

Use of Polyoxypropylene and Polyoxyethylene Terpene Compounds in Emulsion Polymerization

5 This patent application claims priority from provisional patent application serial number 60/633,050 filed on December 3, 2004 and non-provisional patent application filed as RD 05018 on December 1, 2005.

Field of the Invention

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 The present invention relates to emulsion polymerization using terpene based surfactants as emulsifiers. The terpene based surfactants comprise oxypropylene and oxyethylene units. The invention also relates to emulsion polymerization using the sulfate and phosphate salts of the
15 terpene based surfactants as emulsifiers. Further, the present invention relates to methods of using such emulsions formed from the terpene based surfactants.

Background of the Invention

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 Polymers, both synthetic and natural, have been employed in aqueous solutions as thickening and flocculating agents. They have found commercial use in a variety of end uses such as wastewater treatment, water purification, papermaking, petroleum recovery, oil drilling
25 mud stabilizers, and latex. Latex is a water based polymer dispersion, widely used in industrial applications.

 Polymerization is a preferred technology used to make emulsion polymers and polymer latexes. The use of latex, produced by emulsion
30 polymerization, in the production of paints or coatings for substrates is well known in the art. However, such paints or coatings are adversely affected by the presence of emulsifiers required in the emulsion

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polymerization process. The emulsifiers often cause foaming in the paint or coating. It would be desirable to have an emulsifier having low foaming effects and improved stability properties.

5 Furthermore, in latex polymerization, surfactants are necessary to provide stable monomer pre-emulsion, stability during the polymerization, and overall stability of the final latex. However, traditional surfactants for polymerization of latexes and emulsions tend to create foaming upon agitation and cause other difficulties during the polymerization process
10 and in the final formulations containing the latex. To overcome this, a defoamer is generally required. Unfortunately, addition of a defoamer has numerous drawbacks including dewetting of the coating and increased raw material cost. It would be desirable to have a polymerization surfactant having low foaming effects and improved stability properties.

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Summary of the Invention

 This invention provides a process for the production of polyoxypropylene and polyoxyethylene terpene based surfactants, and
20 processes to produce emulsion polymers of such polyoxypropylene and polyoxyethylene terpene based surfactants and the resulting emulsion polymer products. The polyoxypropylene and polyoxyethylene terpene based surfactants produced by the process of this invention produce emulsion polymers of greatly improved properties compared to emulsion
25 polymers produced from conventional surfactants.

 Particularly, the invention is directed to the use of polyoxypropylene and polyoxyethylene terpene based surfactants for latex synthesis. More particularly, the invention is directed to the use of
30 alkoxylate surfactants and their sulfate and phosphate salts useful in emulsion and latex synthesis. Even more particularly, the invention is

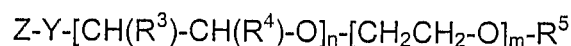
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directed to the use of alkoxylates of 6,6-dimethylbicyclo[3,1,1]hept-2-ene-2-ethanol and their sulfate and phosphate salts as emulsifiers useful in emulsion and latex polymerization.

Furthermore, the polyoxypropylene and polyoxyethylene terpene based
5 surfactants may be nonionic or anionic.

Detailed Description of Invention and Preferred Embodiments

The present invention relates to the use, in emulsion
10 polymerization, of a terpene based surfactant. The terpene based surfactant in accordance with the invention comprises at least one compound having the following formula:



15 in which Z represents a bicyclo[a,b,c]heptenyl or bicyclo[a,b,c]heptyl radical, and wherein $a+b+c=5$ and $a=2, 3$, or 4 ; $b=2$ or 1 ; and $c=0$ or 1 . R^3 and R^4 , which may be identical or different, represent hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1 - C_{22} hydrocarbon
20 radical, provided that at least one of the radicals R^3 or R^4 is other than hydrogen; and R^5 represents hydrogen, or a group selected from the following:

-SO₃M
-PO₃(M)₂
25 -(CH₂)_r-COOM
-(CH₂)_z-SO₃M

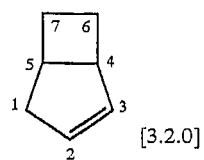
in which formula, M represents hydrogen, an alkali metal or an ammonium function $N(R)_4^+$, in which R, which may or may not be identical,
30 represents hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1 - C_{22} hydrocarbon radical, which may be hydroxylated; r is

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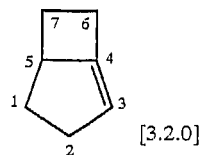
in the range 1 to 6; z is in the range 1 to 6; n is a whole number or fraction in the range 0-20 inclusive; m is a whole number or fraction in the range 2-80 inclusive.

5 The Z radical is optionally substituted by at least one C₁-C₆ alkyl radical and may comprise a backbone selected from those indicated below or the corresponding backbones minus the double bond:

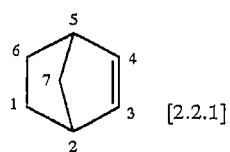
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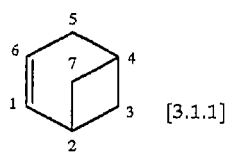
a)



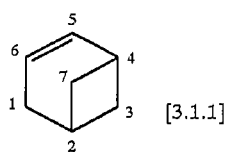
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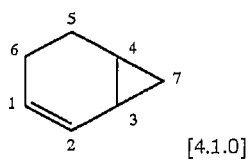
c)



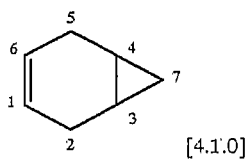
d)



e)



f)



g)

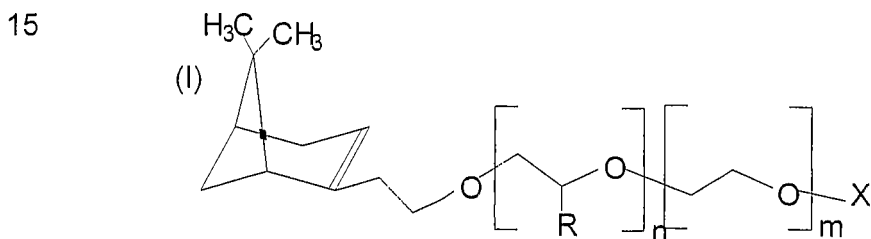
Y represents $-\text{CH}_2-\text{C}(\text{R}^1)(\text{R}^2)-\text{O}-$ or $-\text{O}-\text{CH}(\text{R}^1)-\text{CH}(\text{R}^2)-\text{O}-$, wherein R^1 , R^2 , R'^1 , and R'^2 , which may be identical or different, represent hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1-C_{22}

5 hydrocarbon radical, preferably C_1-C_6

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In a preferred embodiment of the invention a suitable terpene based surfactant comprises the use of Nopol derivative surfactants. Accordingly, the invention further provides for the novel use of Nopol derivative surfactants to make emulsion polymers or polymer latexes. In one aspect, this invention relates to a method of making Nopol alkoxyate surfactants of 6,6-dimethylbicyclo[3,1,1]hept-2-ene-2-ethanol. The alkoxyate surfactants may be nonionic or anionic. The anionic alkoxyate surfactants are preferably sulfates or phosphates of the 6,6-dimethylbicyclo[3,1,1]hept-2-ene-2-ethanol alkoxyate. Suitable alkoxyate compounds are described in US Patent Application No. 10/820,929, which is herein incorporated by reference.

