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[54] **METHOD FOR PRODUCING GLASS BEADS FOR ELECTROSTATOGRAPHIC DEVELOPERS**

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[58] **Field of Search**.....................65/21, 142; 252/62.1; 96/1

[56] **References Cited**

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[57] **ABSTRACT**

Spherical glass beads are produced by isolating individual glass particles on a non-wetting ceramic block and heating the glass to a temperature at which the glass particles are drawn-up into spherical beads. The spherical beads, either coated or uncoated, may be employed as the carrier in an electrostatographic developer. The carriers are characterized by more uniform sizing and greater approximation to a spherical shape.

4 Claims, No Drawings

METHOD FOR PRODUCING GLASS BEADS FOR ELECTROSTATOGRAPHIC DEVELOPERS

BACKGROUND OF THE INVENTION

This invention relates to electrostatography and more particularly to an improved process for producing spherical glass beads for use as a carrier in a electrostatographic developer.

Xerography is exemplary of an electrostatographic process and the basic xerographic process, as taught by C. F. Carlson in U.S. Pat. No. 2,297,691, involves placing a uniform electrostatic charge on a photoconductive insulating layer, exposing the layer to a light and shadow image to dissipate the charge on the areas of the layer exposed to the light and developing the resulting latent electrostatic image by depositing on the image a finely-divided electroscopic material referred to in the art as "toner." The toner is normally attracted to those areas of the layer which retain a charge, forming a toner image corresponding to the latent electrostatic image, which may then be transferred to a support surface, such as paper. The transferred image is generally permanently affixed to the support surface by heat, although other suitable fixing means, such as solvent or overcoating treatment, may be substituted for the foregoing heat fixing steps.

Many methods are known for applying the electroscopic particles to the latent electrostatic image to be developed. One development method as disclosed by E. N. Wise in U.S. Pat. No. 2,618,552 is known as "cascade" development. In this method, developer material comprising relatively large carrier particles having finely-divided toner particles electrostatically clinging to the surface of the carrier particles is conveyed to and rolled or cascaded across the latent electrostatic image-bearing surface. The composition of the toner particles is so chosen as to have a triboelectric polarity opposite that of the carrier particles. In order to develop a negatively charged latent electrostatic image, an electroscopic powder and carrier combination should be selected in which the powder is triboelectrically positive in relation to the carrier. Conversely, to develop a positively charged latent electrostatic image, the electroscopic powder and carrier should be selected in which the powder is triboelectrically negative in relation to the carrier. This triboelectric relationship between the powder and carrier depends on their relative positions in a triboelectric series in which the materials are arranged in such a way that each material is charged with a positive electrical charge when contacted with any material below it in the series and with a negative electrical charge when contacted with any material above it in the series. As the mixture cascades or rolls across the image-bearing surface, the toner particles are electrostatically deposited and secured to the charged portions of the latent image and are not deposited on the uncharged or background portions of the image. Most of the toner particles accidentally deposited in the background are removed by the rolling carrier, due apparently, to the greater electrostatic attraction between the toner and carrier than between the toner and the discharged background. The carrier particles and unused toner particles are then recycled. This technique is extremely good for the development of line copy images. The cascade development process is the most widely used commercial xerographic development technique, a general purpose office copying machine incorporating this technique is described in U.S. Pat. No. 3,099,943.

In the cascade development technique, the carrier particles are rolled across the image-bearing surface so that their gravitation or momentum force is greater than the force of attraction of the toner in the areas of the image-bearing surface retaining the toner to prevent the carrier particles from adhering to the retained toner particles. Thus, the carrier particles should be capable of flowing easily over the image-bearing surface, without the necessity of providing special means for effecting removal of the carrier material from the image-bearing surface.

Glass beads are commonly employed in electrostatographic developer carriers and in order to facilitate rolling of the carrier across an image-bearing surface, such beads should be substantially spherical.

SUMMARY OF THE INVENTION

An object of this invention is to provide an improved process for producing spherical glass beads for use in an electrostatographic developer.

Another object of this invention is to provide an improved process for providing an electrostatographic developer carrier.

A further object of this invention is to provide for the production of spherical glass beads of a more uniform size.

Yet another object of this invention is to provide for improved development of a latent electrostatographic image.

These and other objects of the invention should be more readily apparent from reading the following detailed description thereof.

The objects of this invention are broadly accomplished by placing finely divided glass on a non-wetting ceramic support in a manner such that individual glass particles are isolated from each other, followed by heating of the glass to a temperature at which the particles are drawn up into substantially spherical beads as a result of their surface tension. The spherical glass beads are used in an electrostatographic developer carrier.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the invention, the glass employed as a starting material may be any one of a wide variety of glasses, including soda-lime-silica base glasses, high lead glasses, barium glasses and the like, and may be employed as a starting material in either solid or molten form. If employed as a solid, the glass is screened to the desired size and if employed in molten form, the desired sizing is obtained by uniformaly shearing the desired size from a controlled molten glass stream which is extruded from a continuous glass melting furnace. Alternatively, the desired sizing of molten glass may be achieved by selecting an appropriate orifice size for a glass melting furnace.

