

Process for preparing dispersion powders

The invention relates to a process for preparing dispersion powders by spray drying of aqueous polymer dispersions in a nozzle atomization dryer.

Dispersion powders are polymer powders which are obtainable by spray drying of the corresponding aqueous polymer dispersions. A distinction is made here between dispersion powders which are redispersible in water, and those which do not have this pattern of properties. Water-redispersible polymer powders are obtained generally by drying of the corresponding aqueous polymer dispersions, in the presence of a drying aid (generally a protective colloid) and, optionally, of antiblocking agent and, optionally, further additives. The protective colloid fraction on the one hand prevents irreversible sticking of the polymer particles to one another during the drying operation, the polymer particles being enveloped by the protective colloid particles. On the other hand, this protective colloid matrix, which dissolves again when the polymer powder is dispersed in water, has the effect that in the aqueous redispersion, the polymer particles are present again with the particle size of the original dispersion (TIZ-Fachberichte, 1985, Vol. 109 (9), 698).

In the case of dispersion powders which are not to be redispersible, it is possible optionally to do without the addition of protective colloid at the drying stage.

In order to minimize instances of powder blocking, particularly in the case of dispersion powders based on polymers having a glass transition temperature T_g of $\leq 25^\circ\text{C}$, and in order to improve pourability and flowability, antiblocking agents (anticaking agents) are added to the dispersion powders during their preparation. The antiblocking agent may be added during the drying step, or after drying.

The antiblocking agent (ABA) serves to ensure the pourability and the storage stability of the polymer powder obtained after spray drying (dispersion powder). Antiblocking agents are a constituent of the dispersion powder particularly when a low
5 glass transition temperature on the part of the polymer, or severe hygroscopy, means that instances of blocking of the powder or of caking on the dryer wall are anticipated. The powdering of the particle surface with antiblocking agent also has the particular effect, owing to reduced agglomeration, of
10 reducing the fraction of large granules, and this may have very advantageous consequences for the drying operation and also for the properties of the powder (e.g., pourability and storage stability).

15 Dispersion powders of these kinds are used in a multitude of applications, including in coating materials and in adhesive materials for a very wide variety of substrates. One example of the use of dispersion powders which are not water-
20 redispersible is their use as binding powders for particulate natural materials (Vinnex^R powder from Wacker Chemie AG).

Water-redispersible dispersion powders are in widespread use in chemical construction products, frequently in conjunction with mineral binders (Vinnapas^R powder from Wacker Chemie AG).

25 Examples of these products are construction adhesives, especially tile adhesives, renders, and mortar compositions, paints, filling compounds, leveling compounds, thermal insulation composite systems, and jointing mortars. The advantage of the water-redispersible dispersion powders lies
30 in particular in the possibility of using them in prefabricated, storable dry mixes, optionally together with mineral binders such as cement, and of rendering these mixes ready for use not until immediately before they are used, by addition of water. Dry mixes of these kinds are easier to
35 transport than systems in paste form (since the dry mixes have no water fraction), and offer advantages in the context of storage, such as insensitivity to frost and resistance toward microbial infestation, for example.

The dispersion powders are produced in known spray dryers, which can be divided into nozzle atomization dryers and rotary atomization dryers. In the case of nozzle atomization dryers, the polymer dispersion (feed), generally at the top end of the dryer, is atomized under pressure, by means of one or more single-fluid nozzles (pressure nozzles), or is atomized together with pressurized air via one or more two-fluid nozzles or one or more multifluid nozzles. In the case of rotary atomization dryers, the atomization takes place by means of rotary atomizers, in the form of an atomizer disk, cup atomizer, or porous hollow cylinder, for example.

The general procedure is to supply the polymer dispersion to the spray dryer without preheating, at ambient temperature, and to dry it with a hot drying gas. In general the entry temperature of the drying gas is in the temperature range from 100°C to 200°C. This approach has already been described in numerous instances, as for example in DE 3101413 C2, DE 4406822 A1, DE 19752435 A1, EP 407889 A1, EP 1000113 B1, EP 1110978 B1, EP 1720933 B1, EP 2341084 A1, WO 01/83071 A1. The reason for this is that aqueous polymer dispersions having a low minimum film-forming temperature (MFFT) of below 60°C, in other words a MFFT typical of aqueous dispersions of thermoplastic polymers, are considered to be very sensitive at high temperature. The same is true of dispersions of emulsion polymers having a low glass transition temperature T_g . For these reasons, therefore, EP 332067 A1 advises spraying the dispersion together with water.

