



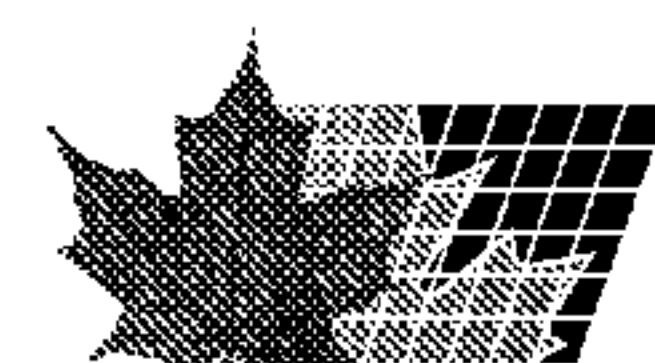
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 (71) Demandeur/Applicant:  
 OMYA DEVELOPMENT AG, CH  
 (72) Inventeurs/Inventors:  
 BURI, MATTHIAS, CH;  
 RENTSCH, SAMUEL, CH;  
 GANE, PATRICK A.C., CH  
 (74) Agent: ROBIC

(54) Titre : UTILISATION DE POLYETHYLENEIMINES COMME ADDITIF DANS DES SUSPENSIONS AQUEUSES DE  
 MATIERES COMPRENANT DU CARBONATE DE CALCIUM  
 (54) Title: USE OF POLYETHYLENIMINES AS ADDITIVE IN AQUEOUS SUSPENSIONS OF CALCIUM CARBONATE-  
 COMPRISING MATERIALS

(57) **Abrégé/Abstract:**

Use of at least one polyethylenimine as an additive in an aqueous suspension, containing from 25 to 62 vol. % of at least one calcium carbonate-comprising material, wherein the use provides improved stability with regard to the conductivity of the suspension.



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(71) Applicant (for all designated States except US): **OMYA DEVELOPMENT AG** [CH/CH]; Baslerstrasse 42, CH-4665 Oftringen (CH).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **BURI, Matthias** [CH/CH]; Mätteliweg 20, CH-4852 Rothrist (CH). **RENTSCH, Samuel** [CH/CH]; Höhweg 1, CH-4663 Aarburg (CH). **GANE, Patrick A.C.** [GB/CH]; Studenweg 8, CH-4852 Rothrist (CH).

(74) Agent: **GLAS, Holger**; Maiwald Patentanwalts GmbH, Elisenhof, Elisenstraße 3, 80335 München (DE).

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(54) Title: USE OF POLYETHYLENIMINES AS ADDITIVE IN AQUEOUS SUSPENSIONS OF CALCIUM CARBONATE-COMPRISING MATERIALS

(57) Abstract: Use of at least one polyethylenimine as an additive in an aqueous suspension, containing from 25 to 62 vol. % of at least one calcium carbonate-comprising material, wherein the use provides improved stability with regard to the conductivity of the suspension.



WO 2011/092145 A1

Use of polyethylenimines as additive in aqueous suspensions of calcium carbonate-comprising materials

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The present invention relates to the technical domain of aqueous suspensions of calcium carbonate-comprising materials and additives added thereto.

In the preparation of aqueous suspensions of calcium carbonate-comprising  
10 materials, the skilled man is often required to select and introduce additives in order to regulate one or more characteristics of this suspension.

In making this additive selection, the skilled man must bear in mind that this additive should remain cost efficient and should not lead to unwanted interactions or effects  
15 downstream during the transportation, processing and application of this suspension.

Among the considerations of the skilled man that have rarely been addressed but which the Applicant has realized is of importance, is the selection of additives that do not cause a significant variation, and namely increase, in the electrical conductivity  
20 of the calcium carbonate-comprising material suspension.

Indeed, it may be advantageous to regulate aspects of the processing and transport of such a suspension based on measurements of the suspension's electrical conductivity.

25 For example, the flow rate of such a suspension through a given passage or unit may be controlled according to measurements made of the suspension conductivity. In the publication entitled "A Conductance Based Solids Concentration Sensor for Large Diameter Slurry Pipelines" by Klausner F et al. (J. Fluids Eng. / Volume 122 / Issue 4 / Technical Papers), an instrument measuring the solids concentration of a slurry  
30 passing through pipelines of a given diameter based on conductance measurements is described. Based on these conductance measurements, it is possible to obtain a



graphical display showing the variation of slurry concentration from the top to the bottom of the pipe, as well as the area-average concentration history.

5 The degree of filling of a container can likewise be managed by detecting conductivity at a given height along a container wall.

10 However, in order to use and take advantage of such regulation systems based on measurements of electrical conductivity, the skilled man is faced with the challenge of selecting additives needed to serve one or more functions that do not in parallel cause significant variations in the electrical conductivity values.

15 Among the functions of the additives used in calcium carbonate-comprising material suspensions, is the adjustment of the suspension pH, whether it is by acidification, neutralization, or alkalisation of this suspension.