Preferred alkoxyated surfactants have the general formula:



20 where R is hydrogen, CH₃, or C₂H₅; n is from 0 to 20 inclusive, m is from 2 to 80 inclusive; and X represents a hydrogen atom, phosphate, sulfate, sulphonate, or carboxylate group. The moiety qualified by the integer "n" corresponds to oxypropylene units. Oxypropylene can also be substituted by oxybutylene or similar alkoxyates. The moiety qualified by the integer "m" corresponds to oxyethylene units. The oxypropylene and oxyethylene units may be of block distribution or intermixed in random or tapered distribution along the chain. The compounds of the formula may also be described as alkoxyates of 6,6-dimethylbicyclo[3.1.1]hept-2-ene-2-ethanol.

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Preferred anionic alkoxyated surfactants have the general formula above wherein X represents a sulfate or phosphate group, and preferred nonionic alkoxyated surfactants have the general formula above wherein X represents a hydrogen group.

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The terpene based surfactants described above are used in latex emulsion polymers or as emulsifiers/surfactants in emulsion polymerization. Latex, water based dispersions of polymers obtained by emulsion polymerization, are widely used in various applications such as paints, adhesives, paper coatings, carpet backing and rheology modifiers (HASE).

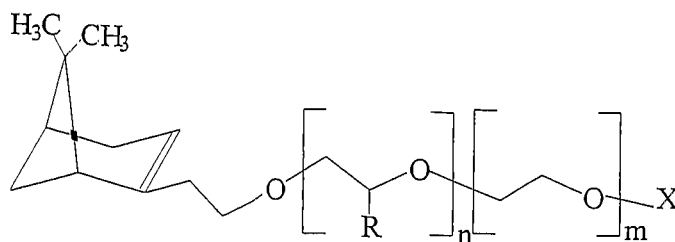
As discussed previously, the surfactants used to stabilize the latex can increase foaming during the manufacturing of the latex and in the final application and require the addition of a defoamer that may have other inconveniences such as the dewetting of the coating responsible for the formation of fish eyes in the paint film. The foaming phenomenon is also detrimental to paint quality and should be avoided.

The terpene based surfactant of this invention may be used as replacements for traditional foamy emulsifiers employed in emulsion polymerization and eliminate or avoid the problem or drawbacks in the resulting latex and its final applications such as paints, coatings, adhesives, or rheology modifiers.

In another aspect, this invention relates to a method of making an emulsion polymer by emulsion polymerization in the presence of a terpene based surfactant. For example, an emulsion polymer is produced by emulsion polymerization in the presence of a Nopol surfactant having the formula:

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where R is hydrogen, CH₃ or C₂H₅.

The Nopol surfactant can be made by different routes. For example, a preferred surfactant wherein X is a sulfate, for example, —OSO₃ H₂ group can be made by sulfation of the product of esterification of a 6,6 dimethylbicyclo [3,1,1] hept-2-ene-2-ethanol alkoxyate. A Nopol surfactant wherein X is a sulfate --OSO₃H₂ group or sulfonate —SO₃ H group, can be made by sulfating one of the hydroxyl groups of the alkoxyate, or replacing the hydroxyl group with a sulfonate group, and then esterifying the remaining hydroxyl group of the alkoxyate with a vinyl-functional carboxylic acid, anhydride, or acid halide thereof.

Emulsion polymerization is discussed in G. Pohlein, "Emulsion Polymerization", Encyclopedia of Polymer Science and Engineering, vol. 6, pp. 1-51 (John Wiley & Sons, Inc., N.Y., N.Y., 1986), the disclosure of which is incorporated herein by reference. Emulsion polymerization is a heterogeneous reaction process in which unsaturated monomers or monomer solutions are dispersed in a continuous phase with the aid of an emulsifier system and polymerized with free-radical or redox initiators. The product, a colloidal dispersion of the polymer or polymer solution, is called a latex.

The comonomers which are typically employed include such monomers as methyl acrylate, ethyl acrylate, methyl methacrylate, butyl acrylate, 2-ethyl hexyl acrylate, other acrylates, methacrylates and their

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blends, acrylic acid, methacrylic acid, styrene, vinyl toluene, vinyl acetate, vinyl esters of higher carboxylic acids than acetic acid, e.g. vinyl versatate, acrylonitrile, acrylamide, butadiene, ethylene, vinyl chloride and the like, and mixtures thereof.

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In the above process, suitable initiators, reducing agents, catalysts and surfactants are well known in the art of emulsion polymerization. Typical initiators include ammonium persulfate (APS), hydrogen peroxide, sodium, potassium or ammonium peroxydisulfate, dibenzoyl peroxide,
10 lauryl peroxide, ditertiary butyl peroxide, 2,2'-azobisisobutyronitrile, t-butyl hydroperoxide, benzoyl peroxide, and the like.

Suitable reducing agents are those which increase the rate of polymerization and include for example, sodium bisulfite, sodium
15 hydrosulfite, sodium formaldehyde sulfoxylate, ascorbic acid, isoascorbic acid, and mixtures thereof.

Suitable catalysts are those compounds which increase the rate of polymerization and which, in combination with the above-described
20 reducing agents, promote decomposition of the polymerization initiator under the reaction conditions. Suitable catalysts include transition metal compounds such as, for example, ferrous sulfate heptahydrate, ferrous chloride, cupric sulfate, cupric chloride, cobalt acetate, cobaltous sulfate, and mixtures thereof.

