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54	METHOD FOR PRODUCING HYDROPHOBICALLY MODIFIED ACRYLIC RHEOLOGY MODIFIERS		

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ABSTRACT OF THE DISCLOSURE

A method for preparing hydrophobically modified rheology modifiers; said method comprising polymerizing a monomer mixture having two or more components. The first component is  $H_2C=C(R)C(O)X(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$  or

5  $H_2C=C(R)C_6H_4C(CH_3)_2NHCO_2(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$ , wherein X is O or NH, R is H or  $CH_3$ , R' is  $C_1-C_2$  alkyl, R'' is  $C_8-C_{22}$  alkyl or  $C_8-C_{16}$  alkylphenyl, n is an average number from 6-100 and m is an average number from 0-50, provided that  $n \geq m$  and  $m+n$  is 6-100. The second component is a  $C_3-C_6$  carboxylic acid monomer; wherein polymerization occurs in the presence of an oxidant, a reductant and a metal catalyst, and substantially in the

10 absence of a peroxide, hydroperoxide or perester containing an alkyl group having at least five carbon atoms.



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## METHOD FOR PRODUCING HYDROPHOBICALLY MODIFIED ACRYLIC RHEOLOGY MODIFIERS

### Background

5 This invention generally relates to a method for preparing hydrophobically modified acrylic rheology modifiers.

Aqueous formulations typically use thickeners to obtain a desired rheology profile. For example, an aqueous paper coating composition requires rheology modifiers to provide sufficient low shear viscosity to allow pickup and application of the coating composition onto 10 a paper substrate as well as the appropriate high shear viscosity to allow metering of the excess applied coating composition to obtain a desired coating weight. One class of thickeners suitable for thickening aqueous formulations are alkali-soluble thickeners. These thickeners, also referred to as alkali-swellable thickeners, are copolymers formed by the polymerization of ethylenically unsaturated monomers and contain acid groups pendant to 15 backbone of the copolymer. Alkali-soluble thickeners have also been prepared containing pendant nonionic surfactant groups or hydrophobes. These thickeners, known in the art as hydrophobically-modified alkali-soluble (swellable) thickeners, are characterized by increased thickening efficiency compared to alkali-soluble thickeners of similar composition and molecular weight. U.S. Patent 4,384,096 discloses a method for preparing rheology 20 modifiers containing hydrophobes. However, the disclosed process is a thermally initiated polymerization.

The problem solved by the present invention is to improve the method for preparing hydrophobically modified (meth)acrylate rheology modifiers to obtain rheology modifiers with an improved viscosity profile.

### 25 Statement of the Invention

The present invention is directed to a method for preparing hydrophobically modified rheology modifiers; said method comprising polymerizing a monomer mixture comprising:

(i) a monomer selected from the group consisting of:

(a)  $\text{H}_2\text{C}=\text{C}(\text{R})\text{C}(\text{O})\text{X}(\text{CH}_2\text{CH}_2\text{O})_n(\text{CH}(\text{R}')\text{CH}_2\text{O})_m\text{R}''$ ;

30 (b)  $\text{H}_2\text{C}=\text{C}(\text{R})\text{C}_6\text{H}_4\text{C}(\text{CH}_3)_2\text{NHCO}_2(\text{CH}_2\text{CH}_2\text{O})_n(\text{CH}(\text{R}')\text{CH}_2\text{O})_m\text{R}''$ ; and combinations thereof; wherein X is O or NH, R is H or  $\text{CH}_3$ , R' is  $\text{C}_1\text{-C}_2$  alkyl; R'' is  $\text{C}_8\text{-C}_{22}$  alkyl,  $\text{C}_8\text{-C}_{16}$  alkylphenyl or  $\text{C}_{13}\text{-C}_{36}$  aralkylphenyl; n is an average number from 6-100 and m is an average number from 0-50, provided that  $n \geq m$  and  $m+n$  is 6-100 and (ii) a  $\text{C}_3\text{-C}_6$  carboxylic acid monomer; wherein at least 30% of polymerization occurs in the presence of an oxidant, a

reductant and a metal catalyst, and substantially in the absence of a peroxide, hydroperoxide or perester containing an alkyl group having at least five carbon atoms.

Detailed Description of the Invention

All percentages are weight percentages (wt%), unless otherwise indicated and all 5 temperatures are in °C, unless otherwise indicated. Weight average molecular weights,  $M_w$ , are measured by gel permeation chromatography (GPC) using polyacrylic acid standards, as is known in the art. The techniques of GPC are discussed in detail in Modern Size Exclusion Chromatography, W. W. Yau, J. J. Kirkland, D. D. Bly; Wiley-Interscience, 1979, and in A Guide to Materials Characterization and Chemical Analysis, J. P. Sibilia; VCH, 1988, p. 81-10 84. The molecular weights reported herein are in units of daltons. As used herein the term "(meth)acrylic" refers to acrylic or methacrylic. A "C<sub>3</sub>-C<sub>6</sub> carboxylic acid monomer" is a mono-ethylenically unsaturated compound having one or two carboxylic acid groups, e.g., (meth)acrylic acid, maleic acid, fumaric acid, itaconic acid, maleic anhydride, crotonic acid, etc. Alkyl groups are saturated hydrocarbyl groups which may be straight or branched. 15 Aralkyl groups are alkyl groups substituted by aryl groups. Examples of aralkyl groups include, e.g., benzyl, 2-phenylethyl and 1-phenylethyl. Aralkylphenyl groups are phenyl groups having one or more aralkyl substituents, e.g., 2,4,6-tris(1-phenylethyl)phenyl.

The redox systems used in the method of this invention use one or more oxidants in combination with a suitable reductant and a metal catalyst. Preferably, at least 40 wt% of 20 total monomer is polymerized in the presence of the redox system, preferably at least 50 wt%, preferably at least 60 wt%, preferably at least 70 wt%, preferably at least 80 wt%. The total weight of monomers includes any monomer which already has been polymerized at the time the redox system is added. Suitable oxidants include, e.g., t-alkyl hydroperoxides, t-alkyl peroxides, and t-alkyl peresters, wherein in each case the t-alkyl group has fewer than 5 25 carbon atoms; hydrogen peroxide, sodium peroxide, potassium peroxide, persulfate, percarbonate, perborate, perphosphoric acid and salts thereof, potassium permanganate, and ammonium or alkali metal salts of peroxydisulfuric acid. Preferred oxidants include persulfate, percarbonate and perborate; preferably persulfate. In the method of this invention, polymerization occurs substantially in the absence of a peroxide, hydroperoxide or perester 30 containing an alkyl group having at least five carbon atoms. Herein, the phrase "substantially in the absence" means that the oxidant contains less than 5 wt% of peroxides, hydroperoxides or peresters having C<sub>5</sub> or larger alkyl groups, preferably less than 2 wt%, preferably less than 1 wt %, preferably less than 0.5 wt%, preferably less than 0.1 wt%, preferably 0 wt%. In

some preferred embodiments, polymerization is conducted substantially in the absence of any peroxides, hydroperoxides or peresters. Preferably, oxidants are present at a total level of from 0.01 to 1 wt %, based on the total weight of the monomers, preferably from 0.03 to 0.5 wt%, preferably from 0.05 to 0.25 wt%. Suitable reductants include sodium sulfoxylate

