

Hydrophilic Siloxane Latex Emulsions

BACKGROUND OF THE INVENTION

Acrylated polysiloxanes copolymerized with organic acrylates and emulsions thereof are known wherein the siloxane and acrylate have been applied to a substrate and are polymerized directly onto a surface. For example, US Patent No. 5,635,546 teaches a curable composition, having utility for threadlocking engageable members of a threaded mechanical fasteners. An emulsion of the reactive silicone acrylate and optional other polymerizable acrylate monomer is applied onto the engagement surface and polymerizing in situ to lock parts in place.

Another example, US Patent No. 5,171,638 teaches organopolysiloxane/acrylate ester copolymer emulsion compositions which offer release, antisoiling and water repellency for paints and textile. Similarly US Patent No. 5,612,433 describes monofunctional dimethylsiloxane acrylates copolymerized with acrylate/methacrylate ester to produce water repellent films on fibers. Additional examples of the emulsified acrylate/methacrylate copolymers with hydrophobic organopolysiloxane, primarily intended for use in paints, is provided in US Patent No. 5,084,489.

SUMMARY OF THE INVENTION

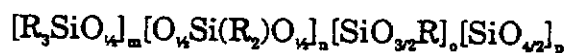
Emulsions of polymers derived from hydrophilic acrylated siloxanes, offer such important properties like hydrophilicity and rewettability while maintaining

other "silicone" characteristics, such as improved aesthetics and tactile properties. The use of these emulsions and copolymer formulations of these emulsions are also taught herein.

5 DETAILED DESCRIPTION OF THE INVENTION

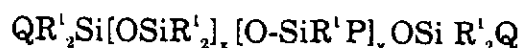
The present invention describes radically polymerized acrylates/methacrylates of polyether modified polysiloxanes and their copolymers with organic acrylates, as well as emulsions including these polymers. The siloxanes have siloxane backbones with pendant polyether functionalities which
 10 polyethers are encapped with an acrylate or methacrylate functionality. The backbone may be linear, branched or cyclic. These acrylated siloxanes then are polymerized in a solvent to form an emulsion of the latex.

The acrylated siloxanes can be represented by Formula I



15 wherein R is selected from the R¹ and P, wherein each R¹ can be the same or different and each is a monovalent hydrocarbon group; each P is R³[(C₃H₇O)_gCOCR⁴=CH₂], wherein, R³ is a poly valent organic moiety, which may be hydroxy substituted alkylene, g is the valency of R³, R⁴ is hydrogen or methyl; b= 2 to 4, preferably 2 to 3; z = 1 to 1000, preferably 3 to 30; and m+n+p+o = 1 to 100,
 20 preferably 2 to 20, at least one R is P; n = 1 to 100; n/o<10:1; n/p<10:1; n/p<10:1; and m = 0 to 10.

Preferably the acrylated siloxane is of the formula (II)



wherein x , and y can be 0 or an integer, preferably each x and y are from 0 to 100, most preferably 0 to 25; Q can be R^1 or P , with the proviso that the average acrylate functionality is >1 unsaturated groups per molecule. In the preferred embodiment $y=0$ and $Q=P$.

5 Preferably R is a C_1 - C_4 alkyl, an aryl or alkaryl. Specifically preferred R are methyl, ethyl, phenyl and ethyl phenyl. R may include heteroatom substituents preferably, which are nonreactive with acrylates.

P may be branched with several polyether branches originating from the alkyl bridge to the silicon atom. For example, P may be an alkoxyated trimethylol
10 propane monoallyl ether which has been hydrosilated onto the siloxane backbone, in which case $g=3$. Other polyvalent precursors for P , which may be hydrosilated and alkoxyated are glycerol monoallyl ether, pentaerythritol allyl ether and trisopropanol amine allyl ether. If there is only branch, $g = 1$, which is preferred. In this preferred embodiment, R^3 is a linear C_2 - C_5 alkylene, most preferably C_2 - C_3 .

15 Not all polyethers in P need be the same as each other. Preferable P structures are ones with ethylene oxide ($b=2$) contents of greater than 80% by weight of the alkylene oxide (C_2H_4O) content, most preferably all of the alkylene oxide chain is ethylene oxide.