DE 10 2011 080 233 A1 describes a process for preparing dispersion powders wherein the drying gas is preheated to an entry temperature of 130°C to 210°C in order to accelerate drying. The polymer dispersion to be dried is preheated to a temperature of 50°C to 98°C and is sprayed using rotary atomizers. Chemie Ingenieur Technik 2009, 81, No.6, 699-716 advises a flash process for temperature-insensitive substances on spraying using single-fluid nozzles, the suspension to be

sprayed in this process being heated to a temperature of 120°C to 200°C.

5 It was an object of the invention to provide a process for the spray drying of aqueous polymer dispersions that allows the drying operation to be improved without any detrimental effect on the dried polymer powder (dispersion powder).

10 The invention provides a process for preparing dispersion powders by spray drying of aqueous polymer dispersions of polymers of one or more ethylenically unsaturated monomers selected from the group encompassing vinyl esters, methacrylic esters, acrylic esters, olefins, dienes, vinylaromatics, and vinyl halides with a drying gas in a nozzle atomization dryer,
15 characterized in that the aqueous polymer dispersion (feed), before being atomized, is preheated under pressure to a temperature of 100°C to 200°C and is atomized at this temperature, the pressure being set such that the aqueous phase of the polymer dispersion (feed) does not boil at the
20 temperature selected.

The base polymers for the dispersion powders are introduced for spray drying in the form of their aqueous polymer dispersions. Suitable base polymers for the dispersion powders
25 (polymer powder) are those of one or more ethylenically unsaturated monomers selected from the group encompassing vinyl esters of carboxylic acids having 1 to 15 C atoms, methacrylic esters, acrylic esters of carboxylic acids with unbranched or branched alcohols having 1 to 15 C atoms,
30 olefins, dienes, vinylaromatics, and 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
35 alpha-branched monocarboxylic acids having 5 to 13 C atoms, as for example VeoVa9^R or VeoVa10^R (trade names of the company Momentive). Particularly preferred is vinyl acetate.

Preferred methacrylic esters or acrylic esters are esters of unbranched or branched alcohols having 1 to 15 C atoms, such as 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.

Preferred olefins or dienes are ethylene, propylene, and 1,3-butadiene. Preferred vinylaromatics are styrene and vinyltoluene. A preferred vinyl halide is vinyl chloride.

It is optionally possible in addition for 0.1 to 10 wt%, based on the total weight of base polymer, of one or in each case of two or more auxiliary monomers to be copolymerized. Examples of auxiliary monomers are ethylenically unsaturated monocarboxylic and dicarboxylic acids, ethylenically unsaturated carboxamides, ethylenically unsaturated sulfonic acids and their salts, precrosslinking comonomers such as polyethylenically unsaturated comonomers, postcrosslinking comonomers such as N-methylolacrylamide, epoxide-functional comonomers, silicon-functional comonomers.

Examples of suitable homopolymers and copolymers are vinyl acetate homopolymers, copolymers of vinyl acetate with ethylene, copolymers of vinyl acetate with ethylene and one or more further vinyl esters, copolymers of vinyl acetate with one or more further vinyl esters, copolymers of vinyl acetate with ethylene and acrylic ester, copolymers of vinyl acetate with ethylene and vinyl chloride, copolymers of vinyl chloride and ethylene and optionally one or more further vinyl esters, copolymers of styrene with acrylic ester, copolymers of styrene with 1,3-butadiene; the polymers may in each case further contain the stated auxiliary monomers in the stated amounts, and the figures in wt% add up to 100 wt% in each case.

Preference is given to vinyl acetate homopolymers; copolymers of vinyl acetate with 1 to 50 wt% of one or more further comonomers from the group of the vinyl esters having 1 to 12 C atoms in the carboxylic acid residue, such as vinyl propionate, vinyl laurate, vinyl esters of alpha-branched carboxylic acids having 5 to 13 C atoms, such as VeoVa9^R, VeoVa10^R, VeoVa11^R; 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 the vinyl esters having 1 to 12 C atoms in the carboxylic acid residue, such as vinyl propionate, vinyl laurate, vinyl esters of alpha-branched carboxylic acids having 5 to 13 C atoms, such as VeoVa9^R, VeoVa10^R, VeoVa11^R; copolymers of vinyl acetate, 1 to 40 wt% of ethylene and preferably 1 to 60 wt% of (meth)acrylic esters of unbranched or branched alcohols having 1 to 15 C atoms, especially methyl methacrylate, methyl acrylate, n-butyl acrylate, or 2-ethylhexyl acrylate; copolymers with 30 to 75 wt% of vinyl acetate, 1 to 30 wt% of vinyl laurate or vinyl esters of an alpha-branched carboxylic acid having 5 to 13 C atoms, and also 1 to 30 wt% of (meth)acrylic esters of unbranched or branched alcohols having 1 to 15 C atoms, especially methyl methacrylate, methyl acrylate, n-butyl acrylate, or 2-ethylhexyl acrylate, which may further contain 1 to 40 wt% of ethylene; copolymers with one or more vinyl esters having 1 to 12 C atoms in the carboxylic acid residue, such as vinyl acetate, vinyl propionate, vinyl laurate, vinyl esters of alpha-branched 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; the polymers may in each case further contain the stated auxiliary monomers in the stated amounts, and the figures 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 2-ethylhexyl acrylate and optionally ethylene; copolymers of