5 formaldehyde, ascorbic acid, isoascorbic acid, alkali metal and ammonium salts of sulfur-containing acids, such as sodium sulfite, bisulfite, thiosulfate, hydrosulfite, sulfide, hydrosulfide, dithionite, formadinesulfinic acid, hydroxymethanesulfonic acid, sodium 2-hydroxy-2-sulfinatoacetic acid, acetone bisulfite, amines such as ethanolamine, acids such as glycolic acid, glyoxylic acid hydrate, lactic acid, glyceric acid, malic acid, tartaric acid, and

10 salts of the preceding acids. Preferably the reductant is isoascorbic acid. Preferably, reductants are present at a total level of from 0.01 to 1 wt %, based on the total weight of the monomers preferably from 0.03 to 0.4 wt%, preferably from 0.05 to 0.2 wt%. Suitable metal catalysts are redox reaction catalyzing metal salts including, e.g., iron, copper, manganese, silver, platinum, vanadium, nickel, chromium, palladium, and cobalt. Preferred metal

15 catalysts are selected from iron, copper and combinations thereof; preferably iron. Preferably, metal catalysts are present at a total level of at least 0.1 ppm, based on metal ion content in the total weight of the monomers, preferably at least 0.5 ppm, preferably at least 1 ppm, preferably at least 2 ppm, preferably at least 3 ppm, preferably at least 4 ppm; preferably the metal catalysts are present at a total level no greater than 100 ppm, preferably

20 no greater than 50 ppm, preferably no greater than 25 ppm, preferably no greater than 20 ppm. The total weight of monomers includes any monomer which already has been polymerized at the time the oxidant, reductant and metal ion are added. When the part of the polymerization reaction catalyzed by oxidant, reductant and metal ion is conducted in contact with equipment containing catalytic metals, e.g., steel reactors, it may not be necessary to add

25 additional metal ion with the other reactants. In some preferred embodiments of the invention, a portion of the monomer mixture is partially polymerized using an oxidant as the initiator, followed by addition of the remaining monomer and polymerization in the presence of an oxidant, a reductant and a metal catalyst. Preferably, less than 50 wt% of total monomer is polymerized using a thermal oxidant, preferably less than 25 wt%, preferably

30 less than 15 wt%, preferably less than 10 wt%. This thermally polymerized material can be formed in situ at the beginning of the polymerization, or from a previously prepared polymer seed, or as the result of a "chaser" addition. Additionally, the polymerization could be started using a redox process (oxidant/ reductant/ and metal catalyst), the second stage employing a

thermal process. The redox portion of the process can be a gradual feed, a shot, a feed followed by a shot, or a shot followed by a feed, or other possible combinations. A shot addition is one in which monomer is added over a relatively short time, e.g., less than 20 minutes, preferably less than 15 minutes, preferably less than 10 minutes, so that the reaction 5 mixture will contain substantial unreacted monomer after the addition. Typically, shot additions contain only monomer, with catalysts being added to the reaction mixture separately, preferably after the shot addition. After most of the polymerization is complete, i.e., at least 85%, preferably at least 90%, preferably at least 95%; additional initiators may be added as a "chaser" to polymerize most of the residual monomer. The chaser may be a 10 thermal initiator or a redox system.

Redox feed run at a monomer addition process temperature from 35 °C to 85 °C, preferably from 40 °C to 75 °C, preferably from 40 °C to 70 °C. For the optional redox shot process, the preferred temperature range to start the polymerization is 35 °C to 85 °C, preferably 40 °C to 75 °C, preferably from 40 °C to 70 °C. The preferred peak temperature 15 after conversion (exotherm) of the monomer shot to polymer is 35 °C to 95 °C, preferably 45 °C to 80 °C, preferably from 50 °C to 75 °C.

Preferably, the rheology modifier is an acrylic polymer, i.e., one having at least 50 wt% polymerized residues of acrylic monomers, preferably at least 70 wt%, preferably at least 80 wt%, preferably at least 90 wt%, preferably at least 95 wt%, preferably at least 98 20 wt%. Acrylic monomers include (meth)acrylic acids and their C<sub>1</sub>-C<sub>22</sub> alkyl or hydroxyalkyl esters, including monomers of structure H<sub>2</sub>C=C(R)CO<sub>2</sub>(CH<sub>2</sub>CH<sub>2</sub>O)<sub>n</sub>(CH(R')CH<sub>2</sub>O)<sub>m</sub>R"; crotonic acid, itaconic acid, fumaric acid, maleic acid, maleic anhydride, (meth)acrylamides, (meth)acrylonitrile and alkyl or hydroxyalkyl esters of crotonic acid, itaconic acid, fumaric acid or maleic acid. Preferably, the acrylic polymer also comprises other polymerized 25 monomer residues including, e.g., non-ionic (meth)acrylate esters, cationic monomers, H<sub>2</sub>C=C(R)C<sub>6</sub>H<sub>4</sub>C(CH<sub>3</sub>)<sub>2</sub>NHCO<sub>2</sub>(CH<sub>2</sub>CH<sub>2</sub>O)<sub>n</sub>(CH(R')CH<sub>2</sub>O)<sub>m</sub>R", monounsaturated dicarboxylates, vinyl esters, vinyl amides (including, e.g., N-vinylpyrrolidone), sulfonated acrylic monomers, vinyl sulfonic acid, vinyl halides, phosphorus-containing monomers, heterocyclic monomers, styrene and substituted styrenes. Preferably, the rheology modifier 30 comprises from 15 to 60 wt% polymerized residues of C<sub>3</sub>-C<sub>6</sub> carboxylic acid monomers, preferably from 22 to 55 wt%, preferably from 30 to 50 wt%, preferably from 23 to 30 wt%. Preferably, the C<sub>3</sub>-C<sub>6</sub> carboxylic acid monomer is a C<sub>3</sub>-C<sub>4</sub> carboxylic acid monomer; preferably the C<sub>3</sub>-C<sub>4</sub> carboxylic acid monomer is selected from among (meth)acrylic acid and

maleic acid, preferably (meth)acrylic acid, preferably methacrylic acid. Preferably, the rheology modifier comprises polymerized residues of a monomer having the structure  $H_2C=C(R)C(O)X(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$ . Preferably, X is O. Preferably, the rheology modifier comprises from 1 to 25 wt% polymerized residues of monomers of

5 structure  $H_2C=C(R)C(O)X(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$ , preferably from 1 to 15 wt%, preferably from 1 to 6 wt%, preferably from 5 to 25 wt%, preferably from 6 to 15 wt%. Preferably, R'' is C<sub>8</sub>-C<sub>22</sub> alkyl, preferably C<sub>10</sub>-C<sub>22</sub> alkyl, preferably C<sub>12</sub>-C<sub>20</sub> alkyl. Preferably, n is 15-30 and m is 0-5; preferably n is 18-25 and m is 0-3; preferably n is 18-25 and m is 0-2; preferably R' is methyl. Preferably, R is methyl. Preferably, R'' is C<sub>10</sub>-C<sub>22</sub> alkyl, n is 15-

10 30 and m is 0-5; preferably, R'' is C<sub>12</sub>-C<sub>22</sub> alkyl, n is 18-25, m is 0-3 and R is methyl. Preferably, the rheology modifier further comprises from 25 to 65 wt% polymerized residues of C<sub>1</sub>-C<sub>4</sub> alkyl (meth)acrylates, preferably from 30 to 60 wt%, preferably from 40 to 60 wt%. Preferably, the C<sub>1</sub>-C<sub>4</sub> alkyl (meth)acrylate residues are C<sub>2</sub>-C<sub>3</sub> alkyl (meth)acrylate residues, preferably C<sub>2</sub>-C<sub>3</sub> alkyl acrylates, preferably ethyl acrylate.