20 Suspension alkalisation is notably required in order to match the pH of application environments into which the suspension is introduced, or in preparation for the addition of pH-sensitive additives. A step of raising the pH may also serve to disinfect or support the disinfection of a suspension. Adjustments to pH may be necessary to avoid the unwanted dissolution of calcium carbonate on contact with an acidic environment during processing.

25 Such pH adjusting additives used in aqueous suspension of calcium carbonate-comprising material suspensions and available to the skilled man are numerous.

A first group of additives that may be used to raise the pH of an aqueous suspension of calcium carbonate-comprising materials are hydroxide-containing additives, and are especially alkali and earth alkali metal hydroxides.

For example, US 6,991,705 refers to increasing the alkalinity of a pulp suspension, which may comprise calcium carbonate, by a combination of an alkali metal hydroxide feed, such as a sodium hydroxide feed, and a carbon dioxide feed.

5

Potassium hydroxide, magnesium hydroxide and ammonium hydroxide are other such additives used to control the pH of a PCC suspension in a range from 10 to 13, as referred to in EP 1 795 502.

10 A second group of additives that may be used to raise the pH of an aqueous suspension of calcium carbonate-comprising materials are additives that do not contain hydroxide ions, but which generate such ions on reaction with water.

Such additives may be salts, such as sodium salts, of weak acids. Examples of this  
15 type of additive would include sodium acetate, sodium bicarbonate, potassium carbonate and alkaline phosphates (such as tripolyphosphates, sodium and/or potassium orthophosphates).

A further possibility is to employ nitrogen-based additives, including for example  
20 ammonia, amines and amides, in order to increase the pH of calcium carbonate-comprising material suspensions. Notably, these may include primary, secondary or tertiary amines. Alkanolamines used to increase suspension pH include for example monoethanolamine (MEA), diethanolamine (DEA), and methylaminoethanol (MAE).

25 All of the above additives raise the pH of the aqueous suspension according to a common mechanism, which is by providing or creating, following reaction with water, hydroxide ions in the suspension.

From the literature, it is known that increasing the hydroxide ion concentration under alkaline condition leads in parallel to an increased conductivity (“Analytikum”, 5<sup>th</sup> Edition, 1981, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig, page 185-186 referring to “Konduktometrische Titration”).

5

Given the above general knowledge documented in the literature, along with the supporting evidence that alkali and earth alkali hydroxides, as well as amines such as triethanolamine cause a significant conductivity increase in parallel to raising the pH of an aqueous suspension of calcium carbonate-comprising materials, as shown in the Examples section hereafter, the skilled man could have no expectation that a particular pH regulating agent, that raises the suspension pH according to the same mechanism as these additives, i.e. the resulting introduction of hydroxide ions in the suspension, would cause only a minimal conductivity increase.

15 It was therefore entirely by surprise, and in contrast to the expectation based on common additives used to increase pH, that the Applicant identified that polyethylenimines (PEIs) can be used as an additive in an aqueous suspension and having a pH of between 8.5 and 11 and containing from 25 to 62 vol. % of at least one calcium carbonate-comprising material, to increase the suspension pH by at least  
20 0.3 pH units, while maintaining the suspension conductivity to within 100  $\mu\text{S}/\text{cm}/\text{pH}$  unit.

Therefore, a first aspect of the present invention refers to the use of at least one polyethylenimine as an additive in an aqueous suspension containing from 25 to 62  
25 vol. %, based on the total volume of the suspension, of at least one calcium carbonate-comprising material and having a pH of between 8.5 and 11, for increasing the suspension pH by at least 0.3 pH units, wherein the suspension conductivity change is not more than 100  $\mu\text{S}/\text{cm}$  per pH unit.



“Conductivity” according to the present invention shall mean the electrical conductivity of an aqueous carbonate-comprising material suspension as measured according to the measurement method defined in the examples section herebelow.

5

For the purpose of the present invention, the pH shall be measured according to the measurement method defined in the examples section herebelow.

The volume % (vol. %) of a solid material in suspension is determined according to the method defined in the examples section hereafter.

10

A “polyethylenimine” (PEI) in the meaning of the present invention includes fragments of the general formula  $-(\text{CH}_2-\text{CH}_2-\text{NH})_n-$  with  $n = 2$  to 10.000. It is to be understood that, unless indicated otherwise hereinafter, the term “polyethylenimine” or “PEI” as used herein includes polyethylenimines per se, as well as modified polyethylenimines, and mixtures of modified and unmodified materials. The polyethylenimine (PEI) according to the present invention may be a homopolymeric polyethylenimine which can be defined by the ratio of primary, secondary and tertiary amine functions.

15

20

In a preferred embodiment, the said at least one polyethylenimine additive is added as a water based solution to the calcium carbonate-comprising material.

