

Process for producing water-redispersible polymer powder compositions having cationic functionality

The invention relates to a process for producing water-
5 redispersible polymer powder compositions having cationic
functionality, to water-redispersible polymer powder
compositions having cationic functionality that are obtainable
by the process, and to the use thereof.

10 Water-redispersible polymer powders (dispersion powders) are
polymer powders which are obtained in general by drying of the
corresponding aqueous polymer dispersions, in the presence of a
drying aid (generally a protective colloid). One of the effects
15 of the protective colloid fraction is to prevent the polymer
particles undergoing irreversible bonding during the drying
operation, because the polymer particles are enveloped by the
water-soluble particles of protective colloid. A second effect
of this protective colloid matrix, which dissolves again when
20 the polymer powder is dispersed in water, is that in the
aqueous redispersion, the polymer particles are present again
with the particle size of the original dispersion.

Dispersion powders of this kind are used especially in chemical
construction products, such as in dry mortar formulations, for
25 example, which are made ready for use by addition of water. The
addition of the dispersion powders improves the processing
properties of the mortars and leads to higher mechanical
strength in the set mortars.

30 From the prior art it is already known that protective colloids
having cationic functionality are among those which can be used
for producing water-redispersible polymer powders.

WO 00/05275 A1 discloses a process in which cationic monomers

are polymerized in an aqueous medium and, in the presence of the polymer formed in situ in this case, further monomers are polymerized. The polymer dispersion obtained accordingly is then spray-dried in the presence of polyvinyl alcohol. A

5 process analogous to this is described in W0 00/05283 A1, the process in this case being controlled in such a way as to form copolymer particles having heterogeneous morphology.

EP 0770640 A2 describes a process for producing dispersion
10 powders by the drying of an aqueous polymer dispersion. A key point there is that the polymer particles in dispersion in water have a positive or negative surface charge and are dried with a drying assistant whose charge is opposite to the charge of the polymer particles in the aqueous polymer dispersion.

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W0 98/13411 A1 describes the production of polymer powders by spray drying of an emulsion polymer which has anionic groups, with an amphoteric polymer of natural origin (polysaccharides, preferably casein, gelatin, and proteins) or of synthetic type
20 (copolymers of acrylic esters and unsaturated carboxylic acids with tertiary or quaternary ammonium groups in the side chain).

W0 2007/093551 A1 describes water-redispersible polymer powders which are obtained by drying a polymer dispersion in the
25 presence of a cationic protective colloid as drying aid. Cationic protective colloids used are polymers of monomers having quaternary ammonium groups and a halide counterion, more particularly a chloride ion. In comparison with dispersion powders dried using polyvinyl alcohol as drying aid, these
30 powders are distinguished by better processing properties in the production of mortar compounds. The mechanical strength of the mortar compounds obtained accordingly is nevertheless deserving of improvement.

An object was therefore to develop a cationic polymer powder composition having improved mechanical properties in construction materials modified therewith, for which water-soluble cationic protective colloids can be used without
5 restriction.

The invention provides a process for producing water-redispersible polymer powder compositions having cationic functionality, by radically polymerizing one or more
10 ethylenically unsaturated monomers in the presence of protective colloid and/or emulsifier in an aqueous medium, and drying the resulting aqueous polymer dispersion after addition of a cationic protective colloid as drying aid, characterized in that said cationic protective colloid used comprises
15 homopolymers or copolymers of one or more cationic monomers having a quaternary ammonium halide group, with 50 wt% to 100 wt% of the halide ions in the quaternary ammonium halide groups having been replaced by nonhalide anions, and with the fraction of halide ions being less than 1 wt%, based on the
20 total weight of the polymer powder composition.

The cationic protective colloids used in this process, based on homopolymers or copolymers of one or more cationic monomers having a quaternary ammonium halide group, in which 50 wt% to
25 100 wt% of halide ions in the quaternary ammonium groups have been replaced by nonhalide anions, and for whose use as a drying aid the fraction of halide ions is less than 1 wt%, based on the total weight of the polymer powder composition, are also referred to below as low-halide cationic protective
30 colloids.

Cationic protective colloids suitable for producing the low-halide cationic protective colloids are described in, for

example, E.W. Flick, Water-Soluble Resins - an Industrial Guide, Noyes Publications, Park Ridge, N.J., 1991. Preference is given to homopolymers or copolymers of one or more cationic monomers from the group encompassing diallyldimethylammonium chloride (DADMAC), diallyldiethylammonium chloride (DADEAC), (3-methacryloyloxy)propyltrimethylammonium chloride (MPTAC), (2-methacryloyloxy)ethyltrimethylammonium chloride (METAC), (3-methacrylamido)propyltrimethylammonium chloride (MAPTAC).

