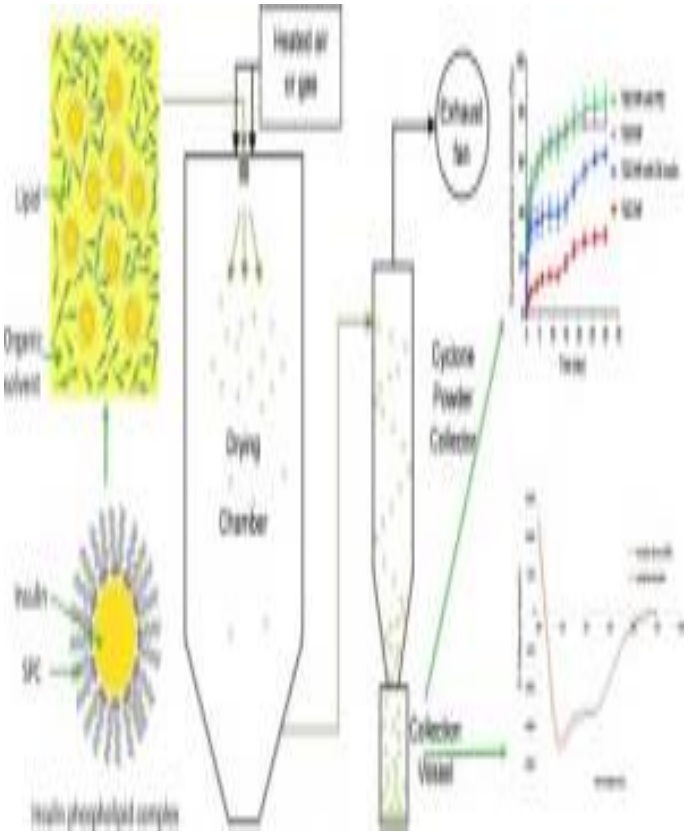
Pneumatic systems spray dryer

- spray dryers differ from most other dryers in that they can handle only fluid materials such as solutions, slurries, & thin pastes.
- The fluid is dispersed as fine droplets into a moving stream of hot gas where they evaporate rapidly before reaching the wall of the drying chamber.
- The product dries into a fine powder which is carried by the gas current & gravity flow into a collection system.

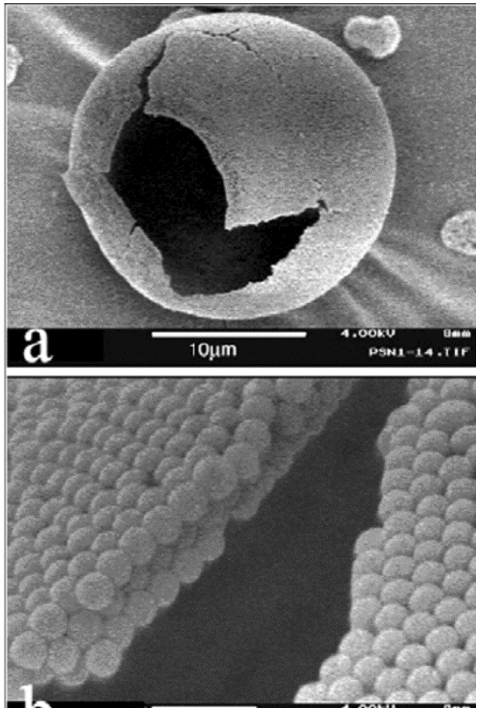


https://www.pharmaexcipients.com/news/effect-of-excipients-on-encapsulation-and-release-of-insulin-from-spray-dried-solid-lipid-microparticles/

- When the liquid droplets come into contact with the hot gas, they quickly reach a temperature slightly above the wet bulb temperature of the gas.
- The surface liquid is quickly evaporated & a tough shell of solids may form in its place.
- As drying proceeds the liquid in the interior of the droplet must diffuse through this shell.
- The diffusion of the liquid occurs at a much slower rate than does the transfer of heat through the shell to the interior of the droplet

- The resultant buildup of heat causes the liquid below the shell to evaporate at a far greater rate than it can diffuse to the surface .
- The internal pressure causes the droplet to swell & the shell becomes thinner allowing faster diffusion.
- If the shell is non elastic or impermeable , it ruptures producing either fragments or budlike forms on the original sphere .

