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LIQUID DEVELOPERS FOR DEVELOPING ELECTROSTATIC IMAGES

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ABSTRACT OF THE DISCLOSURE

A liquid developer for developing electrostatic images in electrophotography in which asphaltic bitumen reacting with sulphur and sulphur compounds provides the image forming material in minute particulate form with the image forming material suspended in an insulating carrier liquid for producing a visible image of high degree of resolution and permanent copy.

The present invention relates to electrophotography where an electrostatic latent image is developed into a visible image by a liquid developer.

Heretofore electrostatic latent images have been developed by means of dry toners and also by means of a liquid developer in which fine toner particles are suspended in a carrier liquid and the latent image is developed by wetting the latent image carrying base so that the toner particles adhere by electrostatic attraction on the electrically charged areas after the light exposure.

In such prior liquid developers, carbon black, iron oxide, Phthalocyanine Blue, zinc oxide, and so forth, are generally used as suitable pigments and a fixing agent such as alkyd resin or linseed oil is mixed with the pigment to render the pigment fast or permanent and the fixing agent may also act as the control agent by a suitable selection thereof. The toner particles which are normally ground down to size are dispersed in a high resistivity carrier liquid to produce the prior art liquid developers.

The prior art liquid developers have not been entirely satisfactory because the milling of the pigment and the milling of the fixing agent in a ball mill required an excessive amount of time to reduce the toner particles to the required fineness. The prior art liquid developer of the carrier liquid and the pigment particles deteriorates on prolonged standing and even though the prior art liquid developer may operate satisfactorily if used promptly after preparation, the usefulness rapidly deteriorates and the liquid developer becomes unsuitable for practical work after one week from the time of preparation and therefore the unused surplus developer goes to waste. It has therefore been necessary to mix the toner particles in the liquid carrier each time development is to take place and this is inconvenient and uneconomical. Further the toner particles are difficult to maintain in suspension and the toner tends to adhere to non-image or background areas and produce images of generally low contrast and a dirty appearance.

An object of the present invention is to overcome the objections to the prior art liquid developers and produce a developer resulting in black images with high resolution which gives a permanent copy.

Another object is to provide a liquid developer which does not require a separate fixing agent.

A further object is to provide a liquid developer in which the image forming material will stay in suspension in the insulating carrier liquid for an extended period of time.

A further object is to provide a chemically stable liquid developer which does not deteriorate on prolonged standing.

Briefly, the liquid developer of the present invention uses asphaltic bitumen as the image forming material and the asphaltic bitumen also serves as the fixing agent to maintain the image forming particles on the copy sheet. Asphaltic bitumen contains some resins which are soluble in the insulating carrier liquid and if these soluble resins are left in the liquid developer the resulting image is brown with low contrast and the asphaltic bitumen tends to adhere only to the edges of the charged areas, thereby producing an unsatisfactory image on the copy sheet.

The present invention provides for removal of these soluble resins and the addition of sulphur, organic materials, and a sulfide whereby the so treated asphaltic bitumen when suspended in an insulating carrier liquid produces a satisfactory image of good contrast and clear background.

Asphaltic bitumen, which is a mixture of artificial or natural petroleum hydrocarbon including liquid, semi-liquid or solid particles, is mixed with sulphur and organic materials in an inert liquid at 200° C. for thirty hours and the reaction product therefrom is oxidized in sodium sulfide solution for five hours at 80° C. by airing. The resins in the reaction product which are soluble in an insulating carrier liquid are removed from the sodium sulfide treated reaction product. The remaining reaction product after the removal of the soluble resin is the image forming material of the present invention and such image forming material is dispersed in an insulating carrier liquid by stirring. The liquid developer which includes the image forming material of the present invention suspended in an insulating carrier liquid possesses reliable and proper positive electrical characteristics and the image forming materials stay in better suspension than the toner particles of the prior art. Furthermore, the image forming materials of the present invention do not adhere to non-image or background areas and a dense image is obtained with higher contrast and definition than has been obtainable when using only asphaltic bitumen for the image forming material.

The following examples are for the purpose of illustration to facilitate the practice of the invention.

EXAMPLE 1

150 g. of asphaltic bitumen (purchased from Daikyo Oil Co., under the trademark "Asphalt Compound"), 15 g. of sulfur and 30 g. of phenol are stirred in a 300 cc. flask having three necks at a temperature of 200° C. for thirty hours. The reaction product is added to sodium sulfide solution and stirred at 80° C. for three hours while airing.