- 10 In general the cationic protective colloids comprise 10 to 100 wt%, preferably 50 to 100 wt%, more preferably 60 to 100 wt%, very preferably 90 to 100 wt%, most preferably about 100 wt%, of monomer units having a quaternary ammonium group, based on the total weight of the cationic protective colloid.
- 15 Suitable nonionic, copolymerizable monomers are vinyl esters having 1 to 15 C atoms in the carboxylic acid radical, such as vinyl acetate, vinyl propionate, vinyl dodecanoate; acrylamide, hydroxyethyl (meth)acrylate, hydroxypropyl (meth)acrylate, esters of methacrylic acid and acrylic acid with alcohols
- 20 having 4 to 13 C atoms, polyalkylene glycol (meth)acrylates having C₂ to C₄ alkylene units and molecular weights of 350 to 2000 g/mol, and also N-vinylpyrrolidone, N-vinylcaprolactam, acryloyloxypropyltrialkoxo- and methacryloyloxypropyltrialkoxo-silanes such as methacryloyloxypropyltrimethoxysilane,
- 25 vinyltrialkoxysilanes such as vinyltrimethoxysilane or vinyltriethoxysilane, and vinylmethyldialkoxysilanes such as vinylmethyldimethoxysilane, and/or mixtures of the stated nonionic comonomers.
- 30 The cationic protective colloids having quaternary ammonium groups may be prepared by polymerization processes known to the skilled person, as for example by free radical polymerization in aqueous solution, in solvent mixtures, or in the presence of salts, including, for example, in precipitation polymerization,
- 35 in suspension, for example, or by inverse emulsion

polymerization, for example. The initiators in these cases may be water-soluble or oil-soluble and may come from the group of the persulfates, peroxides, azo compounds and also the oxidation/reduction initiator pairs. Especially with the latter method, of inverse emulsion polymerization or water-in-oil polymerization, extremely high-molecular-weight cationic polymers are achieved with molecular weights of $> 5\,000\,000\text{ g/mol}$.

- 10 The most preferred preparation is that by solution polymerization in water with low solids contents (preferably $\leq 40\text{ wt\%}$) in the presence of water-soluble initiators such as azo initiators or redox initiators, optionally in the presence of chain transfer agents such as mercaptopropionic acid or 2-mercaptoethanol.

Cationic protective colloids suitable for preparing the low-halide cationic protective colloids are also available commercially. For example, polydiallyldimethylammonium chloride (poly-DADMAC) is offered as Catiofast BP (BASF) or Superfloc® C-592 (Kemira, Water Solutions B.V).

In order to prepare the low-halide, cationic protective colloids, it is possible for a reduction of halide ions in the cationic protective colloid to take place by means of processes known to the skilled person. For example, by means of the ion exchanger processes known from DE 102005050201 B3, such as anion exchange using an anion exchange resin, or membrane filtration processes, more particularly nanofiltration. In the case of the nanofiltration process, the aqueous cationic protective colloid solution is circulated via a nanofiltration membrane, and the polymer-containing retentate is supplied with a nonhalide-containing inorganic salt solution at the same rate at which halide-containing permeate is deposited via the nanofiltration membrane. The halide ion in this case, generally

chloride, is replaced by a nonhalide ion, such as sulfate, nitrate, acetate, thiosulfate, or sulfite, for example. The halide ion is preferably replaced by a sulfate or thiosulfate ion. In general, 50 to 100 wt% of the halide ions, preferably 5 80 to 100 wt% of the halide ions, most preferably 80 to 95 wt% of the halide ions, are replaced, based in each case on the total weight of the halide ions in the cationic protective colloid. The viscosity of the cationic polymer solutions used for the nanofiltration is situated typically in the range from 10 50 to 400 mPas, preferably in the range from 70 to 150 mPas (Brookfield viscosity according to ISO 2555, 20 rpm, 23°C, with the spindle recommended for the corresponding viscosity range). The viscosity of the cationic polymer solution can be adjusted to the preferred viscosity range by dilution with fully 15 demineralized water.

Monomers suitable for preparing the aqueous polymer dispersion of the film-forming base polymer are vinyl esters of unbranched or branched alkyl carboxylic acids having 1 to 15 C atoms, 20 methacrylic esters and acrylic esters of alcohols having 1 to 15 C atoms, vinylaromatics, olefins, dienes, or vinyl halides.

Preferred vinyl esters are vinyl acetate, vinyl propionate, vinyl butyrate, vinyl-2-ethylhexanoate, vinyl laurate, 1-methylvinyl acetate, vinyl pivalate, and vinyl esters of alpha- 25 branched monocarboxylic acids having 9 to 13 C atoms, as for example VeoVa9® or VeoVa10® (trade names of Momentive). Vinyl acetate is particularly preferred.

30 Preferred methacrylic esters or acrylic esters are methyl acrylate, methyl methacrylate, ethyl acrylate, ethyl methacrylate, propyl acrylate, propyl methacrylate, n-butyl acrylate, n-butyl methacrylate, 2-ethylhexyl acrylate, norbornyl acrylate. Particularly preferred are methyl acrylate,

methyl methacrylate, n-butyl acrylate, and 2-ethylhexyl acrylate.