- Thus spray dried material consists of intact spheres , spheres with buds ruptured hollow spheres or sphere fragments.
- The rate of feed is adjusted so that each droplet of sprayed liquid is completely dried before it comes in contact with the walls of the drying chamber & the resultant dried powder is not overheated in the drying process.



https://www.google.com/search?q=sphere+buds+of+spray+dryer&tbm=isch&ved=2ahUKEwjq7v3kmr3wAhWu57sIHcNqAfUQ2-cCegQIABAA&oq=sphere+buds+of+spray+dryer&gs_lcp=CgNpbWcQA1CsQVj6dmDVf2gAcAB4AIAB7QGIAcUSkgEGMC4xNC4xmAEAoAEBqgELZ3dzLXdpei1pbWfAAQE&sclient=img&ei=OyeYYKrlDa7P7_UPw9WFqA8&bih=526&biw=1093&hl=en#imgrc=gr7CMlLYmnyJKM

Spray drying & spray congealing of pharmaceuticals

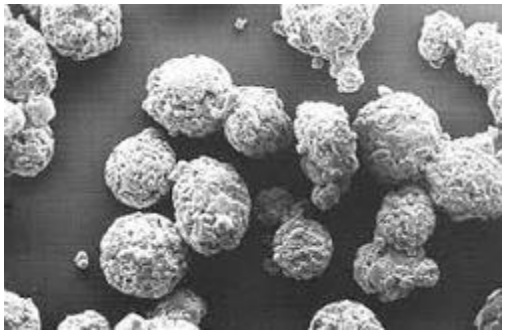
- Spray drying finds great utility in the pharmaceutical industry because of the rapidity of drying & the unique form of the final product.
- There are 3 major uses for the spray drying processes:
- 1- drying heat sensitive materials
- 2- changing the physical form of materials for use in tablet & capsule manufacturer.
- 3- encapsulating solid & liquid particles.

- Spray drying can be used to dry materials that are sensitive to heat & or oxidation without degrading them even when high temperature air is employed.
- The liquid feed is dispersed into droplets which are dried in seconds because of their high surface area & intimate contact with the drying gas.
- The product is kept cool by vaporization of the enveloping liquid & the dried product is kept from overheating by rapid removal from the drying zone.

- Spray drying is valuable in the modification of materials for use in tablet & capsules formulations because the drying process changes the shape , size & bulk density of the dried product.
- The spherical particles produced usually flow better than the same product dried by conventional procedures because the particles are more uniform in size & shape with fewer sharp edges.
- The spherical shape has the least possible surface area

- Thus decrease air entrapment between the particles. The improvement in flow & reduction of air entrapment make the spray dried material suitable for use in the manufacturer of tablets & capsules.
- The spherical particle shape is obtained by spray drying either a solution of the material or a slurry of particles in a saturated solution of the same material.
- In the later case the configuration of the suspended particles is rounded out by deposition of the material in solution.

- An example of a spray dried material that is commonly used as a tablet excipient is spray dried lactose.
- Spray drying has proved extremely useful in the coating & encapsulation of both solids & liquids.
- Solid particles are coated by spray drying a suspension of the material in a solution of the coating agent as the solvent is evaporated the coating material envelops the suspended particle.