In another preferred embodiment, the at least one polyethylenimine is selected from the group of branched polyethylenimines, linear polyethylenimines and mixtures of the foregoing. Preferably, the ratio of primary, secondary and tertiary amine functions in the inventive branched polyethylenimines is in the range of 1 : 0,86 :

25

0,42 to 1 : 1,20 : 0,76, prior to a possible modification of the inventive branched polyethylenimines.

According to one preferred embodiment of the present invention, the at least one  
5 polyethylenimine is selected from the group of modified and unmodified polyethylenimines.

Polyethyleneimines include for the purposes of the present invention the  
homopolymers of ethyleneimine (aziridine) or its higher homologues and also the  
10 graft polymers of polyamidoamines or polyvinylamines with ethyleneimine or its higher homologues. The polyethyleneimines can be crosslinked or uncrosslinked, quaternized and/or modified by reaction with alkylene oxides, dialkyl or alkylene carbonates or C1- to C8-carboxylic acids. The inventive polyethyleneimines may be modified by reaction with alkylene oxides such as ethylene oxide, propylene oxide or  
15 butylene oxide, dialkyl carbonates such as dimethyl carbonate and diethyl carbonate, alkylene carbonates such as ethylene carbonate or propylene carbonate, or C1-C8-carboxylic acids. Modified PEIs according to the present invention include alkoxyated polyethylenimines. Alkoxyated polyethylenimines (APEIs) are well-known in the art and include propoxyated polyethylenimines (PPEIs) and  
20 ethoxyated polyethylenimines (EPEIs). Current methods of making the APEI products start from a composition including polyethyleneimines (PEIs). Further preferred modified polyethylenimines can be obtained by reacting the unmodified PEIs with one or more C1 – C28 fatty acids, preferably with one or more C 6 – C18 fatty acids and especially preferred with C10 – C14 fatty acids, like, e.g. coconut  
25 fatty acid. One method of making compositions comprising PEIs is based on the reaction of ethylenediamine (EDA) and ethylenimine (EI) under acid catalysis, in solvents such as water. An example of a common EI is aziridine. The resulting polyethylenimines (PEIs) in the composition have primary, secondary, and tertiary



amine functionalities that are available for further chemical conversion, e.g. alkoxylation with alkylene oxides such as ethylene oxide to form APEI. The PEIs according to the present invention also may be made from a di- or polyamine such as ethylene diamine (EDA), ethylenimine (EI) such as aziridine, water, and an acid  
5 catalyst. Acid catalysts such as sulfuric acid, carbonic acid, or any lower carboxylic acid catalyst may be used for the production of the composition including the PEI. The PEIs in the composition are available at a broad range of molecular weights. The primary and secondary tertiary amine functionalities of the PEIs are available for further alkoxylation with alkylene oxides, such as ethylene oxide or propylene oxide,  
10 to make APEI products such as ethoxylated polyethyleneimines (EPEIs), propoxylated polyethylenimines (PPEIs), respectively. Both the modified and the unmodified PEIs are well known in the art and readily available on the commercial market.

