ELECTROSTATIC SPRAYING NOZZLE

Inventor: Thomas D. Tadewald, La Crosse, Wis.

Assignee: Universal Oil Products Company, Des Plaines, III.

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Primary Examiner—Lloyd L. King
Attorney, Agent, or Firm—James R. Hoatson, Jr.; Raymond H. Nelson; William H. Page, II

ABSTRACT

An electrostatic spraying nozzle in which at least a portion of the inner surface thereof consists of a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material will be provided with means for applying an electrical potential to said polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material whereby an electrical charge will be imparted to any material being discharged through the nozzle.

11 Claims, 2 Drawing Figures
ELECTROSTATIC SPRAYING NOZZLE

When applying a coating by means of a wet charge such as paint or by means of a dry charge such as powder to an object to be coated, the coating material, when under pressure, will have a tendency to vaporize and be discharged in a random manner before contacting the object to be coated. This is especially true when the coating material is forced through an orifice by pressure means such as an expanding gas plunger or any other pressure means known in the art. The pressure will tend to vaporize or break up the coating material into relatively small particles which may, due to their size, become lighter than air and thus be subject to air currents which will tend to further disperse the particles and thus may create a hazard when used. These hazards may include inhalation by a person utilizing the spraying equipment or a splattering of other objects which the user does not intend to coat. In addition, another disadvantage which may be present is that there will be a tendency for the coating material to be wasted by the loss of efficiency in the coating operation.

To overcome the disadvantages and/or difficulties which are present when utilizing a normal spraying apparatus, the flow of coating material from the source to the object to be coated may be controlled by utilizing an electrostatic spraying nozzle in which at least a portion of the inner surface thereof consists of a material of a type hereinafter set forth in greater detail whereby the atmosphere inside the nozzle can be electrically charged, this charge being imparted to the particles of the coating material which are being discharged through said nozzle.

It is therefore an object of this invention to provide an electrostatic spraying nozzle which will permit a more efficient use of the coating material.

A further object of this invention is to provide an electrostatic spraying nozzle which, after having an electrical potential applied thereto, will impart an electrical charge to material which is being discharged through the nozzle.

In one aspect an embodiment of this invention resides in an electrostatic spraying nozzle, at least a portion of an inner surface thereof consisting of a pyrolytic material containing a pyrolytic semi-conducting organic refractory oxide material, and for applying an electric potential to said pyrolytic material containing a pyrolytic semi-conducting organic refractory oxide material whereby an electrical charge is imparted to the material being discharged through said nozzle.

A specific embodiment of this invention is found in an electrostatic spraying nozzle consisting of an epoxy resin containing a pyrolytic semi-conducting organic refractory oxide material and having a rod comprising an epoxy resin containing a pyrolytic semi-conducting organic refractory oxide material positioned in said nozzle at a spaced distance from the interior wall portions of said nozzle and means for applying electric potential to said epoxy resin containing a pyrolytic semi-conducting organic refractory oxide material whereby an electrical charge is imparted to material being discharged through said nozzle.

Other objects and embodiments will be found in the following further detailed description of the present invention.
may be treated with vinyl chloride and vinyl acetate dissolved in a solvent which is thereafter allowed to evaporate thus forming the laminate. It is also possible to treat a reinforcing material such as canvas with a mixture of self-catalyzing epoxy resins and allowing the resins to set up at room temperature. It is to be understood that the aforementioned polymeric materials are only representative of the class of compounds which may be composited with the fillers to form the novel compositions of matter of the present invention, and that said present invention is not necessarily limited thereto.

