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(54) Title: CONCRETE AND MORTAR ADMIXTURE

(57) Abstract: The invention relates to a copolymer, said copolymer consisting of, as structural units, (i) 0.1 to 50 mole % of units derived from an ethylenically unsaturated monomer (a) having per one mole thereof 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups; (ii) 0.1 to 49.9 mole % of units derived from a monomer (b) of an alkyl, alkenyl or hydroxyalkyl ester of an ethylenically unsaturated mono- or di-carboxylic acid; (iii) 0.1 to 90 mole % units derived from a monomer (c) selected from the group consisting of an ethylenically unsaturated monocarboxylic acid, a salt thereof, an ethylenically unsaturated dicarboxylic acid, an anhydride thereof and a salt thereof; (iv) optionally up to 30 mole % of other monomers. Said copolymer can be used as a concrete and/or mortar admixture that allows optimal flow ability and, at the same time, can maintain a specific consistency, fluidity and workability of the concrete independently of the cement type.



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**CONCRETE AND MORTAR ADMIXTURE****DESCRIPTION****Technical field**

The present invention relates to a concrete and/or mortar admixture. More specifically, it relates to a concrete and/or mortar admixture that allows optimal flowability and, at the same time, can maintain a specific consistency, fluidity and workability of the concrete independently of the cement type.

**Prior Art****Cement**

Portland cement, the fundamental ingredient in concrete and/ mortar is calcium silicate cement made with a combination of calcium, silicon, aluminium, and iron.

Different types of portland cement are manufactured to meet various physical and chemical requirements. The American Society for Testing and Materials (ASTM) Specification C-150 provides for eight types of portland cement and uses Roman numeral designations as follows:

- Type I Normal
- Type IA Normal, air-entraining
- Type II Moderate sulphate resistance
- Type IIA Moderate sulphate resistance, air-entraining
- Type III High early strength
- Type IIIA High early strength, air-entraining
- Type IV Low heat of hydration
- Type V High sulphate resistance

Also according to European Standard Norm: EN 197-1 there are 5 main cement types:

- CEM I Portland cement: comprising Portland cement and up to 5% of minor additional constituents

- CEM II Portland-composite cement: comprising Portland cement and up to 35% of other single constituents
- CEM III Blast furnace cement: comprising Portland cement and higher percentages of blast furnace slag
- CEM IV Pozzolanic cement: comprising Portland cement and higher percentages of pozzolan
- CEM V Composite cement: comprising Portland cement and higher percentages of blast furnace slag and pozzolan or fly ash

Said main cement types can be divided in sub-types depending on the second constituent of the cement, which can be blast-furnace slag, silica fume, natural pozzolan, natural calcined pozzolan, siliceous fly ash (e.g. pulverised fuel ash), calcareous fly ash (e.g. high-lime fly ash), limestone, burnt shale or mixtures thereof.

In addition to the different types of portland cement, a number of special purpose hydraulic cements are manufactured. Among these is white portland cement. White portland cement is identical to grey portland cement except in colour. During the manufacturing process, manufacturers select raw materials that contain only negligible amounts of iron and magnesium oxides, the substances that give grey cement its colour. White cement is used whenever architectural considerations specify white or coloured concrete or mortar.

Blended hydraulic cements are produced by intimately blending two or more types of cementations material. Primary blending materials are portland cement and pozzolans, like ground granulated blast-furnace slag (by-product of steel production in steel blast-furnaces), fly ash (by-product of burning coal), silica fume lime stone and natural pozzolans.

Pozzolans (puzzolans) are strictly volcanic tuffs of the type found near Pozzuoli in southern Italy, which in conjunction with lime were used by the ancient Romans in the mortars employed in many of their buildings. In concrete mix design the term pozzolan is used to describe a powdered material, which when added to the cement in a concrete mix reacts with the lime released by the hydration of the cement

to create compounds, which improve the strength or other properties of the concrete.

Blended hydraulic cements conform to the requirements of ASTM C-1157, ASTM C-595 or EN 197-1 (CEM II, CEM III, CEM IV and CEM V).

Blended hydraulic cements are commonly used in the same manner as portland cements. However, due to environmental protection (carbon dioxide elimination requirements under the Kyoto Protocol), the use of blended (hydraulic) cement by the construction industry is becoming increasingly important.

Due to the fact that cement is produced in a cement kiln that burns limestone, clay and a variety of other minerals at about 1400°C, approximately 1 to 3 tons of carbon dioxide is produced for every ton of cement. Cement manufacturing accounts for approximately 5-15% of total world carbon dioxide production.

The benefits of blended (hydraulic) cement are significant. For example, when pozzolans are mixed with cement the amount of the mix almost directly replaces the amount of carbon dioxide produced in the cement clinker process. For example, a 50% fly ash blend or mix replaces 0.5 ton of carbon dioxide for every ton of cement used.

Finally, expansive cements are hydraulic cements that expand slightly during the early hardening period after setting.