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Suitable surfactants which may be used in conjunction with the Nopol surfactant include ionic and nonionic surfactants such as alkyl polyglycol ethers such as ethoxylation products of lauryl, tridecyl, oleyl, and stearyl alcohols; alkyl phenol polyglycol ethers such as ethoxylation
30 products of octyl- or nonylphenol, diisopropyl phenol, triisopropyl phenol; alkali metal or ammonium salts of alkyl, aryl or alkylaryl sulfonates,

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sulfates, phosphates, and the like, including sodium lauryl sulfate, sodium octylphenol glycoether sulfate, sodium dodecylbenzene sulfonate, sodium lauryldiglycol sulfate, and ammonium tritertiarybutyl phenol and penta- and octa-glycol sulfonates, sulfosuccinate salts such as disodium
5 ethoxylated nonylphenol half ester of sulfosuccinic acid, disodium n-octyldecyl sulfosuccinate, sodium dioctyl sulfosuccinate, and the like.

A typical process of emulsion polymerization preferably involves charging water to a reactor and feeding as separate streams a pre-
10 emulsion of the monomer and a solution of the initiator. A small amount of the pre-emulsion and a portion of the initiator may be charged initially at the reaction temperature to produce a "seed" latex. The "seed" latex procedure results in better particle-size reproducibility. Under "normal" initiation conditions, that is initiation conditions under which the initiator is
15 activated by heat, the polymerization is normally carried out at about 60-90° C. A typical "normal" initiated process, for example, could employ ammonium persulfate as initiator at a reaction temperature of 80+/-2°C. Under "redox" initiation conditions, that is initiation conditions under which the initiator is activated by a reducing agent, the polymerization is
20 normally carried out at 60-70°C. Normally, the reducing agent is added as a separate solution. A typical "redox" initiated process, for example, could employ potassium persulfate as the initiator and sodium metabisulfite as the reducing agent at a reaction temperature of 65+/-2°C.

25 In the above emulsions, the polymer preferably exists as a generally spherical particle, dispersed in water, with a diameter of about 50 nanometers to about 500 nanometers.

In particular, the terpene based surfactants of this invention may be
30 incorporated in effective amounts in aqueous polymer systems to enhance the stability of emulsions of the polymers. Commonly used

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monomers in making acrylic paints are butyl acrylate, methyl methacrylate, ethyl acrylate and the like. In acrylic paint compositions the polymer is comprised of one or more esters of acrylic or methacrylic acid, typically a mixture, e.g. about 50/50 by weight, of a high T_g monomer (e.g. methyl methacrylate) and a low T_g monomer (e.g. butyl acrylate), with small proportions, e.g. about 0.5% to about 2% by weight, of acrylic or methacrylic acid. The vinyl-acrylic paints usually include vinyl acetate and butyl acrylate and/or 2-ethyl hexyl acrylate and/or vinyl versatate. In vinyl-acrylic paint compositions, at least 50% of the polymer formed is comprised of vinyl acetate, with the remainder being selected from the esters of acrylic or methacrylic acid. The styrene/acrylic polymers are typically similar to the acrylic polymers, with styrene substituted for all or a portion of the methacrylate monomer thereof.

In order to further illustrate the invention and the advantages thereof, the following non-limiting examples are given.

EXAMPLES

Example 1

Latex trials 1 to 13 were prepared using the following formulation:

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Description: Acrylic Pressure Sensitive Adhesive Latex

Total Solids (by formula): **55%**

Kettle Charge	Formula Wt (g)	Active Wt (g)	% BOTM ¹
Deionized Water	191.50	0.00	0.00%
Sodium Bicarbonate	0.55	0.55	0.10%
	192.05	0.55	

Monomer Emulsion

Deionized Water	154.1	0.00	0.00%
Surfactant	5.50	3.19	0.58%
Butyl acrylate	533.5	533.50	97.00%
Hydroxyethyl acrylate	11.0	11.00	2.00%
Acrylic acid	5.5	5.50	1.00%
	709.6	553.19	

550.0 =grams total monomer

Initiator Solution

Deionized Water	107.0	0.00	0.00%
Ammonium Persulfate	2.2	2.20	0.40%
	109.2	2.20	

Total	1010.8	555.94
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Reactor setup: 1200 ml 2 piece glass kettle reactor
Overhead mixer with glass shaft/ Teflon paddle blade

PROCEDURE

1. Heat kettle charge to 80°C while purging with nitrogen. Maintain nitrogen purge throughout run. Adjust agitation for homogeneous mixing throughout run.
2. Add 5% of monomer emulsion (35.5 g). Wait 5 minutes for temperature to rebound.
3. Add 25% (27.3 g) of initiator solution and hold at 80°C for 15 minutes.
4. Feed the remainder of monomer emulsion and initiator solution over a 2.5 - 3 hour period.
5. Maintain the reaction temperature at 80°C throughout the feeds.
6. After addition, heat to 85°C and hold for 30 minutes.
7. Cool to below 30°C, adjust pH to 8 ± 0.2 with NH₄OH and filter through 100 mesh screen.

¹ % based on total monomer concentration

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Surfactant substitutions and changes in surfactant percent concentrations, were as indicated in the following trials.

Table 1. Latex trials comparing control surfactant to Nopol propoxy (PO)/ethoxy (EO) sulfate as indicated:

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Trial #	1	2	3	4	5
Surfactant Substitution	Control Rhodapex CO-436	Nopol 3PO/2.5EO Sulfate NH4+	Nopol 5PO/3EO Sulfate, NH4+	Nopol 5PO/5EO Sulfate, NH4+	Nopol 5PO/7EO Sulfate, NH4+
% BOTM Total Surfactant	0.58	0.58	0.58	0.58	0.58
% BOTM Surfactant in Kettle Charge	0.0	0.0	0.0	0.0	0.0
% Wet Coagulum (BOTL)	0.05	0.01	0.03	0.05	0.14
% Wet Grit (100 mesh BOTL)	trace	trace	0.01	0.01	0.04
% Total Solids	54.39	54.2	54.3	54.2	54.3
% Conversion	98.9	98.5	98.8	98.5	98.7
Mean Particle Diameter / Std Dev (nm)	292.1 / 40	406.7 / 35.1	364.7 / 34.7	361.1 / 49.7	400.8 / 60.3
pH	2.0	2.3	2.6	2.4	2.5
Viscosity (cP) at Room Temp	140	67.5	85	70	85
Freeze / Thaw # cycles	0	0	0	0	0
60°C Oven Stability	Pass 30 days	Pass 30 days	Pass 30 days	Pass 30 days	Pass 30 days

BOTM= Based on total monomer

BOTL= Based on total liquid

nm= Nanometer

cP= Centipoise units

Rhodapex CO-436® (commercially available from Rhodia Inc.) is a sulfated alkyl phenol ethoxylate surfactant.

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Table 1 results showed that similar latex properties can be achieved with Nopol PO/EO sulfates of several different molecular weight ranges.

