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(54) **Ink jet recording element and printing method**

Tintenstrahlauzeichnungselement und Druckverfahren

Elément pour impression par jet d'encre et procédé d'impression

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(56) References cited:
EP-A- 0 879 709 **EP-A- 1 138 511**

- **IRVING SAX N ET AL: "Hawley's Condensed Chemical Dictionary, passage" , HAWLEY'S CONDENSED CHEMICAL DICTIONARY, NEW YORK, VAN NOSTRAND REINHOLD, US, XP002251837 * page 299 - page 300 ***
- **KASAHARA K: "A NEW QUICK-DRYING, HIGH-WATER-RESISTANT GLOSSY INK JET PAPER" PROCEEDINGS. IS&T'S PICS CONFERENCE. ANNUAL CONFERENCE, PROCEEDINGS OF CONFERENCE OF THE SOCIETY FOR IMAGING SCIENCE AND TECHNOLOGY, XX, XX, 1998, pages 150-152, XP008020532**

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Description

[0001] This invention relates to an ink jet recording element and a printing method using the element. More particularly, this invention relates to an ink jet recording element containing encapsulated particles.

[0002] In a typical ink jet recording or printing system, ink droplets are ejected from a nozzle at high speed towards a recording element or medium to produce an image on the medium. The ink droplets, or recording liquid, generally comprise a recording agent, such as a dye or pigment, and a large amount of solvent. The solvent, or carrier liquid, typically is made up of water, an organic material such as a monohydric alcohol, a polyhydric alcohol or mixtures thereof.

[0003] An ink jet recording element typically comprises a support having on at least one surface thereof an ink-receiving or image-forming layer, and includes those intended for reflection viewing, which have an opaque support, and those intended for viewing by transmitted light, which have a transparent support.

[0004] It is well known that in order to achieve and maintain photographic-quality images on such an image-recording element, an ink jet recording element must:

- Be readily wetted so there is no puddling, i.e., coalescence of adjacent ink dots, which leads to non-uniform density
- Exhibit no image bleeding
- Exhibit the ability to absorb high concentrations of ink and dry quickly to avoid elements blocking together when stacked against subsequent prints or other surfaces
- Exhibit no discontinuities or defects due to interactions between the support and/or layer(s), such as cracking, repellencies, comb lines and the like
- Not allow unabsorbed dyes to aggregate at the free surface causing dye crystallization, which results in bloom or bronzing effects in the imaged areas
- Have an optimized image fastness to avoid fade from contact with water or radiation by daylight, tungsten light, or fluorescent light

[0005] An ink jet recording element that simultaneously provides an almost instantaneous ink dry time and good image quality is desirable. However, given the wide range of ink compositions and ink volumes that a recording element needs to accommodate, these requirements of ink jet recording media are difficult to achieve simultaneously.

[0006] Ink jet recording elements are known that employ porous or non-porous single layer or multilayer coatings that act as suitable image receiving layers on one or both sides of a porous or non-porous support. Recording elements that use non-porous coatings typically have good image quality but exhibit poor ink dry time. Recording elements that use porous coatings typically contain colloidal particulates and have poorer image quality but exhibit superior dry times.

[0007] While a wide variety of different types of porous image-recording elements for use with ink jet printing are known, there are many unsolved problems in the art and many deficiencies in the known products which have severely limited their commercial usefulness. A major challenge in the design of a porous image-recording layer is to be able to obtain good quality, crack-free coatings with as little non-particulate matter as possible. If too much non-particulate matter is present, the image-recording layer will not be porous and will exhibit poor ink dry times.

[0008] EPA 813,978 A1 relates to an ink jet recording element wherein an ink absorption layer is used comprising fine particles, a hydrophilic binder and oil drops. However, there is a problem with this element in that the oil drops will migrate to the surface and cause changes in the appearance of the image.

[0009] U.S. Patent 6,197,381 B1 relates to the production of a recording sheet from a coating composition comprising fine inorganic particles, a hydrophilic binder and a hydrophobic latex having a glass transition temperature of not more than 30 ° C. However, there is a problem with this recording sheet in that it exhibits poor ink dry times.

[0010] Final Program and Proceedings of IS&T NIP14, pp. 150-152, relates to microporous paper having an image-receiving layer comprising inorganic core/organic shell particles. The organic shells are cationic polymers. However, there is no reference to the properties or identities of the cationic polymers.

[0011] EP-A-0879709 discloses an ink jet recording element comprising an undercoat layer comprising an aqueous emulsion of a composite product of a copolymer having a glass transition temperature of 75°C, in which colloidal silica particles appear to be coated with a styrene-2-methylhexyl acrylate copolymer. Such composite product is used to enhance gloss and improves the releasing property of a cast-coated image-receiving layer.