The pyropolymeric semi-conducting organic refractory oxide material which is utilized as a filler for the polymeric material of a type hereinbefore set forth in greater detail may be prepared by heating an organic compound in the absence of oxygen and passing the pyrolyzable substance over the refractory oxide material in the vapor phase to form a carbonaceous pyropolymer thereon. The refractory oxide material which may be used as the base may be in any form such as loose or compacted dry powders, cast or calcined solids, heated solids, substrates in the form of flats, cylinders, and spheres, rods, pellets, etc. In the preferred embodiment of the present invention the refractory oxide base will be characterized as having a surface area of from 1 to about 500 square meters per gram. Illustrative examples of the refractory oxides which may be used will include alumina in various forms such as gamma-alumina and silica-alumina. In addition, it is also contemplated that the refractory oxide may be preimpregnated with a catalytic metallic substance such as platinum, platinum and rhenium, platinum and germanium, platinum and tin, platinum and lead, nickel and rhenium, tin, lead, germanium, etc.

Examples of organic substances which may be pyrolyzed to form the pyropolymer on the surface of the aforementioned refractory oxides will include aliphatic hydrocarbons, cycloaliphatic hydrocarbons, aromatic hydrocarbons, aliphatic halogen derivatives, aliphatic oxygen derivatives, aliphatic sulfur derivatives, aliphatic nitrogen derivatives, heterocyclic compounds, organometallic compounds, carbohydrates, etc. Some specific examples of these organic compounds which may be pyrolyzed will include ethane, propane, butane, pentane, ethylene, propylene, 1-butene, 2-butene, 1-pentene, 2-pentene, 1,3-butanediene, isoprene, cyclopentane, cyclohexane, methylcyclopentane, benzene, toluene, the isomeric xylenes, naphthalene, anthracene, chloromethane, bromomethane, chloroethane, bromoethane, chloropropene, bromopropene, isopropene, chlorobutane, bromobutane, isobutane, carbon tetra chloride, chloroform, 1,2-dichloroethane, 1,2-dichloropropene, 1,2-dichlorobutane, ethyl alcohol, n-propyl alcohol, isopropyl alcohol, n-butyl alcohol, sec-butyl alcohol, t-butyl alcohol, glycerol, glycerol, ethyl ether, isopropyl ether, butyl ether, ethyl mercaptan, n-propyl mercaptan, butyl mercaptan, methyl sulfide, ethyl sulfide, ethyl methyl sulfide, methyl propyl sulfide, dimethyl amine, diethyl amine, ethyl methyl amine, acetamide, propionamide, nitroethane, 1-nitropropane, 1-nitrobutane, acetonitrile, propionitrile, formic acid, acetic acid, oxalic acid, acrylic acid, formaldehyde, acid aldehyde, propionaldehyde, acetone, methyl ethyl ketone, methyl propyl ketone, ethyl propyl ketone, methyl formate, ethyl formate, ethyl acetate, benzyl chloride, phenol o-cresol, benzyl alcohol, hydroquinone, resorcinol, catechol, anisole, phenetole, benzaldehyde, acetoephone, benzophenone, benzoquinone, benzoic acid, phenyl acetate acid, hydrocinnamic acid, furo, furfurial, pyran, coumarin, indole, dextrose, sucrose, starch, etc. It is to be understood that the aforementioned compounds are only representative of the class of compounds which may undergo pyropolymerization and that the present invention is not necessarily limited thereto.

As hereinbefore set forth the aforementioned organic compounds are admixed with a carrier gas such as nitrogen or hydrogen, heated and passed over the refractory oxide base. The deposition of the pyropolymer on the surface of the base is effected at relatively high temperatures ranging from about 400⁰ to about 800⁰ C. and preferably in a range of from about 600⁰ to about 750⁰ C. It is possible to govern the electrical properties of the pyropolymeric semi-conducting organic refractory oxide material by regulating the temperature and the residence time during which the refractory oxide base is subjected to the treatment with the organic pyrolyzable substance. The thus prepared pyropolymeric semi-conducting organic refractory oxide material when recovered will possess a resistivity in the range of from about 10⁻¹⁰ to about 10⁰ ohm-centimeters. However, if so desired, the pyropolymeric semi-conducting organic refractory oxide material may also be subjected to additional exposure to elevated temperatures ranging from about 500⁰ to about 1200⁰ C. in an inert atmosphere and in the absence of additional pyrolyzable materials for various periods of time, said treatment resulting in the reduction of the electrical resistivity to the lowest resistivity values by as much as six orders of magnitude. While the above material describes one specific method of preparing a pyropolymeric semi-conducting organic refractory oxide material, it is to be understood that we do not wish to be limited to this method of preparing said material and that any suitable method in which a mono-layer of a carbonaceous material is formed on the surface of a refractory oxide material may also be utilized to form the desired filler.