 Said acrylates of Formula I are derived from the polyether polysiloxane
20 copolymers wherein the polyethers are attached to the siloxane backbone through a non-hydrolyzable Si-C bond. Moreover, the polyethers should be uncapped so that the hydroxyl group may be (trans)esterified with the acrylate. Said polyether polysiloxanes are commercially available.

The esterification is catalyzed with a Brönstead acid if the acid is the starting acrylate. If an ester is used an acid or base can be used to catalyze the transesterification.

The acrylated silicone copolymers are polymerized to form polymers (latexes),
5 or if desired, copolymers of Formula I with other comonomers (e.g., other esters).
Said polymerization may be conducted in various solvents, catalysts and
temperatures as are known in the art for polymerizing acrylates. Said
polymerization should not be conducted on a surface to form a film. Rather,
polymerization in a solvent allows for production of a crosslinked latex gel which
10 has broader utility than film forming. The emulsion should contain less than or
equal to 90 wt%, preferably less than 50 wt%, of the polymer in solvent. Suitable
solvents include polar solvents, e.g., water and alcohol, and non-polar solvents, such
as many hydrocarbons or low molecular weight cyclic or linear
polydimethylsiloxanes. Preferably polydimethylsiloxanes should have viscosity of
15 less than 100 cSt.

Any organic acrylate or methacrylate can be employed in forming the
copolymers with Formula I. Thus, for example, acrylic acid and methacrylic acid or their
derivatives such as esters, nitriles and amides can be employed. The esters are preferred
compounds. Specific examples of the acrylates that can be utilized are methyl acrylate, ethyl
20 acrylate, butyl acrylate, amyl acrylate, 2-ethylhexyl acrylate, cyclohexyl acrylate, vinyl acrylate,
allyl acrylate, hydroxyethyl acrylate, perfluoroethyl acrylate, isobornyl acrylate, phenoxyethyl
acrylate, tetraethylene glycol diacrylate, tripropylene glycol diacrylate, trimethylolpropane

triacylate. A single acrylate or various combinations of acrylates can be employed in making the copolymers.

Copolymers of the acrylates/methacrylates of the polyether modified polysiloxanes, with the organic acrylates may consist of 1 to 99% by weight of the polysiloxanes, preferably 20 -
5 90% and most preferably 50-80% of the polysiloxane.

It is also an objective of the present invention to produce emulsions, comprising the polymerized acrylates/methacrylates polyether polysiloxanes copolymers and/or their copolymers with organic acrylates (i.e., latexes), which upon evaporation of water form films with good tactile properties and good integrity. These emulsions may in fact be dispersions of the latex.

10 One particular method to prepare emulsions is:

1. Dispersing an acrylate/methacrylate of polyether polysiloxane copolymers, as defined by Formula I, with or without a separate organic acrylate, using at 5-50% by weight of the siloxane emulsifiers selected from nonionic surfactants (such as alkylaryl -polyoxyethylene adducts and alkyl ethoxylates) or anionic surfactants (such as, carboxylates, sulfates, sulfonates, alkylaryl
15 sulfonates and alkyl phosphates), to form a stable emulsion containing 10-50% of the dispersed siloxane phase, which can be further stabilized by addition of common thickeners, such as xanthan or guar gum, gellatin and cellulose derivatives.
2. Adding a free-radical catalyst, selected from the group of water soluble or oil soluble peroxides, such as hydrogen peroxide, ammonium persulfate, potassium persulfate, various
20 organic peroxy catalysts, such as dialkyl peroxides, e.g., diisopropyl peroxide, dilauryl peroxide, di-t-butyl peroxide, dicumyl peroxide, alkyl hydrogen peroxides such as t-butyl hydrogen peroxide, t-amyl hydrogen peroxide, cumyl hydrogen peroxide, diacyl peroxides, for instance

acetyl peroxide, lauroyl peroxide, benzoyl peroxide, peroxy ester such as ethyl peroxybenzoate, the azo compounds such as 2-azobis(isobutyronitrile), to the emulsion.

