MOMENTIVE™

Silwet* Copolymers
Chameleon Solutions





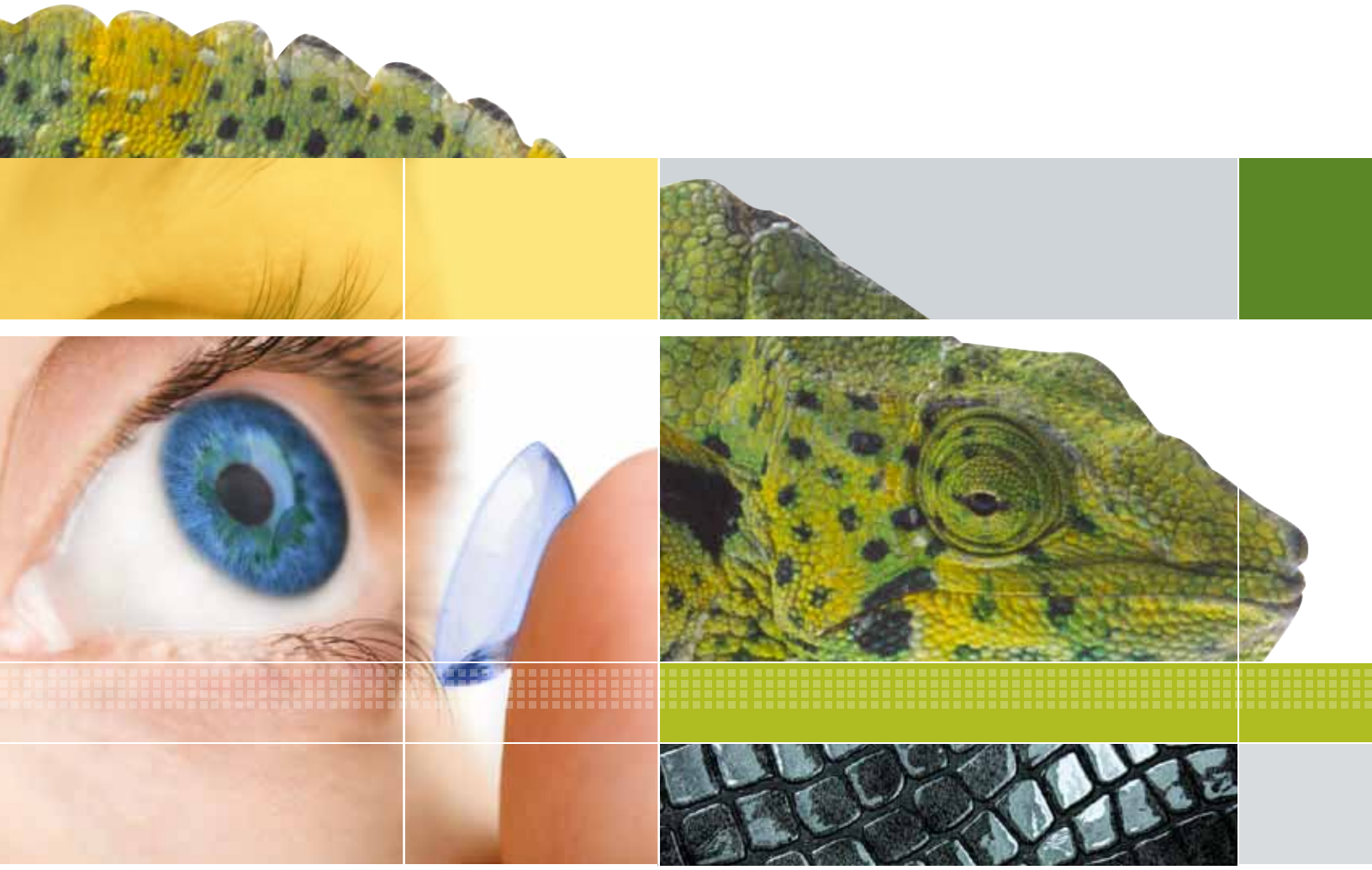
Chemical chameleons - Amazing - Quick - change chemistry

How do you transform a product from “good enough” to superior? What chemical solution is versatile enough to push formulations ahead in virtually every performance category? The answer is Silwet* Copolymers - whether you manufacture fuel additives, cleaners, rain-guards, lubricating fluids, release agents or polymers.

Ordinary siloxanes are chemically limited. By contrast, Silwet copolymers offer virtually unlimited capabilities.

- Through ingenious transformations.
- Through synergy.
- Through attraction, repulsion and molecular interaction.
- Their chemical adaptation at the surface and beneath.

And the potential is hiding right before your eyes.