[0012] EP-A-1138511, which was filed before but published after the priority date of the present application, discloses an ink jet recording element comprising a porous layer having inorganic particles encapsulated with an organic polymer having a $T_g < 20^\circ\text{C}$ and colloidal silica particles, but does not mention the use of a crosslinker for a binder.

[0013] It is an object of this invention to provide a porous ink jet recording element that has instant dry time when used in ink jet printing. It is another object of this invention to provide a porous recording element that has good coating quality, especially reduced cracking. It is another object of this invention to provide an ink jet recording element that exhibits good image quality after printing.

[0014] Another object of the invention is to provide a printing method using the above-described element.

[0015] These and other objects are achieved in accordance with the invention which comprises an ink jet recording element comprising a substrate having thereon a porous image-receiving layer comprising

- 5 a) inorganic particles encapsulated with an organic polymer having a Tg of less than 100 ° C wherein said organic polymer is derived from a cationic or anionic monomer that contains a quaternary ammonium, pyridinium, imidazolium, sulfonate, carboxylate or phosphonate functionality;
 b) particles having a mean particle size of up to 5 μm; and
 c) a polymeric binder in an amount insufficient to alter its porosity and a crosslinker which acts upon the binder.

10 **[0016]** The ink jet recording element of the invention has good coating and image quality when used in ink jet printing.

[0017] Another embodiment of the invention relates to an ink jet printing method comprising the steps of:

- 15 I) providing an ink jet printer that is responsive to digital data signals;
 II) loading the printer with the ink jet recording element described above;
 15 III) loading the printer with an ink jet ink composition; and
 IV) printing on the image-receiving layer using the ink jet ink composition in response to the digital data signals.

20 **[0018]** Any inorganic particle may be used to prepare the (a) encapsulated particles of the invention, such as metal oxides, hydrated metal oxides, boehmite, clay, calcined clay, calcium carbonate, aluminosilicates, zeolites or barium sulfate. In a preferred embodiment of the invention, the inorganic particles are metal oxides such as silica, available commercially as Nalco® (Nalco Co.), Ludox® (DuPont Corp), Snowtex® (Nissan Chemical Co.), alumina, zirconia or titania. In another preferred embodiment of the invention, the particle size of the inorganic particles is from 5 nm to 1000 nm.

25 **[0019]** The (a) encapsulated particles used in the invention may be prepared in a preferred embodiment by silane coupling chemistry wherein first the surface of the inorganic particles is modified with a silane-containing material, and then one or more monomers is polymerized in the presence of the modified particles. Useful polymerization techniques can be found in "Emulsion Polymerization and Emulsion Polymers", edited by P.A. Lovell and M.S. E1-Aassar, John Wiley and Sons, 1997.

30 **[0020]** Silane coupling agents useful for the modification of inorganic particles as described above include 3-aminopropyltriethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyl-diethoxymethylsilane, 3-aminopropyl-dimethoxymethylsilane, 3-aminopropyl-ethoxydimethylsilane, 3-aminopropyl-methoxydimethylsilane, N-(2-aminoethyl)-3-aminopropyltrimethoxysilane, N-(2-aminoethyl)-3-aminopropyltriethoxysilane, N-(2-aminoethyl)-3-aminopropylmethyl dimethoxysilane, N-(2-aminoethyl)-3-aminopropylmethyl-diethoxysilane, 4-aminobutyltriethoxysilane, 4-aminobutyl-trimethoxysilane, N-(2-aminoethyl)-3-aminoisobutylmethyl-dimethoxysilane, and other silane coupler agents listed in Gelest catalogue, pp.105-259(1997). Most preferred silane coupling agents for the modification of inorganic colloids used in the invention include 3-aminopropyl-triethoxysilane, 3-aminopropyl-trimethoxysilane, 3-aminopropyl-diethoxymethylsilane, 3-aminopropyl-dimethoxymethylsilane, N-(2-aminoethyl)-3-aminopropyl-trimethoxysilane, N-(2-aminoethyl)-3-aminopropyl-triethoxysilane, N-(2-aminoethyl)-3-aminopropyl-methyl-dimethoxysilane, N-(2-aminoethyl)-3-aminopropyl-methyl-diethoxysilane.

40 **[0021]** Another embodiment of the invention relates to preparing the (a) encapsulated particles by polymerizing one or more monomers in the presence of the inorganic particles, without first modifying the surface. Another embodiment relates to preparing these encapsulated particles by adsorbing polymer onto the surface of the inorganic particles. Another embodiment relates to preparing these encapsulated particles by forming chemical bonds between the inorganic particles and the polymer either before or after it is formed from the monomer.

