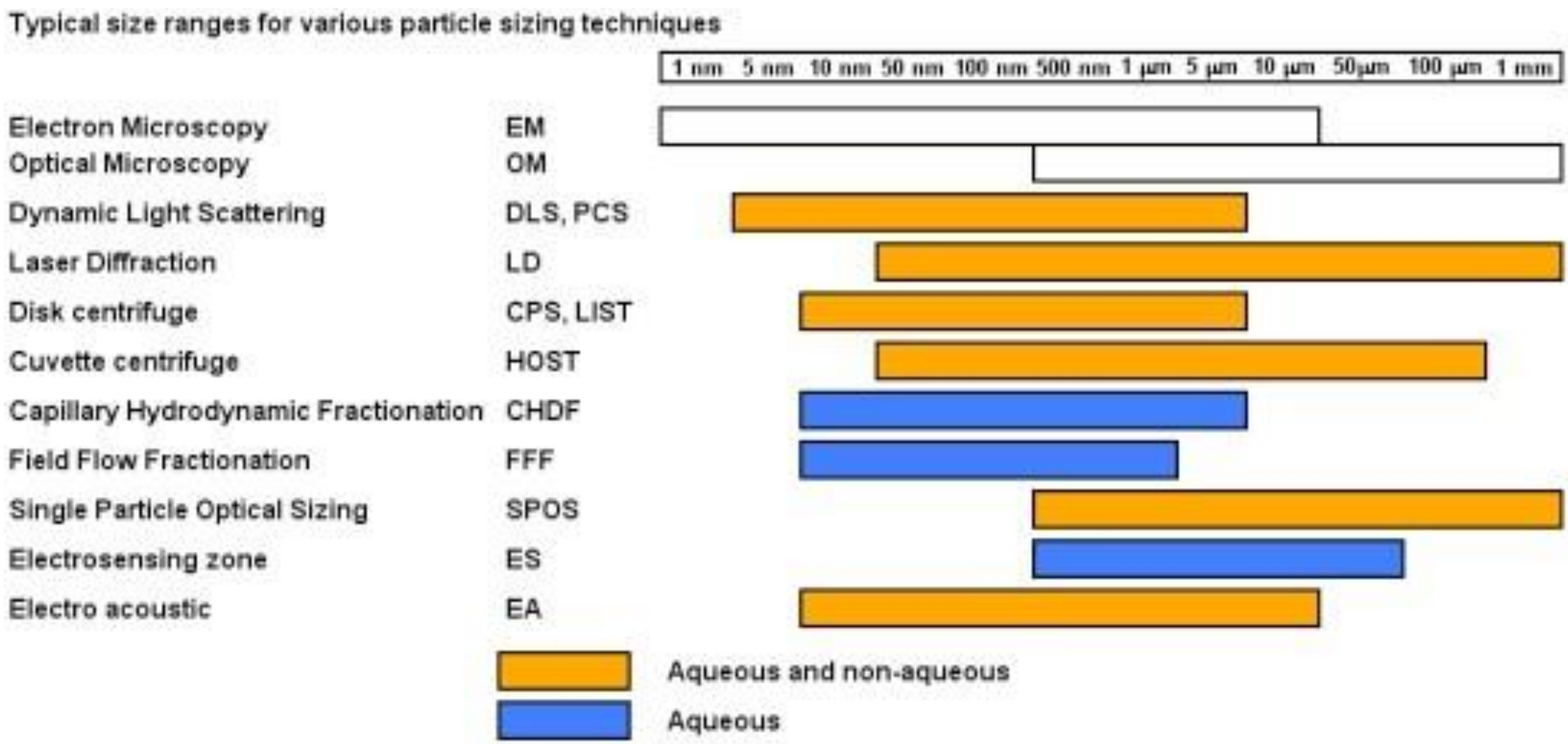
$$s_p = \frac{\pi d_{vs}^2}{\frac{\pi d_{vs}^3}{6}} = \left(\frac{6}{d_{vs}}\right)$$

or,

$$d_{vs} = \left(\frac{6}{s_p}\right) \text{---------} (3)$$

- Where s_p is the specific surface area (surface area per unit volume) of the particle (bubble or drop).
- Thus, once the controlling characteristics is specified, we can define the size of any irregular particle.
- Another particularly popular definition of particle size is the screen size or the screen average size, d_{avg}.

Methods to find particle size



http://www.agfa.com/en/agfa-labs/news/FZ_Juelich_chooses_Agfa_Labs_for_PSD.jsp