Silwet* Copolymers - Chemical Chameleons

How deep an active penetrates a substrate, how evenly paint wets a surface, how well particles get dispersed in a formulation or how far and thin an aqueous product spreads on a leaf can make the difference between success and failure.

Our Silwet copolymers can provide this difference.

They have high surface activity and can reduce the interfacial tension dramatically at very low addition levels. Due to the combination of different chemistries - which each add their respective set of properties – they can adapt to a multitude of needs and environments. This makes them like chemical chameleons.

Silwet Copolymers - Wetting

To provide efficient coverage, a formulation must stay evenly distributed on a surface. You find insufficient wetting or dewetting if a formulation retreats from a surface leaving uncovered areas or craters. Silwet copolymers can significantly reduce the surface tension of formulations. This means that in most cases formulations containing small amounts of Silwet copolymers spread easier and more evenly on surfaces or penetrate substrates more deeply compared to the same formulation without.

Also, many low surface energy substrates - especially those with sharp edges - are difficult to cover. Here Silwet copolymers can provide the solution!

The reason is the low surface tension contribution of the silicone portion of the polymer. However, unmodified silicone is not soluble in water or polar solvents like methanol or ethanol. By attaching polyalkyleneoxide, we design Silwet copolymers to achieve highest solubility, while maintaining the benefits of the silicone.

We do provide a selection of products to support both aqueous and non-aqueous formulations, combined with a unique set of properties, depending on your requirements such as, a water soluble product that supports foam or, alternatively, helps to suppress it.

Silwet* Copolymers - Spreading

While wetting can be achieved by applying a formulation on a surface by brush, roller or blade, in the case of spreading the formulation proactively spreads onto a surface on its own. This is especially useful to reduce application time or if a formulation is applied by spray.

While all spreaders are wetting aids, not all wetting aids provide spreading.

In general, spreading increases with lower surface tension, but that is not the only factor. Size and structure of the surfactant molecule also play key roles in spreading your product across a surface or into a substrate.

Due to their special design, Silwet trisiloxane copolymers and Silwet Hydrostable* Copolymers provide excellent spreading performance and thus are referred to as superspreaders (Figure 1). Most common use levels in the range from 0.01 to 0.75 weight-% are sufficient to achieve the desired effect.

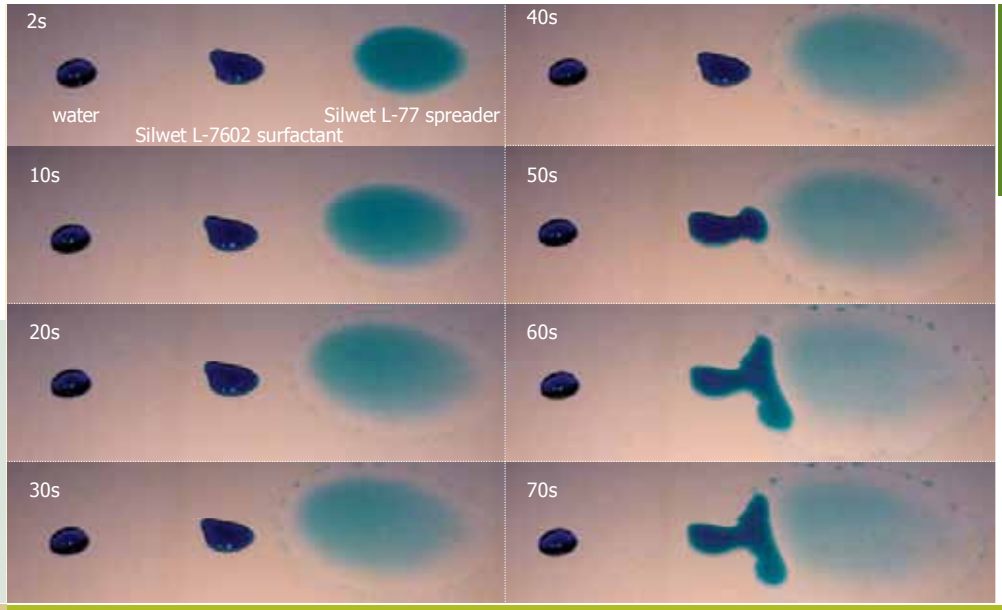


Figure 1:

Comparison of the spreading behavior of water, 0.5 weight-% Silwet L 7602 surfactant and 0.5 weight-% Silwet L-77* Spreader on polyethelene (PE) surface.

Note: Test results. Actual results may vary.