The semi-conducting material comprising the polymeric material and the pyropolymeric semi-conducting organic refractory oxide material of the type hereinbefore set forth in greater detail may be prepared by any method known in the art. A semi-conducting refractory oxide material is comminuted by milling the material to form particles which possess a desired size, that is, less than 100 microns in size and preferably forming particles less than 1 micron. These particle sizes can be obtained by milling the refractory oxide material containing the pyropolymeric substance in a volatile solvent medium by means of a roll mill, colloidal mill or ball mill and thereafter flashing off or evaporating the solvents to obtain the dry powder. Examples of suitable solvents which may be employed in the milling process will include alcohols, ethers and ketones, etc. as such as methyl alcohol, ethyl alcohol, n-propyl alcohol, isopropyl alcohol, acetone, methyl isopropyl ketone, methyl isobutyl ketone, methyl ethyl ketone, ethyl ether, etc., the evaporation or flashing off step being effected at temperatures ranging up to about 100 C. or more. Following this, the powdered pyropolymeric semi-conducting organic refractory oxide material in the necessary particle size may then be admixed with a polymeric material, again in any suitable manner, the pyropolymeric semi-conducting organic refractory...
oxide material usually being present in an amount in the range of from about 95 to about 10% by weight of said material per weight of the finished composition of matter. One such type of mixing which will permit a thorough and uniform distribution of the pyropolymeric semi-conducting organic refractory oxide material throughout the body of the polymer is to admix said material with the polymer in a roll mill, said process being especially effective when the polymer is also in dry form. If so desired, the mixture may be further milled to adjust the particle size of the filler. Following this, a solvent of the type hereinafter set forth may also be added and the resulting mixture stirred until a uniform consistency has been reached. Thereafter the plastic may then be utilized for the final purpose such as a coating or by being poured into a mold whereby the desired shape or form of the electrostatic spraying nozzle is obtained. Another method of preparing the desired product is to admix the polymeric material and the pyropolymeric semi-conducting organic refractory oxide material and thereafter impregnate a backing compound such as canvas followed by pressing into a laminate which may vary in thickness. Following the lamination step the product may then be cut into the desired width, ground and further milled into a desired shape such as a rod which may also be used in the electrostatic spraying nozzle in a manner hereinafter set forth in greater detail.

The electrostatic spraying nozzle may, as hereinbefore set forth, consist of a nozzle which contains, on at least a portion of the inner surface thereof, a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material of the type hereinbefore set forth, the pyropolymeric semi-conducting organic refractory oxide material being applied thereto as a coating over the entire inner surface or on portions of the inner surface as strips or any other form which is desired. Alternatively speaking, the electrostatic spraying nozzle may also be formed entirely of the polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material, said nozzle being formed into any shape so desired. The nozzle may then be used in any form and may comprise a solid-cone wide-angle spray, a hollow-cone wide-angle spray, a narrow-angle spray, a pressure atomizing spray, a tangential spray, a flat spray, a deflector or impact spray, an air or gas atomizing spray or a rotating disc spray. The spray nozzle will be provided with means by which an electrical potential can be applied to the polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material, said means being any of those which are well known in the art. In the event that the entire spray nozzle consists of the polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material, the means for applying the electrical potential are fastened directly to the spray nozzle. Conversely speaking, if the spraying nozzle contains only the polymeric material on at least a portion of the inner surface, the remainder of the body of the spraying nozzle may be formed of metal or plastic different in nature from that of the polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material. The means are attached to said nozzle with connecting means such as wires passing through said nozzle and connecting with the polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material so that an electrical potential may be applied to the polymeric material. In the event that the spraying nozzle has a needle or rod provided therein, said needle or rod consisting of a polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material, it is also contemplated that the electrical potential is to be applied to this rod or needle so that an electrical charge will be imparted to the material passing through said nozzle.