The resins in this reaction product which are soluble in aliphatic hydrocarbon solvent are then removed in the filtrate by filtration. The residue is used for the image-forming material. 10 g. of image-forming material produced by the above procedure is dispersed in an insulating carrier liquid of 1000 cc. of aliphatic hydrocarbon solvent (purchased from Esso Standard Oil Co. under the trademark "Isoper H") to produce a liquid developer according to the present invention. The liquid developer is charged 100% positive and the image-forming materials dispersed in the insulating carrier liquid thereof adhere to negatively charged electrostatic latent image areas without being influenced by the edges of the charged areas so that a uniform dense image is obtained in the charged

areas of the latent image. A black brown image of high resolution and high contrast is obtained from this liquid developer.

EXAMPLE 2

100 g. of asphaltic bitumen (purchased from Maruzen Oil Co., under the trademark "Asphalt Brown"), 10 g. of sulfur, 15 g. of chlorobenzene and 200 cc. of aliphatic hydrocarbon solvent (purchased from Shell Co. under the trademark "Shell-sol 71") are stirred in a 500 cc. flask having three necks at a temperature of 180° C. for twenty hours. The reaction product therefrom is added to a sodium sulfide solution and stirred at 80° C. for five hours while airing. The resins which are soluble in an insulating carrier liquid of an aliphatic hydrocarbon solvent are removed from the resulting reaction product by filtration and the residue remaining provides the image-forming materials. 10 g. of this residue of image-forming materials is dispersed in 100 cc. of Shell-sol 71 to produce a liquid developer of the present invention. This liquid developer is charged 100% positive and when the developer is applied to a negatively charged latent image, the image-forming materials adhere to the latent image without being influenced by the edge effect of the charged areas and a black brown image of high resolution is obtained.

EXAMPLE 3

100 g. of Asphalt Compound, 10 g. of sulfur, 10 g. of Spirit Black and 100 cc. of aliphatic hydrocarbon solvent (purchased from Kyodo Oil Co., under the trademark "White-sol") are stirred in a 300 cc. flask having three necks at 160° C. for ten hours. The reaction product is oxidized by airing. The resins of the reaction product which are soluble in aliphatic hydrocarbon solvent are removed in the filtrate of an aliphatic hydrocarbon solvent and the residue is retained for use as the image forming material. 10 g. of such image forming material is dispersed in an insulating carrier liquid of 1000 cc. of White-sol to produce a liquid developer according to the present invention. The liquid developer is charged 100% positive and image-forming materials dispersed in the insulating carrier liquid adhere to negatively charged electrostatic latent image areas without being influenced by the edges of the charged areas when the liquid developer is applied to a negatively charged electrostatic latent image resulting in a dense black image with high resolution.

It will be apparent that the image-forming materials are stirred with the insulating carrier liquid to obtain the proper dispersion and the resulting liquid developer produces high resolution permanent images by the electrostatic reproduction process.

The liquid developers of the present invention are self-fixing without employing an additional fixing agent and it will therefore be apparent that the present invention provides for efficiently making copies by the electrophotographic process.

It will be apparent that changes may be made within

the practice of the invention as defined by the valid scope of the claims.

What is claimed is:

1. A liquid developer for developing electrostatic images comprising a suspension of (1) an image-forming material comprising a reaction product of asphaltic bitumen, sulfur and an organic compound selected from the group consisting of phenol, chlorobenzene and Spirit Black in (2) an insulating carrier liquid comprising an aliphatic hydrocarbon.

2. A liquid developer described in claim 1 comprising a suspension in which said image-forming material is a reaction product obtained by stirring asphaltic bitumen, sulfur and phenol at 200° C. for 30 hours, adding the resulting mixture at 80° C. for 3 hours while airing, removing the resins soluble in aliphatic hydrocarbons by filtration, and recovering the residue.

3. A liquid developer described in claim 1 comprising a suspension in which said image-forming material is a reaction product obtained by mixing asphaltic bitumen with sulfur, chlorobenzene and an aliphatic hydrocarbon, stirring and heating the mixture for several hours, adding the resulting product to a sodium sulfide solution, stirring the mixture at a moderate temperature while stirring, and removing the resins soluble in aliphatic hydrocarbons by filtration; the residue being dispersed in said insulating liquid.

4. A liquid developer described in claim 1 comprising a suspension in which said image-forming material is a reaction product obtained by mixing asphalt, sulfur and Spirit Black in an aliphatic hydrocarbon solvent, oxidizing the mixture by airing, removing the resins soluble in the hydrocarbon solvent; the residue being dispersed in said insulating carrier liquid.

5. A liquid developer described in claim 1 comprising a suspension in which the image-forming material is a reaction product obtained by stirring and heating asphaltic bitumen, sulfur and an organic compound selected from the group consisting of phenol, chlorobenzene and Spirit Black, adding the resulting product to a sodium sulfide solution, stirring and heating the mixture while airing, and removing the resins soluble in the insulating carrier liquid by filtration; the residue being suspended in said carrier liquid.

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