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Table 2. Latex trials comparing control surfactant to Nopol propoxy (PO)/ethoxy (EO) sulfate as indicated:

Trial #	6	7	8	9
Surfactant substitution	Control Rhodapex CO-436	Nopol 5PO/3EO Sulfate, NH ₄ ⁺	Nopol 5PO/5EO Sulfate, NH ₄ ⁺	Nopol 5PO/7EO Sulfate, NH ₄ ⁺
% BOTM Total Surfactant	0.58	0.58	0.58	0.58
% BOTM Surfactant in Kettle Charge	0	0.025	0.03	0.03
% Wet Coagulum (BOTL)	0.05	0.05	0.08	0.06
% Wet Grit (100 mesh BOTL)	Trace	Trace	0.01	0.11
% Total Solids	54.4	54.2	54.2	53.7
% Conversion	98.9	98.6	98.6	97.7
Mean Particle Diameter / Std Deviation (nm)	292 / 40	260 / 32	257 / 23	288 / 19
pH	2.0	2.4	2.4	2.7
Viscosity (cP) at Room Temp	78	88	80	85

BOTM= Based on total monomer

BOTL= Based on total liquid

nm= Nanometer

cP= Centipoise units

Rhodapex CO-436 is a commercially available sulfated alkyl phenol ethoxylate surfactant from Rhodia.

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The results shown in Table 2 indicate that similar latex properties can be achieved with Nopol PO/EO sulfates of several different molecular weight ranges. Table 2 further illustrates the effect of adding Nopol

- 5 PO/EO sulfate to the kettle charge and the ability to vary the particle size in the final latex (compare to Table 1).

Trials 7-9 were performed to "tune" the particle size of the Nopol PO/EO sulfate so that they were in the 250-300 nm range. Rhodapex
10 CO-436 (trial # 6) was also in the 250-300 nm range. The particle size was controlled so as not to cause interference or variations in tests that can be affected by particle size variation, such as freeze / thaw, foaming, Ca++ and mechanical stability.

- 15 Table 3. Latex trials comparing control surfactant to Nopol propoxy (PO)/ethoxy (EO) sulfate as indicated:

Trial #	6	7	8	9
Surfactant substitution	Control Rhodapex CO-436	Nopol 5PO/3EO Sulfate, NH ₄ ⁺	Nopol 5PO/5EO Sulfate, NH ₄ ⁺	Nopol 5PO/7EO Sulfate, NH ₄ ⁺
Ca++ Stability Test (highest concentration passed)	Passed (0.01 M)	Passed (0.01 M)	Passed (0.01 M)	Passed (0.01 M)
Foam Test – Initial Height (ml)	42	28	28	30
Foam test – Height after 5 minutes (ml)	40	26	25	24
Foam test - Height after 15 minutes (ml)	40	23	21	22
Mechanical Stability (Waring Blender 20,000 rpm for 5 minutes)	Passed	Passed	Passed	Passed
Surface tension (dynes/cm)	39.01	43.05	42.05	41.19
Film Aspect	Good clear film	Good clear film	Good clear film	Good clear film
F/T (# cycles) stability	(0)	(0)	(0)	(0)
60°C Oven Stability	Pass 30 days	Pass 30 days	Pass 30 days	Pass 30 days

M= molar

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The results in Table 3 continue to show that Nopol PO/EO sulfates of several different molecular weights produce similar latex properties such as mechanical, chemical and temperature stability, film quality and surface tension, compared to the control surfactant. Film aspect was excellent for all latexes tested in Table 3, yielding draw downs that are clear and free of defects. No observable difference was seen between the control and Nopol PO/EO sulfate latex films. The results in Table 3 also illustrate that Nopol PO/EO sulfates of several different molecular weights can be used to produce latex with lower foaming properties, as seen in lower initial foam height as well as lower foam height over time.

Table 4. Adhesion results: 180° Peel and Loop Tack Testing

Trial #	Description	Loop Tack (Max Load - N)	180° Peel (N / cm)
6	Control latex made with Rhodapex CO-436	9.80	2.19
7	Latex made with Nopol 5PO/3EO Sulfate	11.06	2.41
8	Latex made with Nopol 5PO/5EO Sulfate	13.34	2.81
9	Latex made with Nopol 5PO/7EO Sulfate	13.18	2.66

Four PSA latexes were tested for peel and tack properties. The latex trials tested are described in Table 2.

Loop Tack Testing:

Samples were prepared by drawing down the neutralized latex onto PET film with a 3 mil 3" drawdown bar. The draw downs were allowed to air dry, and were oven cured at 105°C for 5 minutes prior to covering the film with release paper. A 1" wide strip was cut from the PET/adhesive/release paper "sandwich" and cut to 7" long with the adhesive in the center for loop tack testing. The ends were taped for the grips, and the testing was

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5 performed by lowering the adhesive coated PET film strip to 1" from the SS test surface. The 1" setting ensures that each sample is forced against the SS surface with the same pressure. The Instron Tensiometer® was used to pull the loop up at 12" / minute, and the peak force required to remove the loop was recorded.

180° Peel Test:

10 The sample prep was a little different for the peel test, in that the drawdown was done at the low end of the PET film, as opposed to the center. This was done so that a long "tail" of PET was left for the upper grip to grab for the peel test. Standard SS substrates were used and the pressure applied to the adhesive coated PET film was kept uniform by using a standard roller for the same number of passes at approximately
15 the same speed.

Generally, strong tack and good resistance to peel is desired in pressure sensitive adhesive latexes, and both properties can potentially be
20 impacted by the surfactant used to make the latex.

The data in Table 4 summarizes the results of the 180° peel and loop tack testing. Multiple replications were performed for each sample. The Nopol sulfate latexes showed equivalent or better performance vs. the control.

Table 5. Latex trials with Nopol propoxy (PO)/ ethoxy (EO) sulfate as indicated:

Trial #	10	11	12	13
Surfactant Substitution	Nopol 5PO/19EO Sulfate NH ₄ ⁺	Nopol 5PO/19EO Sulfate NH ₄ ⁺	Nopol 5PO/25EO Sulfate, NH ₄ ⁺	Nopol 5PO/25EO Sulfate, NH ₄ ⁺
% BOTM Total Surfactant	0.58	0.58	0.58	0.58
% BOTM Surfactant in Kettle Charge	0	0.06	0	0.06
% Wet Coagulum (BOTL)	0.11	0.09	0.06	0.10
% Wet Grit (100 mesh BOTL)	0.03	0.10	0.04	1.27
% Total Solids	54.4	54.2	54.4	53.6
% Conversion	98.9	98.6	98.9	97.4
Mean Particle Diameter / Std Dev (nm)	449 / 43	256 / 28	457 / 71	408 / 76
pH	2.6	2.9	2.5	2.7
Viscosity (cP) at Room Temp	73	78	65	70

BOTM= Based on total monomer

BOTL= Based on total liquid

nm= Nanometer

cP= Centipoise units

SS= stainless steel

PET= Polyethylene Terephthalate

The results shown in Table 5 show that similar latex properties can be achieved with Nopol PO/EO sulfates of several different molecular weight ranges, compared to the control surfactant. Table 5 illustrates the effect of adding Nopol PO/EO sulfate to the kettle charge and the ability to vary the particle size in the final latex.