#### Mortar

Mortar is a masonry product composed of cement and sand, generally with a grain size of less than 4 mm (sometimes less than 8 mm, e. g. mortar for special decorative renders or floor screed mortar). When water is mixed in with mortar, its binding element, the cement, is activated. Distinguish mortar from "concrete," which acts in a similar way but which contains coarse aggregate which is bound together by the cement. Concrete can stand alone, while mortar is used to hold brick or stone together.

### Concrete

In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete.

Within this process lies the key to a remarkable trait of concrete: it is plastic and malleable when newly mixed, strong and durable when hardened.

The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients. A concrete mixture that does not have enough paste to fill all the voids between the aggregates will be difficult to place and will produce rough, honeycombed surfaces and porous concrete. A mixture with an excess of cement paste will be easy to place and will produce a smooth surface; however, the resulting concrete is likely to shrink more and be uneconomical.

A properly designed concrete mixture will possess the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 10 to 15 weight % cement, 60 to 75 weight % aggregate and 15 to 20 weight % water. Entrained air in many concrete mixes may also take up another 5 to 8 weight %.

### Admixtures

Admixtures are the ingredients in concrete other than cement, water, and aggregate that are added to the mix immediately before or during mixing. Admixtures mostly chemically interact with the constituents of concrete and affect the properties and characteristics of the fresh and hardened concrete and its durability.

Admixtures, which mostly chemically interact with the constituents of concrete, are used primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during

mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Most organic chemical type admixtures are affected by cement type and brand, water cement ration, aggregate grading and temperature.

Admixtures are classed according to function. There are five distinct classes of chemical admixtures: air-entraining, water-reducing, retarding, accelerating, and plasticizers (superplasticizers). All other varieties of admixtures fall into the specialty category whose functions include corrosion inhibition, shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and colouring.

Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 %. Consequently, concrete containing a water-reducing admixture needs less water to reach a required slump than untreated concrete. The treated concrete can have a lower water-cement ratio. This usually indicates that a higher strength concrete can be produced without increasing the amount of cement.

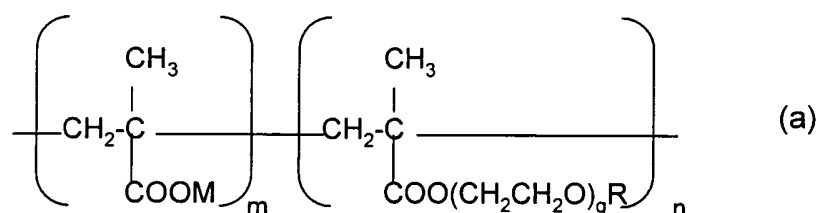
Retarding admixtures, which slow the setting rate of concrete, are used to counteract the accelerating effect of hot weather on concrete setting. High temperatures often cause an increased rate of hardening, which makes placing and finishing difficult. Retarders keep concrete workable during placement and delay the initial set of concrete. Most retarders also function as water reducers and may entrain some air in concrete.

Accelerating admixtures increase the rate of early strength development; reduce the time required for proper curing and protection, and speed up the start of finishing operations. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather.

Superplasticizers, also known as plasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 % and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete. Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction. Normally, the effect of superplasticizers lasts only 30 to 60 minutes, depending on the type and dosage rate, and is followed by a rapid loss in workability. As a result of the slump loss (problematic retention of fluidity), superplasticizers are usually added to concrete at the jobsite.

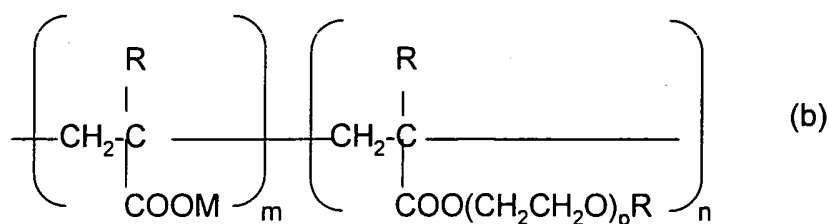
There are a great variety of superplasticizers described in the state of the art. Examples thereof include salts of naphthalenesulfonic acid/formaldehyde condensates (naphthalene derivatives), salts of melaminesulfonic acid/formaldehyde condensates (melamine derivatives), salts of sulfanilic acid/phenol formaldehyde co-condensates (aminosulfonic acid derivatives), polycarboxylate-based superplasticizers, polyether-based superplasticizers and so on.

Polycarboxylate-based superplasticizers (PC) have carboxyl units and ethylene oxide polymer units as the side chains, having a chemical structure according to formula (a)



wherein  $q=10-30$

Polyether-based superplasticizers (PE) have main chains with carboxyl groups and very long side chains of ethylene oxide polymer units, having a chemical structure according to formula (b)



wherein  $p \geq 10$ .

Each of these admixtures has some problems even though each has excellent functions.

