Spray Drying Process


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This invention relates to a method of spray drying solutions of gelatin, and particularly to an improved method of spray drying gelatin solutions of relatively high concentrations.

The conventional process of spray drying materials in solution or suspension comprises generally the step of spraying the solution or suspension to be dried into hot air. The spraying action causes the formation of droplets, the droplets pass through the hot air, and rapid evaporation of the water or other solvent from the solid material occurs. By the time the droplet has reached the end of the drying zone, the water or other solvent has been substantially removed and a dry, particulate, free-flowing material is provided. This method of drying has been successfully employed for a large variety of materials. Various food products, such as coffee extracts, sugar solutions, cereal extracts, starch compositions, milk, and the like, are now being dried commercially in this manner on a fairly large scale. Similarly, various soap products, dyes, and the like are extensively processed in this manner.

In spray drying solutions of gelatin, however, a great deal of difficulty has been encountered, so that little if any spray drying of gelatin is carried out. The major difficulty in spray drying gelatin solutions is encountered in attempting the formation of droplets during the spray drying operation. Instead, filaments are usually formed. These are caused by premature drying of liquid films formed near the spray nozzle before they can be broken up into droplets. To explain, a solution or suspension to be dried is usually atomized directly into a heated atmosphere so that drying begins as soon as the material leaves the nozzle. The atomization of the liquid from a nozzle normally proceeds in three distinct stages. The liquid leaves the nozzle as a sheet at a substantially high velocity. This liquid sheet then forms thin filaments of liquid which at a third stage collapse to form droplets. As these droplets pass through the drying zone, the liquid is removed, leaving dry spherical particles.

Because of the favorable viscosity and surface tension of most atomized solutions or suspensions, discrete droplets form before any significant amount of surface hardening due to drying occurs. It has been found that with gelatin solutions, however, the time required for formation of discrete droplets after spraying is apparently unusually long with the result that, if ordinary spray drying methods are employed, the above-described premature drying of liquid films is encountered and the final product is a coherent, flabby web-like mass of gelatin rather than the desired particulate free-flowing material. Formation of these films also results in a considerable loss of gelatin during drying because of plastrering of the walls of the spray dryer and incomplete drying of the product.

Moreover, where pure solutions of gelatin have been spray dried in the past, it has been generally necessary to employ not more than a 3% concentration and in the case of high Bloom gelatins, i.e., those having high gelling ability per unit weight of gelatin, solutions having a concentration of more than 1% could not be satisfactorily spray dried because of the aforementioned filament formation. Spray drying of these dilute gelatin solutions is not generally practical because of the costly and excessive conditions necessary to obtain the desired product. Where additives such as dextrose, sucrose, and the like, are contained in a solution along with the gelatin, a somewhat higher concentration of gelatin is permissible but the addition of such fillers may be unsuited to the desired end use of the gelatin product and the increase in concentration of solutions that can be spray dried is not significant. Accordingly, the drying of gelatin solutions of such low concentration is considered uneconomical since it is desirable, as in the case of spray drying any solution, that a solution of relatively high concentration be employed. For these reasons spray drying of gelatin solutions has had limited application. It is an object of the present invention to provide a process whereby solutions of gelatin may be suitably spray dried.

Another object of this invention is to provide a process for spray drying relatively concentrated gelatin solutions which avoids the formation of the above-described undesirable filaments and the resultant coherent, flabby mass. It has now been found that a solution of gelatin may be successfully spray dried by providing a cool air zone intermediate the point of atomization of the solution and the warmer drying zone and proximate said point of atomization. In this manner, evaporation of water from the solution is retarded until discrete droplets of solution are formed. As a result, the formation of stringy filaments of gelatin is completely avoided and a dry, particulate, free-flowing gelatin product is obtained. It is believed that the retardation of evaporation of water more readily permits transition from the point of liquid sheet formation to the droplet phase, and substantially prevents drying of the solution while in the filament form.

It has also been found advantageous in some instances to employ, in addition to the cool air zone described above, a degree of control over the temperature of the gelatin solution at the point of atomization. Undesirable filament formation can occur if the temperature of the gelatin solution being fed to the atomizer is excessively high. The maximum gelatin feed temperature varies inversely with the Bloom of the gelatin and the concentration of the gelatin contained in the solution. With relatively dilute solutions of relatively low Bloom gelatin feed solution temperatures as high as 195° F. may be employed without encountering filament formation. On the other hand, with relatively concentrated and high Bloom gelatin solutions feed solution temperatures as low as 125° F. may be employed. Apparently the Bloom of the gelatin in solution is the most significant factor while the concentration of solids in solution is of somewhat lesser importance, although both factors enter into the determination of the maximum temperature allowable. It is generally preferred that higher feed solution temperatures be avoided because of possible deterioration of the gelatin through Bloom loss and the like.