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Example 2

Latex trials 14 to 27 were prepared using the following formula:

Description: Acrylic Paint Latex

Total Solids (by formula): **51%**

Kettle Charge	Formula	Active	%
	Wt (g)	Wt (g)	BOTM ¹
Deionized Water	191.22	0.00	0.00%
Surfactant	1.74	1.02	0.20%
	192.96	1.02	

Monomer Emulsion

Deionized Water	191.67	0.00	0.00%
Surfactant	15.37	9.02	1.80%
Methyl methacrylate	260.00	260.00	52.00%
Butyl acrylate	235.00	235.00	47.00%
Methacrylic acid	5.00	5.00	1.00%
	707.04	509.02	

500.00 = grams total monomer

Initiator Solution

Deionized Water	98.00	0.00	0.00%
Ammonium Persulfate	2.00	2.00	0.40%
	100.00	2.00	

Total	1000.00	512.04
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Reactor setup: 1200 ml 2 piece glass kettle reactor
Overhead mixer with glass shaft/ Teflon paddle blade

PROCEDURE

1. Heat kettle charge to 82°C while purging with nitrogen. Maintain nitrogen purge throughout run. Adjust agitation for homogeneous mixing throughout run.
2. Add 2% of monomer emulsion (14.14 g). Wait 5 minutes for temperature to rebound.
3. Add 25% (25.0 g) of initiator solution and hold at 80°C for 15 minutes.
4. Feed the remainder of monomer emulsion and initiator solution over a 2.5 - 3 hour period.
5. Maintain the reaction temperature at 80°C throughout the feeds.
6. After addition, heat to 85°C and hold for 30 minutes.
7. Cool to below 30°C, adjust pH to 9 with NH₄OH and filter through 100 mesh screen.

¹ % based on total monomer concentration

Surfactant substitutions and changes in surfactant percent concentrations, were as indicated in the following trials.

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Table 6. Latex trials comparing control surfactants to Nopol propoxy (PO)/ ethoxy (EO) sulfate as indicated:

Trial #	14	15	16	17
Surfactant Substitution	Control Rhodapex CO-436	Control Rhodapex AB-20	Control Rhodapex LA-40/S	Nopol 5PO 7EO sulfate
% BOTM Total Surfactant	2.00	2.00	2.00	2.00
% BOTM Surfactant in Kettle Charge	0.20	0.20	0.20	0.20
Wet Coagulum, % BOTL	0.01	0.03	0.48	0.06
Wet Grit, % BOTL	0.04	Nil	1.08	0.01
pH	9.1	9	9	9
Solids, %	49.91	49.93	49.68	49.98
Conversion, %	97.48	97.71	97.2	97.77
Particle Size				
Mean Diameter, nm	114.6	123.6	121.1	137.2
Std. Deviation, nm	20.2	18	8.8	21.3
Std. Deviation, %	17.6%	14.5%	7.3%	15.5%
Viscosity, 25°C, cP	457.9	565.9	535.9	300.9

- 5 BOTM= Based on total monomer
 BOTL= Based on total liquid
 nm= Nanometer
 cP= Centipoise units
- 10 Rhodapex CO-436 is a commercially available sulfated alkyl phenol ethoxylate surfactant from Rhodia.
 Rhodapex AB-20 is a commercially available sulfated alcohol ethoxylate from Rhodia.
 Rhodapex LA-40/S is a commercially available sulfated alcohol ethoxylate from Rhodia.
- 15

Table 6 shows the latex properties of the Example 2 Nopol PO/EO sulfate formulation in comparison to three commercially available surfactants. Table 6 illustrates that similar latex properties were achieved

- 21 -

with the Nopol PO/EO sulfate compared to the control commercial surfactants.

Table 7. Latex trials comparing Nopol propoxy (PO)/ ethoxy (EO)

5 sulfate as indicated:

Trial #	18	19	20	21	22
Surfactant Substitution	Nopol 5PO 5EO sulfate	Nopol 5PO 7EO sulfate	Nopol 5PO 19EO sulfate	Nopol 5PO 25EO sulfate	Nopol 5PO 30EO sulfate
% BOTM Total Surfactant	2.00	2.00	2.00	2.40	2.40
% BOTM Surfactant in Kettle Charge	0.20	0.20	0.20	0.20	0.20
Wet Coagulum, % BOTL	0.04	0.09	0.04	0.02	0.04
Wet Grit, % BOTL	0.16	0.01	0.01	Nil	0.02
pH	9	9	9	9	9
Solids, %	50	49.94	50.09	49.78	50.62
Conversion, %	97.8	97.72	97.83	97.01	98.47
Particle Size					
Mean Diameter, nm	149.5	147.7	162.5	191	176.2
Std. Deviation, nm	31.1	10.9	16.1	24.9	10
Std. Deviation, %	20.8%	7.4%	9.9%	13.0%	5.6%
Viscosity, 25°C, cP	107	269	252	94	274.5

BOTM= Based on total monomer

BOTL= Based on total liquid

nm= Nanometer

cP= Centipoise units

10

The Table 7 results show that similar latex properties can be achieved with Nopol PO/EO sulfates of several different molecular weight ranges, in comparison to the control surfactants (Table 6).