15 In some preferred embodiments of the present invention, the rheology modifier is a crosslinked polymer, that is, a crosslinker, such as a monomer having two or more non-conjugated ethylenically unsaturated groups, is included with the copolymer components during polymerization. Preferred examples of such monomers include, e.g., di- or tri-allyl ethers and di- or tri-(meth)acrylyl esters of diols or polyols (e.g., trimethylolpropane diallyl

20 ether, ethylene glycol dimethacrylate), di- or tri-allyl esters of di- or tri-acids, allyl (meth)acrylate, divinyl sulfone, triallyl phosphate, divinyl aromatics (e.g., divinylbenzene). In some preferred embodiments, the amount of crosslinker residue in the rheology modifier is at least 0.01 wt%, preferably at least 0.05 wt% preferably at least 0.1 wt%, based on weight of the polymer. Preferably, the amount of crosslinker residue is no more than 2 wt%,

25 preferably no more than 1.5 wt%, preferably no more than 1 wt%, preferably no more than 0.5 wt%, preferably no more than 0.3 wt%, preferably no more than 0.2 wt%.

In some preferred embodiments of the invention, chain transfer agents are included in the polymerization mixture. Typical chain transfer agents used in emulsion polymerization include mercaptoalkanes and mercapto alkyl esters, e.g., n-decyl mercaptan, n-dodecyl

30 mercaptan, tert-dodecyl mercaptan, tert-butyl mercaptan, methyl 3-mercaptopropionate, butyl 3-mercaptopropionate, i-octyl 3-mercaptopropionate, decyl 3-mercaptopropionate, dodecyl 3-mercaptopropionate, 2-ethyl hexyl 3-mercaptopropionate, and octadecyl 3-mercaptopropionate. Preferably, the amount of chain transfer agent in the rheology modifier

is at least 0.05 wt%, preferably at least 0.1 wt%, preferably at least 0.2 wt%, based on weight of the polymer. Preferably, the amount of chain transfer agent residue is no more than 0.5 wt%, preferably no more than 0.3 wt%, preferably no more than 0.2 wt%, preferably no more than 0.1 wt%, preferably no more than 0.05 wt% based on weight of the polymer.

5       Typically, when the polymer is used as a thickener or rheology modifier, a typical weight average molecular weight is in the range of from 100,000 to 10,000,000, preferably from 200,000 to 5,000,000.

10      Typically, the rheology modifier is provided as an aqueous composition containing the polymer as discrete particles dispersed in an aqueous medium. In this aqueous dispersion, the average particle diameter of the polymer particles is typically in the range of from 20 to 1,000 nm, preferably in the range of from 50 to 500 nm, and more preferably, in the range of from 75 to 350 nm. Particle sizes herein are those determined using a Brookhaven Model BI-90 particle sizer manufactured by Brookhaven Instruments Corporation, Holtsville, NY, reported as "effective diameter". The level of polymer particles in the aqueous dispersion is typically in the range of from 15 to 60 weight %, based on the weight of the aqueous dispersion.

15      Typically, the rheology modifier is provided as an aqueous composition containing the polymerized monomers as a partly or fully solubilized polymer in an aqueous medium. Partly soluble polymer refers to a polymer that is not fully soluble in the aqueous medium, such as a swellable polymer particle that is enlarged by imbibing the aqueous medium but still retains some aspect of the particle shape. The solution containing the partly or completely solubilized polymer is characterized as having a translucent, semi-transparent, or transparent appearance. Suitable pH ranges for the aqueous solution of this embodiment are related to the level of pendant ionic groups attached to the polymer. A polymer containing less than 70 weight % acid monomer as polymerized units, based on the total weight of the polymer, is typically partly or completely soluble in an aqueous medium having a pH that is at or above the  $pK_a$  of the pendant acid groups. For example, a polymer containing from 25 to 65 weight % polymerized acid monomer, based on the total weight of the polymer, is typically partly or completely soluble at a pH in the range of 5 to 14.

20      Suitable bases to adjust the pH of the polymer dispersion include mineral bases such as sodium hydroxide and potassium hydroxide; ammonium hydroxide; and organic bases such as triethylamine. Mixtures of bases may be used. Suitable acids to adjust the pH of the

aqueous medium include mineral acid such as hydrochloric acid, phosphorus acid, and sulfuric acid; and organic acids such as acetic acid. Mixtures of acids may be used.

Suitable polymerization techniques for use in the method of this invention include emulsion polymerization and solution polymerization. Aqueous emulsion polymerization processes typically are conducted in an aqueous reaction mixture, which contains at least one monomer and various synthesis adjuvants such as the free radical sources, buffers, and reductants in an aqueous reaction medium. The aqueous reaction medium is the continuous fluid phase of the aqueous reaction mixture and contains greater than 50 weight % water and optionally one or more water miscible solvents, based on the weight of the aqueous reaction medium. Suitable water miscible solvents include methanol, ethanol, propanol, acetone, ethylene glycol ethyl ethers, propylene glycol propyl ethers, and diacetone alcohol. Preferably, the aqueous reaction medium contains greater than 90 weight % water, and more preferably, greater than 95 weight % water, based on the weight of the aqueous reaction medium. Most preferred is an aqueous reaction medium containing from 98 to 100 weight % water, based on the weight of the aqueous reaction medium.

The hydrophobically modified rheology modifier is useful as a thickener for paints and other coating compositions, additive for cement products, paper coating thickener, rheology modifier for personal care products (e.g., shampoo, body wash), thickener for laundry detergent formulations, deicing fluids and adhesives, and as an additive for oilfield applications, e.g., oil-water clarification and water-in-oil separation.

The rheology modifier may be used in a "back-acid" formulation wherein the formulated polymer is partially neutralized at high pH, then re-acidified to lower the pH, as described in EP 1,272,159. The rheology modifier also may be used in formulations containing synthetic clays as co-thickeners, e.g., Laponite clays.