The electrostatic spraying nozzle of the present invention will be more readily understood if explained in conjunction with the attached drawings which illustrate some embodiments of the invention. However, it is to be understood that these figures are only for purposes of illustration and that the electrostatic spray nozzle of the present invention is not necessarily limited to the embodiment set forth in the drawings.

FIG. 1 represents a sectional side view of the spray apparatus.

FIG. 2 is a top view of a modification of the spray nozzle.

Referring now to the drawings, FIG. 1 illustrates one embodiment of the invention and represents a sectional side view of an apparatus in which a material which is to be applied to the surface of an object such as paint or powder is contained in a reservoir 1. In this embodiment of the invention reservoir 1 is provided with an electrostatic spraying nozzle 2 which is attached to reservoir 1. Electrostatic spraying nozzle 2 consists of a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material and is provided with means 3 attached to nozzle 2 whereby an electrical potential is applied thereto through line 4. In addition nozzle 2 is also provided with a rod-like member 5 which is positioned in said nozzle at a space distance from the interior wall portion 6 of nozzle 2. Rod 5 is also connected by means not shown in the drawing to the means 3 whereby an electrical potential is also imparted to rod 5. The coating material which is contained in reservoir 1 is forced out through holes 7 by pressure from an exterior source not shown in the drawing through line 8. The coating material, either in liquid or dry form, in passing through nozzle 2 has an electrical charge imparted thereto due to the electrical potential which has been applied to nozzle 2 and rod 5. The object which is to be coated will be provided with an opposite electrical charge thereby setting up an electromagnetic field. The opposite attraction of the object will cause a migration of the coating material, such as paint or powder in particle form, to the object. By utilizing this system of coating, it is possible to apply the paint or powder to all surfaces of the object simultaneously with a concurrent minimization of the loss of coating particles.

FIG. 2 in the drawing is a top view of another modification of the spray nozzle of the present invention. In this modification spray nozzle 9 may be constructed of any material such as cast iron, cast brass, bronze, steel, monel metal, hard lead, ceramics, hard rubber, glass, etc. Spray nozzle 9 has bonded thereto on the inner surface thereof at spaced intervals a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material 10. The polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material may be in the form of ribbons bonded to the inner surface of spray nozzle 9 or in any other shape so desired. The polymeric material con-
taining the pyropolymeric semi-conducting organic refractory oxide material is connected by means not shown in the drawing to electrical means which in turn are connected to an electrical power source. When the coating material, such as paint or powder, is forced from reservoir through hole, the electrical potential which has been imparted to the polymeric material containing the pyropolymeric semi-conducting organic refractory oxide material will impart an electrical charge to the particles which will, in turn, create an electromagnetic field due to the attraction from an opposite charge possessed by the object to be coated.

It is to be understood that the electrostatic spraying nozzle containing the polymeric material which contains a pyropolymeric semi-conducting organic refractory oxide material may be of any geometric design or shape so desired, including but not limited to cones, cylinders, spheres, cubes, etc.

It is also contemplated within the scope of this invention that in another modification, the rod or nozzle which may, if so desired, be present in the spray nozzle may also be prepared by admixing a polymeric material with a pyropolymeric semi-conducting organic refractory oxide material in a manner similar to that hereinbefore set forth, following which the polymeric material such as a phenolic resin impregnated with the pyropolymeric semi-conducting organic refractory oxide material is milled into a rod or needle. The rod is then coated by treatment with a mixture consisting of a dissimilar polymeric material such as an epoxy resin impregnated with a pyropolymeric semi-conducting organic refractory oxide material and containing an accelerator and hardener. The rod may be dipped into the coating solution following which it is cured at an elevated temperature which may be above about 300°C for a period of time sufficient to harden the coating. The thus formed rod would possess the required internal conductivity while the exterior coating would provide a surface conductivity and, in addition, result in an improved appearance of the rod.