5 Examples of olefins and dienes are ethylene, propylene, and 1,3-butadiene. Suitable vinylaromatics are styrene and vinyltoluene. A preferred vinyl halide is vinyl chloride.

10 Optionally it is also possible to copolymerize 0.05 to 50 wt%, preferably 1 to 10 wt%, of auxiliary monomers, based on the total weight of the monomers. Examples of auxiliary monomers are ethylenically unsaturated monocarboxylic and dicarboxylic acids, preferably acrylic acid, methacrylic acid, fumaric acid, and maleic acid; ethylenically unsaturated carboxamides and carbonitriles, preferably acrylamide and acrylonitrile;

15 monoesters and diesters of fumaric acid and maleic acid such as the diethyl and diisopropyl esters, and also maleic anhydride, ethylenically unsaturated sulfonic acids and/or salts thereof, preferably vinylsulfonic acid, 2-acryloylamido-2-methylpropane-sulfonic acid. Other examples are precrosslinking comonomers

20 such as polyethylenically unsaturated comonomers, examples being divinyl adipate, diallyl maleate, allyl methacrylate, or triallyl cyanurate, or postcrosslinking comonomers, examples being acryloylamido glycolic acid (AGA), methylacryloylamido glycolic acid methyl ester (MAGME), N-methylolacrylamide (NMA),

25 N-methylolmethacrylamide (NMMA), N-methylolallylcarbamate, alkyl ethers such as the isobutoxy ether or esters of N-methylolacrylamide, of N-methylolmethacrylamide, and of N-methylolallylcarbamate. Also suitable are epoxide-functional comonomers such as glycidyl methacrylate and glycidyl acrylate.

30 Other examples are silicon-functional comonomers, such as acryloyloxypropyltri(alkoxy)- and methacryloyloxypropyltri(alkoxy)-silanes such as methacryloyloxypropyltrimethoxysilane, vinyltrialkoxysilanes and vinylmethyldialkoxysilanes such as vinyltrimethoxysilane or vinyltriethoxysilane or

35 vinylmethyldimethoxysilane, the alkoxy groups which may be

present being, for example, methoxy, ethoxy, and ethoxypropylene glycol ether radicals. Mention may also be made of monomers having hydroxyl groups or CO groups, examples being methacrylic and acrylic acid hydroxyalkyl esters such as

5 hydroxyethyl, hydroxypropyl, or hydroxybutyl acrylate or methacrylate, and also compounds such as diacetoneacrylamide and acetylacetoxyethyl acrylate or methacrylate. Other suitable comonomers are vinyl alkyl ethers, such as vinyl methyl ether, vinyl ethyl ether, vinyl isobutyl ether, vinyl octadecyl ether,

10 for example.

Examples of homopolymers and copolymers suitable as base polymer are vinyl acetate homopolymers, copolymers of vinyl acetate with ethylene, copolymers of vinyl acetate with

15 ethylene and one or more further vinyl esters, copolymers of vinyl acetate with ethylene and acrylic esters, copolymers of vinyl acetate with ethylene and vinyl chloride, styrene-acrylic ester copolymers, styrene-1,3-butadiene copolymers.

20 Preference is given to vinyl acetate homopolymers; copolymers of vinyl acetate with 1 to 40 wt% of ethylene; copolymers of vinyl acetate with 1 to 40 wt% of ethylene and 1 to 50 wt% of one or more further comonomers from the group of vinyl esters having 1 to 15 C atoms in the carboxylic acid

25 radical such as vinyl propionate, vinyl dodecanoate, vinyl esters of alpha-branched carboxylic acids having 9 to 13 C atoms such as VeoVa9®, VeoVa10®, VeoVa11®; copolymers of vinyl acetate with 1 to 50 wt% of one or more further comonomers from the group of vinyl esters having 1 to

30 15 C atoms in the carboxylic acid radical such as vinyl propionate, vinyl dodecanoate, vinyl esters of alpha-branched carboxylic acids having 9 to 13 C atoms such as VeoVa9®, VeoVa10®, VeoVa11®;

35 copolymers of vinyl acetate, 1 to 40 wt% of ethylene, and preferably 1 to 60 wt% of acrylic esters of unbranched or

branched alcohols having 1 to 15 C atoms, more particularly n-butyl acrylate or 2-ethylhexyl acrylate;

copolymers of 30 to 75 wt% of vinyl acetate, 1 to 30 wt% of vinyl laurate or vinyl esters of an alpha-branched carboxylic

5 acid having 9 to 13 C atoms, and also 1 to 30 wt% of acrylic esters of unbranched or branched alcohols having 1 to 15 C atoms, more particularly n-butyl acrylate or 2-ethylhexyl acrylate, which may optionally further comprise 1 to 40 wt% of ethylene;

10 copolymers of vinyl acetate, 1 to 40 wt% of ethylene, and 1 to 60 wt% of vinyl chloride;

copolymers of one or more vinyl esters having 1 to 12 C atoms in the carboxylic acid radical such as vinyl acetate, vinyl propionate, vinyl laurate, vinyl esters of alpha-branched

15 carboxylic acids having 5 to 13 C atoms such as VeoVa9^R, VeoVa10^R, VeoVa11^R, 1 to 40 wt% of ethylene, and 1 to 60 wt% of vinyl chloride;

where in each case the stated auxiliary monomers may also be copolymerized in the stated quantities, and where the amounts

20 in wt% add up to 100 wt% in each case.