Silwet* Copolymers - Gloss, Release & Antiblock

Silicone is known to provide excellent release and lubricity, especially for rubber-to-rubber, plastic-to-plastic or plastic-to-steel friction. For waterborne applications silicone emulsions are often used. These are white emulsions prone to creaming and separation, especially if diluted to low active content (0.5 to 5 weight-% are most commonly used).

Silwet copolymers translate this benefit of lubricity into a stable, soluble or dispersible form. In contrary to common emulsions no additional components - like emulsifiers and thickeners – are needed.

Where the silicone component dominates, another silicone property also comes into the foreground – a glossy appearance or color deepening effect on plastic surfaces, known from many polish formulations and conditioning agents. Again the water compatibility of Silwet copolymers allows formulating gloss providing products without the need to add other additives, which might diminish the effect.

Silwet copolymers – Foaming & Defoaming

The secret to stabilizing foam lies in the interface between the liquid and the entrapped air. Profoamers stabilize this interface preventing the bubbles from bursting. Defoamers destabilize the barrier forcing the air to escape more quickly.

Silicone – due to its low surface tension – is attracted to this interface and destabilizes it. Thus Silwet copolymers with a high silicone content act as defoamers, while the ones with low silicone content and high water solubility act as foam stabilizers.

Silwet copolymers – Emulsifiers & Dispersants

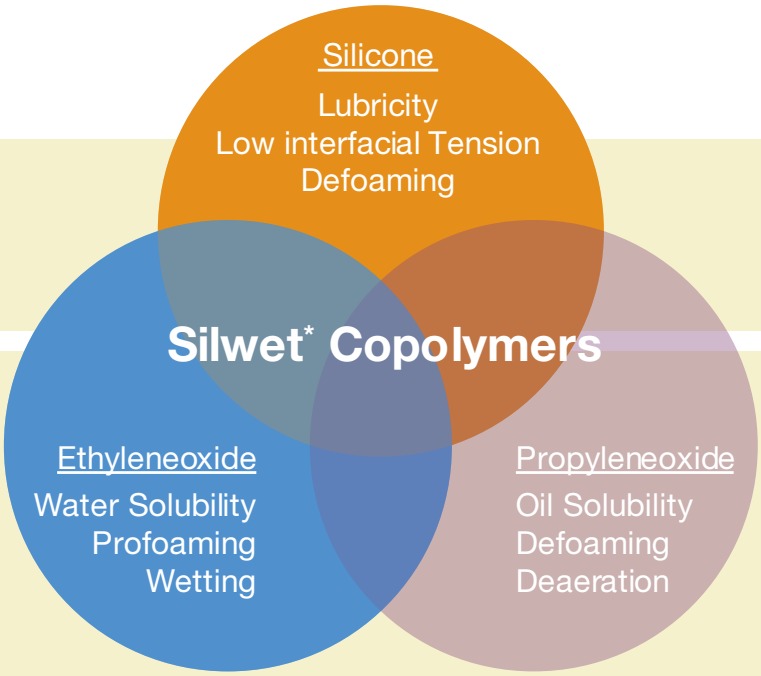
Our specialty surfactants go straight to the oil/water or particle/water interface where stability is essential to prevent or delay separation. They are especially useful to compatibilize silicone based products or silicone coated particles, like many pigments. Their low surface energy makes them effective at low dosage and their high molecular weight keeps them at the interface and protects them against aggregation. 0.5 to 2.0 weight-% addition level, based on the weight of the dispersed phase are good starting levels. The finer the achieved particle size of the emulsion droplets or the larger the surface of the particle to disperse, the more Silwet copolymer is needed.

In many cases Silwet copolymers act synergistically with other organic emulsifiers, so your product can “hold up” for longer periods of time.

The Silwet* Copolymer Portfolio

Most Silwet copolymers are block copolymers of silicone, ethyleneoxide (EO) and/or propyleneoxide (PO). Typically they either have a pendant graft structure (Figure 3) or a linear (ABA)-structure (Figure 4). The composition depends on the respective magnitude of the variables x, y, m and n.

- A molecule with significant silicone content will exhibit lubricity (e.g. fiber lubricants), release (shear stable, water based release agents) coefficient of friction reduction (e.g. assembly of plastic parts), slip, mar resistance, gloss and sheen in polish applications and moderate foam control.
- A product with high polyethyleneoxide content will be self-dispersible or soluble in water or polar solvents. It reduces the interfacial tension and thus aids the wetting, flow and leveling of formulations based on such solvents.
- A material of high polypropyleneoxide content will be self-dispersible or soluble in non-polar solvents. It reduces the interfacial tension of such solvents and thus aids the wetting, flow and leveling of formulations based on such solvents. It will often perform as a foam-control and deaeration agent (anti-cratering).