45 **[0022]** The organic polymer used for encapsulation of the inorganic particles employed in the invention has a Tg of less than 100°C, preferably from -50°C to 65°C. Methods for determining Tg values of the organic polymers are described in "Introduction to Physical Polymer Science", 2nd Edition by L.H. Sperling, published by John Wiley & Sons, Inc., 1992. For each of the organic polymers in Table 1 below, the Tg value was calculated as the weighted sum of the Tg values for homopolymers derived from each of the individual monomers, *i*, that make up the polymer:

$$T_g = \sum_i W_i X_i$$

55 where *W* is the weight percent of monomer *i* in the organic polymer, and *X* is the Tg value for the homopolymer derived from monomer *i*. Tg values for the homopolymers were taken from "Polymer Handbook", 2nd Edition by J. Brandrup

and E.H. Immergut, Editors, published by John Wiley & Sons, Inc., 1975.

[0023] The organic polymer of the (a) encapsulated particles is derived from a cationic or anionic monomer that contains a quaternary ammonium, pyridinium, imidazolium, sulfonate, carboxylate or phosphonate groups. Examples of useful cationic monomers include such as a salt of trimethylammoniummethyl acrylate and trimethylammoniummethyl methacrylate, a salt of triethylammoniummethyl acrylate and triethylammoniummethyl methacrylate, a salt of dimethylbenzyl-ammoniummethyl acrylate and dimethylbenzylammoniummethyl methacrylate, a salt of dimethylbutylammoniummethyl acrylate and dimethylbutylammoniummethyl methacrylate, a salt of dimethylhexylammoniummethyl acrylate and dimethylhexylammoniummethyl methacrylate, a salt of dimethyloctyl-ammoniummethyl acrylate and dimethyloctyl-ammoniummethyl methacrylate, a salt of dimethyldodeceylammoniummethyl acrylate and dimethyldoceyl-ammoniummethyl methacrylate, a salt of dimethyloctadecylammoniummethyl acrylate and dimethyloctadecylammoniummethyl methacrylate, etc. Salts of these cationic monomers which can be used include chloride, bromide, methylsulfate, triflate, etc.

[0024] Examples of the organic polymers which can be used in the invention to prepare the a) encapsulated particles include poly(n-butylacrylate-co-vinylbenzyltrimethylammonium chloride), poly(n-butylacrylate-co-vinylbenzyltrimethylammonium bromide), poly(n-butylacrylate-co-vinylbenzyltrimethylammonium chloride) and poly(n-butylacrylate-co-vinylbenzyltrimethylammonium chloride). In a preferred embodiment of the invention, the polymer can be poly(n-butylacrylate-co-trimethylammoniummethyl acrylate methylsulfate), poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) or poly(n-butylacrylate-co-vinylbenzyltrimethylammonium chloride).

[0025] Any weight ratio of inorganic particle to organic polymer in the a) encapsulated particles may be used. In a preferred embodiment, the weight ratio is 0.2:1 to 20:1. In another preferred embodiment, the weight ratio is 1:1 to 10:1.

[0026] Following are examples of inorganic particles encapsulated with an organic polymer which can be used in the invention:

Table 1

Encapsulated Particle	Inorganic Particle, A	Organic Polymer, B	Tg of B (°C)	Ratio of A/B
1	Nalco® 2329	Poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (2:1)	1	5:1
2	Nalco® 2329	Poly(ethyl methacrylate-co-butyl methacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (1:1:1)	44	3.8:1
3	Nalco® 2329	Poly(ethyl methacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (2:1)	58	3.8:1
4	Nalco® 2329	Poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (1:1)	12	1:1
5	Nalco® 2329	Poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (1:1)	12	2:1
6	Nalco® 2329	Poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (1:1)	12	9:1
7	Ludox® CI	Poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (2:1)	1	5:1
8	Snowtex® OL	Poly(n-butylacrylate-co-trimethylammoniummethyl methacrylate methylsulfate) (2:1)	1	5:1

[0027] In a preferred embodiment of the invention, (b) particles which may be used include metal oxides or hydroxides, such as alumina, boehmite, hydrated aluminum oxide, titanium oxide or zirconium oxide; clay; calcium carbonate; calcined clay; inorganic silicates; barium sulfate; or organic particles such as polymeric beads. Examples of organic

particles useful in the invention are disclosed and claimed in U.S. Patent Application Serial Numbers: 09/458,401, filed Dec. 10, 1999; 09/608,969, filed June 30, 2000; 09/607,417, filed June 30, 2000; 09/608,466 filed June 30, 2000; 09/607,419, filed June 30, 2000; and 09/822,731, filed March 30, 2001. The mean particle size of the (b) particles is up to 5 μm .

5 **[0028]** In a preferred embodiment of the invention, the (a) encapsulated inorganic particles comprise up to 50 wt. % of the image-receiving layer. In another preferred embodiment of the invention, the (b) particles comprise at least 50 wt. % of the image receiving layer.