Preference is also given to (meth)acrylic ester polymers, such as copolymers of n-butyl acrylate or 2-ethylhexyl acrylate or copolymers of methyl methacrylate with n-butyl acrylate and/or

25 2-ethylhexyl acrylate and optionally ethylene;

styrene-(meth)acrylic ester copolymers of one or more monomers from the group of methyl acrylate, ethyl acrylate, propyl acrylate, n-butyl acrylate, 2-ethylhexyl acrylate; vinyl

acetate-(meth)acrylic ester copolymers of one or more monomers

30 from the group of methyl acrylate, ethyl acrylate, propyl acrylate, n-butyl acrylate, 2-ethylhexyl acrylate, and optionally ethylene;

copolymers of styrene and 1,3-butadiene;

where in each case the stated auxiliary monomers may also be copolymerized in the stated amounts, and where the figures in wt% add up to 100 wt% in each case.

- 5 The monomer selection, or the selection of the weight fractions of the comonomers, is made such that in general the resulting glass transition temperature T_g is from -50°C to $+50^{\circ}\text{C}$, preferably -30°C to $+10^{\circ}\text{C}$. The glass transition temperature T_g of the polymers can be determined in a known way by means of
10 differential scanning calorimetry (DSC). The T_g may also be calculated approximately in advance using the Fox equation. According to Fox T. G., Bull. Am. Physics Soc. 1, 3, page 123 (1956), the following is true:
$$1/T_g = x_1/T_{g1} + x_2/T_{g2} + \dots + x_n/T_{gn}$$
, where x_n stands for the
15 mass fraction (wt%/100) of the monomer n , and T_{gn} is the glass transition temperature, in Kelvins, of the homopolymer of the monomer n . T_g values for homopolymers are listed in Polymer Handbook 2nd edition, J. Wiley & Sons, New York (1975).
- 20 The homopolymers and copolymers are prepared preferably by the emulsion polymerization process, with the polymerization temperature being generally, but not necessarily, $< 100^{\circ}\text{C}$.

Independently of the polymerization process, the polymerization
25 may be carried out with or without the use of seed latices, with all or certain constituents of the reaction mixture being included in the initial charge, or with partial inclusion in the initial charge and partial subsequent metering of the constituent or of individual constituents of the reaction
30 mixture, or by the metering method without an initial charge. The comonomers may all be included in the initial charge for preparing the dispersion (batch process), or a portion of the monomers is included in the initial charge and the remainder is metered in (semibatch process).

The polymerization is initiated using the water-soluble initiators or redox initiator combinations that are customary for emulsion polymerization. Examples of water-soluble initiators are the sodium, potassium, and ammonium salts of peroxodisulfuric acid, hydrogen peroxide, tert-butylhydroperoxide, potassium peroxodiphosphate, cumene hydroperoxide, isopropylbenzene monohydroperoxide. The stated initiators are used generally in an amount of 0.001 to 0.02 wt%, preferably 0.001 to 0.01 wt%, based in each case on the total weight of the monomers. Redox initiators used are combinations of the stated initiators in combination with reducing agents. Suitable reducing agents are the sulfites and bisulfites of the alkali metals and of ammonium, sodium sulfite for example, the derivatives of sulfoxylic acid such as zinc or alkali metal formaldehyde-sulfoxylates, sodium hydroxymethanesulfinate for example, ascorbic acid, and mixtures of the salts of 2-hydroxy-2-sulfinatoacetic acid and 2-hydroxy-2-sulfonatoacetic acid with sodium sulfite. The amount of reducing agent is generally 0.001 to 0.03 wt%, preferably 0.001 to 0.015 wt%, based in each case on the total weight of the monomers.

In order to regulate the molecular weight it is possible to add chain transfer agents during the polymerization. If such agents are used, they are customarily employed in amounts between 0.01 to 5.0 wt%, based on the monomers to be polymerized, and are added separately or else as a premix with reaction components. Examples of such agents are n-dodecyl mercaptan, tert-dodecyl mercaptan, mercaptopropionic acid, methyl mercaptopropionate, isopropanol, and acetaldehyde.

The polymerization takes place preferably in the presence of nonionic protective colloid. Suitable nonionic protective colloids are polyvinyl alcohols, polyvinyl acetals, polyvinylpyrrolidones, polysaccharides in water-soluble form

such as starches (amylase and amylopectin), celluloses and their methyl, hydroxyethyl and/or hydroxypropyl derivatives, and poly(meth)acrylamide.