3. Heating the emulsion to or above the temperature necessary for initiating the radical reaction, typically 40 to 100°C, depending on the catalyst, for 1-10 hours or until the unsaturated groups

5 are consumed.

Use

The emulsion may be translucent or milky, depending on the acrylate/methacrylate used.

The emulsions are stable with no separation at up to about 90°C. The viscosity of the emulsion
10 can be from 0.01 to 10,000 cps (25°C). The dry oil phase (i.e., after the solvent has evaporated from the emulsion) can form smooth and soft films to stiff and brittle films, depending on the starting material and ratio of silicone to acrylate. Generally, the higher the silicone content, the softer the film.

The emulsions of the present invention can be used as ingredients of personal care
15 formulations, including skin care and hair care formulations, such as lipsticks, mascaras, foundations, lotions, creams, sunscreens, shampoos and conditioners, to improve their wear, tactile properties, and ease of application. They can also be used in textile and fiber treatments to impart smooth, soft feel and wettability to both natural and synthetic substrates including natural
20 fibers such as hair, cotton, silk, flax and wool; synthetic fibers such as polyester, polyamide, polyacrylonitrile, polyethylene, polypropylene and polyurethane; and inorganic fibers such as glass or carbon fibers. The fabric substrate which can be treated with the copolymers of the present invention is exemplified by the fabric produced from the above-mentioned fibrous materials or blends thereof. These emulsions can be applied onto the substrate such as by

spraying, dipping or kiss roll application or other application method typically employed in hair or textile treatment.

In general the emulsion is applied on skin, hair, fiber, textile or other substrate such that up to 5%, preferable 0.01 to 2.5% of the polymer by weight of the dry substrate remains on the substrate. Optionally other additives, commonly used to treat hair or textile substrates can be employed along with the copolymers of the present invention, including but not limited to additional surfactants, curing resins, preservatives, dyes, colorants, formularies.

Finally, the emulsions of the present invention can be incorporated into waterborne coating formulations for metals, plastic, wood and paper, such as varnishes, latex paints and roofing compositions.

Some sample formulations incorporating the latexes of the present invention are:

- SHAMPOO - comprising:

- a) an anionic surfactant, a zwitterionic surfactant, an amphoteric surfactant or mixtures of;

- b) long chain acyl derivative or long chain amine oxide suspending agents selected from alkanolamides, ethylene glycol long chain esters, glyceryl long chain esters and mixtures thereof; and

- c) water.

- LIPSTICK - comprising :

- a) waxes such as carnauba wax, beeswax, ozokerite, ceresin, candelilla wax and parafin wax;

- b) oils selected from castor oil, ester oils, mineral oils and vegetable oils;

- c) pigments; and

d) other functional additives such as wetting agent, antioxidants.

- FACIAL MAKEUP- oil in water, water in oil or oil free systems comprising :

a) pigments;

b) dispersion stabilizers selected from emulsifiers such as glyceryl monostearate or polysorbate 60, thickeners such as veegum, cellulose derivatives, xanthan gum;

c) oils selected from mineral oils, vegetable oils, ester oils; and

d) other functional ingredients, such as pigment dispersants, antioxidants and uv absorbers

10 EXAMPLES

Example 1. Preparation of the Hydrophilic Silicone Latexes

An acrylate was added slowly to the water /surfactant mixture, followed by the catalyst. The charges are summarized in Table 1. The emulsion was heated with agitation to 75-80°C for 1 to 2 hour. After cooling to room temperature, solid sodium bicarbonate was added to adjust pH of the emulsion to neutral.

Evaluation of Film Forming Properties

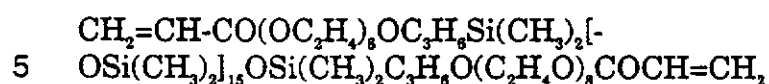
Five ml samples of Emulsions I-XI were placed on the glass panel and dried at room temperature. Results are provided in Table 2.