10 **[0029]** The image-receiving layer of the invention also contains a polymeric binder in an amount insufficient to alter its porosity. In a preferred embodiment, the polymeric binder is a hydrophilic polymer, such as poly(vinyl alcohol), poly(vinyl pyrrolidone), gelatin, cellulose ethers, poly(oxazolines), poly(vinylacetamides), partially hydrolyzed poly(vinyl acetate/vinyl alcohol), poly(acrylic acid), poly(acrylamide), poly(alkylene oxide), sulfonated or phosphated polyesters and polystyrenes, casein, zein, albumin, chitin, chitosan, dextran, pectin, collagen derivatives, collodian, agar-agar, arrowroot, guar, carrageenan, tragacanth, xanthan, rhamsan and the like; or a low Tg latex such as poly(styrene-co-butadiene), a polyurethane latex, a polyester latex, poly(n-butyl acrylate), poly(n-butyl methacrylate), poly(2-ethylhexyl acrylate), a copolymer of n-butylacrylate and ethylacrylate, a copolymer of vinylacetate and n-butylacrylate, etc. The polymeric binder should be chosen so that it is compatible with the aforementioned particles.

15 **[0030]** The amount of binder used should be sufficient to impart cohesive strength to the ink jet recording element, but should also be minimized so that the interconnected pore structure formed by the aggregates is not filled in by the binder. In a preferred embodiment of the invention, the weight ratio of the binder to the total amount of particles is from 1:20 to 1:5.

20 **[0031]** In addition to the image-receiving layer, the recording element may also contain a base layer, next to the support, the function of which is to absorb the solvent from the ink. Materials useful for this layer include inorganic particles and polymeric binder.

25 **[0032]** In addition to the image-receiving layer, the recording element may also contain a layer on top of the image-receiving layer, the function of which is to provide gloss. Materials useful for this layer include sub-micron inorganic particles and/or polymeric binder.

30 **[0033]** The support for the ink jet recording element used in the invention can be any of those usually used for ink jet receivers, such as resin-coated paper, paper, polyesters, or microporous materials such as polyethylene polymer-containing material sold by PPG Industries, Inc., Pittsburgh, Pennsylvania under the trade name of Teslin®, Tyvek® synthetic paper (DuPont Corp.), impregnated paper such as Duraform®, and OPPalyte® films (Mobil Chemical Co.) and other composite films listed in U.S. Patent 5,244,861. Opaque supports include plain paper, coated paper, synthetic paper, photographic paper support, melt-extrusion-coated paper, and laminated paper, such as biaxially oriented support laminates. Biaxially oriented support laminates are described in U.S. Patents 5,853,965; 5,866,282; 5,874,205; 5,888,643; 5,888,681; 5,888,683; and 5,888,714. These biaxially oriented supports include a paper base and a biaxially oriented polyolefin sheet, typically polypropylene, laminated to one or both sides of the paper base. Transparent supports include glass, cellulose derivatives, e.g., a cellulose ester, cellulose triacetate, cellulose diacetate, cellulose acetate propionate, cellulose acetate butyrate; polyesters, such as poly(ethylene terephthalate), poly(ethylene naphthalate), poly(1,4-cyclohexanedimethylene terephthalate), poly(butylene terephthalate), and copolymers thereof; polyimides; polyamides; polycarbonates; polystyrene; polyolefins, such as polyethylene or polypropylene; polysulfones; polyacrylates; polyetherimides; and mixtures thereof. The papers listed above include a broad range of papers, from high end papers, such as photographic paper to low end papers, such as newsprint. In a preferred embodiment, Ektacolor paper made by Eastman Kodak Co. is employed.

35 **[0034]** The support used in the invention may have a thickness of from 50 to 500 μm , preferably from 75 to 300 μm . Antioxidants, antistatic agents, plasticizers and other known additives may be incorporated into the support, if desired.

40 **[0035]** In order to improve the adhesion of the image-receiving layer to the support, the surface of the support may be subjected to a corona-discharge treatment prior to applying the image-receiving layer. The adhesion of the image-receiving layer to the support may also be improved by coating a subbing layer on the support. Examples of materials useful in a subbing layer include halogenated phenols and partially hydrolyzed vinyl chloride-co-vinylacetate polymer.

45 **[0036]** The coating composition can be coated either from water or organic solvents, however water is preferred. The total solids content should be selected to yield a useful coating thickness in the most economical way, and for particulate coating formulations, solids contents from 10-40 wt. % are typical.

50 **[0037]** Coating compositions employed in the invention may be applied by any number of well known techniques, including dip-coating, wound-wire rod coating, doctor blade coating, gravure and reverse-roll coating, slide coating, bead coating, extrusion coating, curtain coating and the like. Known coating and drying methods are described in further detail in Research Disclosure no. 308119, published Dec. 1989, pages 1007 to 1008. Slide coating is preferred, in which the base layers and overcoat may be simultaneously applied. After coating, the layers are generally dried by simple evaporation, which may be accelerated by known techniques such as convection heating.

55 **[0038]** The coating composition may be applied to one or both substrate surfaces through conventional pre-metered

or post-metered coating methods such as blade, air knife, rod, roll coating, etc. The choice of coating process would be determined from the economics of the operation and in turn, would determine the formulation specifications such as coating solids, coating viscosity, and coating speed.