5 Preference is given to partly hydrolyzed or fully hydrolyzed polyvinyl alcohols having a degree of hydrolysis of 80 to 100 mol%, more particularly to partly hydrolyzed polyvinyl alcohols having a degree of hydrolysis of 80 to 95 mol% and a Höppler viscosity, in 4% strength aqueous solution, of 1 to
10 30 mPas (Höppler method at 20°C, DIN 53015). Preference is also given to partly hydrolyzed, hydrophobically modified polyvinyl alcohols having a degree of hydrolysis of 80 to 95 mol% and a Höppler viscosity, in 4% strength aqueous solution, of 1 to 30 mPas. Examples thereof are partly hydrolyzed copolymers of
15 vinyl acetate with hydrophobic comonomers such as isopropenyl acetate, vinyl pivalate, vinyl ethylhexanoate, vinyl esters of saturated, alpha-branched monocarboxylic acids having 5 or 9 to 13 C atoms, dialkyl maleates and dialkyl fumarates such as diisopropyl maleate and diisopropyl fumarate, vinyl chloride,
20 vinyl alkyl ethers such as vinyl butyl ether, and olefins such as ethene and decene. The fraction of the hydrophobic units is preferably 0.1 to 10 wt%, based on the total weight of the partly hydrolyzed polyvinyl alcohol. Mixtures of said polyvinyl alcohols may also be used.

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Most preferred are partly hydrolyzed polyvinyl alcohols having a degree of hydrolysis of 85 to 94 mol% and a Höppler viscosity, in 4% strength of aqueous solution, of 3 to 15 mPas (Höppler method at 20°C, DIN 53015). The stated protective
30 colloids are obtainable by means of methods known to the skilled person, and are added generally in an amount of in total 1 to 20 wt%, based on the total weight of the monomers, in the polymerization.

It is also possible optionally to use mixtures with one or more nonionic protective colloids and with one or more low-halide, cationic protective colloids, in which case the low-halide cationic protective colloids identified as drying aids can be used.

The polymerization can also be carried out in the presence of nonionic emulsifier, or in the presence of the stated nonionic protective colloids in combination with nonionic emulsifier, or in the presence of the stated nonionic protective colloids in combination with nonionic emulsifier and with low-halide cationic protective colloid.

Suitable nonionic emulsifiers are surfactants such as alkyl polyglycol ethers or alkylaryl polyglycol ethers having 8 to 40 alkylene oxide units. Preference is given to alkoxyated C_8 to C_{16} alkanols, alkoxyated with C_2 to C_4 alkylene oxides, more particularly with ethylene oxide and propylene oxide or mixtures thereof. The nonionic emulsifiers are added generally in an amount of 0.05 to 10 wt%, based on the total weight of the monomers, in the polymerization.

It is preferred for only nonionic protective colloid and/or nonionic emulsifier to be used during the polymerization.

After the end of the polymerization, residual monomer may be removed by postpolymerization using known techniques, generally by postpolymerization initiated with redox catalyst. Volatile residual monomers may also be removed by distillation, preferably under reduced pressure, and optionally with air or steam or inert entraining gases such as nitrogen being passed through or over the polymerization batch. The aqueous dispersions obtainable accordingly have a solids content of 30 to 75 wt%, preferably of 50 to 60 wt%.

To produce the water-redispersible polymer powders with cationic functionality, the aqueous polymer dispersions are dried following addition of the low-halide, cationic protective colloids as drying aids. The low-halide cationic protective
5 colloid here may also be used in combination with nonionic protective colloid. Nonionic protective colloids suitable for this purpose are those already specified above as suitable nonionic protective colloids in the polymerization. In a combination of this kind, the nonionic protective colloid used
10 preferably comprises partly hydrolyzed polyvinyl alcohol having a degree of hydrolysis of 80 to 95 mol% and a Höppler viscosity, in 4% strength aqueous solution, of 1 to 30 mPas (Höppler method at 20°C, DIN 53015), more preferably partly hydrolyzed polyvinyl alcohol having a degree of hydrolysis of
15 85 to 94 mol% and a Höppler viscosity, in 4% strength aqueous solution, of 3 to 15 mPas (Höppler method at 20°C, DIN 53015). The weight ratio in a combination of this kind between low-halide cationic protective colloid and nonionic protective colloid may be from 90:10 to 10:90, preferably from 70:30 to
20 30:70.

Generally speaking, the drying aid is used in an amount of in total 0.1 to 20 wt%, preferably 1 to 7 wt%, based in each case on the polymeric constituents of the dispersion.

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The drying is accomplished for example by means of fluidized bed drying, freeze drying, or spray drying. Preferably the dispersions are spray-dried. This spray drying takes place in customary spray-drying units, in which atomization may take
30 place with a rotating disk or by means of single-fluid, two-fluid or multifluid nozzles. The exit temperature is generally selected in the range from 45°C to 120°C, preferably 60°C to 90°C, depending on the unit and the desired degree of drying.