Table 1. Charges for the Preparation of the Hydrophilic Silicone Latexes

Emulsion ID	Acrylate	Acrylate Charge	Water Charge	Sodium Lauryl Sulfate Charge	Catalyst	Catalyst Charge
I	Polysiloxane A"	40.0g	155.8g	4.0g	potassium persulfate	0.2g
II	Polysiloxane	40.0g	155.8g	4.0g	potassium	0.2g

	B ^{III}				persulfate	
III	Polysiloxane A 2-Ethylhexyl acrylate	20.0g 20.0g	155.8g	4.0g	potassium persulfate	0.2g
IV	Polysiloxane A 2-Ethylhexyl acrylate	30.0g 10.0g	155.8g	4.0g	potassium persulfate	0.2g
V	Polysiloxane A 2-Phenoxyethyl acrylate	20.0g 20.0g	155.8g	4.0g	potassium persulfate	0.2g
VI	Polysiloxane B 2-Phenoxyethyl acrylate	20.0g 20.0g	155.8g	4.0g	potassium persulfate	0.2g
VII	Polysiloxane A Isobornyl acrylate	20.0g 20.0g	155.8g	4.0g	potassium persulfate	0.2g
VIII	Polysiloxane A Tripropylene glycol diacrylate	20.0g 20.0g	155.8g	4.0g	potassium persulfate	0.2g
IX	Polysiloxane A	80.0g	111.6	8.0g	potassium persulfate	0.4g
X	Polysiloxane A	40.0g	155.8g	4.0g	ammonium persulfate	0.2g
XI	Tripropylene glycol diacrylate	40.0g	155.8g	4.0g	potassium persulfate	0.2g

^{II} Polysiloxane A:



^{III} Polysiloxane B:

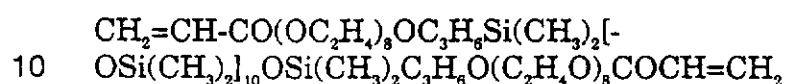


Table 2. Film Forming Properties of Silicone Latex Emulsions I-XI

Emulsion ID	Film Properties
I	uniform, smooth, soft, dry
II	uniform, smooth, soft, dry

III	uniform, sticky
IV	uniform, slightly sticky, soft
V	brittle
VI	uniform, soft
VII	brittle
VIII	uniform, smooth, soft, dry
IX	uniform, smooth, soft, dry
X	uniform, smooth, soft, dry
XI	brittle solid

Most of the Silicone Latex Emulsions formed uniform, smooth, soft and dry films, while the organic acrylate (Emulsion XI) produced brittle solids.

Emulsion XII

- 5 Polysiloxane A (50g) was combined with 20 g of the aqueous 2% solution of ammonium persulfate containing 0.5 g of sodium dodecyl sulfate and the mixture was added slowly, with mixing, to the blend of 50g of decamethyl cyclopentasiloxane and 5g of SILWET FZ-2108. A resulting dispersion was stirred and heated to 80-85°C for 2 hours.

Example 2. Application of the Hydrophilic Silicone Latexes in Lipstick Formulations

Five weight percent of the silicone latex emulsions I, IV, VI, VIII and XI were combined with the ingredients of the Control Lipstick Formulation. The ease of application, gloss and non-transfer properties were evaluated. Gloss was evaluated visually after applying lipsticks to skin; non-transfer was tested by blotting white facial tissue and visually evaluating coloration on the tissue. Results are summarized in Table 3.

MODEL FORMULATION :CONTROL LIPSTICK

Ingredients:

	parts
Carnuba Wax	13.70
Syncrowax BB4 (Croda)	8.50
Castor Oil	32.8
Isopropyl Myristate	30.0
Cloisonne Red Pigment (Mica, TiO ₂ , Carmine-Mearl Corp.)	15.0

Mixing Procedure: Combine ingredients, mix and heat to 80°C or until melted and uniform. Pour into the mold.

Table 3. Evaluation of Lipstick Formulations.

Formulation	Comments
Control Lipstick Formulation	easy to apply, moderate gloss, significant blotting
Control Lipstick Formulation + Emulsion XI	draggy, dull, less transfer than control
Control Lipstick Formulation + Emulsion VIII	easy to apply, high gloss, less transfer than control
Control Lipstick Formulation +	easy to apply, high gloss, less transfer than control

Emulsion VI	
Control Lipstick Formulation + Emulsion IV	easy to apply, high gloss, less transfer than control
Control Lipstick Formulation + Emulsion I	easy to apply, high gloss, less transfer than control

All hydrophilic silicone latex emulsions I, IV, VI and VIII improved non-transfer properties and gloss of the lipsticks; organic acrylate emulsion (XI) also reduced the transfer but at the same time negatively affected the feel and gloss.