Other type of superplasticizers are described in the international patent application WO A-9748656, disclosing a concrete admixture, which comprises a copolymer comprising, as structural units, units derived from an ethylenically unsaturated monomer (a) having 25 to 300 moles of  $\text{C}_2\text{--C}_3$  oxyalkylene groups per mole of copolymer and units derived from a monomer (b) of an alkyl, alkenyl or hydroxyalkyl ester of an ethylenically unsaturated mono- or di-carboxylic acid. Said copolymer may further contain units derived from a monomer (c) as structural units. The monomer (c) is an ethylenically unsaturated monocarboxylic acid or a salt thereof, or an ethylenically unsaturated dicarboxylic acid or an anhydride or salt thereof. In the case wherein the copolymer contains the monomer unit (c), the proportions of the units (a), (b) and (c) are 0.1 to 50 mole %, 50 to 90 mole % and 0.1 to 50 mole % respectively. Preferably, the proportions of the units (a), (b) and (c) are 5 to 40 mole %, 50 to 90 mole % and 5 to 40 mole % respectively. Even more preferably, the proportions of the units (a), (b) and (c) are 10 to 30 mole %, 50 to 70 mole % and 10 to 30 mole % respectively.

Although the admixtures described in the international patent application WO A-9748656 are useful to maintain the fluidity of the concrete for a reasonable period of time (around two hours), they are very much affected by the type of cement used and their working time for placement and finishing operations is relatively long.

The concrete admixture according to the present invention, do not present these drawbacks from the prior art.



In particular, the concrete admixture according to the present invention allows optimal flow ability and, at the same time, can maintain a specific consistency, fluidity and workability of the concrete. The concrete admixtures according to the present invention exhibit an earlier working time and, at the same time, maintain the fluidity of the concrete during a long period of time and can work with different cement types, even with blended hydraulic cement, comprising Portland cement and higher percentages of other constituents, like cement types CEM II, III, IV or V (according to EN 197-1). This permits control the quality parameters of the concrete even in different working conditions (temperature, water-cement ratio, etc.) independently of the cement type.

#### **Summary of the invention**

In order to solve the drawbacks from the prior art, the present invention provides a copolymer consisting of, as structural units,

- i) 0.1 to 50 mole % of units derived from an ethylenically unsaturated monomer (a) having per one mole thereof 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups;
- ii) 0.1 to 49.9 mole % of units derived from a monomer (b) of an alkyl, alkenyl or hydroxyalkyl ester of an ethylenically unsaturated mono- or di-carboxylic acid;
- iii) 0.1 to 90 mole % units derived from a monomer (c) selected from the group consisting of an ethylenically unsaturated monocarboxylic acid, a salt thereof, an ethylenically unsaturated dicarboxylic acid, an anhydride thereof and a salt thereof; and
- iv) optionally up to 30 mole % of other monomers.

The present invention also provides a method for dispersing a cement mixture, in which the copolymer of the

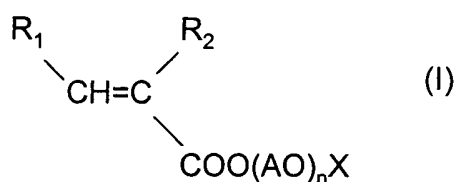
present invention, either alone or in combination with other admixtures, is added to a cement mixture, preferably to a blended hydraulic cement mixture.

The present invention also provides concrete composition comprising cement, aggregates, water and the copolymer of the present invention.

The present invention also provides mortar composition comprising cement, sand, water and the copolymer of the present invention.

#### **Detailed description of the invention**

In the copolymer of the present invention, the ethylenically unsaturated monomer (a) having 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups includes (meth)acrylic esters of C<sub>1</sub>-C<sub>4</sub> alkoxyalkylene glycols; polyalkylene glycol monoallyl ethers; and adducts of dicarboxylic acids such as maleic anhydride, itaconic anhydride, citraconic anhydride, maleic acid, itaconic acid and citraconic acid, acrylamide and acrylalkylamide with C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups. Preferable examples of the monomer (a) include those represented by the following general formula (I):



wherein R<sub>1</sub> and R<sub>2</sub> are each hydrogen atom or methyl, AO is a C<sub>2</sub>-C<sub>3</sub> oxyalkylene group, n is a number of 25 to 300 and X is hydrogen atom or a C<sub>1</sub>-C<sub>3</sub> alkyl group.

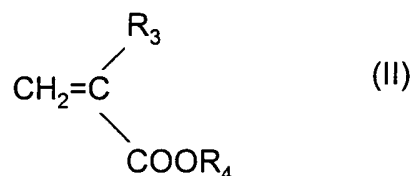
Monomer (a) is produced by methods known by the skilled in art. Usually, an alcohol represented by the formula R-OH, where R represents an alkyl group having from 1 to 22 carbon

atoms, a phenyl group or an alkylphenyl group having from 1 to 22 carbon atoms, is alkoxyated, preferably with ethylene oxide and/or propylene oxide, using appropriate catalysts under a temperature in the range of 80-155°C. Said alkoxyated alcohol is esterified with a carboxylic acid such as acrylic acid, methacrylic acid, crotonic acid, maleic acid, itaconic acid, citraconic acid and fumaric acid and salts thereof.

Specific examples of the monomer (a) represented by the above formula (I) include acrylic and methacrylic esters of polyalkylene glycols blocked with an alkyl group at one end such as methoxypolyethylene glycol, methoxypolyethylenepolypropylene glycol, ethoxypolyethylene glycol, ethoxypolyethylenepolypropylene glycol, propoxypolyethylene glycol and propoxypolyethylenepolypropylene glycol; and adducts of acrylic and methacrylic acids with ethylene oxide and propylene oxide.