Having often proven favorable during drying is the presence of up to 2 wt% of antifoam, based on the base polymer. To increase the shelf life by improving the blocking stability, especially in the case of powders with a low glass transition temperature, the resulting powder may be furnished with an antiblocking agent (anticaking agent), preferably at up to 30 wt%, based on the total weight of the polymeric constituents. Examples of antiblocking agents are Ca and/or Mg carbonate, talc, gypsum, silica, kaolins, metakaolins, and silicates with particle sizes preferably in the range from 10 nm to 100 μ m.

The viscosity of the mixture for atomization and for drying may be adjusted via the solids content in such a way as to give a figure of < 1000 mPas (Brookfield viscosity at 20 revolutions and 23°C), preferably < 500 mPas, especially preferably < 250 mPas. The solids content of the mixture for atomization ought to be > 30 wt%, preferably > 40 wt%.

In order to improve the performance properties, further additions may be made before or during or after drying. Further constituents included in preferred embodiments in dispersion powder compositions are, for example, pigments, fillers, foam stabilizers, hydrophobizing agents, and plasticizers.

The water-redispersible polymer powder compositions with cationic functionality that are obtained in accordance with the invention can be used in the fields of application typical for such compositions. Also possible is the use of blends of the dispersion powders having cationic functionality with conventional dispersion powders.

Examples of applications are those in chemical construction products, optionally in conjunction with hydraulically setting binders such as cements (Portland, high-alumina, trass, blast furnace, magnesia, and phosphate cement), gypsum and

waterglass, for the production of construction adhesives, especially tile adhesives (high-flex adhesives, for example) and adhesives for exterior insulation and finishing systems, and renders, filling compounds, floor-filling compounds, leveling compounds, grouts, jointing mortars, and paints. Preferred fields of application are grouts and tile adhesives, including, in particular, tile adhesives for wood substrates. Other possible applications come about through use in the adhesives and coatings sector, the latter, for example, for paper and textile.

It has surprisingly been found that the use of these water-redispersible polymer powder compositions having cationic functionality leads to a significant improvement in the mechanical properties, as has been shown for grouts as an example.

Examples:

The starting dispersions and protective colloids used for producing the polymer powders of the invention were those described below.

Preparation of the low-halide cationic protective colloid (PC1):

Starting material used was Superfloc® C-592 from Kemira, Water Solutions B.V, a 39 wt% strength aqueous solution of polydiallyldimethylammonium chloride, with a chloride content of 22 wt%. The 39 wt% strength aqueous solution was diluted to 10 wt% with fully demineralized water. In order to reduce the chloride ions, a membrane filtration was carried out using a nanofiltration membrane (Semicon, Nitto Denko NTR-7450 HG F4T). In the presence of a 10% strength sodium thiosulfate solution, the aqueous solution was circulated via the aforementioned nanofiltration membrane (retentate) and the amount of permeate

removed, in the form of fully demineralized water, was returned to the circuit. The membrane filtration was continued until the chloride content of the polydiallyldimethylammonium chloride had been reduced to 4.4 wt% by replacement of the chloride ions with thiosulfate ions. The fraction of chloride ions was reduced by 80 wt% in this way. Following the ion exchange procedure, the concentration of the retentate was increased to 20 wt%, by removal of permeate only, but fully demineralized water is not returned to the circuit.

Dispersion A:

Aqueous polymer dispersion based on a vinyl acetate-ethylene copolymer, prepared with 6 wt%, based on the total weight of the monomers, of polyvinyl alcohol having a degree of hydrolysis of 88 mol% and a Höppler viscosity for a 4% strength aqueous solution of 4 mPas, with a polymer dispersion solids content of 53% and a Tg of -6°C.

Dispersion B:

Aqueous polymer dispersion based on a vinyl acetate-ethylene-VeoVa10 copolymer, prepared with 5 wt%, based on the total weight of the monomers, of polyvinyl alcohol having a degree of hydrolysis of 88 mol% and a Höppler viscosity for a 4% strength aqueous solution of 4 mPas, with a polymer dispersion solids content of 50% and a Tg of -15°C.

Dispersion C:

Aqueous polymer dispersion based on a vinyl acetate-ethylene copolymer, prepared with 5.5 wt%, based on the total weight of the monomers, of polyvinyl alcohol having a degree of hydrolysis of 88 mol% and a Höppler viscosity for a 4% strength aqueous solution of 4 mPas, and with 0.5 wt% (dry fraction), based on the total weight of the monomers, of protective

colloid PC1 with a polymer dispersion solids content of 53% and a Tg of -5°C.

Protective colloid - PC1:

- 5 20% strength aqueous solution of polydiallyldimethylammonium chloride with a chloride ion fraction of 4.4 wt% and with a Höppler viscosity for a 4% strength aqueous solution of 7 mPas.