[0039] The image-receiving layer thickness may range from 1 to 60 μm , preferably from 5 to 40 μm .

[0040] After coating, the ink jet recording element may be subject to calendaring or supercalendaring to enhance surface smoothness. In a preferred embodiment of the invention, the ink jet recording element is subject to hot soft-nip calendaring at a temperature of 65°C and a pressure of 14000 kg/m at a speed of from 0.15 m/s to 0.3 m/s.

[0041] In order to impart mechanical durability to an ink jet recording element, crosslinkers which act upon the binder discussed above are added in small quantities. Such an additive improves the cohesive strength of the layer. Crosslinkers such as carbodiimides, polyfunctional aziridines, aldehydes, isocyanates, epoxides, polyvalent metal cations, and the like may all be used.

[0042] To improve colorant fade, UV absorbers, radical quenchers or antioxidants may also be added to the image-receiving layer as is well known in the art. Other additives include pH modifiers, adhesion promoters, rheology modifiers, surfactants, biocides, lubricants, dyes, optical brighteners, matte agents, antistatic agents, etc. In order to obtain adequate coatability, additives known to those familiar with such art such as surfactants, defoamers, alcohol and the like may be used. A common level for coating aids is 0.01 to 0.30 wt. % active coating aid based on the total solution weight. These coating aids can be nonionic, anionic, cationic or amphoteric. Specific examples are described in MC-CUTCHEON's Volume 1: Emulsifiers and Detergents, 1995, North American Edition.

[0043] Ink jet inks used to image the recording elements of the present invention are well-known in the art. The ink compositions used in ink jet printing typically are liquid compositions comprising a solvent or carrier liquid, dyes or pigments, humectants, organic solvents, detergents, thickeners, preservatives, and the like. The solvent or carrier liquid can be solely water or can be water mixed with other water-miscible solvents such as polyhydric alcohols. Inks in which organic materials such as polyhydric alcohols are the predominant carrier or solvent liquid may also be used. Particularly useful are mixed solvents of water and polyhydric alcohols. The dyes used in such compositions are typically watersoluble direct or acid type dyes. Such liquid compositions have been described extensively in the prior art including, for example, U.S. Patents 4,381,946; 4,239,543 and 4,781,758.

Reference Example 1

Synthesis of Encapsulated Particle 1 Employed in the Invention

[0044] 60 dry g of Nalco® 2329 colloidal silica as a 40 wt. % solution and 150 g of distilled water were mixed in a 500 mL 3-neck round bottom flask equipped with a mechanical stirrer and nitrogen inlet. 3 g of 3-aminopropylmethyl-diethoxysilane was added over one min. The pH of the mixture was adjusted slowly to 4.0 with IN HCl. The viscosity of the dispersion increased first in the beginning but reduced again with the addition of acid. 1.2 g of cetyltrimethylammonium bromide (CTAB) and 0.6 g of Triton X-100® were added. The dispersion was stirred one hour at room temperature.

[0045] The solution was heated to 80 °C in a constant temperature bath and purged with nitrogen for 30 min. 0.12 g of 2,2'azobis(2-methylpropionamide) dihydrochloride was added to the reactor. A monomer emulsion comprising 8 g of n-butyl acrylate, 5 g of trimethylammoniummethyl methacrylate methylsulfate (80% solid), 0.24 g of CTAB, 0.12 g of 2,2'azobis(2-methylpropionamide) dihydrochloride, and 40 g of deionized water was fed to the reactor over one hour to encapsulate the Nalco® 2329. The resulting dispersion was 40 wt. % solids.

Synthesis of Encapsulated Particle 2 Employed in the Invention

[0046] 45 g of Nalco® 2329 colloidal silica as a 40 wt. % solution and 150 g of distilled water were mixed in a 500 mL 3-neck round bottom flask equipped with a mechanical stirrer and nitrogen inlet. 3.0 g of 3-aminopropylmethyl-diethoxysilane was added over one min. The pH of the mixture was adjusted slowly to 4.0 with IN HCl. The viscosity of the dispersion increased first in the beginning but reduced again with the addition of acid. 1.2 g of CTAB and 0.6 g of Triton X-100® were added. The dispersion was stirred one hour at room temperature.

[0047] The solution was heated to 80°C in a constant temperature bath and purged with nitrogen for 30 min. 0.12 g of 2,2'azobis(2-methylpropionamide) dihydrochloride was added to the reactor. A monomer emulsion comprising 4 g of ethyl methacrylate, 4 g of butyl methacrylate, 5 g of trimethylammoniummethyl methacrylate methylsulfate (80% solid), 0.24 g of CTAB, 0.12 g of 2,2'azobis(2-methylpropionamide) dihydrochloride, and 40 g of deionized water was fed to the reactor over one hour to encapsulate the Nalco® 2329. The resulting dispersion was 19.8 wt. % solids.