styrene with acrylic esters preferably with one or more monomers from the group of methyl acrylate, ethyl acrylate, propyl acrylate, n-butyl acrylate, 2-ethylhexyl acrylate; copolymers of styrene with 1,3-butadiene; the polymers may also contain the stated auxiliary monomers in the stated amounts, and the figures in wt% add up to 100 wt% in each case.

The monomer selection or the selection of the weight fractions of the comonomers is preferably made such as to result in a polymer glass transition temperature T_g of -20°C to $+40^{\circ}\text{C}$, preferably -20°C to $+20^{\circ}\text{C}$. The glass transition temperature T_g of the polymers can be determined in a known way by means of Differential Scanning Calorimetry (DSC) in accordance with DIN 53520. The T_g may also be calculated approximately in advance by means of the Fox equation. According to Fox T. G., Bull. Am. Physics Soc. 1, 3, page 123 (1956), the following holds true: $1/T_g = x_1/T_{g1} + x_2/T_{g2} + \dots + x_n/T_{gn}$, where x_n is the 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).

The aqueous dispersions of the stated polymers generally have a minimum film-forming temperature of 0°C to $+20^{\circ}\text{C}$ (measured according to DIN 53787).

Of the homopolymers or copolymers stated as being preferred, those most preferred are the ones in each case having a glass transition temperature T_g of -20°C to $+40^{\circ}\text{C}$.

The preparation of aqueous polymer dispersions has been widely described before now and is known to the skilled person; for example, in Encyclopedia of Polymer Science and Engineering, Vol. 8 (1987), John Wiley and Sons, pp. 659-677, and, for example, in EP 1916275 A1.

The base polymers are prepared preferably by the emulsion polymerization process. The polymerization temperature is preferably between 40°C and 100°C, more preferably between 60°C and 90°C. In the case of the copolymerization of gaseous comonomers such as ethylene, 1,3-butadiene, or vinyl chloride, it is also possible to operate under pressure, in general between 5 bar and 100 bar.

The polymerization is initiated preferably using the water-soluble initiators or redox initiator combinations that are customary for emulsion polymerization.

The polymerization takes place in the presence of protective colloids and/or emulsifiers. Suitable protective colloids for the polymerization are polyvinyl alcohols; polyvinyl acetals; polyvinylpyrrolidones; polysaccharides in water-soluble form such as starches (amylose and amylopectin), celluloses and their carboxymethyl, methyl, hydroxyethyl, hydroxypropyl derivatives, dextrans and cyclodextrins; proteins such as casein or caseinate, soy protein, gelatin; lignosulfonates; synthetic polymers such as poly(meth)acrylic acid, copolymers of (meth)acrylates with carboxyl-functional comonomer units, poly(meth)acrylamide, polyvinylsulfonic acids and the water-soluble copolymers thereof; melamine-formaldehydesulfonates, naphthalene-formaldehydesulfonates, styrene-maleic acid copolymers, and vinyl ether-maleic acid copolymers. Preference is given to using partially hydrolyzed or fully hydrolyzed polyvinyl alcohols with a degree of hydrolysis of 80 to 100 mol%, especially partially 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 30 mPas (Höppler method at 20°C, DIN 53015). The protective colloids are added generally in an amount of 1 to 20 wt%, based on the total weight of the monomers, in the polymerization.

Where polymerization takes place in the presence of emulsifiers, the amount of the latter is 1 to 5 wt%, based on the total weight of the monomers. Suitable emulsifiers are

anionic, cationic, and nonionic emulsifiers, examples being anionic surfactants, such as alkyl sulfates having a chain length of 8 to 18 C atoms, alkyl or alkylaryl ether sulfates having 8 to 18 C atoms in the hydrophobic radical and up to 40 ethylene oxide or propylene oxide units, alkyl- or alkylarylsulfonates having 8 to 18 C atoms, esters and monoesters of sulfosuccinic acid with monohydric alcohols or alkylphenols, or nonionic surfactants such as alkyl polyglycol ethers or alkylaryl polyglycol ethers having 8 to 40 ethylene oxide units.