Protective colloid - PC2:

- 10 Aqueous polyvinyl alcohol solution having a degree of hydrolysis of 88 mol% and a Höppler viscosity for a 4% strength aqueous solution of 4 mPas.

Protective colloid - PC3:

- 15 Aqueous polyvinyl alcohol solution having a degree of hydrolysis of 88 mol% and a Höppler viscosity for a 4% strength aqueous solution of 13 mPas.

Protective colloid - PC4:

- 20 39% strength aqueous solution of polydiallyldimethylammonium chloride with a chloride ion fraction of 22 wt% and with a Höppler viscosity for a 4% strength solution in water of 12.2 mPas (Superfloc® C-592 from Kemira, Water Solutions B.V).

- 25 Examples 1 to 6:

The initial dispersions A to C were each mixed with protective colloids PC1 to PC3 in accordance with the quantities (dry mass) indicated in table 1, with addition of 0.3 wt% of defoamer (Silfoam S860 from Wacker Chemie), based on the solid fraction of the dispersion, and the resulting mixtures were stirred for 30 minutes and filtered. No coagulum was formed in any of examples 1 to 6. The mixtures were spray-dried with addition of 15 wt% of antiblocking agent (calcium carbonate, Omyacarb 5GU), based on the solid fraction of the dispersion.

Comparative example 7:

The initial dispersion A was mixed with protective colloid PC4 in the quantities (dry mass) indicated in table 1, with addition of 0.3 wt% of defoamer (Silfoam S860), based on the solid fraction of the dispersion, and the resulting mixture was stirred for 30 minutes and filtered. The mixture was spray-dried with addition of 15 wt% of antiblocking agent (calcium carbonate, Omyacarb 5GU), based on the solid fraction of the dispersion.

Table 1: Powder composition

Example	Dispersion	Protective colloid (% = wt% of protective colloid, based on the polymeric fraction of the dispersion)
1	A	6% PC 1
2	A	3% PC1, 1.5% PC2, 1.5% PC3
3	B	6% PC 1
4	B	3% PC1, 1.5% PC2, 1.5% PC3
5	C	6% PC 1
6	C	3% PC1, 1.5% PC2, 1.5% PC3
C7(comp. ex.)	A	6% PC 4

Testing:

The powders obtained were each investigated for their powder properties and for processing in a grout.

Determination of the blocking score:

To determine the blocking resistance, the dispersion powder was introduced into an iron tube with screw closure, and then loaded with a metal die. The powder was stored under loading in a drying cabinet at 50°C for 16 hours. After cooling to room temperature had taken place, the powder was removed from the tube and the blocking stability was determined qualitatively by

crushing of the powder. The blocking stability was classed as follows:

1 = very good blocking stability, no caking

2 = good blocking stability

5 3 = satisfactory blocking stability

4 = not stable to blocking, powder no longer free-flowing after crushing.

Determination of the settling behavior (tube settling):

10 The settling behavior of the redispersion serves as a measure of the redispersibility of the powder. The redispersions were produced using the respective dispersion powders at 50 wt% in water through exposure to strong shearing forces. The settling behavior was then determined in each case with the diluted
15 redispersions (0.5 wt% solids content). 100 ml of each of these redispersions were introduced into a graduated tube and the settling height of solid was measured. The figure is reported in mm settling after 1 hour and after 24 hours. Figures of greater than 1 mm after 1 hour and figures of greater than 3
20 after 24 h indicate inadequate redispersion of the polymer powder.

The results of the testing of the blocking score and of the tube settling of the dispersion powders are summarized in
25 table 2.

Table 2: Powder properties

Example	Chloride content (wt% in the cationic PC/in the polymer composition)	Blocking score	Tube settling after 1 h	Tube settling after 24 h
1	4.4/0.26	2	0.8	1.9
2	4.4/0.13	1.5	0.3	0.9
3	4.4/0.26	2.5	0.2	1.0

4	4.4/0.13	2.5	0.2	0.7
5	4.4/0.23	2	0.2	0.9
6	4.4/0.13	1.5	0.2	0.7
C7 (comp. ex.)	22.0/1.32	3	1.0	1.8

For the production of a cementitious grout, the following formula was employed:

5	Silica sand	665 parts
	Portland cement	50 parts
	Cellulose	5 parts
	Dispersion powder	280 parts
	Water	400 parts

10

The tensile bond strength (TBS) in the assembly was tested in each case after the following storage conditions (DIN CEN 1897):

28 days' standard-conditions storage at 23°C and 50%

15

atmospheric humidity (28 d SC) = dry,

7 days' standard-conditions storage and 21 days' water storage at 23°C (7 d SC + 21 d water) = wet

Testing took place in accordance with EN 1348. For this purpose the mortar was applied to a concrete plate using a stencil (50 mm diameter, 10 mm thickness) in each case, and the test specimens were stored as indicated above. Thereafter, using epoxide adhesive, metal tensile anchors were adhered to the mortar layer under test, in order to carry out the tensile adhesion test. This test took place using a pull-off apparatus from Herion, with a load increase rate of 250 N/s. The measured values in N/mm² represent average values from 5 measurements.