The molar addition number of the oxyalkylene group is 25 to 300. When both ethylene oxide and propylene oxide are used, the copolymer may take any form of random addition, block addition and alternating addition. It is preferable from the viewpoint of not causing any retardation of the hardening of concrete that the number of the oxyalkylene group is 50 or above, particularly 80 or above. When the number exceeds 300, not only the polymerizability of the monomer will be poor but also the resulting copolymer will be poor in the dispersing effect.

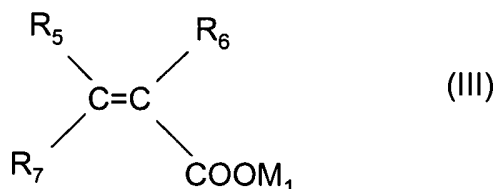
Preferable examples of alkyl, alkenyl or hydroxyalkyl ester of an ethylenically unsaturated mono- or di-carboxylic acid to be used as the monomer (b) in the present invention, which is different from monomer (a), include unsaturated monocarboxylate ester represented by, e.g., the following general formula (II):



wherein  $\text{R}_3$  is hydrogen atom or methyl and  $\text{R}_4$  is a  $\text{C}_1\text{-C}_{18}$  alkyl or  $\text{C}_2\text{-C}_{18}$  alkenyl group or a  $\text{C}_2\text{-C}_6$  hydroxyalkyl group.

Specific examples of the monomer (b) include  $\text{C}_1\text{-C}_{18}$  linear and branched alkyl (meth)acrylates;  $\text{C}_1\text{-C}_{18}$  linear and branched alkenyl (meth)acrylates;  $\text{C}_2\text{-C}_6$  hydroxyalkyl (meth)acrylates; di( $\text{C}_1\text{-C}_{18}$  linear and branched alkyl) esters of maleic acid, fumaric acid, itaconic acid and citraconic acid; and di( $\text{C}_1\text{-C}_{18}$  linear and branched alkenyl) esters of maleic acid, fumaric acid, itaconic acid and citraconic acid. It is particularly preferable with regard to the solubility of the copolymer in water that  $\text{R}_4$  in the above general formula (II) be one having 1 to 4 carbon atoms, though  $\text{R}_4$  is not particularly limited in the form but may be any of linear and branched ones.

In the copolymer of the present invention, the monomer (c) is an ethylenically unsaturated monocarboxylic acid or a salt thereof, or an ethylenically unsaturated dicarboxylic acid or an anhydride or salt thereof, and can be represented by, e.g., the following general formula (III):



wherein  $\text{M}_1$  is hydrogen atom, an alkali metal, an alkaline earth metal, ammonium, an alkylammonium or a substituted alkylammonium group;  $\text{R}_5$  and  $\text{R}_7$  are each hydrogen

atom, methyl or  $(\text{CH}_2)_{m_2}\text{COOM}_2$ ;  $\text{R}_6$  is hydrogen atom or methyl;  $\text{M}_2$  has the same definition as  $\text{M}_1$ ;  $m_2$  is 0 or 1.

Specific examples of the monomer (c) to be used include monocarboxylic acid monomers such as acrylic acid, methacrylic acid and crotonic acid and salts thereof with alkali metals, ammonium, amines and substituted amines; and unsaturated dicarboxylic acid monomers such as maleic acid, itaconic acid, citraconic acid and fumaric acid and salts thereof with alkali metals, alkaline earth metals, ammonium, amines and substituted amines.

Further, the copolymer may contain other co-monomers, as far as the effects of the present invention are not adversely affected, in a maximum amount of 30 mole %, preferably 20 mole %, more preferably 5 mole %. Examples of such co-monomers include vinyl acetate, styrene, vinyl chloride, acrylonitrile, methallylsulfonic acid, acrylamide, methacrylamide and styrenesulfonic acid. Most preferred are copolymers that essentially consist of structural units derived from the monomers (a), (b), and (c).

The copolymer according to the present invention is excellent in the effect of maintaining the slump, preferably when the proportions of the units (a), (b) and (c) are 0.1 to 50 mole %, 0.1 to 49.9 mole % and 0.1 to 90 mole % respectively. In particular, when the proportions of the units (a), (b) and (c) are 1 to 30 mole %, 5 to 45 mole % and 10 to 90 mole %, respectively, even more preferred, when the proportions of the units (a), (b) and (c) are 5 to 20 mole %, 10 to 40 mole % and 25 to 80 mole %, respectively, the resulting copolymer exhibits almost no fluidity loss and shows shorter working time independently of the type of concrete used.

The copolymer according to the present invention can be prepared by known processes, e.g. solution polymerization as

described in WO-A-9748656. That is, the copolymer can be prepared by polymerising the monomers (a), (b) and (c) in a suitable solvent at the above-described reacting ratio.

The solvent to be used in the solution polymerization includes water, methyl alcohol, ethyl alcohol, isopropyl alcohol, benzene, toluene, xylene, cyclohexane, n-hexane, ethyl acetate, acetone, methyl ethyl ketone and so on. It is preferable from the viewpoints of manageability and reaction equipment to use water, methyl alcohol, ethyl alcohol and isopropyl alcohol.