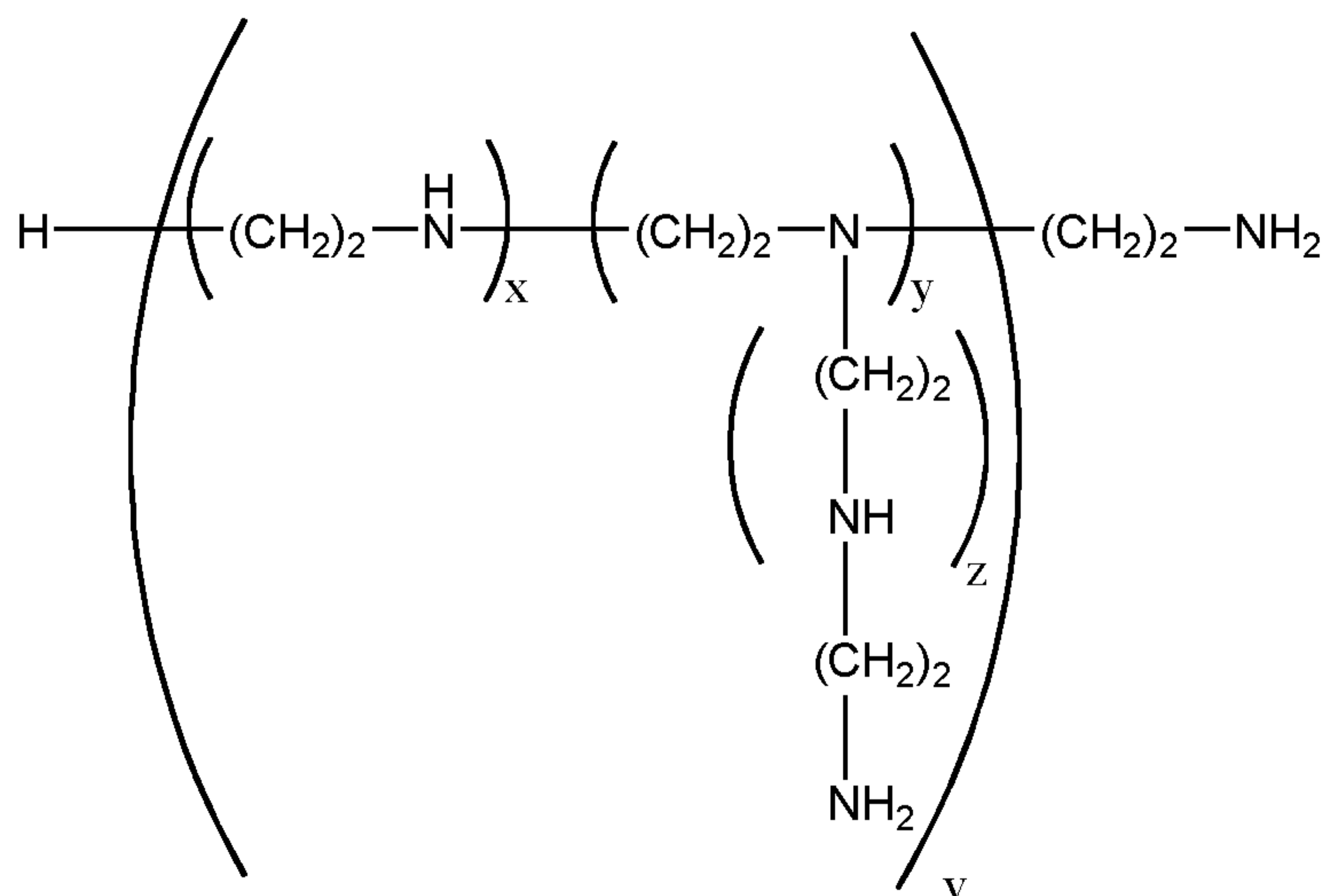
15 According to a preferred embodiment of the present invention, the at least one polyethylenimine is modified and preferably is modified with a carboxylic acid group, more preferably with one or more C1 – C28 fatty acids, one or more C 6 – C18 fatty acids or with one or more C10 – C14 fatty acids or is modified by alkoxylation, preferably by ethoxylation, more preferably by ethoxylation with 10 to  
20 50 ethylene oxide group.

In a preferred embodiment of the present invention, the at least one polyethylenimine has a molecular weight in the range of 100 g/mol and 10.000 g/mol. The “molecular weight” of linear polyethylenimines may be directly calculated from the respective  
25 chemical formula. The “molecular weight” of branched polyethylenimines in the meaning of the present invention is the weight average molecular weight as being measured by light scattering (LS) techniques.

In another preferred embodiment of the present invention the at least one polyethylenimine is selected from the group of linear polyethylenimines having a molecular weight of 100 to 700 g/mol and preferably of 146 to 232 g/mol and preferably is selected from triethylenetetramine, pentaethylenehexamine and tetraethylenepentamine. A linear polyethylenimine may be defined by the general formula  $H-[NH-CH_2-CH_2-]_n-NH_2$ , wherein n preferably is an integer such as 2, 3, 4, 5, 6, 7, 8, 9, or 10.

According to yet another preferred embodiment of the present invention the at least one polyethylenimine is selected from the group of branched polyethylenimines having a weight average molecular weight of 500 to 8000 g/mol and preferably of 800 to 1200 g/mol. In the meaning of the present invention, the term “branched polyethylenimine” also encompasses “spherical polyethylenimines”. A branched polyethylenimine may have the following general formula:

15



In a preferred embodiment, said suspension has a conductivity of between 700 and 2000  $\mu\text{S}/\text{cm}$ , and preferably of between 800 and 1300  $\mu\text{S}/\text{cm}$ , prior to the addition of the at least one polyethylenimine.

- 5 In another preferred embodiment, following the addition of the at least one polyethylenimine, the suspension conductivity change is not more than 70  $\mu\text{S}/\text{cm}$  per pH unit, and preferably not more than 50  $\mu\text{S}/\text{cm}$  per pH unit and the change preferably is a decrease in conductivity..
- 10 In another preferred embodiment, following the addition of the at least one polyethylenimine, the suspension conductivity does not change by more than 10 %, preferably does not change by more than 6 %, and more preferably does not change by more than 3 %.
- 15 In another preferred embodiment, prior to addition of the at least one polyethylenimine, the suspension has a pH between 9 and 10.3.

In another preferred embodiment, the at least one polyethylenimine is added to said suspension in an amount to increase the pH of the aqueous suspension by at least 0.4  
20 pH units.

When the suspension pH prior to the addition of the at least one polyethylenimine is between 8.5 and 9, the at least one polyethylenimine is preferably added to said suspension in an amount to increase the pH of the suspension by at least 1.0 pH  
25 units. In the case where the suspension pH prior to the addition of the at least one polyethylenimine is between 9 and 10, the at least one polyethylenimine is preferably added to said suspension in an amount to increase the pH of the aqueous suspension by at least 0.7 pH units.