Polymer synthesis

MA-20 = methacrylate ester of a 20 ethoxylate of cetyl-stearyl alcohol (70%), 20% methacrylic acid, 10% water

5 MA-23 = methacrylate ester of a 23 ethoxylate of lauryl alcohol (70%), 30% methacrylic acid

Example 1 (redox)

10 To a three liter round bottom flask, equipped with a mechanical stirrer, heating mantle, thermocouple, condenser and inlets for the addition of monomer, initiator and nitrogen was charge 18.7 grams of 28% sodium lauryl sulfate and 731 grams of deionized water. The mixture was set to stir with a nitrogen flow of 20 mls/minute and heated to 89°C. To a plastic lined vessel, 12.6 grams of 28% sodium lauryl sulfate and 630 grams deionized water was added and mixed with overhead stirring. 99 grams of MA-20 was charged to the vessel followed by 343 grams of ethyl acrylate (EA) and then 261 grams of methacrylic acid (MAA) was added slowly to form a smooth, stable monomer emulsion. 68.6 grams of the stable monomer emulsion seed was set aside. A kettle initiator charge was prepared adding 0.75 grams of sodium persulfate and 21.4 grams of deionized water and set aside. A cofeed activator solution of 0.77 grams of isoascorbic acid and 75 grams of deionized water was prepared and added to syringe for the addition to the kettle. A cofeed catalyst solution of 0.38 grams of sodium persulfate and 75 grams of deionized water was prepared and added to syringe for the addition to the kettle.

25 When the reaction was at temperature, the monomer emulsion seed was added to the kettle and rinsed with 28 grams of deionized water, which was immediately followed by the kettle initiator charge. The kettle contents was allowed to react and exotherm to 85°C, and then held for 10 minutes. At the completion of the hold, the reaction was then cooled to 51°C. An addition of 28.6 grams of a solution of 0.15% iron sulfate heptahydrate was added to the kettle during the cool down.

30 When the reaction temperature reached 51°C, with a bottom target temperature of 48°C, the initiator activator and catalyst cofeeds were started at a rate of 0.815 mls / minute over 92 minutes. 2 minutes after the start of the initiator cofeed solutions, the monomer emulsion cofeed began at a rate of 14.18 mls / minute for a total of 90 mins. At the

completion of the reaction, the feed lines were rinsed with 51 grams of deionized water and held at 48°C for 10 minutes. During the hold chaser solutions were prepared. 0.28 grams isoascorbic acid was dissolved in 25 grams deionized water and added to a syringe. 0.5 grams of a 70% tert-butyl hydroperoxide was mixed with 25 grams deionized water and added to a syringe. At the end of the hold, the chaser solutions were added linearly over 10 minutes and held 20 minutes at 48°C. The reaction was then allowed to cool to room temperature and filtered through a 100 mesh bag. The final emulsion polymer had a solids content of 28.11% and a pH = 2.5. By GC, the total polymers residual monomer content was <5 ppm.

10

Example 2 (Comparative)

To a three liter round bottom flask, equipped with a mechanical stirrer, heating mantle, thermocouple, condenser and inlets for the addition of monomer, initiator and nitrogen was charge 17.55 grams of 28% sodium lauryl sulfate and 792.5 grams deionized water. The mixture was set to stir with a nitrogen flow and heated to 89°C. To a plastic lined vessel, 11.75 grams of 28% sodium lauryl sulfate and 815 grams deionized water was added and mixed with overhead stirring. 93.55 grams of MA-20 was charged to the vessel followed by 327.5 grams ethyl acrylate and then 243.3 grams methacrylic acid was added slowly to form a smooth, stable monomer emulsion. 54.9 grams of the stable monomer emulsion seed was set aside. A kettle initiator charge was prepared adding 0.70 grams ammonium persulfate and 20 grams deionized water and set aside. Cofeed catalyst solution of 0.3 grams ammonium persulfate dissolved in 60 grams deionized water was added to a syringe.

When the reaction was at temperature, the monomer emulsion seed was added to the kettle and rinsed with 27.5 grams deionized water, which was immediately followed by the kettle initiator charge solution. The kettle contents was allowed to react and immediately after the peak exotherm is observed and temperature is 85-89°C, begin monomer emulsion at a rate of 7.97 mls / minute and the initiator catalyst solution at a rate of 0.67 mls / minute for a total of 180 minutes. At the completion of the cofeeds, a line rinse of 20 grams deionized water was added and the reaction was held for 5 minutes at 85°C. During the hold a thermal chaser solution of 0.25 grams of ammonium persulfate was dissolved in 75 grams of deionized water and added to a syringe. At the completion of the hold, the thermal chaser was added over 15 minutes. At the end of the chaser, the reaction was then cooled to 75°C.

Two sets of chaser activator and catalyst solutions were prepared by dissolving 0.4 grams of 70% tert-butyl hydroperoxide in 12.5 grams deionized water and 0.55 grams isoascorbic acid dissolved in 12.5 grams deionized water. When the reaction temperature reaches 75°C, a promoter solution of 0.006 grams iron sulfate heptahydrate dissolved in 1 gram deionized water was added to the kettle. Immediately chaser activator and catalyst solutions #1 were added to the kettle over 15 minutes with cooling. The reaction was held for 15 minutes then chaser activator and catalyst solutions #2 were added over 15 minutes and then allowed to stir for 20 minutes while cooling to room temperature. The kettle contents were then filtered through 100 mesh bag. The final emulsion polymer had a solids content of 30% and a pH = 2.5. By GC, the total polymers residual monomer content was <5 ppm.

Example 3 (thermal w redox chaser) (Comparative)

To a three liter round bottom flask, equipped with a mechanical stirrer, heating mantle, thermocouple, condenser and inlets for the addition of monomer, initiator and nitrogen was charge 12.29 grams of 28% sodium lauryl sulfate and 588 grams deionized water. The mixture was set to stir with a nitrogen flow and heated to 84°C. To a plastic lined vessel, 24.29 grams of 28% sodium lauryl sulfate and 792 grams deionized water was added and mixed with overhead stirring. 175.7 grams of MA-20 was charged to the vessel followed by 355.2 grams ethyl acrylate, 0.99 grams trimethylolpropane diallyl ether (TMPDE), 0.55 grams 1-dodecyl mercaptan, 33.19 grams methacrylic acid and 136.62 grams acrylic acid was added slowly to form a smooth, stable monomer emulsion. A kettle initiator charge was prepared adding 0.47 grams ammonium persulfate and 22 grams deionized water and set aside. Cofeed catalyst solution of 0.76 grams ammonium persulfate dissolved in 112.75 grams deionized water was added to a syringe.

When the kettle contents reached reaction temperature of 84°C, the kettle initiator was charged. The monomer emulsion cofeed was added over 107 mins at the following rate: 8.92 mls / minute for 20 minutes, 17.85 mls / minute for 40 minutes and 13.32 mls / minute for 47 minutes. The initiator cofeed was added linearly over 112 minutes. A rinse of 16.5 grams deionized water was added to the monomer cofeed. At the end of the initiator overfeed, the reaction was held for 10 minutes at 84°C. At completion of the hold, the reaction was then cooled to 55°C.

