DRYING

Shubhashree Das Assistant Professor School of Pharmacy and Life Sciences Centurion University of Technology and Management Bhubaneswar shubhashree.das@cutm.ac.in

Definition:

Drying is the process of removal of small amount of liquid(water/volatile liq./moisture) by application of heat to obtain dry solid or solid product.

- In general drying process involves to operations; 1) Heat transfer 2) Mass transfer
- Drying and Evaporation are relatively same term but are distinguish in terms of removal of water. Here are some differences between drying and evaporation;

	Drying	Evaporation
1.	In drying processes, the main operation usually carried out on solid materials, e.g. powders, or products	In evaporation processes, the main operation usually carried out on liquid materials, e.g. solution, or products
2.	Drying in most of the cases means the removal of relatively small amounts of water from solids.	Evaporation include the removal of large amounts of water from solutions.
3.	Drying involves the removal of water at temperatures below its boiling point.	Evaporation involves the removal of water by boiling a solution.
4.	In drying , water is usually removed by circulating air over the material in order to carry away the water vapour	While in evaporation , water is removed from the material as pure water vapour mixed with other gases.

Objectives

- 1. It decreases food decomposition caused by moisture present.
- 2. It prevents decomposition by microbes.
- 3. It prevents bacterial and mould growth, so increase product stability.
- 4. It is used in granule formulation.
- 5. Size reduction is more efficient in dry state.

Applications of drying:-

Preservation of drug products

- > Drying is necessary in order to avoid deterioration. A few examples are...
- blood products, tissues undergo microbial growth
- effervescent tablets, synthetic & semi synthetic drugs undergo chemical decomposition.

Preparation of bulk drugs

- Drying is the final stage of processing .
- Eg: dried aluminium hydroxide
- spray dried lactose
- powdered extracts

Improved handling

- Removal of moisture makes the material light in weight and reduces bulk.
- Thus cost of transportation will be less & storage will be efficient.
- If moisture is present, size reduction of drugs is difficult.
- > Drying reduces the moisture content.

Improved characteristics

- Drying produces materials of spherical shape, uniform size, free flowing & enhanced solubility. Some specific areas of importance are:-
- 1. Granules are dried to improve the fluidity & compression characteristics. These are essential for production of tablets and capsules.
- 2. Viscous & sticky materia. To not free flowing, Drying modifies these characteristics. ⁵

List of equipments used for drying:

- Drum dryer,
- Fluidised bed dryer,
- Tray dryer,
- Vacuum dryer,
- Rotary dryer
- Freeze dryer

Fluidised bed dryer:

- Principle:
- In fluidised bed dryer hot air is passed at high pressure through a perforated bottom of the container.
- The granules are lifted from the bottom and suspended in the stream of air, this condition is called as fluidized state.
- The hot gas surrounding every granule to completely dry them.



Construction:

- Fluidised bed dryer is available in two forms;
- i) Horizontal FBD ii) Vertical FBD
- The dryer is made up of SS or plastic.
- A detachable perforated bowl is placed at the bottom of the dryer which is used for charging and discharging of material.
- A fan is mounted in the upper part for circulating hot air.
- Fresh air inlet, pre-filter and heat exchanger are connected serially to the required temperature.
- Bag filters are placed over bowl for recovery of fines.

Working:

- The wet granules to be dried are placed in detachable bowl and bowl is placed into the dryer.
- Fresh air is allowed to pass through pre-filter which subsequently gets heated by passing through heat exchanger.
- Hot air passed through bottom of bowl and fan is allowed to rotate.
- The granules rise in the container because of high velocity gas and later fall back in random motion.

- The gas surrounds every granule to completely dry them. The air leaves the dryer by passing through bag filter.
- The entrained particle remain adhere to the inside surface of bags. Periodically the bags are shaken to remove the particles.
- The material is collected after some time so as to reach the ambient temperature.

Uses:

- For drying granules.
- It can be used for drying, mixing and granulation process.
- It is modified for coating of granules.

- Advantages (1) Fluidised bed dryer requires less time to complete drying, i.e., 20 to 40 minutes compared to 24 hours of tray dryer. Handling time is also short. It is 15 times faster than the tray dryer.
 - (2) It is available in different sizes with the drying capacity ranging from 5 to 200 kg per hour.
 - (3) The drying containers are mobile, making handling simple and reducing labour costs.
 - (4) The thermal efficiency is 2 to 6 times than tray dryer.
- (5) It is also used for mixing the ingredients and its mixing efficiency is also high.
- (6) Hot spots are not observed in the dryer, because of its excellent mixing and drying capacities.
- (7) Higher drying temperatures can be used that are not possible in tray dryer and truck dryer.
- (8) It facilitates the drying of thermolabile substances, since the contact time for drying is short.
- (9) It can be used either as batch type or continuous type.
- (10) It has a high output from a small floor, space.
- (11) The free movement of individual particles eliminates the risk of soluble material migrating as may occur in static beds.