Synthesis of Encapsulated Particle 3 Employed in the Invention

[0048] 45 g of Nalco® 2329 colloidal silica as a 40 wt. % solution and 150 g of distilled water were mixed in a 500 mL 3-neck round bottom flask equipped with a mechanical stirrer and nitrogen inlet. 3 g of 3-aminopropylmethyldiethoxysilane was added over one min. The pH of the mixture was adjusted slowly to 4.0 with IN HCl. The viscosity of the dispersion increased first in the beginning but reduced again with the addition of acid. 1.2 g of CTAB and 0.6 g of Triton X-100® were added. The dispersion was stirred one hour at room temperature.

[0049] The solution was heated to 80°C in a constant temperature bath and purged with nitrogen for 30 min. 0.12 g of 2,2'azobis(2-methylpropionamidine) dihydrochloride was added to the reactor. A monomer emulsion comprising 8 g of ethyl methacrylate, 5 g of trimethylammoniummethyl methacrylate methylsulfate (80% solid), 0.24 g of CTAB, 0.12 g of 2,2'azobis(2-methylpropionamidine) dihydrochloride, and 40 g of deionized water was fed to the reactor over one hour to encapsulate the Nalco® 2329. The resulting dispersion was 19.9 wt. % solids.

Reference Element 1

[0050] A coating solution for a base layer was prepared by mixing 254 dry g of precipitated calcium carbonate Albagloss-s® (Specialty Minerals Inc.) as a 70% solution, 22 dry g of silica gel Gasil® 23F (Crosfield Ltd.), 2.6 dry g of poly (vinyl alcohol) Airvol® 125 (Air Products) as a 10% solution, 21 dry g of styrene-butadiene latex CP692NA® (Dow Chemical Co.) as a 50% solution and 0.8 g of Alcocum® L-229 (Alco Chemical Co.). The solids of the coating solution was adjusted to 35 wt. % by adding water. The base layer coating solution was bead-coated at 25°C on Ektacolor Edge Paper (Eastman Kodak Co.) and dried by forced air at 60°C. The thickness of the base layer was 25 µm or 27 g/m².

[0051] A coating solution for the image receiving layer was prepared by mixing 15.0 dry g of silica gel Nalco® 2329 (Nalco Co.) as a 40 wt. % solution, 3.8 dry g of Encapsulated Particles 1 as a 40 wt. % solution and water to total 125 g.

[0052] The image-receiving layer coating solution was bead-coated at 25°C on top of the base layer described above. The recording element was then dried by forced air at 104°C for 5 minutes. The thickness of the image-receiving layer was 8 µm or 8.6 g/m².

Reference Element 2

[0053] This element was prepared the same as Element 1 except that 4.0 dry g of Encapsulated Particles 2 as a 19.8 wt. % solution was used instead of Encapsulated Particles 1.

Reference Element 3

[0054] This element was prepared the same as Element 1 except that 4.0 dry g of Encapsulated Particles 3 as a 19.9 wt. % solution was used instead of Encapsulated Particles 1.

Synthesis of Comparative Encapsulated Particles 1

[0055] 60 dry g of Nalco® 2329 colloidal silica as a 40 wt. % solution and 150 g of distilled water were mixed in a 500 mL 3-neck round bottom flask equipped with a mechanical stirrer and nitrogen inlet. 3.0 g of 3-aminopropylmethyldiethoxysilane was added over one min. The pH of the mixture was adjusted slowly to 4.0 with IN HCl. The viscosity of the dispersion increased first in the beginning but reduced again with the addition of acid. 1.2 g of CTAB and 0.6 g of Triton X-100® were added. The dispersion was stirred one hour at room temperature.

[0056] The solution was heated to 80°C in a constant temperature bath and purged with nitrogen for 30 min. 0.12 g of 2,2'azobis(2-methylpropionamidine) dihydrochloride was added to the reactor. A monomer emulsion comprising 12.7 g of methyl methacrylate, 0.26 g of ethyleneglycol dimethacrylate, 0.24 g of CTAB, 0.12 g of 2,2'azobis(2-methylpropionamidine) dihydrochloride, and 40 g of deionized water was fed to the reactor over one hour to encapsulate the Nalco® 2329. The resulting dispersion was 19.9 wt. % solids.

[0057] The Tg of these particles is 110°C. This value is obtained by adding 5°C to the Tg value of the homopolymer derived from methyl methacrylate in order to account for the presence of the small amount of ethyleneglycol dimethacrylate.

Synthesis of Comparative Encapsulated Particles 2

[0058] 60 dry g of Nalco® 2329 colloidal silica as a 40 wt. % solution and 150 g of distilled water were mixed in a 500 mL 3-neck round bottom flask equipped with a mechanical stirrer and nitrogen inlet. 3.0 g of 3-aminopropylmethyldiethoxysilane was added over one min. The pH of the mixture was adjusted slowly to 4.0 with IN HCl. The viscosity

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of the dispersion increased first in the beginning but reduced again with the addition of acid. 1.2 g of CTAB and 0.6 g of Triton X-100® were added. The dispersion was stirred one hour at room temperature.