Silwet* Trisiloxanes are a special case within the Silwet copolymers of the pendent graft structure type (Figure 5). These materials are referred to as superspreaders, because they provide active spreading and penetration, especially to waterborne formulations (Figure 2).

Though their exceptional benefits make trisiloxanes one of the most commonly used type of silicone surfactants, they have one weakness: they degrade outside neutral pH conditions over time.

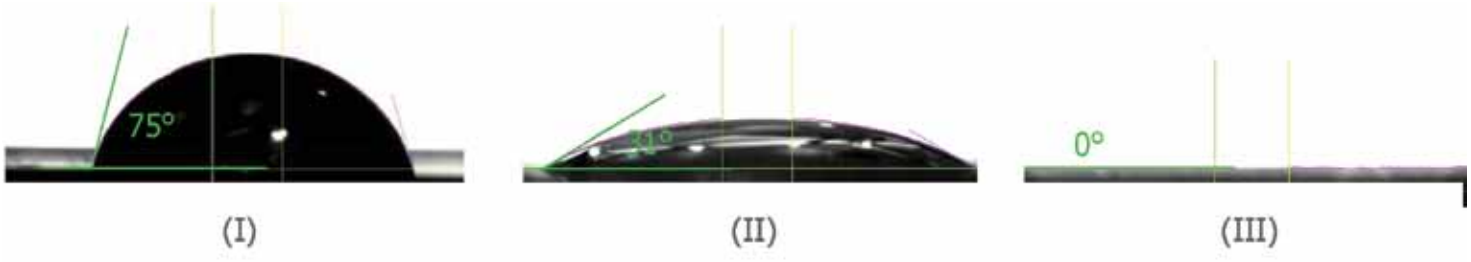


Figure 2:

Contact angle measurements on polystyrene of (I) water and aqueous solutions of (II) 0.25 weight-% Octylphenolethoxylate and (III) 0.10 weight-% Silwet L-77* Spreader.

To overcome this we invented the Silwet Hydrostable* product series, which combine the excellent spreading and wetting performance of the well-known Silwet trisiloxanes with stability ranging from pH-value 2 to 12.

Surfactant	Wt.-%	Eq. surface tension [mN·m^{-1}]	Relative spread area	pH-Stability range
Organic	**0.5**	**~35**	**4**	**n/a**
Silwet L-77	0.1	20.5	172	6.5-7.5
Silwet Hydrostable 68	0.1	21.0	130	6.0-8.0
Silwet Hydrostable 611	o.1	25.8	100	6.0-11.0
Silwet Hydrostable 212	0.1	26.7	105	2.0-12.0

Table 1: Physical properties of our Silwet copolymer portfolio. Note: Typical data are average data and actual results may vary. Typical data shall not be used as product specifications.
Note: Test results. Actual results may vary.

Figure 3:

Silicone-Polyether Block copolymer, pendant graft structure.

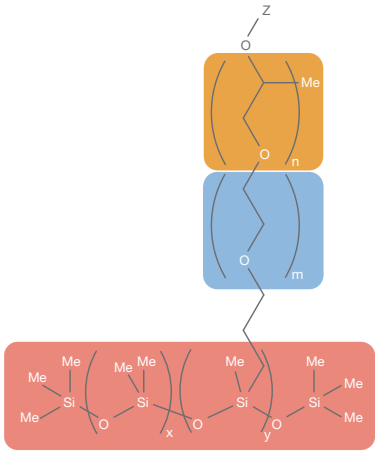


Figure 4:

Silicone-Polyether Block copolymer, linear (ABA)-structure.

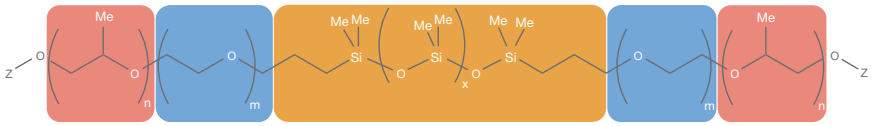
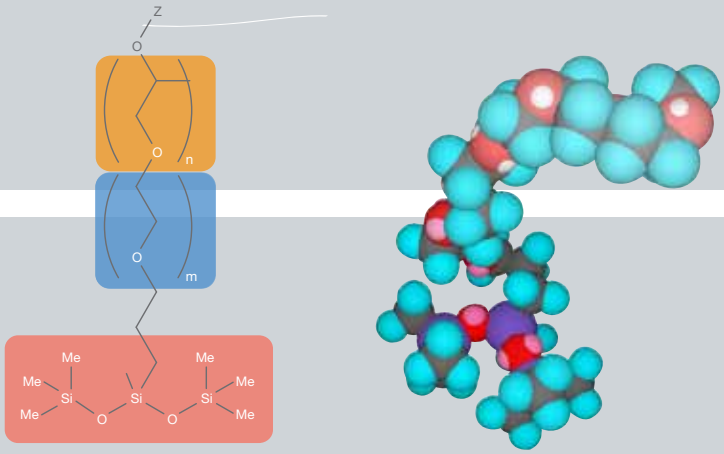


Figure 5:

Silicone-Polyether Block copolymer, Trisiloxane structure and sphere plot of a structure simulation.