Generally, in pumping a gelatin solution under the high pressure required for atomization the temperature of the solution increases so that in some cases it is possible that said temperature will exceed the maximum permissible temperature discussed above. Accordingly, the gelatin feed solution is usually cooled before pumping although, as discussed hereinbelow, such cooling should not serve to reduce the temperature of the feed solution appreciably.
below 100°F. Since the temperature rise occurring on pumping increases somewhat directly with the concentration and Bloom of the gelatin contained in the solution, it may be necessary in spray drying relatively concentrated and high Bloom gelatin solutions to employ cooling. Such cooling may be accomplished by cooling the pump itself or by adding cooling means between the pump and the atomization device.

The minimum temperature of feed solution which may be employed is governed by the considerations of viscosity and equipment limitations. Thus, for example, a 10% solution of 180 Bloom gelatin at a temperature below 100°F. has a high viscosity and is extremely difficult to handle. Pressure-atomizing nozzles and pumps do not provide the degree of atomization and pressure required to satisfactorily spray dry these solutions of extremely high viscosity. Similar difficulties are encountered at temperatures below 100°F. with solutions of other Bloom gelatins and of other gelatin concentrations and accordingly a feed solution temperature above 100°F. is preferred.

The term "Bloom" as used herein and in the appended claims is defined as the weight in grams required to impress a 1/2 inch plunger 4 mm. into a gelatin solution containing 6% solids dried at 105°C for 17 hours. A suitable test procedure for determining Bloom is outlined in U.S. Patent 2,282,487, in The Mechanical Engineering Chemistry, Analytical Edition, Volume II, page 348, and Volume XVII, page 64.

The desired cool zone may be supplied by any number of suitable means. For example, a conventional spray dryer may be introduced by modification of cold air into the body of the dryer, the cold air being directed to surround the atomizing area and to provide the retardation of evaporation necessary to allow formation of discrete droplets. As an alternative, a spray dryer containing two distinct zones may be constructed, the cool air zone being confined to the area immediately surrounding the spray pattern from the nozzle and the remainder of the dryer area containing the usual warmed drying zone. In this case, the gelatin solution would be atomized into the cool air zone. Following the formation of discrete droplets, the material would pass into the warmer drying zone by gravity, airflow or any other suitable means.

A conventional spray dryer may be modified according to the present invention by providing for the introduction of a stream of cold air at the nozzle area. In many cases it will be preferred to follow this procedure rather than incur the expense of constructing a new dryer. In modifying the conventional dryer, a cool air duct is preferably inserted into the dryer at a point adjacent to the nozzle, as to cover the cold air over the zone of atomization. Preferably the cool air is directed coaxially with and in the direction of atomization. At the end of the duct immediately adjacent the nozzle a conical shield is preferably constructed coaxial with the duct and the spray pattern which causes cold air introduced into the dryer to spread within the dryer and cover substantially the same area as the spray pattern from the nozzle. The solution is then atomized into the area of cool air surrounding the nozzle and allowed to form droplets which thereafter pass into the warmer drying air of the spray dryer.

As a specific example of the present invention, gelatin solutions are spray dried in a conventional dryer having the following characteristics. The spray dryer comprises a cylindrical tower 10 ft. in diameter and 30 ft. in height. The dryer is of the co-current type wherein warmed drying air is introduced at the top of the dryer and is removed at the bottom of the dryer. The dryer has a spray dryer nozzle ST60-21 described fully in Industrial Spray Nozzles published by Spraying Systems Incorporated, 1953, Catalog No. 24 at pages 25-27.

This nozzle, located in the center of the dryer approximately 2.5 ft. from the top, is adapted to direct the atomized solution downwardly in a specified spray pattern. A 12" diameter cold air duct terminates in a conical shield which flares downwardly and outwardly from the nozzle.

and describes a truncated cone 9" in height and 25" in base diameter. The upper extremity of the shield is at substantially the same elevation as the spray nozzle. A smaller air-diffusing conical shield is located within and at the same level as the outer shield and covers the larger outer shield, also flaring downwardly and outwardly and describing a truncated cone 9" in height, 8" in top diameter, and 20" in base diameter. Cool air is passed through the above mentioned 12" duct downwardly and outwardly through the top of the inner shield as well as through the zone between the inner and outer shields. This arrangement prevents entrance of any warm drying air to the cool air zone surrounding the nozzle and avoids localized heating of the atomized solution. Also, the pair of concentric cones provides a more uniform distribution of cool air around the spray pattern of atomized solution leaving the spray nozzle.