15

Table 8. Latex trials comparing control surfactants to Nopol propoxy (PO)/ ethoxy (EO) sulfate as indicated:

- 22 -

Trial #	23	24	25	26	27
Surfactant Substitution	Control Rhodapex CO-436	Control Rhodapex AB-20	Control Rhodapex LA-40/S	Nopol 5PO 7EO sulfate	Nopol 5PO 7EO sulfate
% BOTM Total Surfactant	2.00	2.00	2.00	2.00	2.00
% BOTM Surfactant in Kettle Charge	0.05	0.15	0.10	0.20	0.20
Wet Coagulum, % BOTL	0.05	0.04	0.01	0.06	0.02
Wet Grit, % BOTL	0.06	0.08	0.02	0.01	0.01
pH	9	9	9	9	9
Solids, %	49.83	50.03	50.11	49.98	50.3
Conversion, %	97.32	97.71	97.72	97.77	98.4
Particle Size					
Mean Diameter, nm	140.6	153.1	143.2	137.2	145.6
Std. Deviation, nm	17	20.4	20.2	21.3	18.4
Std. Deviation, %	12.1%	13.3%	14.1%	15.5%	12.6%
Viscosity, 25°C, cP	180.0	239.4	247.9	300.9	227.0
Foam Test					
Initial Liquid volume, ml	200	200	200	200	200
Initial Foam Height, ml	425	420	410	355	372.5
Height after 5 minutes, ml	425	415	400	350	370
Height after 15 minutes, ml	415	410	390	345	365
Initial increase in volume, %	113%	110%	105%	78%	86%

BOTM= Based on total monomer

BOTL= Based on total liquid

nm= Nanometer

cP= Centipoise units

5

Rhodapex CO-436 is a commercially available sulfated alkyl phenol ethoxylate surfactant from Rhodia.

Rhodapex AB-20 is a commercially available sulfated alcohol ethoxylate from Rhodia.

10

Rhodapex LA-40/S is a commercially available sulfated alcohol ethoxylate from Rhodia.

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The Table 8 results show that latex particle size can be adjusted ("tuned") by changing the amount of surfactant added upfront in the kettle charge while maintaining the same total amount of surfactant used in the polymerization. (See control surfactant trials in Table 6, for comparison.)

- 5 When the control surfactants and Nopol PO/EO sulfate were adjusted to the same particle size range, as in Table 8, lower foaming results are achieved with the Nopol PO/EO sulfate in comparison to the commercially available surfactants.

10 Example 3

Latex trials 28 to 32 were prepared using the following formula:

Description: Vinyl Acrylic Paint Latex

Total Solids (by formula): **51.7%**

Kettle Charge	Formula	Active	%
	Wt (g)	Wt (g)	BOTM ¹
Deionized Water	199.50	0.00	0.00%
Sodium Bicarbonate	0.50	0.50	0.10%
	200.00	0.50	

Monomer Emulsion

Deionized Water	154.26	0.00	0.00%
Surfactant A	25.85	7.50	1.50%
Surfactant B	7.69	5.00	1.00%
Sodium Bicarbonate	1.50	1.50	0.30%
Vinyl acetate	400.00	400.00	80.00%
Butyl acrylate	92.50	92.50	18.50%
Acrylic acid	7.50	7.50	1.50%
	689.30	514.00	

500.00 = grams total monomer

Initiator Solution

Deionized Water	98.00	0.00	0.00%
Sodium Persulfate	2.00	2.00	0.40%
	100.00	2.00	

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Chaser Solutions

Deionized Water	5.00	0.00	0.00%
T-BHP (70%) ²	0.40	0.28	0.06%
		0.00	0.00%
Deionized Water	5.00	0.00	0.00%
Isoascorbic acid	0.30	0.30	0.06%
		0.00	0.00%
	10.70	0.58	

Total 1000.00 517.08

Reactor setup: 1200 ml 2 piece glass kettle reactor
 Overhead mixer with glass shaft/ Teflon paddle blade

PROCEDURE

1. Heat kettle charge to 80°C while purging with nitrogen. Maintain nitrogen purge throughout run. Adjust agitation for homogeneous mixing throughout run.
2. Add 3% of monomer emulsion (20.68 g). Wait 5 minutes for temperature to rebound.
3. Add 25% (25.0 g) of initiator solution and hold at 80°C for 15 minutes.
4. Feed the remainder of monomer emulsion for 3.75 hours and initiator solution for 4.25 hours.
5. Maintain the reaction temperature at 80°C throughout the feeds.
6. After addition, hold at 80°C for 15 minutes.
7. Cool reactor to 65°C. Add chaser solutions. Hold temperature at 63+/-2°C for 20 minutes.
8. Cool to below 30°C, adjust pH to 7.0-7.5 with NH₄OH and filter through 100 mesh screen.

¹ % based on total monomer concentration

² tert- butyl hydroperoxide, 70%

Surfactant substitutions and changes in surfactant percent concentrations, were as indicated in the following trials.

- 25 -

Table 9. Latex trials comparing control surfactants to Nopol propoxy (PO)/ ethoxy (EO) sulfate as indicated:

Trial #	28	29	30	31	32
Description					
Surfactant A Substitution, %BOTM Total Surfactant	Control Rhodapex LA- 40/S, 1.5%	Control Rhodapex LA- 40/S, 1.5%	Nopol 5PO 7EO sulfate, 1.5%	Control Rhodapex LA- 40/S, 1.5%	Nopol 5PO 7EO sulfate, 1.5%
Surfactant B Substitution, %BOTM Total Surfactant	Control Rhodasurf 3065, 1%	Control Rhodasurf 3065, 1%	Control Rhodasurf 3065, 1%	Nopol 5PO 30EO, 1%	Nopol 5PO 30EO, 1%
Wet Coagulum, % BOTL	0	0	0	0	0
Wet Grit, % BOTL	0.09	0.07	0.26	0.38	0.28
pH	7.4	7.3	7.15	7.45	7.35
Solids, %	49.53	49.71	49.28	50.15	49.77
Conversion, %	95.91	96.29	93.02	96.6	96.33
Particle Size					
Mean Diameter, nm	149.8	159.63	184.6	148.17	186.06
Std. Deviation, nm	17.9	12.6	25.5	23.2	30.27
Std. Deviation, %	13.13	7.97	13.83	12.33	16.33
Viscosity, 25°C, cP	280	285	230	275.0	220
Foam Test					
Initial Liquid volume, ml	200	200	200	200	200
Initial Foam Height, ml	415	415	385	435	405
Height after 5 minutes, ml	415	415	385	435	405
Height after 15 minutes, ml	415	415	385	435	405
Initial increase in volume, %	108%	108%	93%	118%	103%

5

BOTM= Based on total monomer

BOTL= Based on total liquid

nm= Nanometer

cP= Centipoise units

Rhodasurf 3065 is a commercially available alcohol ethoxylate (nonionic) from Rhodia.

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Rhodapex LA-40/S is a commercially available sulfated alcohol ethoxylate (anionic) from Rhodia.

Table 9 shows the latex properties of the Example 3 formulations,
5 which uses both an anionic surfactant (Surfactant A) and a nonionic surfactant (Surfactant B).

Anionic surfactants, such as sulfated alcohol ethoxylates, carry a negative charge. Nonionic surfactants, such as alcohol ethoxylates, have a neutral charge. Some latex formulations use both types of surfactant to optimize
10 certain properties, such as stability and resistance to salts.