Silwet* Triangle - a decision-making tool

The Silwet triangle offers an easy route to find the right Silwet copolymer in our broad portfolio. Each vertex equals a polymer composition of 100% silicone, polyethylene- or polypropyleneoxide by weight respectively. Each point within the triangle depicts a composition in percent based on the three vertex materials (always adding up to 100%). For example Silwet L-7002 surfactant contains ~25% Silicone and ~37,5% polyethyleneoxide and polypropyleneoxide respectively. Additionally the different structural-types can be distinguished by their label color:

Silwet Triangle

The Silwet triangle offers an easy access to the world of Silwet copolymers. Each point within the triangle depicts a percent composition based on silicone, polyethyleneoxide and polypropyleneoxide. Each vertex equals a product containing 100% by weight of silicone (top), EO (bottom left) and PO (bottom right)

- Need foaming, antifogging, leveling or water solubility? Your best bet is to select surfactants nearest to ethyleneoxide, at the left hand vertex.
- Need defoaming in water or water based systems, deaeration or oil solubility? Silwet Copolymers closest to propyleneoxide, at the right hand vertex.
- Need release, lubricity, coefficient of friction reduction, slip, defoaming, surface tension reduction, sheeting or gloss? Start at the top, with the highest silicone content.
- Need maximum static- and dynamic surface tension reduction and thus wetting, spreading, leveling or antifog? Look for Silwet Trisiloxanes.
- Need a combination of properties from opposing corners of the Silwet triangle select a Silwet copolymer grade from the center with the best formulation stability in your product.