Examples of the polymerization initiator usable in an aqueous medium include ammonium and alkali metal salts of persulfuric acid; hydrogen peroxide; and water-soluble azo compounds such as 2,2'-azobis(2-amidinopropane) dihydrochloride and 2,2'-azobis(2-methylpropionamide) dehydrate. Examples of the polymerization initiator usable in conducting the solution polymerization in a non-aqueous medium include peroxides such as benzoyl peroxide and lauroyl peroxide; and aliphatic azo compounds such as azobisisobutyronitrile.

A polymerization accelerator such as sodium hydrogensulfite and amine compounds may be used simultaneously with the polymerization initiator. Further, a chain transfer agent such as 2-mercaptoethanol, mercaptoacetic acid, 1-mercaptoglycerin, mercaptosuccinic acid or alkylmercaptan may be simultaneously used for the purpose of controlling the molecular weight.

It is preferable that the copolymer according to the present invention has a weight-average molecular weight ( $M_w$ ) of 8,000 to 1,000,000, still preferably 10,000 to 300,000 (in terms of polyethylene glycol as determined by gel permeation chromatography). When the molecular weight is too large, the copolymer will be poor in the dispersing property, while when

it is too small, the copolymer will be poor in the property of maintaining the slump.

The molecular weight is essentially determined by the polymerisation degree (i.e. the total sum of structural units of monomers (a), (b) and (c) in the backbone) and the alkoxylation degree of monomer (a). The higher the alkoxylation degree of monomer (a), the lower is preferably the polymerisation degree in the backbone. Preferred ranges are indicated in the following table:

alkoxylation degree (mole)	25-100	100-200	200-300
Backbone (mole)	200-50	50-25	25-15

It is preferable that the amount of the copolymer as 100% active matter added to concrete and/or mortar be 0.02 to 1.0% by weight, still preferably 0.05 to 0.5% by weight based on cement in terms of solid matter.

A concrete and/or mortar admixture composition comprising the copolymer of the present invention also forms part of the present invention. Said admixture composition may further contain at least one superplasticizer, other than the copolymer according to the invention, selected from the group consisting of naphthalene derivatives, melamine derivatives, aminosulfonic acid derivatives, polycarboxylate-based superplasticizers and polyether-based superplasticizers.

Examples of superplasticizer agents include naphthalene derivatives such as Mighty 150 (a product of Kao Corporation), melamine derivatives such as Mighty 150V-2 (a product of Kao Corporation), amino-sulfonic acid derivatives such as Paric FP (a product of Fujisawa Chemicals), and polycarboxylic acid derivatives such as Mighty 2000WHZ (a product of Kao Corporation). Among these known superplasticizer agents, it is particularly preferred to use

Mighty 21EG, Mighty 21ES and Mighty 21ER (products of Kao Chemicals GmbH) which are copolymers prepared by copolymerizing a polyalkylene glycol monoester monomer, wherein the polyalkylene glycol moiety is composed of 110 to 300 moles of oxyalkylene groups having 2 to 3 carbon atoms, with an acrylic acid monomer. It is also particularly preferred to use the copolymers described in WO-A-9748656.

It is preferable from the viewpoint of maintaining the fluidity that the weight ratio of the copolymer of the present invention to the superplasticizers lies between 10:90 and 90:10.

The admixture composition of the present invention may be used in combination with other known additives. Examples of such additives include an air entraining agent, a water-reducing agent, a plasticizer, a retarding agent, an early-strength enhancer, an accelerator, a foaming agent, a blowing agent, an antifoaming agent, a thickener, a waterproofing agent, a defoaming agent, quartz sand, blast furnace slag, fly ash, silica fume, lime stone and so on.

The admixture of the present invention can be added either alone or in combination with other additives to a cement mixture, preferably to blended hydraulic cements, said blended hydraulic cements comprising preferably from 5-95% of cement and from 5-95% wt% of other constituents. Examples of the cement mixture include Portland-slag cement (CEM II/A-S and CEM II/B-S), Portland-silica fume cement (CEM II/A-D), Portland-pozzolana cement (CEM II/A-P, CEM II/B-P, CEM II/A-Q and CEM II/B-Q), Portland-fly ash cement (CEM II/A-V, CEM II/B-V, CEM II/A-W and CEM II/B-W), Portland-burnt shale cement (CEM II/A-T and CEM II/B-T), Portland-limestone cement (CEM II/A-L, CEM II/A-LL, CEM II/B-L and CEM II/B-LL), Portland-composite cement (CEM II/A-M and CEM II/B-M), Blast furnace cement (CEM III/A, CEM III/B and CEM III/C),



Pozzolanitic cement (CEM IV/A and CEM IV/B), and Composite cement (CEM V/A and CEM V/B).

The invention also provides a method for dispersing a cement mixture, which comprises adding to a cement mixture, preferably to blended hydraulic cements, an admixture composition of the present invention either alone or in combination with other additives.

The present invention also provides concrete composition comprising cement, aggregates, water and the admixture composition of the present invention, either alone, or in combination with other additives.