After the conclusion of the polymerization, postpolymerization may be carried out in order to remove residual monomers, employing 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 inert entraining gases such as air, nitrogen or steam being passed through or over the reaction mixture.

The aqueous polymer dispersions obtainable accordingly have a solids content of 30 to 75 wt%, preferably of 50 to 60 wt%.

For the preparation of the dispersion powders, the aqueous polymer dispersions, optionally after addition of protective colloids as a drying aid to the polymer dispersion, are dried by spray drying. In general the drying aid (protective colloid) is used in a total amount of 0.5 to 30 wt%, based on the base polymer of the dispersion. Suitable drying aids are the substances recited before as protective colloids: Polyvinyl alcohols; polyvinyl acetals; polyvinylpyrrolidones; polysaccharides in water-soluble form such as starches (amylose and amylopectin), celluloses and their carboxymethyl, methyl, hydroxyethyl, hydroxypropyl derivatives, dextrans and cyclodextrins; proteins such as casein or caseinate, soy protein, gelatin; lignosulfonates; synthetic polymers such as poly(meth)acrylic acid, copolymers of (meth)acrylates with carboxyl-functional comonomer units, poly(meth)acrylamide,

polyvinylsulfonic acids and the water-soluble copolymers thereof; melamine-formaldehydesulfonates, naphthalene-formaldehydesulfonates, styrene-maleic acid copolymers, and vinyl ether-maleic acid copolymers. Preference is given to using partially hydrolyzed or fully hydrolyzed polyvinyl alcohols with a degree of hydrolysis of 80 to 100 mol%, especially partially 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 30 mPas (Höppler method at 20°C, DIN 53015).

As further constituents of the dispersion powders, additional additives may be added to the polymer dispersion in order to tailor the powders for particular applications where appropriate. Examples of such additives are defoamers, hydrophobizing agents, and rheological additives. The polymer dispersion to be supplied to drying, optionally modified with protective colloids and optionally with further additives, is also referred to in the technical jargon as the "feed".

Spray drying takes place by means of atomization in customary spray drying units (nozzle atomization dryers) equipped with single-fluid nozzles (pressure nozzles), two-fluid nozzles or multifluid nozzles, in which the energy for the evaporation of the aqueous phase is transferred by thermal conduction from the drying gas to the polymer dispersion that is to be dried (the feed). The feed is supplied to the nozzles generally by means of pumps. Drying is accomplished by intimate mixing of the atomized polymer dispersion (feed) with the drying gas. Air is used generally as drying gas. In order to accelerate the drying, the drying gas is preheated, preferably to an entry temperature of 130°C to 210°C (hot air), more preferably to 150°C to 190°C. Spray drying takes place preferably in accordance with the cocurrent principle. Here, the polymer dispersion (feed) is atomized in each case by means of one or more single-fluid nozzles (pressure nozzles), two-fluid nozzles or multifluid nozzles, and preferably is atomized by means of single-fluid nozzles (pressure nozzles).

The polymer dispersion (feed), optionally modified with protective colloid and optionally with further additives, is preheated under pressure to a feed temperature of 100°C to 200°C, preferably 100°C to 150°C, more preferably 110°C to 140°C. The pressure here is set such that the feed does not boil at the preheating temperature level. The minimum pressure required for this to be the case at the temperature in question for the aqueous polymer dispersion (feed) may be estimated in a known way, for example, from the widely published phase diagram (p-T diagram) for water (for example, on the Internet page of London South Bank University: <http://www.lsbu.ac.uk/water/phase.html>).

The heating may take place, for example, on the suction side or on the pressure side of a pump which conveys the feed to the nozzles. Pressures applied on the suction side are generally up to 20 bar abs., preferably up to 10 bar abs. The pressure prevailing on the pressure side of the pump is the atomization pressure, generally 10 to 200 bar abs., preferably 30 to 150 bar. Also practicable is the combination of heating on the suction side and pressure side of the pump. Heating may take place in one stage or in a plurality of stages. The feed may be heated using heat exchangers. The feed may also be heated by introduction of steam into the polymer dispersion. Suitable heat exchangers are known to the skilled person and generally available. Examples are plate-type or shell-and-tube heat exchangers in cocurrent, countercurrent, or cross-flow versions. The feed may be heated in one or more stages, with one-stage heat exchangers being preferred. Particularly preferred are countercurrent plate-type heat exchangers, on account of their easy disassembly and cleaning.