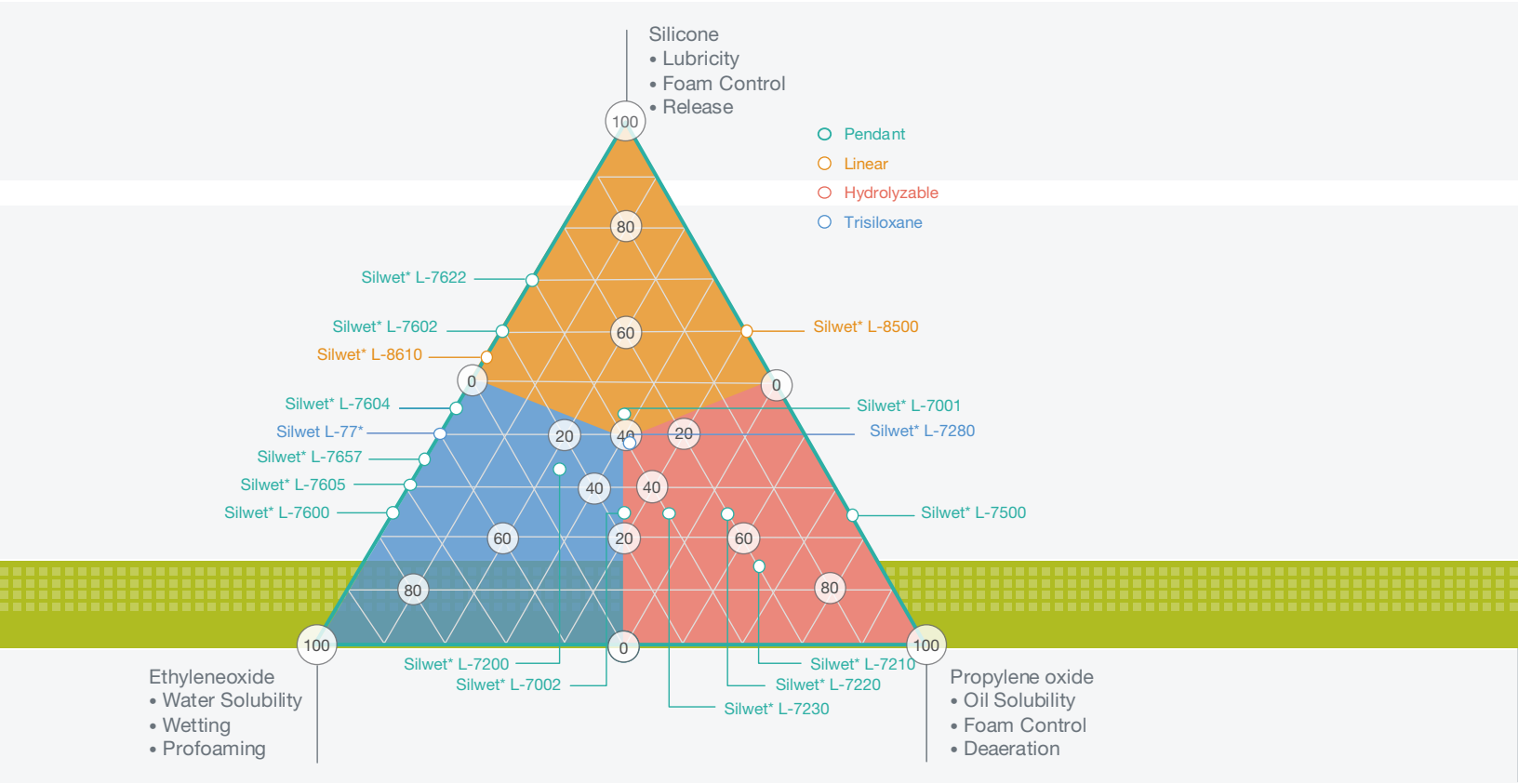


Table 2 lists typical application areas and initial dosage recommendations for our Silwet* Copolymers. The suitability and applicability of the respective grade depends on the formulation and the desired effect.

Application	Recommended use level [weight-%]
Textile fibre processing	
Fibre finish	0.5 - 2.0[1]
Texturising finish	0.5 - 2.0[1]
Chemical specialities	
Levelling aid	0.1 - 1.0
Anti-static agent	0.1 - 1.0
Anti-fog	0.1 - 1.0
Lubricant	0.5 - 100
Solvent based coatings/inks	
Mar resistance	0.05 - 2.0
Water based coatings	
Urethane bubble release	0.05 - 2.0
Flow and leveling	0.05 - 2.0
Metal forming	
Cutting fluid	0.1 - 2.0
Rolling oil	2.0 - 1.0
Plastic Processing	
Anti-blocking agent	0.1 - 1.0
Anti-static	0.1 - 1.0
Lubricant / release	
Rubber and Plastic	0.5 - 1.0
Paint and glue receptivity	1.0 - 3.0
[1]Parts by weight additive per hundred parts textile	

Table 2: Typical application areas and dosage recommendation for Silwet copolymer.

Note: Typical data are average data and actual results may vary. Typical data shall not be used as product specifications.

Silicone, the backbone of the Silwet copolymers, can be attacked and hydrolyzed under acidic or alkaline conditions. However, if and at which rate the polymer degrades depends on multiple factors. The composition of the formulation the product is contained in, the temperature and the structure of the Silwet copolymers are of highest importance.

Trisiloxane based products are especially vulnerable to acidic or alkaline attack. Here our Silwet Hydrostable* Superspreaders offer a suitable alternative (please consult the Silwet Trisilioxane section in this brochure). For the other products in general, a lower solubility in water, a higher molecular weight and higher concentration of Silwet copolymers increase the stability.

Typically, each type of Silwet* Copolymer structure shows a good long term stability within the pH-range listed below:

- Silwet Trisiloxanes: pH 6.5 to 7.5
- Silwet hydrolyzable copolymers: pH 6.9 to 8.01
- Silwet linear and graft copolymers: pH 5.5 to 8.5
- Silwet Hydrostable* Copolymers: pH 2.0 to 12.0 (best case)

Since the stability may also depend on other ingredients contained in the formulation and contact materials, storage trials are always recommended to confirm the above mentioned pH-stability range in individual cases.

In the case of our Silwet Hydrolizable copolymers the hydrolytic instability towards hydrolysis is utilized for hydrophobization of substrates like glass or leather. Here the solubilizing polyether groups are cleaved from the silicone at a rate defined by the pH-value of the solution. The silicone becomes insoluble and deposits on the substrate to be treated, to which it can cure if suitable moieties are present. The polyether can be easily washed away afterwards.

- 1 Due to their chemical structure, long term stability cannot be achieved in aqueous formulations. This pH-range allows moderate stability.

Additional Product Information

Though the Silwet triangle offers a quick and easy access to the world of Silwet copolymers, it does not contain all information needed, like for example the total molecular weight or the type of terminal group of the polyether blocks. Thus the additional data conglomerated in the attached tables might be of help to you. They summarize typical physical, chemical, solubility and application properties.