[0059] The solution was heated to 80°C in a constant temperature bath and purged with nitrogen for 30 min. 0.12 g of 2,2'azobis(2-methylpropionamidine) dihydrochloride was added to the reactor. A monomer emulsion comprising 8 g of methyl methacrylate, 5 g of trimethylammoniummethyl methacrylate methylsulfate (80% solid), 0.24 g of CTAB, 0.12 g of 2,2'azobis(2-methylpropionamidine) dihydrochloride, and 40 g of deionized water was fed to the reactor over one hour to encapsulate the Nalco® 2329. The resulting dispersion was 19.1 wt. % solids.

[0060] The Tg of these particles is 110°C.

Comparative Element 1

[0061] This element was prepared the same as Element 1 except that 4.0 dry g of Comparative Encapsulated Particles 1 as a 19.9 wt. % solution was used instead of Encapsulated Particles 1.

Comparative Element 2

[0062] This element was prepared the same as Element 1 except that 3.9 dry g of Comparative Encapsulated Particles 2 as a 19.1 wt. % solution was used instead of Encapsulated Particles 1.

Comparative Element 3

[0063] This element was prepared the same as Element 1 except that 0.6 dry g of poly(vinyl alcohol) Gohsenol® GH-17 (Nippon Gohsei Co. Ltd.) as a 10 wt. % solution was used instead of Encapsulated Particles 1.

Coating Quality

[0064] The above dried coatings for visually evaluated for cracking defects. Results are tabulated in Table 2 below.

Image Quality & Dry Time

[0065] An Epson Stylus Color 740 printer for dye-based inks using Color Ink Cartridge S020191/IC3CL01 was used to print on the recording elements. The image consisted of adjacent patches of cyan, magenta, yellow, black, green, red and blue patches, each patch being in the form of a rectangle 0.4 cm in width and 1.0 cm in length. Bleed between adjacent color patches was qualitatively assessed. A second image was printed, and immediately after ejection from the printer, the image was wiped with a soft cloth. The dry time was rated as 1 if no ink and was smudged on the image. The dry time was rated as 2 if some ink smudged, and 3 if alot of ink smudged. Results are shown in Table 2 as follows:

Table 2

Recording Element	Coating Quality	Image Quality	Dry Time
1	No cracking	Little bleeding	1
2	No cracking	Little bleeding	1
3	No cracking	Little bleeding	1
Comparative 1	No cracking	Little bleeding	2
Comparative 2	No cracking	Little bleeding	2
Comparative 3	No cracking	Considerable bleeding	3

[0066] The above table shows that the recording elements 1-3 have good coating quality, image quality and instant dry time as compared to the comparative recording elements.

Claims

1. An ink jet recording element comprising a substrate having thereon a porous image-receiving layer comprising

- a) inorganic particles encapsulated with an organic polymer having a T_g of less than 100°C wherein said organic polymer is derived from a cationic or anionic monomer that contains a quaternary ammonium, pyridinium, imidazolium, sulfonate, carboxylate or phosphonate functionality;
- b) particles having a mean particle size of up to 5 μm; and
- c) a polymeric binder in an amount insufficient to alter its porosity and a crosslinker which acts upon the binder.
2. The recording element of Claim 1 wherein said (a) inorganic particles comprise metal oxides, hydrated metal oxides, boehmite, clay, calcined clay, calcium carbonate, aluminosilicates, zeolites or barium sulfate.
3. The recording element of Claim 2 wherein said metal oxide is silica, alumina, zirconia or titania.
4. The recording element of Claim 1 wherein said (a) inorganic particles have a particle size of from 5 nm to 1000 nm.
5. The recording element of Claim 1 wherein said T_g is from -50°C to 65°C.
6. The recording element of Claim 1 wherein said organic polymer is derived from an acrylate-containing monomer.
7. The recording element of Claim 1 wherein said organic polymer is derived from a styrene-containing monomer.
8. The recording element of Claim 1 wherein the weight ratio of the binder to the total amount of particles is from 1:20 to 1:5.
9. An ink jet printing method comprising the steps of:
- I) providing an ink jet printer that is responsive to digital data signals;
- II) loading said printer with the ink jet recording element of Claim 1;
- III) loading said printer with an ink jet ink composition; and
- IV) printing on said image-receiving layer using said ink jet ink composition in response to said digital data signals.