Disadvantages:

- Some organic material may develop electrostatic charge so requires earthing.
- Due to attrition fines are observed in large quantity.

Freeze dryer:

Principle:

In freeze drying water is removed from the frozen state by sublimation. (direct change of water from solid into vapour)

Construction:

Freeze dryer is consist of

- 1) Drying chamber in which trays are loaded
- 2) Heat supply in the form of radiation
- 3) Vapour condensing or adsorption system
- 4) Vacuum pump or steam jacket or both



Working:

It involves following steps;

- 1) Preparation and pretreatment
- 2) Pre-freezing for solidifying water
- 3) Primary drying (sublimation of ice)
- Secondary drying (removal of residual moisture)
- 5) Packing

Preparation and pretreatment : The volume of solution introduced into the container is limited by its capacity. Satisfactory freeze drying beyond a certain limit of depth of liquid is not possible. Therefore pretreatment is essential. The solution is pre-concentrated under normal vacuum tray drying. This reduces the actual drying by 8 to 10 times. The final product becomes more porous. Liquid or solid desiccants are also used for this purpose.

Prefreezing to solidify water : Vials, ampoules or bottles in which the aqueous solution is packed are frozen in cold shelves (about -50° C). During this stage, cabinet is maintained at low temperature and atmospheric pressure. The normal cooling rate is about 1 to 3 Kelvin per minute so that large ice crystals with relatively large holes are formed on sublimation of ice. This is also responsible for giving a porous product.

• Primary drying (sublimation of ice under vacuum) : In this step, the material to be dried is spread as much large surface as possible for sublimation. The temperature and pressure should be below the triple point of water, i.e., 0.0098°C and 0.533 kilopascals, (4.58 mmHg) for the sublimation, when water alone is present.

Vacuum is applied to the tune of about 3 mmHg (0.4 kilopascals) on the frozen sample. The temperature is linearly increased to about 30°C in a span of 2 hours.

Heat (about 2900 kilojoules per kg) is supplied which transfers as latent heat and ice sublimes directly into vapour state. The heat controls the movements of ice layer inwards. It has to be controlled in such a

As the drying proceeds, thickness of the frozen layer decreases and the thickness of partially dried solids increases. Primary drying stage removes easily removable moisture. During this stage, about 98% to 99% water is removed. Still traces of moisture is present in the sample.

Secondary drying (Removal of residual moisture under high vacuum) : During this stage, traces of moisture is removed. The temperature of the solid is raised to as high as 50 to 60°C, but vacuum is lowered below that is used in primary drying (50 mmHg). The rate of drying is very low and it takes about 10 to 20 hours.

Packing : After vacuum is replaced by inert gas, the bottles and vials are closed.

Uses : Freeze dryer is most commonly used in the production of dosage forms, such as injections, solutions and suspensions. It is used for drying of a number of products.

- (1) Blood plasma and its fractionated products.
- (2) Bacterial and viral cultures.
- (3) Human tissue (arteries and corneal tissue).
- (4) Antibiotics and plant extracts.
- (5) Steroids, vitamins and enzymes.

Several other products such as food items (prawns, mushrooms, meat and poultry products), coffee and tea concentrates and citrus fruit juices are dried.

Advantages : The entire operation is carried out well below the freezing point. This offers several advantages.

- (1) Thermolabile materials (heat sensitive materials) can be dried.
- (2) The product retains its bulk volume. It is porous and uniform. The reconstitution of the material is easy.
 - Denaturation does not occur.
- (4) Migration of salts and other solutes does not take place.
- (5) Loss of volatile material is less.
- (6) Moisture level can be kept as low as possible without decomposition.

- Material can be dried in its final container such as single dose and multiple dose vials.
- Sterility can be maintained.
- The final product can be stored at ambient temperature, if well (9)sealed by providing inert atmosphere.
- Disadvantages : () The product is prone to oxidation, due to high porosity and large surface area. Therefore, the product should be packed in vacuum or using inert gas or in a container impervious to gases.
 - Equipment and running costs are high.
- It is difficult to adopt the method for solutions containing nonaqueous solvents.
- (The period of drying is high (rarely less than 10 hours). Time cannot be shortened.