Two sets of chaser activator and catalyst solutions were prepared by dissolving 0.5 grams of 70% tert-butyl hydroperoxide in 15 grams deionized water and 0.28 grams isoascorbic acid dissolved in 15 grams deionized water. When the reaction temperature reaches 55°C, a promoter solution of 6.82 grams of a 0.15% iron sulfate heptahydrate 5 solution was added to the kettle. Immediately chaser activator and catalyst solutions #1 were added to the kettle over 10 minutes then held for 20 minutes. Then chaser activator and catalyst solutions #2 were added over 10 minutes and then held for 20 minutes. At completion of hold, the reaction was cooled to room temperature and filtered through 100 mesh bag. The final emulsion polymer had a solids content of 28.9% and a pH = 2.4. By 10 GC, the total polymers residual monomer content was <200 ppm.

Example 4

To a three liter round bottom flask, equipped with a mechanical stirrer, heating mantle, thermocouple, condenser and inlets for the addition of monomer, initiator and 15 nitrogen was charge 18.7 grams of 28% sodium lauryl sulfate and 731 grams deionized water. The mixture was set to stir with a nitrogen flow of 20 mls/minute and heated to 89°C. To a plastic lined vessel, 24.29 grams of 28% sodium lauryl sulfate and 792 grams deionized water was added and mixed with overhead stirring. 175.7 grams of MA-20 was charged to the vessel followed by 355.2 grams ethyl acrylate, 0.99 grams trimethylolpropane dially 20 ether (TMPDE), 0.55 grams 1-Dodecyl mercaptan, 33.19 grams methacrylic acid and 136.62 grams acrylic acid was added slowly to form a stable monomer emulsion. 68.5 grams of the stable monomer emulsion seed was set aside. A kettle initiator charge was prepared adding 0.64 grams sodium persulfate and 21.4 grams deionized water and set aside. A cofeed 25 activator solution of 0.44 grams isoascorbic acid and 75 grams deionized water was prepared and added to syringe for the addition to the kettle. A cofeed catalyst solution of 0.64 grams sodium persulfate and 75 grams deionized water was prepared and added to syringe for the addition to the kettle.

When the reaction was at temperature, the monomer emulsion seed was added to the kettle and rinsed with 16 grams deionized water, which was immediately followed by the 30 kettle initiator charge. The kettle contents was allowed to react and exotherm to 85°C, and then held for 10 minutes. At the completion of the hold, the reaction was then cooled to 60°C. An addition of 21.45 grams of a 0.15% solution of iron sulfate heptahydrate and 0.54

grams of a 0.15% solution of copper sulfate pentahydrate was added to the kettle during the cool down.

When the reaction temperature reached 60°C, with a bottom target temperature of 55°C, the initiator activator and catalyst cofeeds were started at a rate of 0.797 mls / minute 5 over 94 minutes. 4 minutes after the start of the initiator cofeed solutions, the monomer emulsion cofeed began at a rate of 14.18 mls / minute for a total of 90 mins. At the completion of the reaction, the feed lines were rinsed with 20 grams of deionized water and held at 55C for 20 minutes. During the hold, 2 sets of chaser solutions were prepared. 0.28 grams isoascorbic acid was dissolved in 15 grams deionized water and added to a syringe. 10 0.5 grams of a 70% tert-butyl hydroperoxide was mixed with 15 grams deionized water and added to a syringe. At the end of the hold, the chaser solutions #1 were added linearly over 10 minutes and held 20 minutes at 55°C. Chaser solutions #2 were added linearly over 10 minutes and held 20 minutes at 55°C The reaction was then allowed to cool to room temperature and filtered through a 100 mesh bag. The final emulsion polymer had a solids 15 content of 27.93% and a pH = 2.4. By GC, the total polymers residual monomer content was <300 ppm.

Example 5 (redox / shot)

To a three liter round bottom flask, equipped with a mechanical stirrer, heating 20 mantle, thermocouple, condenser and inlets for the addition of monomer, initiator and nitrogen was charge 18.7 grams of 28% sodium lauryl sulfate and 731 grams deionized water. The mixture was set to stir with a nitrogen flow of 20 mls/minute and heated to 89°C. To a plastic lined vessel, 12.6 grams of 28% sodium lauryl sulfate and 630 grams deionized water was added and mixed with overhead stirring. 99 grams of MA-23 was charged to the 25 vessel followed by 302 grams ethyl acrylate and then 302 grams methacrylic acid was added slowly to form a smooth, stable monomer emulsion. 68.6 grams of the stable monomer emulsion seed was set aside. A kettle initiator charge was prepared adding 0.5 grams sodium persulfate and 21.4 grams of deionized water and set aside. A cofeed activator solution of 0.385 grams isoascorbic acid and 75 grams deionized water was prepared and 30 added to syringe for the addition to the kettle. A cofeed catalyst solution of 0.19 grams sodium persulfate and 75 grams deionized water was prepared and added to syringe for the addition to the kettle.

When the reaction was at temperature, the monomer emulsion seed was added to the kettle and rinsed with 16 grams deionized water, which was immediately followed by the kettle initiator charge. The kettle contents was allowed to react and exotherm to 85°C, and then held for 10 minutes. At the completion of the hold, the reaction was then cooled to 5 53°C. An addition of 14.3 grams of a solution of 0.15% iron sulfate heptahydrate and 0.54 grams of 0.15% solution of copper sulfate pentahydrate was added to the kettle during the cool down.

When the reaction temperature reached 53°C, with a bottom target temperature of 50°C, the initiator activator and catalyst cofeeds were started at a rate of 0.81 mls / minute 10 over 69.5 minutes. 2 minutes after the start of the initiator cofeed solutions, the monomer emulsion cofeed began at a rate of 14.18 mls / minute for a total of 67.5 mins. The cofeeds were then stopped and the reaction was held for 15 minutes. The monomer emulsion cofeed was then re-started and added at a rate of 31 mls/minute for 10 minutes. 25 grams deionized water was added to the monomer vessel as a rinse. Temperature decrease of 4°C was 15 observed. After a 5 minutes hold the remaining initiator cofeeds were added quickly over 30 seconds. In 4 minutes the kettle returned to reaction temperature of 53°C and reached a maximum temperature of 56°C. After a 10 minute hold the reaction returned to 53°C. During the hold chaser solutions were prepared. 0.28 grams isoascorbic acid was dissolved in 25 grams deionized water and added to a syringe. 0.5 grams of a 70% tert-butyl 20 hydroperoxide was mixed with 25 grams deionized water and added to a syringe. At the end of the hold, the chaser solutions were added linearly over 10 minutes and held 20 minutes at 53°C. The reaction was then allowed to cool to room temperature and filtered through a 100 mesh bag. The final emulsion polymer had a solids content of 29.3% and a pH = 2.98. By GC, the total polymers residual monomer content was <5 ppm.