The polymer dispersion (feed) and the drying gas are supplied at the top end of the spray dryer, generally a cylindrical tower (dryer tower) having a volume of up to several hundred cubic meters. There are various possible configurations for the dryer outlet at the bottom end of the spray dryer: for

example, the dried polymer powder is discharged with the drying gas and isolated by means of a filter separator and/or cyclone separator. The exit temperature of the drying gas is preferably 45°C to 120°C, depending on unit, resin Tg, and desired degree of drying.

The dispersion powders may further comprise antiblocking agents. Suitable antiblocking (anticaking) agents are known to the skilled person, examples being aluminum silicates such as kaolin, bentonite, fumed silica or precipitated silica, which may optionally have been rendered hydrophobic, or talc, clays, light spar, carbonates such as calcium carbonate, magnesium carbonate, and Ca/Mg carbonate, and barium sulfate. Mixtures of antiblocking agents may also be used. The antiblocking agents are used in general in an amount of 0.1 to 30 wt%, preferably 2 to 30 wt%, more preferably 7 to 30 wt%, based in each case on the total weight of the polymeric constituents of the polymer dispersion to be atomized. In the case of fumed silica or precipitated silica, preference is given to using 0.1 to 2 wt%, based on the polymeric constituents of the polymer dispersion to be atomized. The fraction of the polymeric constituents of the polymer dispersion to be atomized is composed of the base polymer of the polymer dispersion and, optionally, the protective colloid fraction.

The antiblocking agent may be added at least partly continuously and cocurrently, but spatially separately from the polymer dispersion (feed) to be atomized. For this purpose, the antiblocking agent is conveyed into the dryer tower, preferably at the top end, for drying, by means of a conveying gas, generally air (conveying air), in a conveying line. Optionally the antiblocking agent may also be added wholly or partly to the fully dried polymer powder before or after it is separated from the drying gas.

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The dispersion powders obtainable by the process of the invention can be used for example in chemical construction products in conjunction with inorganic, hydraulically setting

binders such as cements (Portland, high-alumina, trass, blast
furnace, magnesia, and phosphate cement), gypsum, and
waterglass, for the production of structural adhesives,
renders, filling compounds, floor-filling compounds, jointing
5 mortars, and paints. Additionally as binders for coating
materials, examples being emulsion paints and powder paints,
and as binders in bonding agents, for wood, cardboard, paper,
and fiber materials, for example, especially in wood
adhesives, wood-floor adhesives, packaging adhesives, and
10 bookbinding adhesives. A further application is as binders for
textiles and paper. The dispersion powders obtainable by the
process of the invention are also suitable as binders for
particulate materials such as fiber materials or particulate
materials composed of mineral materials, plastics, or natural
15 substances such as woodchips, cork particles, glass particles
or glass powder, or combinations of these materials.

With the process according to the invention, distinct
increases are achieved in throughput performance in the
20 production of the dispersion powders by spray drying, and also
in the product quality of the dispersion powders, on the basis
of a number of factors:

In the prior-art processes with feed temperatures below 100°C,
25 a fairly large quantity of heat must first be transferred from
the hot drying air onto the "cold" feed droplets in order to
bring about the evaporation of water. With the process of the
invention, in contrast, a large part of the quantity of heat
needed for evaporation is already present in the feed. As a
30 result of the more efficient energy distribution ("already in
the droplet instead of heat transition from the air to the
droplet"), droplet drying is quicker.

With the process of the invention, the energy supplied to the
35 drying operation (total energy per unit time) is increased
without any need for an increase in the temperature of the hot
drying air. This is of greater advantage particularly in the

case of temperature-sensitive products, which dispersion powders are.

In addition to the increase in the dryer capacity, a
5 contribution to improved product quality is obtained. A key contribution to product quality and energy efficiency is also obtained with the increased feed temperature because there is also a reduction in feed viscosity proportional to the level of preheating of the feed. Finer droplets are formed, and dry
10 more quickly because of the greater droplet surface area of the atomized liquid. This, surprisingly, also has a positive effect on product quality: fewer powder agglomerates are formed as a consequence.

15 Given that the process of the invention allows the atomization of feeds with higher viscosity and correspondingly higher feed solids content, the specific energy consumption per unit quantity of powder is markedly reduced, since the amount of water to be evaporated is substantially reduced.

20 The viscosity of the feed is temperature-dependent and decreases with increasing temperature. The atomization behavior of nozzle atomization, such as the droplet size distribution, for example, is dependent on factors including
25 the feed viscosity. With the process of the invention it is possible to achieve good atomization results with feeds of higher viscosity, whereas inadequate atomization or insufficient powder properties have been obtained with relatively high-viscosity feeds at feed temperatures below
30 100°C.