The particle size of the solid or molten glass employed as the starting material controls the particle size of the spherical glass bead produced. In general, the carrier material of xerographic developer should have a particle size from about 30 to about 1,000 microns, and therefore the particle size of the glass starting material is controlled to provide a final product having a particle size suitable for a xerographic developer carrier.

The glass starting material, either in solid or molten form, having the appropriate particle size, is placed on a non-wetting ceramic block, i.e., a ceramic block to which the glass does not stick, in a manner such that the individual particles do not touch each other, thereby preventing fusion of two or more particles which reduces the production of individual spherical particles. The non-wetting ceramic materials which may be employed in producing the block, include, as representative examples; graphite, chrome oxide, iron oxide, zirconium oxide, aluminum oxide, ball clays, etc.

In accordance with a particularly preferred embodiment of the invention, the surface of the ceramic block on which the glass particles are to be placed, includes a plurality of small impressions of a size suitable for holding an individual glass particle, whereby each individual particle is effectively separated from the adjacent particles. The impressions preferably have a conical shape to facilitate production of spherical beads and may be arranged on the surface of the block in any manner, provided the impressions are spaced from each other by a distance sufficient to isolate each individual glass particle. The forming of suitable impressions on the block for isolating individual glass particles is deemed to be within the scope of those skilled in the art from the teachings herein, and therefore no further description is deemed necessary for a full understanding of the invention.

The glass particles, which are isolated from each other on the nonswetting ceramic block, are heated to a temperature at which the viscosity of the glass is sufficiently reduced to permit the surface tension to draw the glass particle into a spherical bead. The temperature to which the glass particles are heated varies with the particular glass material used and the choice of a suitable temperature for causing the glass to draw-up into spherical beads is deemed to be within the scope of those skilled in the art from the teachings herein. In general, the glass particles are heated to temperatures from about 1,200° F. to about 2,210° F., preferrably from about 1,700° F. to about 1,850° F., and at such temperatures, the glass particles are rapidly fromed into spherical beds; generally in the order of from about 2 to about 5 minutes.

The heating of the glass particles may be effected in any one of a wide variety of furnaces heated by any one of a wide variety of heat sources and the choice of a particular heating apparatus is well within the scope of those skilled in the art. In a preferred procedure, the spherodizing procedure is effected in a continuous manner by the use of a controlled tunnel furnace, of a type known in the art, including preheat, spherodizing, annealing and cooling zones. The non-wetting ceramic block, containing the sized glass particles, is sequentially conveyed through the furnace zones, providing improved control over the overall process.

After the glass beads are formed on the ceramic block, the beads are allowed to cool while on the block, to a temperature at which the beads are solidified, i.e., the beads are not at a temperature at which the beads will adhere to each other or other particles. In general, the beads are initially cooled to a temperature from about 1,800° F. to about 610° F. or lower, and are then placed in suitable containers for subsequent classification as to size.

The spherical glass beads produced, as hereinabove described, may then be employed as the core material of an electrostatographic developer carrier as generally known in the art. Thus, the glass beads may be encased in a suitable covering which imparts the triboelectric properties required for an electrostatographic developer carrier, i.e., the carrier properly charges the toner when mixed therewith. The coating material for the glass beads may be any one of the wide variety of coating materials employed as coatings in electrostatographic developer carriers, generally resinous material including, but not limited to: polyolefins, such as polyethylene, polypropylene, etc.; vinyl and vinylidene resins, such as styrene, vinyl chloride, vinyl acetate, acrylonitrile, methyl methacrylate and like resins; phenolic resins, such as phenol-formaldehyde, etc.; amino-resins, such as melamine-formaldehyde; and the like, and the coating may be applied by any one of a wide variety of procedures, such as spraying, dipping, a fluidized bed coating, tumbbling, brushing and the like. In accordance with one procedure, the glass beads are coated with an intermediate bonding layer, and the coated core added to the dry resinous material in which the glass bead is to be encased, whereby the resinous casing material adheres to the coated glass bead and constitutes a coating which is fused or otherwise affixed to the core material. The production of electrostatographic carriers is further described in U.S. Pat. No. 2,618,551 to Walkup which is hereby incorporated by reference.

The spherical glass beads produced in accordance with the invention may also be employed as an uncoated electrostatographic developer carrier. Thus, for example, glass compositions, as disclosed in copending U.S. application Ser. No. 631,192 filed on Apr. 17, 1967, now U.S. Pat. No. 3,591,503 by Hagenback et al., are suitable for the production of uncoated carriers and such glasses may be formed into spherical glass carriers in accordance with the teachings of the invention.

The toner particles of the developer may be any one of the wide variety of toner materials generally employed in developer compositions and as representative examples of typical toner materials, there may be mentioned: gum copal, gum sandarac, rosin, cumaroneindene resin, asphaltium, gilsonite, phenolformaldehyde resins, rosin-modified phenol-formaldehyde resins, methacrylic resins, polystyrene resins, polypropylene resins, epoxy resins, polyethylene resins and mixtures thereof. Among the patents describing electroscopic toner compositions are U.S. Pat. No. 2,659,670 to Copely; U.S. Pat. No. 2,753,308 to Landrigan; U.S. Pat. No. 3,079,342 to Insalaco; U.S. Pat. Reissue No. 25,136 to Carlson and U.S. Pat. No. 2,788,288 to Rheinfrank et al.