Silwet copolymer	Color GVS[a]	Specific Gravity[b]	Flash Point[c]		Pour Point		Viscosity[d]	Ross Miles foam height[e]	Aqueous surface tension[f]	Cloud Point[g]	CMC	VOC[h]
			°F	°C	°F	°C	cSt		mN/m	°C	g/100g	%
L-77*	1	1.007	240	116	35	2	20	58	20.5	(D)	0.007	3.0
L-7280	1	1.002	290	143	-22	-30	35	66	21.5	(D)	0.003	2.4
L-7001	1	1.023	206	97	-55	-48	1700	58	28.2	39	0.003	0.8
L-7002	3	1.028	170	82	-40	-40	900	102	30.5	39	0.004	1.1
L-7200	1	1.064	230	110	40	4	2500	102	34.2	77	0.02	0.9
L-7210	1	1.020	300	149	-25	-32	1000	7	30.3	25	0.009	1.6
L-7220	1	1.017	290	143	-8	-22	1100	14	26.8	24	0.01	0.9
L-7230	2	1.033	275	135	-25	-32	4000	119	32.4	40	0.02	1.3
L-7500	1	0.987	250	121	-45	-43	140	(l)	(i)	(i)	(l)	1.1
L-7600	2	1.006	165	74	35	2	110	97	25.1	64	0.005	1.1
L-7602	2	1.027	192	93	28	-2	100	15	26.6	d	0.003	1.3
L-7604	1	1.074	175	79	30	-1	420	27	25.4	50	0.004	1.6
L-7605	3	1.068	308	149	90	32	210	124	30.2	93	0.03	0.5
L-7622	<1	1.019	230	110	35	2	400	(l)	(i)	(i)	(l)	1.4
L-7657	<1	1.090	265	129	55	13	600	118	27.6	89	0.002	0.2
L-8500	1	0.989	235	113	-54	-48	250	(i)	(i)	(i)	(l)	4.1
L-8610	2	1.032	270	132	19	-7	125	16	25.7	(D)	0.005	6.7

Table 3: Physical properties of our Silwet copolymer portfolio. Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications

[a] Typical Values on Gardner Varnish Scale.

[b] Apparent Specific Gravity at 25/25°C (35/25°C for Silwet* L-7605).

[c] Pensky-Martens, Closed Cup, ASTM method D93.

[d] Typical Viscosity at 25°C (35°C for Silwet* L-7605).

[e] 1% Solutions, 5 minute reading ASTM D1173-53.

[f] Typical Values at 25°C on 0.1% (w/w) aqueous solutions using either DeNooy Ring or Wilhelmy Plate Method.

[g] Typical values measured visually on 1% (w/w) aqueous solutions.

[h] ASTM D-2392

Silwet® Copolymers	Foam aqueous	Sheeting	Penetration wetting	Finish gloss	Antifog	Lubricant	Antiblock release	Dispersant solids in water	Emulsifier oil in Water
L-77®	Profoamer	+++	+++	++	+++	++	O	+++	+++
L-7280	Moderate	+++	+++	++	+++	++	O	+++	+++
L-7001	Moderate	+	+	++	++	++	+	++	++
L-7002	Profoamer	+	++	++	++	++	+	++	++
L-7200	Profoamer	+	+	+++	++	++	++	++	++
L-7210	Defoamer	+	++	++	O	+	O	+++	+++
L-7220	Defoamer	O	+	++	O	+	+	++	+++
L-7230	Profoamer	+	-	++	++	++	+	++	++
L-7500	Defoamer	O	++	-	O	+	O	+++	-
L-7600	Profoamer	++	++	-	++	+	+	++	++
L-7602	Defoamer	++	++	++	++	++	++	+++	+++
L-7604	Moderate	+	++	++	++	+	+	+	++
L-7605	Profoamer	+	+	-	++	+	+	+	++
L-7622	Defoamer	O	-	+++	O	+++	+++	+	-
L-7657	Profoamer	+	+	-	++	+	+	+	++
L-8500	Defoamer	O	++	++	O	+++	+++	++	-
L-8610	Defoamer	++	++	++	++	++	++	++	++

Table 4: This application property selector guide gives you an indication of the typical relative performance of the respective Silwet copolymer products. It is based on empirical experience and structure based assessments. Since other components of formulations might have an impact on the Silwet copolymers performance we recommend to use this guide to select a starting point only. Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.