25

Example 6 (Redox paper coatings example)

To a three liter round bottom flask, equipped with a mechanical stirrer, heating mantle, thermocouple, condenser and inlets for the addition of monomer, initiator and nitrogen was charge 18.7 grams of 28% sodium lauryl sulfate and 731 grams deionized 30 water. The mixture was set to stir with a nitrogen flow of 20 mls/minute and heated to 89°C. To a plastic lined vessel, 12.6 grams of 28% sodium lauryl sulfate and 630 grams deionized water was added and mixed with overhead stirring. 19.8 grams of MA-20 was charged to the vessel followed by 401.9 grams ethyl acrylate, and 273 grams methacrylic acid was added

slowly to form a stable monomer emulsion. 68.2 grams of the stable monomer emulsion seed was set aside. A kettle initiator charge was prepared adding 0.48 grams sodium persulfate and 21.4 grams deionized water and set aside. A cofeed activator solution of 0.35 grams isoascorbic acid and 75 grams deionized water was prepared and added to syringe for the 5 addition to the kettle. A cofeed catalyst solution of 0.55 grams sodium persulfate and 75 grams deionized water was prepared and added to syringe for the addition to the kettle.

When the reaction was at temperature, the monomer emulsion seed was added to the kettle and rinsed with 16 grams deionized water, which was immediately followed by the kettle initiator charge. The kettle contents was allowed to react and exotherm to 85°C, and 10 then held for 10 minutes. At the completion of the hold, the reaction was then cooled to 60°C. An addition of 21.45 grams of a 0.15% solution of iron sulfate heptahydrate and 0.54 grams of a 0.15% solution of copper sulfate pentahydrate was added to the kettle during the cool down.

When the reaction temperature reached 60°C, with a bottom target temperature of 15 55°C, the initiator activator and catalyst cofeeds were started at a rate of 0.797 mls / minute over 94 minutes. 4 minutes after the start of the initiator cofeed solutions, the monomer emulsion cofeed began at a rate of 14.18 mls / minute for a total of 90 mins. At the completion of the reaction, the feed lines were rinsed with 30 grams of deionized water and held at 55C for 20 minutes. During the hold, 2 sets of chaser solutions were prepared. 0.582 20 grams isoascorbic acid was dissolved in 25 grams deionized water and added to a syringe. 0.423 grams of a 70% tert-butyl hydroperoxide was mixed with 25 grams deionized water and added to a syringe. At the end of the hold, the chaser solutions #1 were added linearly over 10 minutes and held 20 minutes at 55°C. Chaser solutions #2 were added linearly over 10 minutes and held 20 minutes at 55°C The reaction was then allowed to cool to room 25 temperature and filtered through a 100 mesh bag. The final emulsion polymer had a solids content of 28.3% and a pH = 2.6. By GC, the total polymers residual monomer content was <50 ppm.

A summary of the monomer contents of inventive Examples 1, 4, 5 and 6 is presented in the table below

Example 1	10% MA-20 / 49.5% EA / 40.5% MAA
Example 4	17.98% MA-20 / 51.92% EA / 9.99% MAA / 19.97% AA / 0.13% TMPDE
Example 5	9.8% MA-23 / 43 EA / 47.2% MAA
Example 6	2% MA-20 / 58% EA / 40% MAA

5 Example 7 (Comparative) (Thermal @ 86°C)

A monomer emulsion was prepared by combining 977g water, 37g sodium lauryl sulfate (28%), 182.9g MA-23, 556g ethyl acrylate, and 554.1g methacrylic acid in the order specified. A reactor initiator charged was prepared consisting of 1.43g ammonium persulfate in 15g deionized water. A separate cofeed initiator solution was prepared consisting of 0.57g ammonium persulfate in 120g deionized water.

10 To a 5L, 4-neck flask equipped with a stirrer, reflux condenser, thermocouple, nitrogen inlet, and feed inlet ports was charged 1084g water and 37g sodium lauryl sulfate. The reactor contents were heated to 86°C with nitrogen and the reactor initiator charged. Immediately following the initiator charge, the monomer emulsion and the cofeed initiator 15 solution were each added separately to the reactor over a period of 110 minutes at uniform rate while maintaining the temp at 86°C. Upon completion of the monomer emulsion and cofeed initiator feeds, the feed lines were rinsed to the reactor with 65g water and 12 gram water respectively. The reaction mixture was then cooled to 60°C and 26g ferrous sulfate solution (0.15%), 16g tert butyl hydroperoxide solution (4.94%) and 15g isoascorbic acid 20 solution (3.8%) added as shot to the reactor in 1 minute intervals. 15 minutes later another shot of 16g tert butyl hydroperoxide solution (4.94%) and 15g isoascorbic acid solution (3.8%) were added to the reactor. The reaction mixture was cooled to 40°C and 360g sodium acetate solution (0.9%) added. 190g isothiazolone biocide solution (0.076%) was then feed to the reactor over 10 minutes. The reaction mixture was cooled to room temp and filtered 25 through a 100 mesh screen. Final emulsion polymer was 30.2% solids and had a pH= 4.2. Residual monomer content was <5 ppm.

**Example 8 (Comparative) (Thermal @ 86°C)**

A monomer emulsion was prepared by combining 977g water, 37g sodium lauryl sulfate (28%), 37g MA-20, 751.57g ethyl acrylate, and 507.86g methacrylic acid in the order specified. A reactor initiator charged was prepared consisting of 1.43g ammonium persulfate in 15g deionized water. A separate cofeed initiator solution was prepared consisting of 0.57g ammonium persulfate in 120g deionized water.

To a 5L, 4-neck flask equipped with a stirrer, reflux condenser, thermocouple, nitrogen inlet, and feed inlet ports was charged 1084g water and 37g sodium lauryl sulfate. The reactor contents were heated to 86°C with nitrogen and the reactor initiator charged.

10 Immediately following the initiator charge, the monomer emulsion and the cofeed initiator solution were each added separately to the reactor over a period of 110 minutes at uniform rate while maintaining the temp at 86°C. Upon completion of the monomer emulsion and cofeed initiator feeds, the feed lines were rinsed to the reactor with 65g water and 12 gram water respectively. The reaction mixture was then cooled to 60°C and 26g ferrous sulfate

15 solution (0.15%), 16g tert butyl hydroperoxide solution (4.94%) and 15g isoascorbic acid solution (3.8%) added as shot to the reactor in 1 minute intervals. 15 minutes later another shot of 16g tert butyl hydroperoxide solution (4.94%) and 15g isoascorbic acid solution (3.8%) were added to the reactor. The reaction mixture was cooled to 40°C and 360g sodium acetate solution (0.9%) added. 190g isothiazolone biocide solution (0.076%) was then feed to

20 the reactor over 10 minutes. The reaction mixture was cooled to room temp and filtered through a 100 mesh screen. Final emulsion polymer was 29.45% solids and had a pH= 4.1. Residual monomer content was <5 ppm.