The present invention also provides mortar composition comprising cement, sand, water and the admixture composition of the present invention, either alone, or in combination with other additives.

The following examples are given in order to provide a person skilled in the art with a sufficiently clear and complete explanation of the present invention, but should not be considered as limiting of the essential aspects of its subject, as set out in the preceding portions of this description.

### **Examples**

The weight-average molecular weights (Mw) of copolymers indicated in the examples are determined by gel permeation chromatography (GPC) in terms of polyethylene glycol.

#### Example 1 (Admixture C-1)

Water (211 mole) was charged into a reactor equipped with a stirrer, and the resulting system was purged with nitrogen under stirring, followed by heating to 75°C in a nitrogen atmosphere. A solution comprising 0.05 mole of methoxypolyethylene glycol methacrylate (having 280 mole on

overage of ethylene oxide), 0.4 mole of ethyl acrylate and 0.55 mole of acrylic acid, a 20 wt.% aqueous solution of ammonium persulfate (0.05 mole) (1) and a 20 wt.% aqueous solution of 2-mercaptoethanol (0.1 mole) were separately and simultaneously dropped into the reactor in 2 hours. Then, a 20 wt.% aqueous solution of ammonium persulfate (0.02 mole) (2) was dropped into the reactor in 30 minutes. The resulting mixture was aged at that temperature (75°C) for 1 hour and thereafter heated to 95°C. 35 wt.% aqueous solution of hydrogen peroxide (0.2 mole) was dropped into the resulting mixture in 30 minutes and the mixture thus obtained was aged at that temperature (95°C) for 2 hours. After the completion of the aging, 48 wt.% aqueous solution of sodium hydroxide (0.39 mole) was added to the mixture. Thus, a copolymer having a weight average molecular weight of 130,000 was obtained.

In the same manner as before, but with the reaction conditions indicated in Table 1 and Table 2, copolymers according to the invention and comparative experiments were prepared.

A summary of the monomers used for preparing the copolymers according to the invention and comparative examples is presented in Table 3 and Table 4.

Table 1 - Reaction conditions - copolymers according to the invention

	Water (mole)	ammonium persulfate (mole)		2- mercapto -ethanol (mole)	H <sub>2</sub> O <sub>2</sub> (mole)	NaOH (mole)	Mw (weight average)
		(1)	(2)				
C-1	211	0.05	0.02	0.10	0.20	0.39	130,000
C-2	72	0.05	0.02	0.10	0.20	0.32	62,000
C-3	45	0.05	0.02	0.08	0.20	0.35	55,000
C-4	60	*	0.02	0.08	0.15	0.39	65,000
C-5	50	0.05	0.02	0.08	0.20	0.46	55,000
C-6	102	0.05	0.02	0.04	0.20	0.42	115,000
C-7	54	0.05	0.02	0.08	---	0.15	34,000
C-8	32	0.05	0.01	0.08	0.02	0.18	37,000
C-9	56	0.05	0.02	0.08	0.20	0.35	85,000
C-10	56	0.05	0.02	0.08	0.20	0.35	83,500
C-11	56	0.05	0.02	0.08	0.20	0.35	82,000

\*0.02 mole of 2,2'-azobis(2-amidinopropane)  
dihydrochloride

Table 2 - Reaction conditions - Copolymers - comparative examples

	Water (mole)	ammonium persulfate (mole)		2- mercapto -ethanol (mole)	H <sub>2</sub> O <sub>2</sub> (mole)	NaOH (mole)	Mw (weight average)
		(1)	(2)				
CE-1	30	0.10	0.01	0.06	0.1	0.35	58,000
CE-2	45	0.05	0.02	0.08	---	0.15	57,000
CE-3	135	0.03	0.01	0.05	0.1	0.35	120,000
CE-4	32	0.05	0.01	0.08	0.2	0.04	41,000
CE-5	56	0.05	0.02	0.08	0.2	0.35	86,000

Table 3 - Copolymers according to the invention

	Monomer (a)				Monomer (b)		Monomer (c)	
	Mole %	Kind	EO units	PO units	Mole %	Kind	Mole %	Kind
C-1	5	PEM	280		40	EA	55	AAC
C-2	10	PEM	185		45	MA	45	MAC
C-3	10	PEM	130		40	MA	50	MAC
C-4	15	PEM	125	15	30	MMA	55	AAC
C-5	15	PEM	118		20	HEA	65	AAC
C-6	20	PEM	130		20	HEA	60	AAC
C-7	25	Allyl alcohol	120		25	MA	50	Maleic acid, sodium salt
C-8	35	PEM	28		40	MMA	25	MAA
C-9	25	PEM	130		49	EA	26	MAC
C-10	25	PEM	130		40	EA	35	MAC
C-11	25	PEM	130		30	EA	45	MAC

Table 4 - Copolymers - comparative examples

	Monomer (a)				Monomer (b)		Monomer (c)	
	Mole %	Kind	EO units	PO units	Mole %	Kind	Mole %	Kind
CE-1	10	PEM	9		40	MA	50	MAC
CE-2	10	PEM	130		70	MA	20	MAC
CE-3	25	PEM	350		25	MA	50	MAC
CE-4	35	PEM	28		60	MMA	5	MAC
CE-5	25	PEM	130		55	EA	20	MAC