Prior to the addition of the at least one polyethylenimine, said suspension preferably has a temperature of between 5 and 100°C, more preferably of between 35 and 85°C, and even more preferably of between 45 and 75°C.

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In a preferred embodiment, the at least one polyethylenimine is added to said suspension in an amount of from 500 to 15000 mg, preferably of from 1000 to 5000 mg, and more preferably of 1300 to 4000 mg, per liter of the aqueous phase of said suspension.

10

As regards said calcium carbonate-comprising material in suspension, this material preferably comprises at least 50 %, preferably of at least 80 %, and more preferably of at least 98 %, by weight of calcium carbonate relative to the total equivalent dry weight of said calcium carbonate-comprising material.

15

The calcium carbonate of said carbonate-comprising material may be a precipitated calcium carbonate (PCC), a natural ground calcium carbonate (NGCC), a surface-reacted calcium carbonate (SRCC), or a mixture thereof.

20 Surface-reacted calcium carbonates are understood to refer to products resulting from the reaction of a calcium carbonate with an acid and carbon dioxide, said carbon dioxide being formed in situ by the acid treatment and/or supplied externally, and the surface-reacted natural calcium carbonate being prepared as an aqueous suspension having a pH of greater than 6.0, measured at 20°C. Such products are described in,  
25 among other documents, WO 00/39222, WO 2004/083316 and EP 2 070 991, the content of these references herewith being included in the present application.

In a preferred embodiment, said suspension comprises from 45 to 60 vol. % and preferably from 48 to 58 vol. % and most preferred from 49 to 57 vol. %, of said calcium carbonate-comprising material based on the total volume of said suspension.

- 5 In another preferred embodiment, the at least one polyethylenimine is added prior to, during or after, and preferably after, a step of grinding said calcium carbonate-comprising material in said suspension

10 It may also be advantageous that the at least one polyethylenimine be added to the dry form of said calcium carbonate-comprising material and preferably dry ground therewith before forming said suspension of calcium carbonate-comprising material.

15 Following addition of the at least one polyethylenimine to said suspension, the suspension may be introduced in a unit equipped with a conductivity-based regulation device.

For example, the suspension may be introduced in a container or unit up to a level determined by measurement of the suspension conductivity.

20 The suspension may additionally or alternatively be passed through a passage having a suspension throughput regulated as a function of the suspension conductivity.

25 In this respect, "passage" can relate to a confined region of throughput, as well as a throughput without any definition of confinement, i.e. after one passage of the process.

It is to be understood that the above-mentioned embodiments of the invention can be used and are contemplated to be used in combination with each other.

In view of the advantages of the use of the at least one polyethylenimine described above, a further aspect of the present invention refers to a method for increasing the pH of an aqueous suspension containing from 25 to 62 vol. % of at least one calcium carbonate-comprising material and having a pH in the range of between 8.5 and 11 is provided, wherein the method involves the step of adding the at least one polyethylenimine to the suspension in an amount, so that the pH of the suspension is increased by at least 0.3 pH units, preferably by at least 0.5 or at least 0.7 pH units and, at the same time, the suspension conductivity change caused by the addition of the at least one polyethylenimine is not more than 100  $\mu\text{S}/\text{cm}$  per pH unit, preferably is not more than 50  $\mu\text{S}/\text{cm}$  per pH unit and very preferably is not more than 20  $\mu\text{S}/\text{cm}$  per pH unit.

According to another embodiment of the present invention, the suspensions obtained by the inventive method or use may be used in paint and/or paper applications.

It is to be understood that the advantageous embodiments described above with respect to the inventive use of the at least one polyethylenimine also can be used for the inventive method. In other words, the preferred embodiments described above and any combinations of these embodiments can also be used for the inventive method.

The scope and interest of the invention will be better understood based on the following examples which are intended to illustrate certain embodiments of the invention and are non-limitative.



## EXAMPLES

**Measurement methods:**

5

Suspension pH measurement

The pH of a suspension is measured at 25°C using a Mettler Toledo Seven Easy pH meter and a Mettler Toledo InLab<sup>®</sup> Expert Pro pH electrode.

10

A three point calibration (according to the segment method) of the instrument is first made using commercially available buffer solutions having pH values of 4, 7 and 10 at 20°C (from Aldrich).

15

The reported pH values are the endpoint values detected by the instrument (the endpoint is when the measured signal differs by less than 0.1 mV from the average over the last 6 seconds).

Suspension conductivity measurement

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The conductivity of a suspension is measured at 25°C using Mettler Toledo Seven Multi instrumentation equipped with the corresponding Mettler Toledo conductivity expansion unit and a Mettler Toledo InLab<sup>®</sup> 730 conductivity probe, directly following stirring this suspension at 1 500 rpm using a pendraulik tooth disc stirrer.