In the operation of the dryer a warm air mass at a temperature in the order of 550°F is uniformly introduced by suitable means at a rate of 3000-cubic ft. per minute (standard conditions) at the top of the dryer and is directed downwardly past the outer conical shield. At the same time cool air at a temperature of about 70°F is introduced by suitable means through the duct and into the area surrounding the spray pattern at a rate of about 1000 cubic ft. per minute (standard conditions). Under these conditions, cool air is introduced at a velocity sufficient to prevent entrance of warm air from the warm zone into the area immediately surrounding the spray pattern and the material is dried almost entirely within the cool air zone. The nozzle is located in the center of the dryer approximately 2.5 ft. from the top, is adapted to direct the atomized solution downwardly in a specified spray pattern. A 12" diameter cold air duct terminates in a conical shield which flares downwardly and outwardly from the nozzle.

Solutions of gelatin, having concentrations of as high as 35% may be satisfactorily spray dried in the modified spray dryer and under the conditions described above. Generally, it is more difficult to spray dry solutions of high Bloom gelatin than solutions of lower Bloom gelatin of the same concentration. Thus, a 12%-solution of 285 Bloom gelatin or a 30% solution of 35 Bloom gelatin are satisfactorily spray dried under the aforementioned drying conditions. Various modifications may be made in the drying conditions set forth above without departing from the spirit of this invention. Warm air temperature in the drying zone may range from 250°F to 1000°F depending on the rate at which the solution is to be dried, the time of contact of air with the material, the type of material being dried and the size of the cool air zone. Where temperatures in the lower portion of this range are employed, an extremely long period of contact between solution and drying air and a correspondingly long column of air are required. On the other hand, where extremely high drying temperatures are employed, care must be taken to avoid excessive heating of the material being dried. In general, it is preferred to employ drying air of a temperature of 500°F-600°F.
The temperature of the cool air zone may range from 0° F. or below to about 200° F. Temperatures below 0° F. may be required in drying highly concentrated solutions of high Bloom gelatin at a relatively low feed solution temperature. Under present equipment limits, however, use of low feed solution temperatures are not considered practical. For this reason and because of the unfavorable economics involved in using a cool air zone temperature below 0° F., such temperatures are generally not employed. Room temperature air in the order of 60°–80° F. is generally preferred because of its ready availability.

Feed pressures for the gelatin solution will depend to some extent on the viscosity of the particular solution and upon the nozzle and equipment employed and may range up to 3000 lbs. per sq. inch (gage) or higher. Also, the proportion of cool air to warm air introduced into the dryer employed in the specific example above may be departed from, as long as adequate retardation of evaporation prior to complete droplet formation is achieved, and further providing that the cool air is introduced with a velocity sufficient to provide a cool air zone of the desired dimension.

On the other hand, as above mentioned the temperature of the solution at the time of atomization has been found to be somewhat critical under certain circumstances. In the example given above the temperature of the feed solution at the time it leaves the nozzle must be maintained within the range of 100–140° F. Solution temperatures below the range result in formation of insoluble materials and are extremely difficult to handle, the latter caused by the greatly increased viscosity of the solution. In this case spray drying of solutions at temperatures above 140° F. results in the formation of undesirable filaments. Further, it is realized that a change in the atomization, air temperature and air flow conditions described in the specific example will influence to some extent the maximum feed solution temperature which may be employed.

Gelatin dried according to the process of the invention is in the form of dry spherical free-flowing particles which dissolve when placed in cold water. The addition of sugar or other additives to the gelatin solution prior to drying further enhances cold water solubility. For example, a solution containing 6 parts by weight of dextrose to 1 part by weight of gelatin when sprayed dried according to this invention will provide a material which dissolves rapidly at 80° F. Furthermore, the addition of dispersing agents such as lecithin, sorbitol, fructose, polyoxyethylene sorbitan monostearate, and glycerol monostearate may be employed to improve the rate of solution, and various antifoaming agents such as sorbitan monoleate may be used to reduce the formation of foam during solution. Some of these materials such as lecithin, and polyoxyethylene sorbitan monostearate serve as both dispersing and antifoaming agents.