Surprisingly, it has not been possible to observe any decomposition in the polymers. Even in the case of polymers with ester groups, that are sensitive to hydrolysis, such as
35 polymers containing vinyl acetate, for example, there is no significant elimination of the acetate group. Another surprise was that the blocking stability of the polymers dried in accordance with the invention is not adversely affected. In

spite of thermal load during preheating of the dispersion and on contact with the drying gas, in each case at temperatures above 100°C and hence well above the glass transition temperature Tg of the polymers (for example, vinyl acetate-
5 ethylene copolymers with a Tg around 0°C) or the glass transition temperature Tg of the drying aid (for example, polyvinyl alcohol with a Tg of about 70°C), no caking or agglomeration of the polymer particles was observed. The redispersion quality is not impaired by the process of the
10 invention; instead, on the contrary, there are improvements in respect of redispersibility and blocking resistance (see examples).

15 The examples which follow serve for further elucidation of the invention:

Methods for assessing dispersion powder quality:

20 Blocking test for determining the blocking stability:

For the determination of the blocking stability, the
25 dispersion powder in question was introduced into an iron tube with screw closure and then loaded with a metal die. The tube was stored under load 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
30 stability was determined qualitatively by crushing of the respective powder. The blocking stability was classed as follows:

1 = very good blocking stability

2 = good blocking stability

35 3 = satisfactory blocking stability, slightly agglomerated powder

4 = not stable to blocking, powder cannot be crushed or is no longer free-flowing after crushing.

Test of redispersing behavior - redispersion:

5 The settling behavior of the redispersion (redispersing behavior) served as a measure of the redispersibility of the powders. First of all, the dispersion powders were each redispersed in water, under the action of strong shearing forces in a mortar mill (e.g., from Retsch). A redispersion
10 with a solids content of 50 wt% was prepared. Then the redispersion was diluted in each case to a solids content of 0.5 wt%. The settling behavior was then determined on the diluted redispersions. For this purpose, 100 ml of each of these redispersions were introduced into a graduated tube, and
15 the settled height of solid was measured. The measurement results, in mm sediment after 24 hours, were classed as follows in order to qualify the redispersion:

- 1 = very good redispersion (sediment less than 1.0 mm)
- 2 = good redispersion (sediment 1.0 mm to 2.0 mm)
- 20 3 = moderate redispersion (sediment 2.0 mm to 5.0 mm)
- 4 = poor redispersion (sediment greater than 5.0 mm)

25 Method for determining the residual moisture content of the dispersion powder:

The residual moisture content of the dispersion powder was measured in a method based on DIN EN ISO 3251. In deviation from the standard, 5 g to 6 g of dispersion powder in each
30 case were dried at 115°C to constant weight on an aluminum dish in a halogen dryer (from Mettler Toledo, model HR 73 or HB 43). The loss of mass in wt% corresponds to the residual moisture fraction of the dispersion powder in wt%.

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Method for determining the particle size (median) of the dispersion powder:

The particle size was measured by laser diffraction using the LS 100Q laser diffraction apparatus with drying module from Beckman Coulter in accordance with the instrument protocol.

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Method for determining the bulk weight of the dispersion powder:

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The bulk weight (bulk density) was determined by the method according to standard EN ISO 60.

Method for determining the viscosity:

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The viscosity of the dispersion or feed was measured after conditioning to 23°C with a Brookfield viscometer (DV Prime) at 20 rpm using the standard spindle required according to manufacturer specification.

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Method for determining the solids content:

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The solids content of the dispersion or feed was measured in a method based on DIN EN ISO 3251 (aluminum foil, 20 min at 110°C in a drying cabinet).

Example 1:

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An aqueous vinyl acetate-ethylene copolymer dispersion (T_g = about +15°C, solids content about 54%) was admixed with 9 wt% of polyvinyl alcohol, based on copolymer, in the form of a 20 wt% strength aqueous polyvinyl alcohol solution. The polyvinyl alcohol had a Höppler viscosity of 4 mPas (in 4% strength aqueous solution, Höppler method at 20°C, DIN 53015) and a degree of hydrolysis of 88 mol%. This was followed by dilution with water and the setting of a feed solids content of 43.0 wt%. The feed viscosity at 23°C was 180 mPas.

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Prior to spray drying, the feed was heated in each case to the temperature specified in Table 1, with the heating taking place on the pressure side of a high-pressure pump by means of heated oil bath and tube heat exchanger.

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Spray drying took place in a commercial spray drying tower with a single-fluid nozzle (pressure nozzle) in cocurrent with drying air having a drying air entry temperature of about 136°C and a drying air exit temperature of about 85°C. The atomizing pressure was about 30 bar (i.e., the pressure on the pressure side of the high-pressure pump). In the course of drying, 10 wt% of antiblocking agent (1:1 mixture of kaolin and calcium carbonate) was added to the drying gas in each case, based in each case on the polymeric constituents of the feed dispersion.