25

The instrument is first calibrated in the relevant conductivity range using commercially available conductivity calibration solutions from Mettler Toledo. The

influence of temperature on conductivity is automatically corrected by the linear correction mode.

5 Measured conductivities are reported for the reference temperature of 20 °C. The reported conductivity values are the endpoint values detected by the instrument (the endpoint is when the measured conductivity differs by less than 0.4 % from the average over the last 6 seconds).

10 Particle size distribution (mass % particles with a diameter < X) and weight median grain diameter ( $d_{50}$ ) of particulate material

Weight median grain diameter and grain diameter mass distribution of a particulate material are determined via the sedimentation method, i.e. an analysis of sedimentation behavior in a gravimetric field. The measurement is made with a  
15 Sedigraph™ 5100.

The method and the instrument are known to the skilled person and are commonly used to determine grain size of fillers and pigments. The measurement is carried out in an aqueous solution of 0.1 % by weight of  $\text{Na}_4\text{P}_2\text{O}_7$ . The samples were dispersed using a high speed stirrer and ultrasonic.

20

#### Viscosity measurement

The Brookfield viscosity is measured after 1 minute of stirring by the use of a RVT model Brookfield™ viscometer at room temperature and a rotation speed of 100 rpm  
25 (revolutions per minute) with the appropriate disc spindle 2, 3 or 4 at room temperature.

Volume solids (vol. %) of a material in suspension

The volume solids is determined by dividing the volume of the solid material by the  
5 total volume of the aqueous suspension.

The volume of the solid material is determined by weighing the solid material  
obtained by evaporating the aqueous phase of suspension and drying the obtained  
material to a constant weight at 120°C, and converting this weight value to a volume  
10 value by division with the specific gravity of the solid material.

The examples herebelow, employing a material consisting of essentially only  
calcium carbonate, used a specific gravity value of 2.7 g/ml, based on that listed for  
natural calcite in the Handbook of Chemistry and Physics (CRC Press; 60th edition),  
15 for the purpose of the above volume solids calculation.

Weight solids (% by weight) of a material in suspension

The weight solids is determined by dividing the weight of the solid material by the  
20 total weight of the aqueous suspension.

The weight of the solid material is determined by weighing the solid material  
obtained by evaporating the aqueous phase of suspension and drying the obtained  
material to a constant weight  
25



Additive addition amount in mg per litre of aqueous phase of a suspension

In order to evaluate the amount of additive per litre of the aqueous phase of a suspension, the volume in litres (l) of the aqueous phase is first determined by subtracting the volume of the solid phase (see volume solids determination above) from the total volume of the suspension.

The PEIs used in the following tests are mentioned and characterized in the following table 1:

10

Name	CAS Number	Formula/ Mw	Boiling point
PEI 5000 (Lupasol® G100) (branched) [2]	9002-98-6	5000 g/mol	>> 200°C
Lupasol® 800 (branched) [2]	9002-98-6	800 g/mol	>> 200°C
PEI Mw 1200 g/mol (branched) [3]	9002-98-6	1200 g/ mol	>> 200°C
Triethylenetetramine [1]	112-24-3	H(NHCH <sub>2</sub> CH <sub>2</sub> ) <sub>3</sub> NH <sub>2</sub> 146 g/mol	approx. 270-300 °C
Pentaethylenehexamine [1]	4067-16-7	H(NHCH <sub>2</sub> CH <sub>2</sub> ) <sub>5</sub> NH <sub>2</sub> 232 g/mol	approx. 220-290°C (at 20 mbar)
Tetraethylenepentamine [1]	112-57-2	H(NHCH <sub>2</sub> CH <sub>2</sub> ) <sub>4</sub> NH <sub>2</sub> 189 g/mol	approx. 190-240°C (at 20 mbar)

[1] according to technical data sheet LANXESS Distribution GmbH

[2] according to technical data sheet BASF

[3] according to technical data sheet Sigma-Aldrich

15

EXAMPLE 1

This example implements a natural calcium carbonate of Norwegian origin obtained by first autogeneously dry grinding 10 to 300 mm calcium carbonate rocks to a fineness corresponding to a d<sub>50</sub> of between 42 to 48 μm, and subsequently wet grinding this dry-ground product in water to which 0.65 % by weight, based on the

20

equivalent dry weight of the solids material, of a sodium and magnesium-neutralised polyacrylate ( $M_w = 6\,000$  g/mol,  $M_n = 2\,300$  g/mol), in a 1.4-litre vertical attritor mill (Dynomill 1.4 L, Bachofen, Switzerland, using 2.7 kg  $ZrO_2 / ZrSiO_4$  beads of 0.7 -1.5 mm) at a weight solids content of 77.5 % by weight, and recirculated through  
5 the mill until 90 % by weight of the particle have a diameter  $< 2\ \mu m$ , 65 % by weight of the particle have a diameter  $< 1\ \mu m$ , 15 % by weight of the particle have a diameter  $< 0.2\ \mu m$  and a  $d_{50}$  of approximately  $0.8\ \mu m$  is reached.