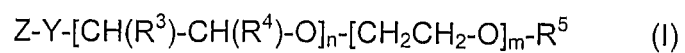
The results in Table 9 compare two commercially available standard surfactants to a Nopol PO/EO sulfate (anionic) and also a Nopol PO/EO (nonionic). In Trial # 30 the Nopol PO/EO sulfate is substituted for the control anionic surfactant. In Trial # 31 the Nopol PO/EO is substituted
15 for the control nonionic surfactant. In Trial # 32, both Nopol surfactants were substituted for the control surfactants.

As illustrated in Table 9 similar latex properties were achieved with the Nopol based surfactants. Table 9 further illustrates that lower foaming properties were achieved by substituting the Nopol PO/EO sulfate for the
20 control anionic surfactant.

- 27 -

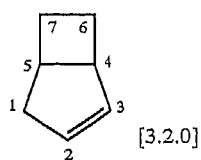
Claims:

- 5 1. A polymerization surfactant comprising at least one compound having a formula (I):

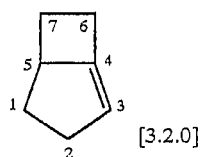


wherein Z represents a group having the following formula:

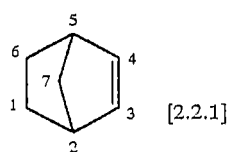
- 28 -



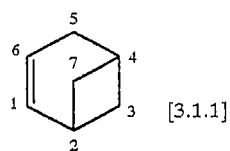
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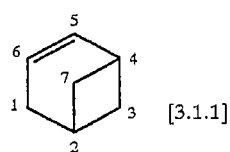
b)



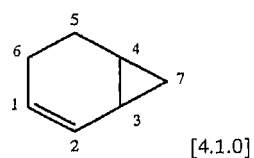
c)



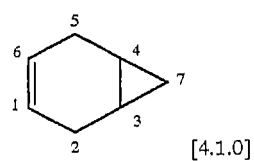
d)



e)



f)



g)

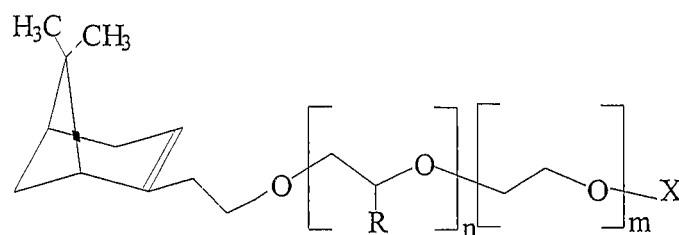
wherein:

R^3 and R^4 , which may be identical or different, represent hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1 - C_{22} hydrocarbon radical, provided that at least one of the radicals R^3 or R^4 is other than hydrogen;

- 29 -

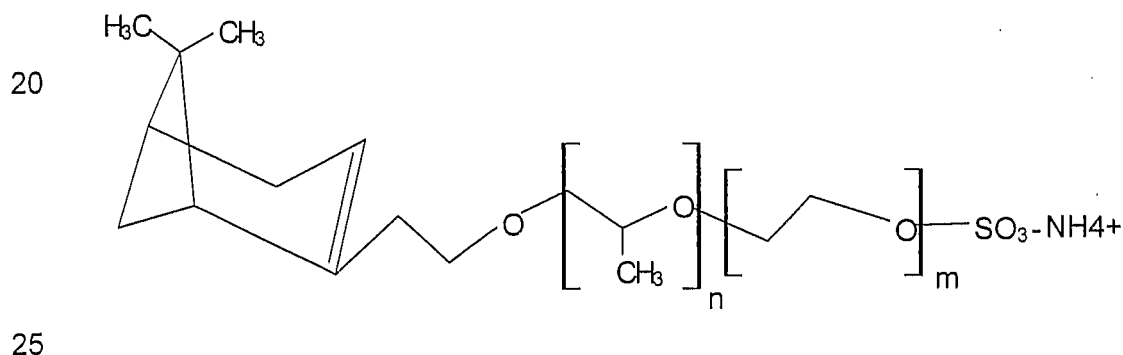
R^5 is hydrogen, $-\text{SO}_3\text{M}$, $-\text{PO}_3(\text{M})_2$, $-(\text{CH}_2)_r\text{COOM}$, or $-(\text{CH}_2)_z\text{SO}_3\text{M}$;
 Y represents $-\text{CH}_2\text{C}(\text{R}^1)(\text{R}^2)\text{O}-$ or $-\text{OCH}(\text{R}^1)\text{CH}(\text{R}^2)\text{O}-$, wherein
 R^1 , R^2 , R'^1 , and R'^2 , which may be identical or different, represent
hydrogen or a linear, branched or cyclic, saturated or unsaturated $\text{C}_1\text{-C}_{22}$
5 hydrocarbon radical;
 n is an integer or fractional number from 0 to 20 inclusive;
 m is an integer or fractional number from 2 to 80 inclusive.

2. The polymerization surfactant of claim 1 wherein said compound has
10 the formula:



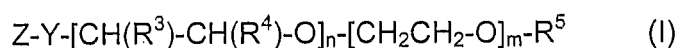
wherein X represents a hydrogen, phosphate, sulfate, carboxylate, or
15 sulphonate group and R is hydrogen, CH_3 or C_2H_5 .

3. The polymerization surfactant of claim 2 wherein said compound has
the formula:



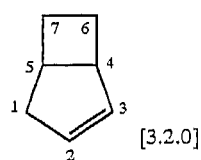
- 30 -

4. The polymerization surfactant of claim 1 wherein said polymerization surfactant is nonionic.
5. The polymerization surfactant of claim 1 wherein said polymerization surfactant is anionic.
6. The polymerization surfactant of claim 1 further comprising surfactants selected from the group consisting of ionic surfactants, nonionic surfactants, or combinations thereof.
7. The polymerization surfactant of claim 1 wherein at least one of R^1 , R^2 , R'^1 , or R'^2 represent a saturated or unsaturated C_1 - C_6 hydrocarbon radical.
8. A formulation polymerized using the polymerization surfactant of claim 1 characterized in that said formulation has less foaming than a formulation polymerized without using the polymerization surfactant of claim 1.
9. Latex polymerized using the polymerization surfactant of claim 1.
10. A polymerization process comprising the step of using the polymerization surfactant of claim 1.
11. A process for the preparation of latex comprising the step of: emulsion polymerization of a reaction mixture, said reaction mixture comprising at least one compound having a formula (I):

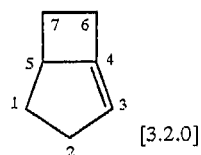


- wherein Z represents a group having the following formula:

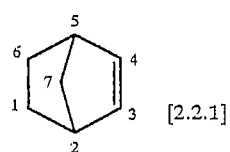
- 31 -



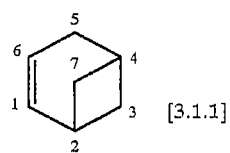
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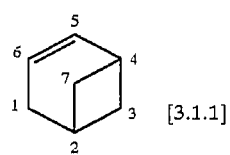
b)



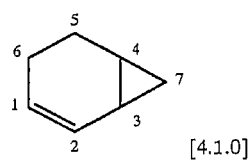
c)



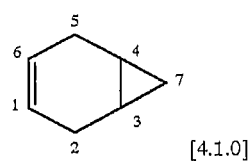
d)



e)



f)



g)

wherein:

R^3 and R^4 , which may be identical or different, represent hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1 - C_{22} hydrocarbon radical, provided that at least one of the radicals R^3 or R^4 is other than hydrogen;

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R^5 represents hydrogen, $-\text{SO}_3\text{M}$, $-\text{PO}_3(\text{M})_2$, $-(\text{CH}_2)_r-\text{COOM}$, or $-(\text{CH}_2)_z-\text{SO}_3\text{M}$;

Y represents $-\text{CH}_2-\text{C}(\text{R}^1)(\text{R}^2)-\text{O}-$ or $-\text{O}-\text{CH}(\text{R}'^1)-\text{CH}(\text{R}'^2)-\text{O}-$, wherein R^1 , R^2 , R'^1 , and R'^2 , which may be identical or different, represent

5 hydrogen or a linear, branched or cyclic, saturated or unsaturated $\text{C}_1\text{-C}_{22}$ hydrocarbon radical;

n is an integer or fractional number from 0 to 20 inclusive;

m is an integer or fractional number from 2 to 80 inclusive.

10 12. The process of claim 11 further comprising the following steps:
a) forming a stable aqueous pre-emulsion from a monomer and the compound having formula (I),

b) forming said reaction mixture comprising the pre-emulsion, an initiator, and water

15 c) introducing the reaction mixture into a reactor and adding from 1 to 10% by weight of said pre-emulsion into to said reaction mixture, and

d) heating said reaction mixture obtained at the end of step c) to a temperature of between 40°C and 90°C to generate a seed formed of latex particles in dispersion in the water.

20

13. The process of claim 11 further comprising the

e) reacting the seed formed of latex particles in dispersion in the water obtained in step d) with an additional amount of initiator to produce latex, and

25 f) optionally, heating the latex obtained in step e) at a temperature of between 40°C and 90°C .

14. The process of claim 12 wherein said monomer is selected from the group consisting of methyl acrylate, ethyl acrylate, methyl

30 methacrylate, butyl acrylate, 2-ethyl hexyl acrylate, acrylates, methacrylates, acrylic acid, methacrylic acid, styrene, vinyl toluene, vinyl

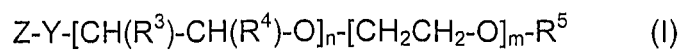
- 33 -

acetate, vinyl esters of higher carboxylic acids than acetic acid, vinyl versatate, acrylonitrile, acrylamide, butadiene, ethylene, vinyl chloride and mixtures thereof.

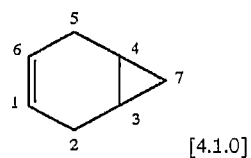
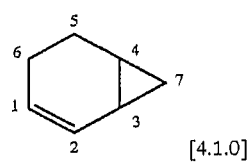
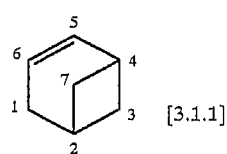
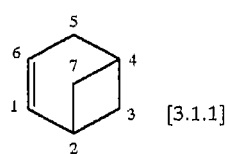
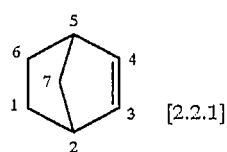
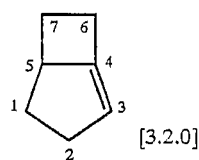
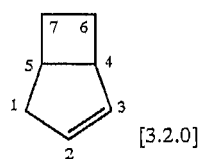
- 5 15. The process of claim 12 wherein said initiator is selected from the group consisting of ammonium persulfate, hydrogen peroxide, sodium, potassium, ammonium peroxydisulfate, dibenzoyl peroxide, lauryl peroxide, ditertiary butyl peroxide, 2,2'-azobisisobutyronitrile, t-butyl hydroperoxide, benzoyl peroxide, and mixtures thereof.
- 10 16. The process of claim 12 characterized in that use is made of from 0.2% to 5% by weight of the compound having formula (I) with respect to the total weight of water used during the polymerization.
- 15 17. The process of claim 16 characterized in that use is made of from 1% to 4% by weight of the compound having formula (I) with respect to the total weight of water used during the polymerization.
- 20 18. The process of claim 12 characterized in that use is made of from 1% to 8% by weight of the compound having formula (I) with respect to the total weight of the monomers employed during the polymerization.
- 25 19. The process of claim 18 characterized in that use is made of from 2 to 5 % by weight of the compound having formula (I) with respect to the total weight of the monomers employed during the polymerization.
- 30 20. Formulations intended for applications in the field of building materials, paper, paints, adhesives or rheology modifiers comprising the latex prepared according to the process of claim 13.

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21. An emulsifier for use in emulsion polymerization, said emulsifier comprising at least one compound having a formula (I):



5 wherein Z represents a group having the following formula:



- 35 -

wherein:

R^3 and R^4 , which may be identical or different, represent hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1 - C_{22} hydrocarbon radical, provided that at least one of the radicals R^3 or R^4 is other than

5 hydrogen;

R^5 represents hydrogen, $-SO_3M$, $-PO_3(M)_2$, $-(CH_2)_r-COOM$, or $-(CH_2)_z-SO_3M$;

Y represents $-CH_2-C(R^1)(R^2)-O-$ or $-O-CH(R'^1)-CH(R'^2)-O-$, wherein R^1 , R^2 , R'^1 , and R'^2 , which may be identical or different, represent

10 hydrogen or a linear, branched or cyclic, saturated or unsaturated C_1 - C_{22} hydrocarbon radical;

n is an integer or fractional number from 0 to 20 inclusive;

m is an integer or fractional number from 2 to 80 inclusive.

15 22. The emulsifier of claim 21 wherein at least one of R^1 , R^2 , R'^1 , or R'^2 comprises a saturated or unsaturated C_1 - C_6 hydrocarbon radical.