AAC = Acrylic Acid

MA = Methyl Acrylate

EA = Ethyl Acrylate

MAC = Methacrylic Acid

HEA = Hydroxyethyl Acrylate

MMA = Methyl Methacrylate

PEM = Methoxypolyethylenglycol methacrylate

The tests were carried out with following components:

- Cement type:

a) CEM I 42.5 R from Zementwerke AG, Geseke cement plant in Germany (Portland cement)

b) CEM II/A-M 42.5 N from Lafarge, Mannersdorf cement plant in Austria (Portland-composite having from 6-20% of other main constituents)

- Sand 0/4 (having a grain size of less than 4 mm), region Markgraneusiedel (MGN), Niderösterreich (Austria)

- Water (tap water from Emmerich am Rhein, Germany)

Mortar mix design (per batch) is as follows;

- Cement 450 g

- Sand 1350 g

- Water 225 g

Water/Cement (%) = 0.50

The materials specified above and each admixture were mixed in a 4 L capacity mortar mixer (model ZZ 30 from Zyklos Mischtechnik GmbH) at 140 r.p.m. for 2 minutes.

Copolymers according to the invention (C-1 to C-11) and comparative examples (CE-1 to CE-5) were evaluated by using the Japanese Industrial Standard JIS R 5201:1997 (mortar flow test).

The results are given in Table 5 and Table 6.

Table 5 - Cement type a: CEM I 42.5 R

	Dosage (%) *	Mortar Flow (mm)				
		just after	after 15min	After 30min	after 60min	after 90min
C-1	0.16	245	248	245	242	240
C-2	0.16	240	245	243	243	242
C-3	0.15	243	242	242	240	240
C-4	0.16	235	237	239	237	234
C-5	0.14	250	258	259	257	256
C-6	0.15	250	253	258	254	252
C-7	0.15	238	239	240	238	236
C-8	0.16	231	233	237	240	243
C-9	0.16	232	235	238	240	238
C-10	0.16	242	240	238	237	234
C-11	0.15	235	232	230	230	228
CE-1	0.20	238	217	201	181	158
CE-2	0.21	240	242	236	230	227
CE-3	0.28	239	218	207	186	167
CE-4	0.54	241	216	198	176	155
CE-5	0.22	235	230	228	234	238

Table 6 - Cement type b: CEM II/A-M 42.5 N

	Dosage (%) *	Mortar Flow (mm)				
		just after	after 15min	After 30min	after 60min	after 90min
C-1	0.11	243	245	243	239	238
C-2	0.11	238	242	240	238	237
C-3	0.10	240	241	240	238	237
C-4	0.11	233	235	237	234	231
C-5	0.09	248	256	258	256	254
C-6	0.10	245	248	255	251	249
C-7	0.10	235	237	239	236	234
C-8	0.11	230	232	233	237	238
C-9	0.11	240	242	241	238	235
C-10	0.10	238	238	236	235	233
C-11	0.10	242	240	237	234	234
CE-1	0.18	233	210	192	177	143
CE-2	0.17	178	180	185	215	248
CE-3	0.22	238	216	204	183	162
CE-4	0.34	165	167	186	198	195
CE-5	0.16	182	180	188	198	201

\* wt.% in terms of solid matter (100 % active matter) based on the weight of cement

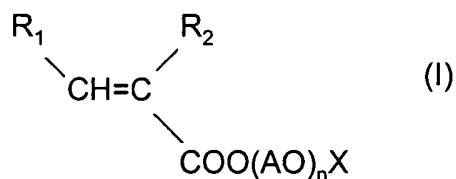
As it was evidenced from the results given in Table 5 and 6, it can be concluded that the copolymers of the present invention can maintain the mortar flow (fluidity) during a long period of time and are not affected by the type of cement, i.e. by using blended hydraulic cement (CEM II/A-M 42.5 N). This permits control the quality parameters of the concrete or mortar even in different working conditions (temperature, water-cement ratio, etc.) independently of the cement type.

On the other hand, the comparative experiments, and among them CE-2 (reproduction of example C-13 of WO-A-9748656) and CE-5 (reproduction of example C-6 of WO-A-9748656) are very much affected by the cement type.

## CLAIMS

1. Copolymer consisting of, as structural units,
  - i) 0.1 to 50 mole % of units derived from an ethylenically unsaturated monomer (a) having per one mole thereof 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups;
  - ii) 0.1 to 49.9 mole % of units derived from a monomer (b) of an alkyl, alkenyl or hydroxyalkyl ester of an ethylenically unsaturated mono- or di-carboxylic acid;
  - iii) 0.1 to 90 mole % units derived from a monomer (c) selected from the group consisting of an ethylenically unsaturated monocarboxylic acid, a salt thereof, an ethylenically unsaturated dicarboxylic acid, an anhydride thereof and a salt thereof; and
  - iv) optionally up to 30 mole % of other monomers.
2. Copolymer according claim 1, in which the monomer (a) is selected from the group consisting of
  - (a-1) an ester product prepared by the reaction between methoxy-polyalkylene glycol having per one mole 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups with acrylic acid or methacrylic acid,
  - (a-2) a monoallyl ether prepared by the reaction between polyalkylene glycol having per one mole 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups and allyl alcohol, and
  - (a-3) an adduct prepared by the reaction between maleic anhydride, itaconic anhydride, citraconic anhydride, maleic acid, itaconic acid, citraconic acid, acrylic amide or an acrylalkyl amide and a polyalkylene glycol having per one mole 25 to 300 moles of C<sub>2</sub>-C<sub>3</sub> oxyalkylene groups.
3. Copolymer according claim 1 or 2, in which the monomer (a) is defined by the formula (I):