The obtained suspension is then diluted to a volume solids content of 56.9 % by  
10 volume.

0.4 kg of this suspension are introduced in a 1-litre beaker having a diameter of 8 cm. A pendraulik tooth disc stirrer, is introduced in the beaker such the stirrer disk is located approximately 1 cm above the bottom of the beaker. The initial suspension  
15 conductivity and pH values measured are reported in the table below.

Under stirring at 5000 rpm, the additive type (in the form of an aqueous solution) indicated in each of the tests described in the table below (PA = additive according to the prior art, IN = additive according to the present invention), is added in the  
20 indicated amount to the slurry over a period of one minute. After completed addition, the slurry is stirred for an additional 5 minutes, after which time the suspension pH and the conductivity are measured.

Test		Suspension volume solid content (vol. %)	Initial suspension conductivity (+/-10 $\mu$ S/cm) / pH (+/- 0.1)	Additive Type (in solution) / Solution concentration	Additive addition amount (mg/L of aqueous phase)	Conductivity (+/-10 $\mu$ S/cm) / pH (+/- 0.1) after additive addition	$\Delta$ Conductivity
1	PA	56.9	1024/ 8.8	KOH/ 30%	3565	1767/ 12.9	+ 743
2	IN	56.9	1029/ 9.0	PEI Mw 5000 (Lupasol® G100)	3411	929/ 10.22	-82
3	IN	56.9	1101/ 8.7	PEI Mw 1200 g/mol	3546	1062/ 9.2	-87
4	IN	56.9	1177/ 8.3	PEI 800	3546	1078/ 10.4	-61
5	IN	56.9	1065/ 8.0	Pentaethylenhexamine	3387	910/ 10.0	-78
6	IN	56.9	1065/ 8.0	Tetraethylenepentamine	3387	946/ 10.3	-52
7	IN	56.9	1065/ 8.0	Triethylenetetramine	3387	960/ 10.2	-48

- Table 2 -

5

Differences in the pH, conductivity and viscosity of the initial suspension are due to aging effects of the suspension.



Further detailed experimental results for different amounts of added additive are given in the table below.

Test	Additive addition amount (mg/L of aqueous phase)	Brookfield viscosity [mPas] at 23°C ± 2°C	pH at 23°C ± 2°C	Conductivity at 23°C ± 2°C
2	0	468	9	1029
	567	455	9.31	1004
	1138	473	9.34	985
	1706	498	9.44	970
	2273	620	9.84	950
	2840	944	10.11	932
	3411	1240	10.22	929

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- Table 3 -

The results of the above table show that the objectives and advantages of the present invention (especially the stable conductivity) are attained by the using the inventive PEIs.

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Claims

- 5 1. Use of at least one polyethylenimine as an additive in an aqueous suspension,  
containing from 25 to 62 vol. %, based on the total volume of the suspension, of at  
least one calcium carbonate-comprising material and having a pH of between 8.5 and  
11, for increasing the suspension pH by at least 0.3 pH units, wherein the suspension  
conductivity change is not more than 100  $\mu\text{S}/\text{cm}$  per pH unit, the at least one  
10 polyethylenimine is added to said suspension in an amount of from 500 to 15000 mg,  
per liter of the aqueous phase of said suspension.
2. Use according to claim 1, characterized in that said least one  
polyethylenimine additive is added as a water based solution to the calcium  
15 carbonate-comprising material.
3. Use according to claims 1 or 2, characterized in that the at least one  
polyethylenimine is selected from the group of branched polyethylenimines, linear  
polyethylenimines and mixtures of the foregoing.  
20
4. Use according to any one of the preceding claims, characterized in that the at  
least one polyethylenimine is selected from the group of modified and unmodified  
polyethylenimines and mixtures of the foregoing.
- 25 5. Use according to any one of the preceding claims, characterized in that the at  
least one polyethylenimine has a molecular weight in the range of 100 g/mol and  
10.000 g/mol.
6. Use according to any one of the preceding claims, characterized in that the at  
30 least one polyethylenimine is selected from the group of linear polyethylenimines  
having a molecular weight of 100 to 700 g/mol and preferably of 146 to 232 g/mol  
and preferably is selected from triethylenetetramine, pentaethylenehexamine and  
tetraethylenepentamine.