5

Example 3. Application of the Hydrophilic Silicone Latexes in Foundations

Five weight percent of the silicone latex emulsions I, IV, VIII and XI were post added to the pre-formed Control Foundation Cream. The ease of application, spreadability and after- feel were evaluated. Results are summarized in Table 4.

10

MODEL FORMULATION : *CONTROL FOUNDATION CREAM*

Phase I

	parts
15 Stearic Acid	12.0
Isopropyl Myristate	1.0
Glyceryl Monostearate	2.0
Polysorbate 60 NF	1.0
Sorbitan Monostearate	2.0
20 Propylene Glycol	12.0
<u>Phase II</u>	
Pigments*	3.0
Water	qs
PIGMENTS COMPOSITION:	
25 Microna Matte White	79.6 parts
Red	9.6
Yellow	9.8
Black	1.0

30 Procedure: Heat Phase I to 65°C, add phase II with mixing. Cool to 35°C, continue mixing.

Table 4. Evaluation of the Foundation Cream Formulations

Formulation	Comments
Control Foundation Cream	draggy, dry, not easy to spread
Control Foundation Cream + Emulsion I	easy to apply, smooth, non-tacky, soft after feel
Control Foundation Cream + Emulsion IV	easy to apply, spreadable, smooth, non-tacky,
Control Foundation Cream + Emulsion VIII	easy to apply, spreadable, smooth, soft after feel
Control Foundation Cream + Emulsion XI	dry, draggy, harsh

5

Silicone latex emulsions I, IV and VIII improved ease of application and after feel of the foundation cream formulation, while the organic acrylate emulsion (XI) offered no improvement.

10 Example 4. Application of the Hydrophilic Silicone Latexes in Textile Treatments

Emulsions X and XI were diluted to 1% actives applied by dip and nip method onto polyester fabric (DACRON heatset Style 7774). Treated fabrics were dried in the textile oven at 100°C for 3 minutes and evaluated for softness and wettability. Results are provided in Table 5.

In this example the test procedures used were as follows:

- 15
- Conditioning Textiles for Testing, ASTM Method D-1776-79
 - Absorbency of Bleached Textiles, AATCC Method 79-1992
 - Softness evaluation was done by the hand panel and the tested fabrics were ranked from the softest to the harshest (1 being the softest).

Treatment	Softness Ranking ^{a)}	Wettability (sec)
Emulsion XI	3	73
Emulsion X	1	55
Water (control)	2	180

^{*)} lower rank means softer fabric

Silicone Latex Emulsion X imparted softness and hydrophilicity to the polyester fabric, while organic acrylate (XI) made the fabric hydrophilic but harsh.

Example 5 – Evaluation of Mascara

Model Mascara Formulation

	Ingredients	Control (parts)	With Silicone (parts)
5	Water Phase		
	Deionized Water	45.32	39.12
	Polyvinylpyrrolidone	2.0	2.0
	Hydroxyethylcellulose	1.0	1.0
10	Triethanolamine	20	1.0
	Methyl Paraben	0.3	0.3
	Disodium EDTA	0.1	0.1
	Black Iron Oxide	10.0	10.0
	Silicone Emulsion I	-	7.2
15	Oil Phase		
	Stearic Acid	4.5	4.5
	Glyceryl Monostearate	2.0	2.0
	White Beeswax	7.0	7.0
20	Carnauba Wax	4.5	4.5
	Hydroxylated Lanolin	1.0	1.0
	Propyl Paraben	0.1	0.1
25	Acrylates Copolymer (Avalure AC 120)	20.0	20.0
	DMDM Hydantoin	0.18	0.18

Mixing procedure:

1. Combine water, PVP and hydroxyethylcellulose, mix well
2. Heat to 82-85 °C, add remaining ingredients of the Water Phase
3. Add Oil Phase preheated to 87°C
4. Cool to 60 °C. Add AVALURE copolymer.
5. Continue mixing while cooling . At 45 °C add DMDM Hydantoin. Cool to room temp.