**Example 9 Heavy Duty Liquid Laundry Formulation; Comparison of Example 1 (Redox**

25 Process) and Example 2 (Thermal Process)

Base Formulation:

Chemical	Wt % Added
NANSA SS/U -30% Active (LABS)	30.0 [9% actives]
EMPICOL ESB 70% Active (AEOS)	17.1 [12% actives]
Alcohol Ethoxylate (NEODOL 25-7, 100% active)	15.0 [15% actives]
Polypropylene Glycol 400	4.0
Sodium Citrate	3.0
Water	20.9
polymer	10.0

Notes: 1. LABS=Linear Alkyl Benzene Sulfonate; 2. AEOS= Alkyl Ether Sulfate

( $C_{12}H_{25}(OCH_2CH_2)_{2-4}SO_4 Na^+$ ); 3. NEODOL 25-7 is  $C_{13}H_{27}(CH_2CH_2O)_7H$

5 The formulation was prepared in the following order with overhead mechanical mixing: 1. water; 2. NANSA SS; 3. ESB 70 ; 4. Poly Propylene Glycol 400; 5. Na Citrate; 6 Alcohol Ethoxylate (Neodol 25-7).

	time to dissolve raw materials
Water + NANSA SS 30	2 min
+ EMPICOL ESB 70	5 min
+ PPG 400	14 min
+ Sodium Citrate	18 min
+ NEODOL 25-7	27 min

10 The polymer was added to the base with mixing to achieve a level of 0.5% active in the formulation. The final pH was checked and adjusted with 10% NaOH (in water) to a pH 8.2 to 8.5 for final formulation.

15 Rheology: TA Instrument Advanced Rheometer AR2000. The sample was measured using the rheometer to obtain the viscosity versus shear rate (Flow Curve), starting at low shear to high shear at 20 °C.

Additional Measurements: Formulation samples were measured at 20 C at 1 day using a standard Brookfield viscometer LV DVIII Ultra. Measures were done with spindle 3 (for this rheology study).

	90 RPM Brookfield at 1 day	viscosity at 1 sec <sup>-1</sup>	viscosity at 10 sec <sup>-1</sup>	viscosity at 20 sec <sup>-1</sup>
Example 2 (Comparative)	370	522	515	511
Example 1 (Invention)	465	623	611	604

5

viscosities are reported in mPa·s

Example 10 Body Wash Formulation:

	polymer solids (%)	polymer dry gram (g)	water (g)	26% STEOL CS-230 (g)	10% KOH (g)	30% AMPHOSO L CA (g)	pH	Clarity (NTU)
Ex. 3	28.91%	1.7076	37.5	48.5	2.34	5.80	6.14	5.3
Ex. 4	27.93%	1.7076	37.0	48.5	2.64	5.80	6.22	3.6

10 Notes: STEOL CS-230 is 26% Sodium Laureth Sulfate from Stepan Chemical; AMPHOSOL CA = 30% COCAMIDOPROPYL BETAINE from Stepan  
Clarity was measured using an AF Scientific, Micro 100 Turbidimeter.

Samples: Ex. 3 - Thermal process; Ex. 4 - Redox 55 °C process

15

STEPS:

1. Mixed DI Water with RM Polymer
2. Added STEOL CS-230 under agitation.
3. Adjusted pH with 10% KOH solution to 6.1 - 6.2.
4. Added AMPHOSOL CA addition.
5. Qs to 100 grams with deionized water then check pH.

Example 3		Example 4	
shear rate	viscosity	shear rate	viscosity
1/s	Pa.s	1/s	Pa.s
1.01E-04	34.8	1.03E-04	684.5
1.23E-04	36.0	1.28E-04	689.9
1.47E-04	38.0	1.59E-04	702.1
1.94E-04	36.3	2.01E-04	698.8
2.29E-04	38.6	2.58E-04	684.5
2.86E-04	39.1	3.41E-04	652.7
3.62E-04	38.8	4.30E-04	651.3
4.54E-04	38.9	5.56E-04	634.9
5.74E-04	38.7	7.32E-04	606.8
7.10E-04	39.5	9.94E-04	562.7
9.03E-04	39.1	1.34E-03	526.1
1.13E-03	39.3	1.90E-03	467.5
1.44E-03	38.9	2.75E-03	405.8
1.87E-03	37.7	4.05E-03	346.5
2.44E-03	36.4	5.99E-03	295.4
3.21E-03	34.8	8.97E-03	248.2
4.29E-03	32.8	0.01339	209.2
5.88E-03	30.1	0.01983	177.8
8.22E-03	27.1	0.02898	153.2
0.01168	24.0	0.04167	134.2
0.01678	21.0	0.05892	119.4
0.02435	18.2	0.08196	108.1
0.03545	15.8	0.1128	98.9
0.05152	13.7	0.1532	91.7
0.07415	12.0	0.2069	85.4
0.1054	10.6	0.2771	80.3
0.1481	9.5	0.3686	76.0
0.2028	8.7	0.4888	72.2
0.2752	8.1	0.6486	68.5
0.3677	7.6	0.857	65.2
0.4825	7.3	1.123	62.7
0.6255	7.1	1.457	60.8
0.7981	7.0	1.875	59.5
1.01	7.0	2.403	58.4
1.263	7.0	3.083	57.3
1.563	7.1	3.511	57.0
1.918	7.3		
2.337	7.6		
2.839	7.8		
3.442	8.1		

### Example 11 Paint Data

The performance obtained by the use of associative thickeners is demonstrated in a latex paint composition. A latex unthickened paint composition, Pre-paint #1, was prepared by combining:

5	KRONOS 4311 titanium dioxide slurry	263.4 g
	Water	150.4 g
	Ethylene glycol	24.3 g
	ROPAQUE Ultra	49.8 g
	RHOPLEX SG-30 binder	421.8 g
10	TEXANOL	19.2 g
	TRITON X-405	2.5 g
	DREWPLUS L-475	<u>4.1 g</u>
	Total	935.5 g

15 KRONOS 4311 is a product of KRONOS Incorporated, Chelmsford, MA. TRITON X-405, ROPAQUE Ultra and RHOPLEX SG-30 are products of The Dow Chemical Company, Midland, MI. DREWPLUS L-475 is a product of Ashland Specialty Chemical Company, Dublin, OH. AMP-95 is a product of Angus Chemicals, Buffalo Grove, IL.

20 The formulated paint was obtained by adding thickener and water to 935.5 g of Pre-paint #1. To maintain constant solids of the fully formulated paint, the combined weight of added thickener, AMP-95 and water equals 79.9 g. The density of the fully formulated paint was 1015.4 pounds per 100 gallons (1.2 kg per liter). Thickeners were added as aqueous dispersions at 15% weight solids.

25 Formulated paints were made by the following method. To 935.5 g Pre-paint #1, an amount of aqueous thickener dispersion and an amount of water and an amount of AMP-95 were slowly added and stirred on a lab mixer for ten minutes. The total combined amount of aqueous thickener dispersions, AMP-95 and water is 79.9 grams. Final paint pH is 8.9. Sufficient thickener was added to provide a paint with an initial Stormer viscosity of 103 KU.