7. Use according to any one of the preceding claims, characterized in that the at least one polyethylenimine is selected from the group of branched polyethylenimines having a molecular weight of 500 to 8000 g/mol and preferably of 800 to 1200 g/mol, wherein the ratio of primary, secondary and tertiary amine functions in the branched polyethylenimines preferably is in the range of 1 : 0,86 : 0,42 to 1 : 1,20 : 0,76, prior to a possible modification of the inventive branched polyethylenimines.
8. Use according to any one of the preceding claims, characterized in that the at least one polyethylenimine is modified and preferably is modified with a carboxylic acid group, more preferably with one or more C1 – C28 fatty acids, one or more C6 – C18 fatty acids or with one or more C10 – C14 fatty acids and/or is modified by alkoxylation, preferably by ethoxylation, more preferably by ethoxylation with 10 to 50 ethylene oxide group.
9. Use according to any one of the preceding claims, characterized in that said suspension has a conductivity of between 700 and 2000  $\mu\text{S}/\text{cm}$ , and preferably of between 800 and 1300  $\mu\text{S}/\text{cm}$ , prior to the addition of said at least one polyethylenimine.
10. Use according to any one of the preceding claims, characterized in that following the addition of said at least one polyethylenimine, the suspension conductivity change is not more than 70  $\mu\text{S}/\text{cm}$  per pH unit, preferably is not more than 50  $\mu\text{S}/\text{cm}$  per pH unit and the change preferably is a decrease in conductivity.
11. Use according to any one of the preceding claims, characterized in that following the addition of said at least one polyethylenimine, the suspension conductivity does not change by more than 10 %, preferably does not change by more than 6 %, and more preferably does not change by more than 3 %.



12. Use according to any one of the preceding claims, characterized in that prior to addition of said at least one polyethylenimine, the suspension has a pH between 9 and 10.3.

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13. Use according to any one of the preceding claims, characterized in that said at least one polyethylenimine is added to said suspension in an amount to increase the pH of the suspension by at least 0.4 pH units.

10 14. Use according to any one of the preceding claims, characterized in that in the case where the suspension pH prior to the addition of said at least one polyethylenimine is between 8.5 and 9, said of said at least one polyethylenimine is added to said suspension in an amount to increase the pH of the suspension by at least 1.0 pH unit, and that in the case where the suspension pH prior to the addition  
15 of said at least one polyethylenimine is between 9 and 10, said at least one polyethylenimine is added to said suspension in an amount to increase the pH of the suspension by at least 0.7 pH units.

15. Use according to any one of the preceding claims, characterized in that prior  
20 to the addition of the at least one polyethylenimine, said suspension has a temperature of between 5 and 100°C, preferably of between 35 and 85°C, and more preferably of between 45 and 75°C.

16. Use according to any one of the preceding claims, characterized in that said  
25 the at least one polyethylenimine is added to said suspension in an amount of from 1000 to 5000 mg, and more preferably of 1300 to 4000 mg, per liter of the aqueous phase of said suspension.

17. Use according to any one of the preceding claims, characterized in that said calcium carbonate-comprising material comprises at least 50 %, preferably at least 80 %, and more preferably at least 98 %, by weight of calcium carbonate relative to the total weight of said calcium carbonate-comprising material.

5

18. Use according to any one of the preceding claims, characterized in that the calcium carbonate of said carbonate-comprising material is a precipitated calcium carbonate (PCC), a natural ground calcium carbonate (NGCC), a surface-reacted calcium carbonate (SRCC), or a mixture thereof.

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19. Use according to any one of the preceding claims, characterized in that said suspension comprises from 45 to 60 vol. %, preferably from 48 to 58 vol. % and most preferred from 49 to 57 vol. %, of said calcium carbonate-comprising material based on the total volume of said suspension.

15

20. Use according to any one of the preceding claims, characterized in that said at least one polyethylenimine is added prior to, during or after, and preferably after, a step of grinding said calcium carbonate-comprising material in said suspension.

20

21. Use according to any one of the preceding claims, characterized in that said at least one polyethylenimine is added to the dry form of said calcium carbonate-comprising material, and is optionally dry ground therewith before forming said suspension of calcium carbonate-comprising material.

25

22. Use according to any one of the preceding claims, characterized in that following addition of the at least one polyethylenimine to said suspension, the suspension is introduced in a unit equipped with a conductivity-based regulation device.

23. Use according to claim 22, characterized in that following addition of the at least one polyethylenimine to said suspension, the suspension is introduced in a container or unit up to a level determined by measurement of the suspension conductivity.

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24. Use according to claim 22, characterized in that following addition of the at least one polyethylenimine to said suspension, the suspension is passed through a passage having a suspension throughput regulated as a function of the suspension conductivity.

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25. A method for increasing the pH of an aqueous suspension containing from 25 to 62 vol. % of at least one calcium carbonate-comprising material and having a pH in the range of between 8.5 and 11, characterized in that the method involves the step of adding at least one polyethylenimine to the suspension in an amount, so that the pH of the suspension is increased by at least 0.3 pH units and, at the same time, the suspension conductivity change is not more than 100  $\mu\text{S}/\text{cm}$  per pH unit preferably is not more than 50  $\mu\text{S}/\text{cm}$  per pH unit and very preferably is not more than 20  $\mu\text{S}/\text{cm}$  per pH unit.

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20 26. Use of the suspension obtained by the method according to claim 25 in paint and/or paper applications.