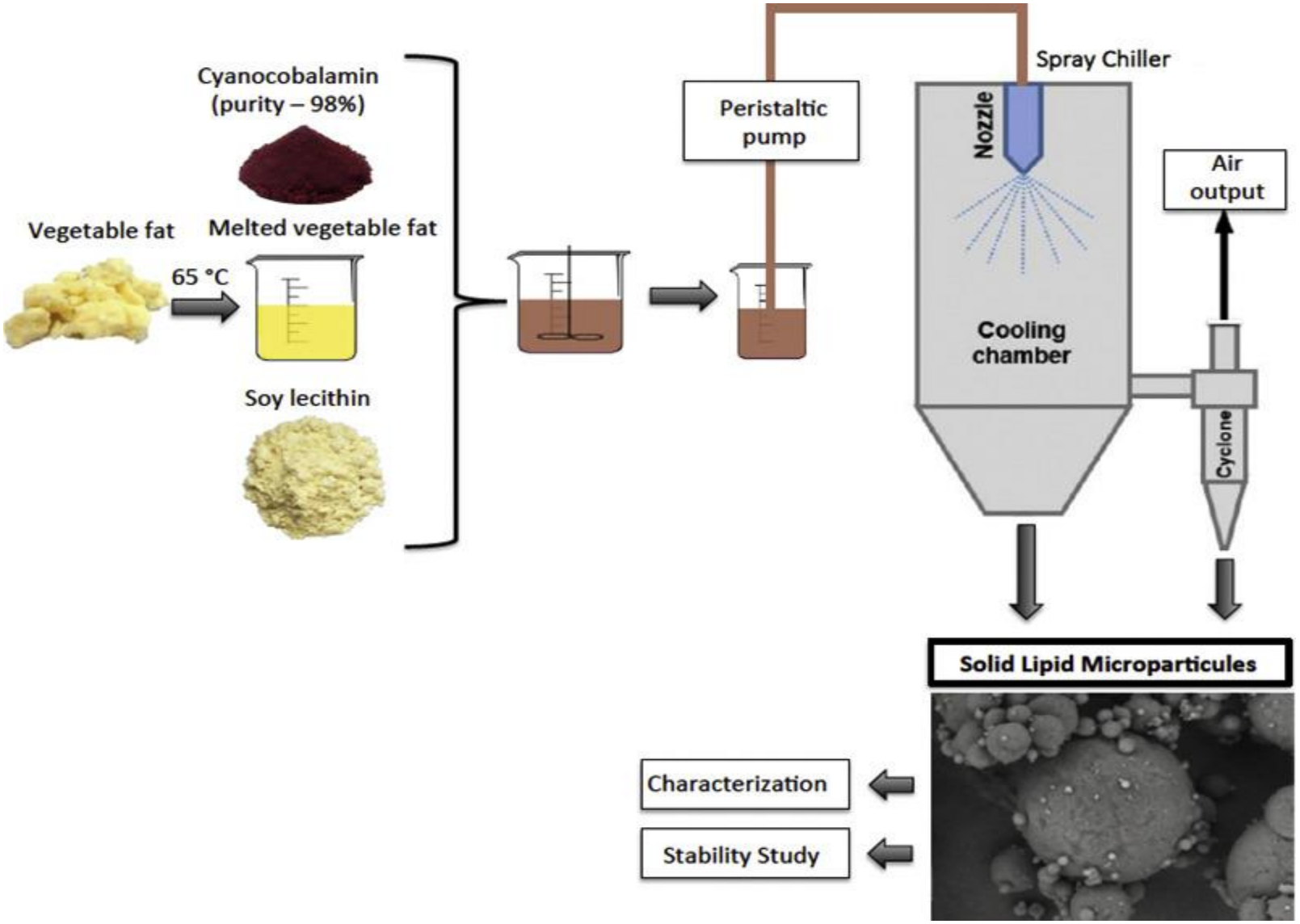
https://www.indiamart.com/proddetail/spray-dried-lactose-19931336188.html

https://www.indiamart.com/proddetail/spray-dried-lactose-5679080248.html

- The coating provides such valuable characteristics as taste & odor masking improvement in stability, enteric coating & sustained release.
- Oily liquids may be encapsulated by emulsification in water with the aid of a gum such as acacia or starch & subsequent spray drying.
- As the water evaporates the oil is entrapped in a shell of the gum.
- This process is used for the preparation of dry flavor oils.