Furthermore, the process of this invention may be employed to advantage in the fixation of various water immiscible and water miscible materials in a gelatin matrix. Thus, various vitamins, vitamin oils, biological preparations, other food supplements and various flavoring materials may be emulsified or dissolved in the gelatin solution prior to spray drying to result in their being fixed or encapsulated in the gelatin particles. Citrus oils such as the lime, lemon, orange, and oils containing vitamins A and D may be satisfactorily fixed in gelatin by emulsifying said oil in a solution of gelatin and spray drying the emulsion according to the process outlined above. In this manner a dry particulate free-flowing material is obtained containing the material fixed within the spray dried particle. As a specific example of the manner in which water immiscible oils such as the vitamins and citrus oils mentioned above may be fixed in gelatin employing the process of the present invention, an emulsion of 1 part by weight of the oil to 16 parts by weight of a 25% solution of 50 Bloom gelatin is prepared and spray dried in accordance with the specific example given above. Generally, relatively concentrated solutions of relatively low Bloom gelatin are employed in order to obtain the highest gelatin concentration while permitting sufficiently low gelatin viscosities for ease of handling. Similarly, water-soluble materials such as vitamins B1, B2, C, B6, and the like, may also be fixed in a gelatin matrix by dissolving about 1 part by weight of the vitamin in about 30 parts by weight of a concentrated solution of low Bloom gelatin such as that mentioned immediately above and the spray solution dried as aforesaid.

Application of this fixation procedure to the various materials described above provides the advantages of improved storage stability and reduced loss of potency during handling and storage. Further, the free-flowing particulate form of the material contributes greatly to ease of handling and ease of incorporation of said material into various other food products.

While the process of this invention has been described with reference to specific examples of gelatin solutions, other concentrations of various gelatin types may be spray dried under a variety of processing conditions to produce the desired results characteristic of the present invention and will specifically provide for the formation of a particulate, free-flowing material which is substantially free of any stringy filaments. Accordingly, a broad interpretation of the accompanying claims is desired realizing that gelatin solutions of various Bloom types over a wide range of concentrations may be spray dried in accordance with the spirit of the present invention.

What is claimed is:

1. A process of spray drying a gelatin solution, the improvement comprising the step of atomizing the solution into a cool air zone prior to introduction of the atomized solution into a drying zone.

2. A process of spray drying a gelatin solution, the improvement comprising the step of atomizing the solution into a cool air zone having a temperature of 0°–200° F. prior to introduction of the atomized solution into the drying zone.

3. A process of spray drying a gelatin solution, the improvement comprising the step of atomizing the solution into a cool air zone having a temperature of 0°–200° F. prior to introduction of the atomized solution into a drying zone having a temperature of 250°–1000° F.

4. A process for spray drying an aqueous gelatin solution which comprises atomizing the gelatin solution into a cool air zone within a drying chamber to retard solvent evaporation until discrete droplets of the solution are formed, passing said discrete droplets to a drying zone of elevated temperature, and drying said droplets.

5. A process according to claim 4 wherein the cool air zone has a temperature of 0°–200° F. and wherein the drying zone has a temperature of 250°–1000° F.

6. A process of fixing a water immiscible oil in gelatin comprising the steps of emulsifying said water immiscible oil in an aqueous gelatin solution, atomizing said emulsion into a cool air zone within a drying chamber to retard solvent evaporation until discrete droplets of the solution are formed, passing said discrete droplets to a drying zone of elevated temperature, and drying said droplets.

7. A process of fixing a water miscible material in gelatin comprising the steps of dissolving said water miscible material in an aqueous gelatin solution, atomizing said solution into a cool air zone within a drying chamber to retard solvent evaporation until discrete droplets of the solution are formed, passing said discrete droplets to a drying zone of elevated temperature, and drying said droplets.

8. A process of fixing in gelatin a vitamin preparation containing water miscible and water immiscible materials comprising the steps of dissolving and emulsifying
the vitamin preparation in an aqueous gelatin solution, atomizing said emulsion into a cool air zone within a drying chamber to retard solvent evaporation until discrete droplets of the solution are formed, passing said discrete droplets to a drying zone of elevated temperature, and drying said droplets.

9. The process of fixing a water-immiscible flavor oil in gelatin comprising admixing the said oil with an aqueous gelatin solution to form an emulsion, atomizing said emulsion into a cool air zone wherein solvent evaporation is retarded and discrete droplets of the emulsion are formed, and passing said discrete droplets to a drying zone of elevated temperature wherein said droplets are dried.

10. The process claimed in claim 9 wherein the said water-immiscible flavor oil is a citrus oil.

References Cited in the file of this patent

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CERTIFICATE OF CORRECTION

Patent No. 2,824,807

Richard Laster et al.

February 25, 1958

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 23, for "½" read --- ½ ---; lines 26 and 27, for "Edition" read --- Editions ---; column 4, line 66, for "with" read --- with ---.

Signed and sealed this 15th day of April 1958.

(Seal)
Attest:
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