Patentansprüche

1. Tintenstrahlzeichnungselement aus einem Substrat und einer darauf befindlichen porösen Bildempfangsschicht mit
- a) anorganischen Partikeln, die in einem organischen Polymer gekapselt sind, das eine Glasübergangstemperatur T_g von kleiner als 100°C aufweist, worin das organische Polymer von einem kationischen oder anionischen Monomer abgeleitet ist, das eine quartäre Ammonium-, Pyridinium-, Imidazol-, Sulfonat-, Carboxylat- oder Phosphonatfunktionalität beinhaltet;
- b) Partikeln mit einer mittleren Partikelgröße von bis zu 5 μm; und
- c) einem polymeren Bindemittel in einer Menge, die ausreicht, um dessen Porosität zu verändern, und einem Vernetzungsmittel, das als Bindemittel dient.
2. Tintenstrahlzeichnungselement nach Anspruch 1, worin die a) anorganischen Partikel Metalloxide, hydrierte Metalloxide, Boehmit, Ton, gebrannten Ton, Calciumcarbonat, Aluminiumsilicate, Zeolite oder Bariumsulfat umfassen.
3. Tintenstrahlzeichnungselement nach Anspruch 2, worin das Metalloxid Siliziumdioxid, Aluminiumoxid, Zirconiumdioxid oder Titandioxid ist.
4. Tintenstrahlzeichnungselement nach Anspruch 1, worin die a) anorganischen Partikel eine Partikelgröße zwischen 5 nm und 1000 nm aufweisen.
5. Tintenstrahlzeichnungselement nach Anspruch 1, worin die Glasübergangstemperatur zwischen -50°C und 65°C beträgt.
6. Tintenstrahlzeichnungselement nach Anspruch 1, worin das organische Polymer von einem acrylathaltigen

Monomer abgeleitet ist.

7. Tintenstrahlaufzeichnungselement nach Anspruch 1, worin das organische Polymer von einem styrolhaltigen Monomer abgeleitet ist.

8. Tintenstrahlaufzeichnungselement nach Anspruch 1, worin das Gewichtsverhältnis des Bindemittels zur Gesamtmenge der Partikel zwischen 1:20 und 1:5 beträgt.

9. Tintenstrahldruckverfahren mit folgenden Schritten:

- I) Bereitstellen eines Tintenstrahldruckers, der auf digitale Datensignale anspricht;
- II) Beladen des Druckers mit dem Tintenstrahlaufzeichnungselement nach Anspruch 1;
- III) Laden des Druckers mit einer Tintenstrahl-tintenzusammensetzung; und
- IV) Bedrucken der Bildempfangsschicht mithilfe der Tintenstrahl-tintenzusammensetzung in Abhängigkeit von den digitalen Datensignalen.

Revendications

1. Élément d'enregistrement par jet d'encre comprenant un substrat revêtu d'une couche poreuse réceptrice d'image comprenant :

- a) des particules inorganiques encapsulées dans un polymère organique ayant une Tg inférieure à 100 °C, ledit polymère organique étant issu d'un monomère cationique ou anionique qui contient un groupe fonctionnel ammonium quaternaire, pyridinium, imidazolium, sulfonate, carboxylate ou phosphonate ;
- b) des particules ayant une taille moyenne allant jusqu'à 5 µm ; et
- c) un liant polymère en une quantité insuffisante pour modifier sa porosité et un agent de réticulation qui agit sur le liant.

2. Élément d'enregistrement selon la revendication 1, dans lequel lesdites particules inorganiques (a) comprennent des oxydes métalliques, des oxydes métalliques hydratés, de la boehmite, de l'argile, de l'argile cuite, du carbonate de calcium, des aluminosilicates, des zéolites ou du sulfate de baryum.

3. Élément d'enregistrement selon la revendication 2, dans lequel ledit oxyde métallique est la silice, l'alumine, la zircone ou l'oxyde de titane.

4. Élément d'enregistrement selon la revendication 1, dans lequel lesdites particules inorganiques (a) ont une taille comprise entre 5 nm et 1000 nm.

5. Élément d'enregistrement selon la revendication 1, dans lequel ladite Tg est comprise entre -50 °C et 65 °C.

6. Élément d'enregistrement selon la revendication 1, dans lequel ledit polymère organique est issu d'un monomère contenant un acrylate.

7. Élément d'enregistrement selon la revendication 1, dans lequel ledit polymère organique est issu d'un monomère contenant un styrène.

8. Élément d'enregistrement selon la revendication 1, dans lequel le rapport pondéral du liant à la quantité totale de particules est compris entre 1:20 et 1:5.

9. Procédé d'impression par jet d'encre comprenant les étapes suivantes :

- I) fourniture d'une imprimante à jet d'encre sensible à des signaux de données numériques ;
- II) chargement dans ladite imprimante de l'élément d'enregistrement par jet d'encre selon la revendication 1 ;
- III) chargement dans ladite imprimante d'une composition d'encre pour jet d'encre ; et
- IV) impression sur ladite couche réceptrice d'image en utilisant ladite composition d'encre pour jet d'encre en réponse auxdits signaux de données numériques.