25

The determination of the tensile strength (TS) and of the tensile elongation (TE) from the tensile test took place using

a standard specimen 3 (1B) according to DIN ISO 527 with a pulling speed of 50 mm/min, in each case after 28 days' standard-conditions storage at 23°C and 50% atmospheric humidity (28 d SC) = dry,

- 5 7 days' standard-conditions storage and 21 days' water storage at 23°C (7 d SC + 21 d H₂O) = wet

The results for the tensile adhesive strength in the assembly, tensile strength, and tensile elongation are reproduced in
10 table 3.

Table 3: Performance properties in the grout

Example	TBS dry (N/mm ²)	TBS wet (N/mm ²)	TS dry (N/mm ²)	TS wet (N/mm ²)	TE dry (%)	TE wet (%)
1	1.57	1.01	1.30	0.40	42.9	9.6
2	1.96	1.18	1.67	0.43	52.6	13.2
3	1.52	1.05	1.22	0.37	51.2	11.4
4	1.68	1.12	1.63	0.39	45.0	14.8
5	1.55	1.10	1.25	0.38	55.3	15.7
6	1.87	1.18	1.62	0.41	51.7	15.1
C7 (comp. ex.)	1.36	0.77	1.2	0.22	39.8	6.2

The results for the examples given show that by using low-
15 halide, cationic protective colloids, polymer powders are obtained which are stable to blocking and are readily redispersible in water (table 2). Surprisingly it was found that, moreover, the polymer powder compositions of the invention produce improved mechanical properties: comparison of
20 example 1 and comparative example 7 in table 3.

The improved mechanical properties are evident in particular after wet storage. A further improvement is obtained with a combination of low-halide cationic protective colloid and

polyvinyl alcohol as drying aid: comparison of example 1 and example 2.

Claims

1. A process for producing water-redispersible polymer powder compositions having cationic functionality, by radically
5 polymerizing one or more ethylenically unsaturated monomers in the presence of protective colloid and/or emulsifier in an aqueous medium, and drying the resulting aqueous polymer dispersion after addition of a cationic protective colloid as drying aid, characterized in that said cationic protective
10 colloid used comprises homopolymers or copolymers of one or more cationic monomers having a quaternary ammonium halide group, with 50 wt% to 100 wt% of the halide ions in the quaternary ammonium halide groups having been replaced by nonhalide anions, and with the fraction of halide ions being
15 less than 1 wt%, based on the total weight of the polymer powder composition.
2. The process as claimed in claim 1, characterized in that said cationic protective colloid used comprises homopolymers
20 or copolymers of one or more cationic monomers from the group encompassing diallyldimethylammonium chloride (DADMAC), diallyldiethylammonium chloride (DADEAC), (3-methacryloyloxy)propyltrimethylammonium chloride (MPTAC), (2-methacryloyloxy)ethyltrimethylammonium chloride (METAC), (3-methacrylamido)propyltrimethylammonium chloride (MAPTAC).
25
3. The process as claimed in claim 1 or 2, characterized in that the cationic protective colloids comprise at least
30 10 wt% of monomer units having a quaternary ammonium halide group, based on the total weight of the cationic protective colloid.
4. The process as claimed in claim 1 to 3, characterized in that 80 to 100 wt% of the halide ions, based in each case on

the total weight of the halide ions in the cationic protective colloid, have been replaced by nonhalide anions.

- 5 5. The process as claimed in claim 1 to 4, characterized in that the drying aid is used in an amount of 0.1 to 20 wt%, based in each case on the polymeric constituents of the dispersion.
- 10 6. The process as claimed in claim 1 to 5, characterized in that the cationic protective colloid is used as sole drying aid.
- 15 7. The process as claimed in claim 1 to 6, characterized in that a combination of cationic protective colloid and nonionic protective colloid is used, having a weight ratio of cationic protective colloid to nonionic protective colloid of 90:10 to 10:90.
- 20 8. The process as claimed in claim 1 to 7, characterized in that the aqueous polymer dispersion is prepared using one or more ethylenically unsaturated monomers from the group containing vinyl esters of unbranched or branched alkyl carboxylic acids having 1 to 15 C atoms, methacrylic esters and acrylic esters of alcohols having 1 to 15 C atoms,
25 vinylaromatics, olefins, dienes, and vinyl halides.
- 30 9. A water-redispersible polymer powder composition having cationic functionality, produced by means of one of the processes as claimed in claim 1 to 8.
10. The use of the water-redispersible polymer powder composition having cationic functionality from claim 9 in chemical construction products for the production of construction adhesives, renders, filling compounds, floor-

filling compounds, leveling compounds, grouts, jointing mortars, and paints.