Spray chilling or spray congealing

- This process consists of suspending the particles in a molten coating material & pumping the resultant slurry into a spray dryer in which cold air is circulated .The slurry droplets congeal & coming into contact with the air & are collected in the same manner as the spray dried product.
- The coating agents normally employed are low melting materials such as waxes.
- The congealing process requires a much higher ratio of coating agent to active material than does spray drying because only a molten coating agent constitutes the liquid phase.
- Spray congealed coatings are used mainly for taste masking & for sustained release formulations.



https://www.sciencedirect.com/science/article/abs/pii/S0963996919305496#f0030

Improving stability of vitamin B12 (Cyanocobalamin) using microencapsulation by spray chilling technique

Flash dryer

- In flash drying the moistened solid mass is suspended in a finely divided state in a high velocity , high temperature air stream.

Specialized drying methods
Freeze dryers

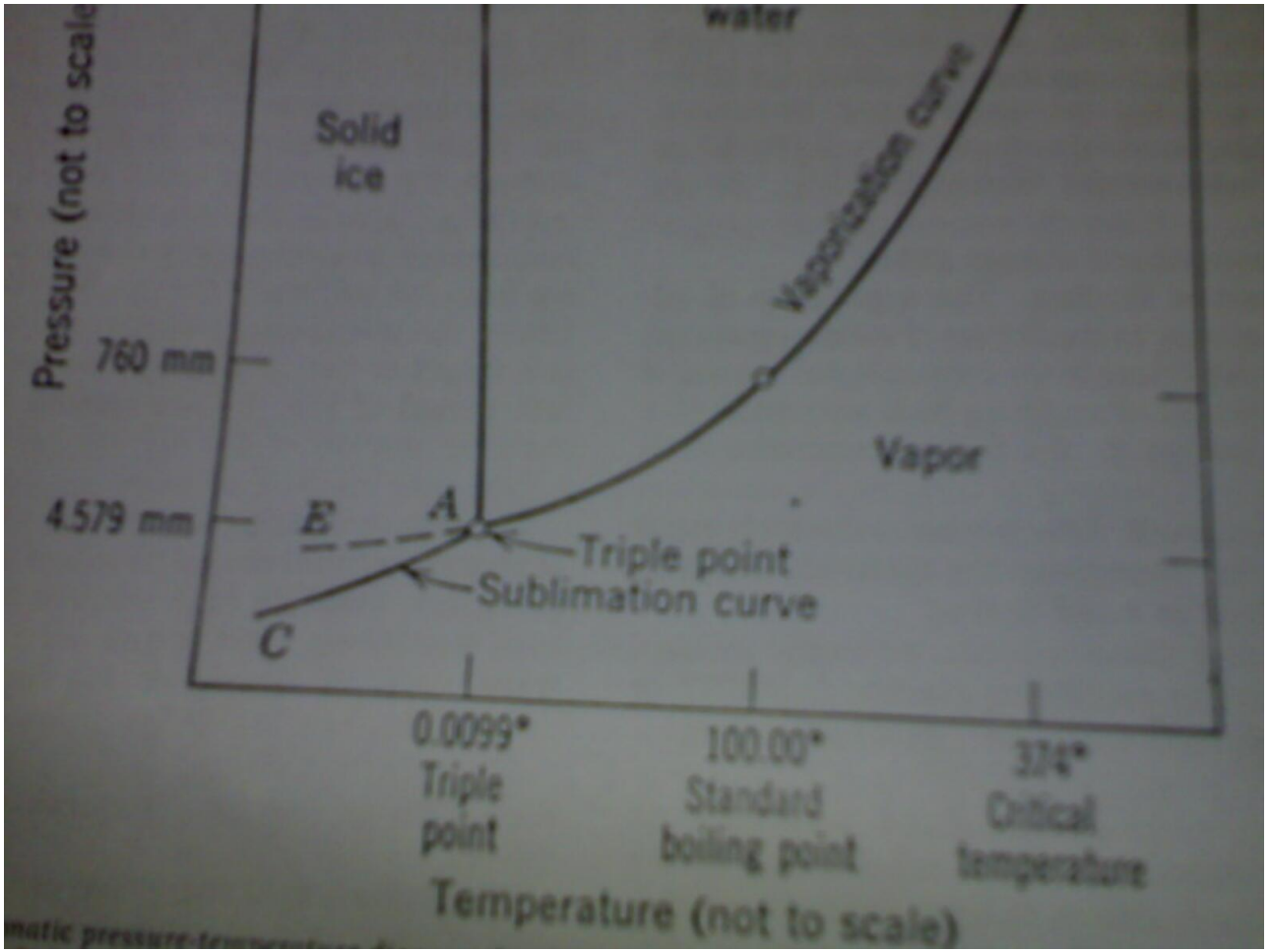
- Many products lose their viability in
- 1- the liquid state
- 2-readily deteriorate if dried in air at normal atmospheric pressures.
- These materials are heat sensitive or react with oxygen readily → so that in order to be stabilized , ***they must be dehydrated to a solid state.***
- The material to be dried is first frozen & then subjected under a high vacuum to heat so that