The following example is given to illustrate one embodiment of the invention. However, it is to be understood that this example is given only for representative purposes and that the present invention is not to be construed to be limited thereto.

**EXAMPLE**

A pyropolymeric semi-conducting organic refractory oxide material is prepared by pyrolyzing gamma-alumina in a benzene and nitrogen environment for a period of 1 hour at 700°C followed by wet milling in an isopropyl alcohol medium and subsequent drying. Following this 200 grams of the pyropolymeric semi-conducting organic refractory oxide material is blended with polypropylene pellets at a temperature of 260°C, for a period of 10 minutes in a nitrogen atmosphere until the mixture is homogenous. The polypropylene containing the pyropolymeric semi-conducting organic refractory oxide material is then injection molded into the form of a nozzle and cured. Following the curing, the nozzle is removed from the mold and attached to a paint reservoir, the top of said reservoir being provided with a series of minute orifices. A source of electrical power is attached to the side of the nozzle. In addition, the reservoir for the paint is provided with a rod positioned in such a manner so that the rod is at a spaced distance from the interior wall portion of the nozzle, said rod also being connected to the source of electrical power. The rod is prepared by pyrolyzing gamma-alumina which has been impregnated with dextrose at a temperature of about 900°C for a period of about 1.5 hours. Upon completion of the time period, the resulting pyropolymeric semi-conducting organic refractory oxide material is milled with acetone and dried. The pyropolymeric semi-conducting organic refractory oxide material is suspended in isopropyl alcohol and admixed with a thermosetting phenolic resin. After thoroughly admixing the two components for a period of 15 minutes, the solution is brushed onto an 8 ounce canvas, the resin-soaked canvas is then placed in an oven at a temperature of about 300°F to form an intermediate stage, cured and thereafter is pressed into a laminate. The laminate is then cut, ground, and milled to form a rod. The thus formed rod is, as hereinbefore set forth, positioned in the nozzle.

The paint which is contained in the reservoir is forced out of said reservoir through the minute orifices which the nozzle and rod have an electrical potential imparted thereto. The vaporized paint particles when passing through the nozzle pick up an electrical charge. The charged paint particles are attracted to an object which is to be painted, thus setting up an electromagnetic field which causes the paint to be directed at all surfaces of the object with a minimal loss of paint particles.

1. A claim as my invention.
   1. An electrostatic spraying nozzle, at least a portion of an inner surface thereof consisting of a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material, and means for applying an electric potential to said polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material whereby an electrical charge is imparted to the material being discharged through said nozzle.
   2. The nozzle of claim 1 further characterized in that said inner surface formed of a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material comprises the interior wall of said nozzle.
   3. The nozzle of claim 1 further characterized in that said inner surface formed of a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material comprises a rod-like member positioned in said nozzle at a spaced distance from said interior wall portion of said nozzle.
   4. The nozzle of claim 3 further characterized in that said rod-like member comprises a single rod positioned in said nozzle to provide an electrical charge radially in all directions.
   5. The nozzle of claim 3 further characterized in that said entire rod comprises a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material.
   6. The nozzle of claim 1 further characterized in that said entire nozzle is formed at a polymeric material containing a pyropolymeric semi-conducting organic refractory oxide material.
   7. The nozzle of claim 1 further characterized in that said polymeric material is a phenolic resin.
   8. The nozzle of claim 1 further characterized in that said polymeric material is a polyester resin.
   9. The nozzle of claim 1 further characterized in that said polymeric material is a polypropylene resin.
10. The nozzle of claim 1 further characterized in that said polymeric material is nylon.