30 In the following data presentation, thickener concentrations in the thickened paint are described in terms of dry grams of thickener added.

	g thickener (dry)	Stormer viscosity (KU)	ICI viscosity (poise)
Ex. 7 (comp.)	3.39	103	0.75
Ex. 5	2.65	103	0.75

“Stormer viscosity” is a measure of the mid-shear viscosity as measured by a Stormer viscometer. The Stormer viscometer is a rotating paddle viscometer that is compliant with 5 ASTM-D562. Stormer viscosity was measured on a Brookfield Krebs Unit Viscometer KU-1+ available from Brookfield Engineering Labs, Middleboro, MA. “KU” indicates Krebs units.

“ICI viscosity” is the viscosity, expressed in units of poise, measured on a high shear rate, cone and plate viscometer known as an ICI viscometer. An ICI viscometer is described 10 in ASTM D4287. It measures the viscosity of a paint at approximately  $10,000\text{ sec}^{-1}$ . ICI viscosities of paints were measured on a viscometer manufactured by Research Equipment London, Ltd. An equivalent ICI viscometer is the ELCOMETER 2205 manufactured by ELCOMETER, Incorporated in Rochester Hills, Michigan. The ICI of a paint typically correlates with the amount of drag force experienced during brush application of the paint.

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#### Example 12 Paper Coatings Data

Four identical paper coating master batches were made by blending on a benchtop mixer 172.5 g of OMYACARB H-90 calcium carbonate (76.09% solids slurry from Omya), 61.48 g of KAOGLOSS #1 clay (71.16% solids slurry), 39.16 g of GENCRYL 9780 binder 20 (49.15% solids from Rohmova Solutions, Inc.). The coating thickened with 0.12% of Example 8 was produced by adding 1.17 g of Example 8, 15.13 g of water and 1.28 g of 15% by weight sodium hydroxide aqueous solution to one of the four master batches. The coating thickened with 0.12% of Example 6 was produced by adding 1.22 g of Example 6, 14.86 g of water and 1.58 g of 15% by weight sodium hydroxide aqueous solution. The coating 25 thickened with 0.18% of Example 8 was produced by adding 1.76 g of Example 8, 14.44 g of water and 1.75 g of 15% by weight sodium hydroxide aqueous solution. The coating thickened with 0.18% of Example 6 was produced by adding 1.83 g of Example 6, 14.19 g of water and 1.98 g of 15% by weight sodium hydroxide aqueous solution. Final pH values of all paper coatings were 8.6. The paper coatings were equilibrated for one hour in a 25°C

constant temperature room before measurements were recorded. The rate of water loss from the coating was measured three times for each coating on a Å-A-GWR device. A lower rate of water loss indicates better water retention. Better water retention is a desirable property in a paper coating.

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GENCRYL 9780 paper Coatings

	dry thickener weight on wet coating weight	Åbo Åkademi method Rate of Water Loss (g/sq meter)	Å Åkademi method Average Rate of Water Loss (g/sq meter)	Brookfield Viscosity #5 spindle 100 rpm (mPa·s)
Ex. 8 (comp.)	0.12%	98.7 102.5 99.5	100.3	1436
Ex. 6	0.12%	83.7 87.8 86.1	85.9	1372
Ex. 8 (comp.)	0.18%	78.4 80.8 79.2	79.5	2348
Ex. 6	0.18%	69.5 68.3 66.2	68.0	2448



Claims

1. A method for preparing hydrophobically modified rheology modifiers; said method comprising polymerizing a monomer mixture comprising:
  - (i) a monomer selected from the group consisting of:
    - 5 (a)  $H_2C=C(R)C(O)X(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$ ;
    - (b)  $H_2C=C(R)C_6H_4C(CH_3)_2NHCO_2(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$ ; and combinations thereof; wherein X is O or NH, R is H or  $CH_3$ , R' is  $C_1$ - $C_2$  alkyl; R'' is  $C_8$ - $C_{22}$  alkyl,  $C_8$ - $C_{16}$  alkylphenyl or  $C_{13}$ - $C_{36}$  aralkylphenyl; n is an average number from 6-100 and m is an average number from 0-50, provided that  $n \geq m$  and  $m+n$  is 6-100; and
  - 10 (ii) a  $C_3$ - $C_6$  carboxylic acid monomer;  
wherein at least 30% of polymerization occurs in the presence of an oxidant, a reductant and a metal catalyst, and substantially in the absence of a peroxide, hydroperoxide or perester containing an alkyl group having at least five carbon atoms.
- 15 2. The method of claim 1 in which the oxidant is selected from the group consisting of persulfate, perborate, percarbonate, and combinations thereof; polymerization is conducted substantially in the absence of peroxides, hydroperoxides or peresters; and the polymerization is an aqueous emulsion polymerization.
- 20 3. The method of claim 2 in which the reductant is isoascorbic acid; and the metal catalyst is selected from the group consisting of iron, copper and combinations thereof.
4. The method of claim 3 in which the monomer mixture comprises from 15 to 60 wt%  $C_3$ - $C_6$  carboxylic acid monomer, 1 to 25 wt%  $H_2C=C(R)CO_2(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$  and 25 to 65 wt%  $C_1$ - $C_4$  alkyl (meth)acrylate.
- 25 5. The method of claim 4 in which R'' is  $C_{10}$ - $C_{22}$  alkyl, n is 15-30 and m is 0-5.
6. The method of claim 1 in which the monomer mixture comprises from 15 to 60 wt%  $C_3$ - $C_6$  carboxylic acid monomer, 1 to 25 wt%  $H_2C=C(R)CO_2(CH_2CH_2O)_n(CH(R')CH_2O)_mR''$  and 25 to 65 wt%  $C_1$ - $C_4$  alkyl (meth)acrylate.
- 30 7. The method of claim 6 in which R'' is  $C_{10}$ - $C_{22}$  alkyl, n is 15-30 and m is 0-5.

8. The method of claim 7 in which the C<sub>3</sub>-C<sub>6</sub> carboxylic acid monomer is (meth)acrylic acid.
9. The method of claim 8 in which the C<sub>1</sub>-C<sub>4</sub> alkyl (meth)acrylate is a C<sub>2</sub>-C<sub>3</sub> alkyl acrylate, R" is C<sub>12</sub>-C<sub>20</sub>alkyl, n is 18-25, m is 0-3 and R is methyl.
10. The method of claim 9 in which the monomer mixture comprises 25 to 55wt% (meth)acrylic acid, 5 to 25 wt%H<sub>2</sub>C=C(R)CO<sub>2</sub>(CH<sub>2</sub>CH<sub>2</sub>O)<sub>N</sub>(CH(R')CH<sub>2</sub>O)<sub>m</sub>R" and 40 to 60 wt% C<sub>2</sub>-C<sub>3</sub> alkyl acrylate.
11. A method for preparing hydrophobically modified rheology modifiers, the method substantially as any one embodiment herein described and/or exemplified with reference to the accompanying examples, excluding comparative examples.

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Dated this 8<sup>th</sup> of March 2011

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BOWMAN GILLILAN INC  
FOR THE APPLICANT