- The frozen liquid sublimes leaving only the solid, dried components of the original liquid.
- Such materials as blood serum, plasma , antibiotics, hormones, bacterial cultures, vaccines & many foodstuffs are dehydrated by freeze drying.
- The dried product can be readily redissolved or resuspended by the addition of water prior to use a procedure referred to a ***reconstitution .***
-

- freeze drying depends on phenomenon of sublimation , whereby water passes readily from the solid state (ice) to the vapor state without passing through the liquid state.
- Sublimation can take place at pressure & temperature below the triple point 4.579 mm hg & 0.0099°C.

The pressure & temperature at which the frozen solid vaporizes without conversion to a liquid is referred to as the eutectic point.

Freeze drying is carried out at temperatures & pressures below this point to prevent the frozen water from melting which would result in frothing as the liquid & frozen solid vaporize simultaneously.


Pressure (not to scale)
760 mm
4.579 mm
Solid
ice
water
Vaporization curve
Vapor
E
A
Triple point
Sublimation curve
C
0.0099°
Triple
point
100.00°
Standard
boiling point
374°
Critical
temperature
Temperature (not to scale)

Microwave drying

- The application of microwave energy to the drying of solids represents a radical departure from conventional means of drying.
- Instead of applying heat externally to a material , energy in the form of microwaves is converted into internal heat by interaction with the material itself. → This permits extremely rapid heat transfer throughout the material lead to rapid drying.

- The heating effect is produced by the interaction of a rapidly oscillating electric field (915 or 2450 megahertz) with the polarized molecules & ions in the material .The field imposes order on otherwise randomly oriented molecules. As the field reverses polarity, it relaxes & allows the molecules to return to their random orientation, giving up stored potential energy as random kinetic energy or heat.

- The interaction of the alternating field with ions causes billiard ball like collisions with unionized molecules & the impact energy is converted into heat.
- Industrial microwave dryers are usually of the static bed continuous type. Materials to be dried are placed on conveyor belts & conveyed through the microwave applicator then a stream of a hot air is used with simultaneously with the microwave to sweep away the moisture evolving from the surface of the material being dried .

- Often the microwave treatment is used in the last stages of hot air drying (the 2nd falling rate period) to remove the last remaining portion of the solvent reducing total drying time by 50% or more.