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Table 1:

Experi- ment	T(feed) (°C)	Median (μ m)	Residual moisture content (%)	Blocking test	Bulk weight (g/L)	Redispersion
1.1	45	123	1.3	3 to 4	441	poor
1.2	76	100	0.7	3	482	poor
1.3	94	119	0.7	1 to 2	520	moderate
1.4	104	112	0.7	1	566	good
1.5	110	109	0.6	1	573	good
1.6	119	110	0.6	1	582	good
1.7	130	108	0.7	1	580	very good
1.8	140	100	0.9	2	559	very good

In Table 1, the dispersion powders prepared at relatively low feed temperatures of 40°C and 76°C show a distinct lack of blocking stability and redispersion quality. Only with further increasing feed temperatures did these powder quality properties become better. Very surprisingly, by increasing the feed temperature above 100°C, a further improvement was

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achieved in powder quality. Not only were the blocking stability and redispersion improved significantly; the bulk weight of the powder was also increased.

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Example 2:

The procedure of Example 1 was repeated, but the feed at 23°C had a higher feed solids content of 44.7 wt% and a higher feed viscosity of 340 mPas at 23°C. The atomizing pressure was raised to about 60 bar. The feed temperature was varied in each case from 40°C to 130°C. The results are summarized in Table 2.

15 Table 2:

Experi- ment	T(feed) (°C)	Median (μ m)	Residual moisture content (%)	Blocking test	Bulk weight (g/L)	Redispersion
2.1	40	atomization not possible	none	none	none	none
2.2	74	94	1.8	4	460	poor
2.3	96	80	0.5	1 to 2	533	moderate
2.4	118	88	0.5	1	558	good
2.5	130	82	0.5	1	563	good

In comparison to Example 1, the feed solids content and consequently the feed viscosity were raised in Example 2. If the viscosity is too high, droplet formation at the pressure nozzle may be disrupted or may be completely absent. In Example 2, in spite of increased atomization pressure (60 bar instead of 30 bar), no atomization was achievable at 40°C feed temperature, and the results at 74°C and 96°C as well were inadequate.

As in Example 1, it was possible to achieve distinct improvements in the powder and redispersion properties with

feed temperatures above 100°C in Example 2 as well. Owing to the drying of a feed with higher viscosity, in other words higher solids content, there was also a reduction in the specific energy consumption relative to Example 1.

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Example 3:

The procedure of Example 2 was repeated, but the feed had an even higher feed solids content of 46.3 wt% and an even higher feed viscosity of 550 mPas at 23°C. The atomizing pressure remained at about 60 bar. The feed temperature was varied from 40°C to 129°C. The results are summarized in Table 3.

15 Table 3:

Experiment	T(feed) (°C)	Median (μ m)	Residual moisture content (%)	Blocking test	Bulk weight (g/L)	Redispersion
3.1	40	atomization not possible	none	none	none	none
3.2	74	atomization not possible	none	none	none	none
3.3	96	104	1.7	3 to 4	451	poor
3.4	115	92	0.9	2	537	good
3.5	129	87	0.8	2	525	good to very good

In the case of the feed used in Example 3 with a high solids content of 46.3%, it was impossible to produce an acceptable dispersion powder by spray drying at feed temperatures below 100°C. Even at 96°C feed temperature, the powder was very moist, not stable to blocking, and poor in redispersion. Only the heating of the feed above 100°C produced effective atomization and, consequently, good dispersion powders. Since the solids content of the feed was increased, less water,

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specifically, had to be evaporated, and the specific energy consumption decreased further relative to Examples 1 and 2.

5 Example 4:

An aqueous vinyl chloride/ethylene/vinyl laurate copolymer dispersion (T_g = about 0°C , dispersion solids content about 50 wt%) was admixed with 10 wt% of polyvinyl alcohol, based on
 10 copolymer, in the form of a 10 wt% strength aqueous polyvinyl alcohol solution. The polyvinyl alcohol had a Höppler viscosity of 23 mPas (in 4% strength aqueous solution, Höppler method at 20°C , DIN 53015) and a degree of hydrolysis of 88 mol%. This was followed by dilution with water and the setting
 15 of a feed solids content of 29.3 wt%. The feed viscosity at 23°C was 150 mPas.

The heating of the feed and the spray drying were carried out in the same way as in Example 1. The feed temperature was varied from 40°C to 131°C . The results are summarized in
 20 Table 4.