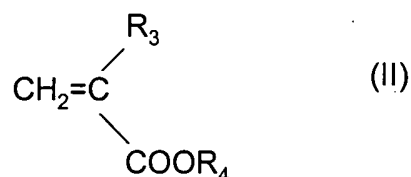




wherein  $R_1$  and  $R_2$  are each hydrogen atom or methyl, AO is a  $C_2$ - $C_3$  oxyalkylene group,  $n$  is a number of 25 to 300 and  $X$  is hydrogen atom or a  $C_1$ - $C_3$  alkyl group.

4. Copolymer according to claim 3, in which  $n$  is a number of 80 to 300.

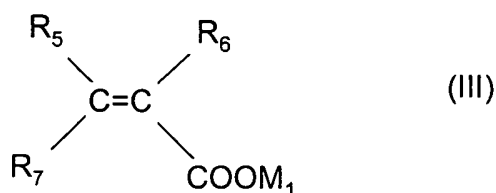
5. Copolymer according to any of the preceding claims, in which the monomer (b) is an unsaturated monocarboxylate ester having the formula (II):



wherein  $R_3$  is hydrogen atom or methyl and  $R_4$  is a  $C_1$ - $C_{18}$  alkyl or alkenyl group or a  $C_2$ - $C_6$  hydroxyalkyl group.

6. Copolymer according to any of the preceding claims, in which the monomer (b) is selected from the group consisting of a maleic diester, a fumaric diester, an itaconic diester and a citraconic diester, each diester is bonded to a  $C_1$ - $C_{18}$ , straight or branched, alkyl or alkenyl group.

7. Copolymer according to any of the preceding claims, in which the monomer (c) is defined by the formula (III):



wherein  $M_1$  is hydrogen atom, an alkali metal, an alkaline earth metal, ammonium, an alkylammonium or a substituted alkylammonium group;  $R_5$  and  $R_7$  are each hydrogen atom, methyl or  $(CH_2)_{m_2}COOM_2$ ;  $R_6$  is hydrogen atom or methyl;  $M_2$  has the same definition as  $M_1$ ;  $m_2$  is 0 or 1.

8. Copolymer according to any of the preceding claims, wherein the copolymer comprises 1 to 30 mole % of the units (a), 5 to 45 mole % of the units (b) and 10 to 90 mole % of the units (c).

9. Copolymer according to any of the preceding claims, wherein the copolymer comprises 5 to 20 mole % of the units (a), 10 to 40 mole % of the units (b) and 25 to 80 mole % of the units (c).

10. Copolymer according to any of the preceding claims, in which the copolymer has a weight average molecular weight (Mw) of 8,000 to 1,000,000.

11. A concrete and/or mortar admixture composition comprising the copolymer as defined in claims 1 to 10.

12. Composition according to claim 11 further comprising at least one superplasticizer, other than the copolymer as defined in claims 1 to 10, selected from the group consisting of naphthalene derivatives, melamine derivatives, aminosulfonic acid derivatives, polycarboxylate-based superplasticizers, polyether-based superplasticizers and mixtures thereof.

13. Composition according to claim 12, in which a mixing weight ratio of the copolymer to the superplasticizer/s ranges between 10:90 and 90:10.

14. Method for dispersing a cement mixture which comprises adding to a cement mixture

- (i) a copolymer as defined in claims 1 to 10, or
- (ii) an admixture composition as defined in claims 11 to 13.

15. Concrete composition comprising cement, aggregates, water and

- (i) a copolymer as defined in claims 1 to 10, or
- (ii) the admixture composition as defined in claims 11 to 13.

16. Mortar composition comprising cement, sand, water and

- (i) a copolymer as defined in claims 1 to 10, or
- (ii) the admixture composition as defined in claims 11 to 13.

17. Composition according to claims 15 or 16, which comprises 0.02 to 1.0 percent by weight of the copolymer as a 100% active matter based on solid matter of the cement.

18. Composition according to claims 15 to 17, in which the cement is a blended hydraulic cement.

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2006/003951

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. C08F220/00 C04B24/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
C08F C04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95/16643 A (KAO CORPORATION; YAMATO, FUJIO; FUJITA, SHUICHI; TANISHO, YOSHIAKI; KI) 22 June 1995 (1995-06-22) claims 1-11	1-18

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

### \* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

14 June 2006

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2006/003951

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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			JP 2774445 B2	09-07-1998
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