The toner contains a pigment or dye in a quantity sufficient to impart color to the toner, generally in an amount from about 1 percent to about 10 percent, by weight, of the toner. Any one of a wide variety of pigments or dyes which do not adversely affect the properties of the toner may be employed to impart color to the toner particles; e.g., carbon black, a commercial red, blue or yellow dye, and since such dyes and/or pigments are well known in the xerographic art, no detailed enumeration of such dyes or pigments is deemed necessary for a full understanding of the invention. The toner is prepared by thoroughly mixing the various components to form a uniform dispersion of the dye or pigment in the toner material and thereafter the toner material is finely divided; e.g., to a particle size of less than about 30 microns, preferrably from about 2 to about 10 microns in average particle size. The preparation of toner compositions in this manner is well known in the art and therefore no detailed description thereof is deemed necessary for a full understanding of the invention.

The toner particles are mixed with the carrier, acquiring a charge having an opposite polarity to the carrier, whereby the toner particles adhere to and surround the carrier. The degree of contrast or other photographic qualities of the finished image, may be varied in part, by changing the relative proportions of carrier material and toner, with the choice of optimum proportions being well within the scope of those skilled in the art. In general, however, the ratio of carrier to toner varies from about 250:1 to about 25:1, depending on the toner material carrier.

The electrostatic developer produced in accordance with the invention may then be employed for developing a latent electrostatic image in accordance with procedures well-known in the art. Thus, for example, the developers of the invention are particularly suitable as developers in the "cascade" development technique, hereinabove described, employed in a xerographic process.

The invention is further described with reference to the following examples, which are illustrative of preferred embodiments thereof, but the scope of the invention is not to be limited thereby.

EXAMPLE I

A crushed soda-lime glass ranging in size from 20–35 mesh is placed on a non-wetting ceramic block formed of chrome oxide in a manner such that the individual particles to not touch each other. The block is placed in a controlled muffle furnace operated at a temperature of 1,850° F. and retained in the furnace for a period of 5 minutes to permit the glass particles to soften to the point at which the surface tension causes the glass particles to form a spherical shape.

The spherical glass beads are removed from the furnace, cooled and encapsulated in a resinous coating, as described in Example I of U.S. Pat. No. 2,613,551 to Walkup.

The coated carrier is then mixed with a toner comprising a styrene-n-butyl methacrylate copolymer, polyvinylbutyral and carbon black, produced by the method disclosed in Example I of U.S. Pat. No. 3,079,342 to Insalaco, to provide a composition containing about 1 percent toner, by weight. The cascading of the developer over a latent-electrostatic image formed on a xerographic plate provides good development with minimal background deposition.

EXAMPLE II

Crushed Flint glass ranging in size from 20 – 25 mesh is placed on a non-wetting ceramic block formed of graphite in a manner such that the individual particles do not touch each other. The block is placed in a controlled muffle furnace operated at a temperature of 1,350° F. and retained in the furnace for a period of four minutes to permit the glass particles to soften to the point at which the surface tension causes the glass particles to form a spherical shape. The spherical glass beads are removed from the furnace and cooled.

The glass beads are then mixed with a toner comprising a styrene-n-butyl methacrylate copolymer, polyvinylbutyral and carbon black, produced by the method disclosed in Example I of U.S. Pat. No. 3,079,342 to Insalaco to provide a composition containing about 0.5 percent toner, by weight. The cascading of the developer over a latent-electrostatic image formed on a xerographic plate provides good development with minimal background deposition.

The glass beads produced in accordance with the invention are clean and of a more uniform size than those presently produced in commercial processes. As a result of the more uniform sizing and nearer approximation to a spherical shape, the use of the glass beads either coated or uncoated, as an electrostatographic developer carrier enables the developer to be more easily rolled across an image-bearing surface, thereby facilitating effective transfer of toner to the image-bearing surface.

Numerous modifications and variations of the present invention are possible in light of the above teachings and therefore the invention may be practised otherwise than as particularly described.

What is claimed is:

1. A process for producing spherical glass beads for use as an electrostatographic developer carrier comprising:
   heating stationary glass particles isolated from each other in a plurality of small impressions in a non-wetting ceramic support, a single glass particle being placed and heated in a single impression, said glass particles being of a particle size to provide spheres having a particle size from about 30 microns to about 1,000 microns, said heating being effected to a temperature at which the glass particles are drawn-up into spherical glass beads; cooling the beads; and recovering the beads.

2. The process as defined in claim 1 wherein the glass particles are in solid form.

3. The process as defined in claim 1 wherein the glass particles are in molten form.

4. A process as defined in claim 1 wherein the glass particles are heated to a temperature from about 1,200° F. to about 2,210° F.

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