Table 4:

Experi- ment	T(feed) ($^\circ\text{C}$)	Median (μm)	Residual moisture content (%)	Blocking test	Bulk weight (g/L)	Redispersion
4.1	40	atomization not possible	none	none	none	none
4.2	96	151 *)	1.9	4	392	moderate
4.3	110	135	1.2	2 to 3	429	good
4.4	131	122	1.0	2	439	good

*) copious residue on sieving, large lumps -> very moist
 25 material sieved off

As Example 4 shows, the inventive increase in the feed temperature can be employed even for particularly temperature-

sensitive dispersion powders such as a vinyl chloride copolymer, without adversely affecting the powder quality or redispersion quality.

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Example 5:

In analogy to Example 1, a feed with a solids content of 42.5 wt% and a feed viscosity of about 150 mPas at 23°C was produced. Spray drying took place in a large, commercial spray drying tower with a plurality of single-fluid nozzles (pressure nozzles) on the cocurrent principle. The drying air entry temperature was about 160°C, the drying air exit temperature about 80°C. The atomizing pressure was about 100 bar. Heating of the feed to the levels indicated in Table 5 (70°C to 115°C) took place on the suction side of a high-pressure pump by means of a multi-plate-type heat exchanger on the countercurrent principle. The results are summarized in Table 5.

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Table 5:

Experiment	T(feed) (°C)	Median (μ m)	Residual moisture content (%)	Block- ing test	Bulk weight (g/L)	Redis- persion	Relative dryer perform- ance in %
5.1	70	180	1.0	3 to 4	415	moderate to good	100 %
5.2	86	158	0.8	2 to 3	446	good	106 %
5.3	93	157	0.8	2	442	good	107 %
5.4	98	147	0.8	2	458	good	109 %
5.5	104	148	0.8	2	461	good	112 %
5.6	115	141	0.7	1 to 2	470	good to very good	114 %

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The results in Table 5 show that on spray drying of the feeds heated to above 100°C, the powder properties of the resultant dispersion powders underwent improvement, and a distinct increase in the dryer performance was possible.

New version of the claims:

1. A process for preparing dispersion powders by spray drying
of aqueous polymer dispersions of polymers of one or more
5 ethylenically unsaturated monomers selected from the group
encompassing vinyl esters, methacrylic esters, acrylic
esters, olefins, dienes, vinylaromatics, and vinyl
halides, which have a glass transition temperature T_g of
-20°C to +40°C, with a drying gas in a nozzle atomization
10 dryer, characterized in that the aqueous polymer
dispersion, before being atomized, is preheated under
pressure to a temperature of 100°C to 200°C and is
atomized at this temperature, the pressure being set such
that the aqueous phase of the polymer dispersion does not
15 boil at the temperature selected.
2. The process as claimed in claim 1, characterized in that
the aqueous polymer dispersion, before being atomized, is
preheated under pressure to a temperature of 100°C to
20 150°C.
3. The process as claimed in claim 1, characterized in that
the aqueous polymer dispersion, before being atomized, is
preheated under pressure to a temperature of 110°C to
25 140°C.
4. The process as claimed in claim 1 to 3, characterized in
that the aqueous polymer dispersion is atomized in a
nozzle atomization dryer by means of one or more single-
30 fluid nozzles, or one or more two-fluid nozzles or one or
more multifluid nozzles.
5. The process as claimed in claim 1 to 4, characterized in
that the preheating takes place under pressure on the
35 suction side or the pressure side of a pump which conveys
the feed to the nozzles.

6. The process as claimed in claim 5, characterized in that the preheating takes place on the suction side of the pump at a pressure of up to 20 bar abs.
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7. The process as claimed in claim 5, characterized in that the preheating takes place on the pressure side of the pump at a pressure of 10 to 200 bar abs.
- 10
8. The process as claimed in claim 1 to 7, characterized in that the drying gas is preheated to an entry temperature of 130°C to 210°C.
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9. The process as claimed in claim 1 to 8, characterized in that aqueous polymer dispersions are spray dried of polymers from the group containing vinyl acetate homopolymers, copolymers of vinyl acetate with ethylene, copolymers of vinyl acetate with ethylene and one or more further vinyl esters, copolymers of vinyl acetate with one or more further vinyl esters, copolymers of vinyl acetate with ethylene and acrylic ester, copolymers of vinyl acetate with ethylene and vinyl chloride, copolymers of vinyl chloride and ethylene and optionally one or more further vinyl esters, copolymers of styrene with acrylic ester, copolymers of styrene with 1,3-butadiene, the stated polymers in each case possibly further containing 0.1 to 10 wt%, based on the total weight of the polymer, of one or in each case of two or more auxiliary monomers in copolymerized form, and the figures in wt% adding up to 100 wt% in each case.
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