35 The mascara formulations were compared with the following tests:

Contact Angle – The silicone containing mascara had a contact angle of about 70 degrees versus about 25 degrees for the control, as measured on a goniometer. The contact angle was measured using a NRL Contact Angle Goniometer. A water droplet was placed gently on the mascara film which had been deposited onto an aluminum plate. The horizontal and vertical axes of the

40 microscope were aligned to the bottom of the droplet and tangentially, respectively. The contact

angle formed by these two axes was measured from the circular graduated dial. The contact angle was measured from the opposite sides of the droplet, and the average of both readings was recorded.

Water Resistance – weight loss after 1 minute immersion in an agitated bath at ambient

- 5 conditions – The control mascara lost 75 wt%, while the silicone containing mascara lost about 5 wt%.

Dry Rub Off - Weight loss onto a Scotch tape – The control lost 35 wt%, while the mascara of the present invention lost 5 wt%.

- 10 Humidity Resistance- weight loss after 10 minutes at 80 degreesC/100%rel. humidity – The control lost 90 wt%, while the mascara with the silicone lost about 3 wt%.

Example 6 – Pigment Dispersion Testing –

- Dispersions were prepared by incorporating 10 wt% dry pigments into water or propylene glycol (PG) containing the silicone of Emulsion I at one weight percent. Particle size
- 15 distributions were evaluated using GRIND GAUGE and reported in Hegman Scale (1-coarse, 8-very fine).

Model Pigment Composition:

20	Cosmetic Red (Sun Chemical)	5.7%
	Cosmetic Black (Sun Chemical)	0.8%
	Cosmetic Brown (Sun Chemical)	0.8%
	Cosmetic Tan (Sun Chemical)	8.3%
	Zinc Oxide (Whittaker)	84.4%

25	Formulation	
	Silicone in Water	5
	Control in Water	1
	Silicone in PG	5.5
	Control in PG	2

We claim:

1. A composition comprising:
a polymer formed from the polymerization in a solvent of an acrylated or methacrylated polyether siloxane copolymer.
- 5 2. A composition according to claim 1 wherein the copolymer is present at 1 to 50 weight percent of the composition.
3. A composition according to claim 2 wherein the solvent is water.
4. A composition according to claim 2 wherein the solvent is a cyclic or linear polydimethylsiloxane.
- 10 5. A composition according to claim 1 wherein the siloxane copolymer is of the formula $[R_3SiO_{1/2}]_m [O_{1/2}Si(R_2)O_{1/2}]_n [SiO_{3/2}R]_o [SiO_{4/2}]_p$, wherein R is selected from the R^1 and P, wherein each R^1 can be the same or different and each is a monovalent hydrocarbon group; each P is $R^3[(C_6H_4O)_x COCR^4=CH_2]_z$ wherein, R^3 is a poly valent organic moiety, which may be hydroxy substituted alkylene, g is the valency of R^3 , R^4 is hydrogen or methyl; $b = 2$ to 4 , $z = 1$ to 100 , and $m+n+p+o = 1$ to 100 , at least one R is P; $n = 1$ to 100 ; $n/o < 10:1$; $n/p < 10:1$; $n/p < 10:1$; and $m = 0$ to 10 .
- 15 6.. A composition according to claim 4 wherein the siloxane is of the formula $QR^1_2Si[OSiR^1_2]_x [O-SiR^1P]_y OSiR^1_2Q$ wherein each x and y are from 0 to 100; Q can be R^1 or P, with the proviso that the average acrylate functionality is >1 unsaturated groups per molecule.
- 20 7. A composition according to claim 5 wherein $Q=P$ and $y=0$.

8. A composition according to claim 1 which includes comonomers of acrylates or methacrylates.
9. A process comprising the polymerization of an acrylate or methacrylate polyether siloxane copolymer in a solvent.
- 5 10. A process according to claim 9 wherein at least one other acrylate or methacrylate is present during polymerization.