Silwet® Copolymers	Structure[i]	CAS-number	Ratio EO/PO	Cap[j] [Z]	Molecular weight [g/mol]	Percent actives	Est. HLB-value[k]
L-77®	Trisiloxane	27306-78-1	All EO	CH_3	600	100%	12,0
L-7280	Trisiloxane	134180-76-0	60/40S	H	600	100%	7,5
L-7001	Graft	67762-85-0	40/60	CH_3	20000	75%	4,6
L-7002	Graft	67762-87-2	50/50	$(CH_2)_3CH_3$	8000	100%	7,6
L-7200	Graft	68937-55-3	75/25	H	19000	100%	9,9
L-7210	Graft	68937-55-3	20/80	H	13000	100%	3,8
L-7220	Graft	68937-55-3	20/80	H	17000	100%	3,4
L-7230	Graft	68937-55-3	40/60	H	29000	100%	6,3
L-7500	Graft	68440-66-4	All PO	$(CH_2)_3CH_3$	3000	100%	0,0
L-7600	Graft	68938-54-5	All EO	CH_3	4000	100%	14,3
L-7602	Graft	68938-54-5	All EO	CH_3	3000	100%	7,3
L-7604	Graft	68937-54-2	All EO	H	4000	100%	10,6
L-7605	Graft	68938-54-5	All EO	CH_3	6000	100%	13,9
L-7622	Graft	68938-54-5	All EO	CH_3	10000	100%	5,7
L-7657	Graft	68937-54-2	All EO	H	5000	100%	12,9
L-8500	Linear	161755-53-9	All PO	H	2800	100%	0,0
L-8610	Linear	102783-01-7	All EO	H	1700	100%	8,6

Table 5: Structural information on Silwet copolymers. Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.

[i] Generic structural types as displayed in Figure 3, Figure 4 & Figure 5.

[j] Variable ‚Z' as per generic structural types as displayed in Figure 3, Figure 4 & Figure 5.

[k] Estimated HLB-values calculated by the formula: Estimated HLB = weight-%(EO)·20.

Silwet* Copolymers	Water	Hexane	Methanol	Acetone	Xylenes	Dichlor-methane	Isopropanol
L-77*	DDDG	SDIDS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7280	DDDGS	SSDDS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7550	IIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7001	SSDDS	IIIIS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7002	SSSSS	IIIIS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7200	SSSSG	IIIIS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7210	SDDIG	IIIIS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7220	DDDDI	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7230	SSSSG	IIIIS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7500	IIIIG	SSSDS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7600	SSSSS	IIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7602	DDDDG	SIIIS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7604	SSSSS	IIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7605	SSSSS	IIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7622	IIIIG	SSIID	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-7657	SSSSS	IIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-8500	IIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS
L-8610	SDIIG	SIIII	SSSSS	SSSSS	SSSSS	SSSSS	SSSSS

Table 6: Solubility of Silwet copolymers in a selection of solvents at 25°C (77°F) at 0.1, 1, 5, 20 and 80 weight-%: **Note:** Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.

S = Soluble: Clear or slightly hazy solution.

D = Dispersible: Hazy, stable dispersion, partially soluble.

I = Insoluble: Unstable dispersion, separates on standing into two phases.

G = Gel: A clear Gel at low water concentration, except an opaque gel in the case of Silwet* L-7500.

Patent Status

Nothing contained herein shall be construed to imply the nonexistence of any relevant patents or to constitute the permission, inducement or recommendation to practice any invention covered by any patent, without authority from the owner of the patent.

Product Safety, Handling and Storage

Customers considering the use of this product should review the latest Material Safety Data Sheet and label for product safety information, handling instructions, personal protective equipment if necessary, and any special storage conditions required. Material Safety Data Sheets are available at www.momentive.com or, upon request, from any Momentive Performance Materials representative. Use of other materials in conjunction with Momentive Performance Materials products (for example, primers) may require additional precautions. Please review and follow the safety information provided by the manufacturer of such other materials.

Limitations

Customers must evaluate Momentive Performance Materials products and make their own determination as to fitness of use in their particular applications.

Emergency Service

Momentive Performance Materials maintains an around-the-clock emergency service for its products.

Location	Emergency Service Provider	Emergency Contact Number
Mainland U.S., Puerto Rico	CHEMTREC	1.800.424.9300
Alaska, Hawaii	CHEMTREC	1.800.424.9300
Canada,	CHEMTREC	1.800.424.9300
Europe, Israel	NCEC	+44(0) 1235239670
Middle East	NCEC	+44(0) 1235239671
Asia/Pacific (except China)	NCEC	+44(0) 1235239670
China	NCEC	+86.10.5100.3039
Latin Ameria (except Brazil)	NCEC	+44(0) 1235239670
Brazil	SOS Cotec	08000111767 or 08007071767
All other locations world wide	NCEC	+44(0) 1235239670
At sea	Radio U.S. Coast Guard in US waters	
	NCEC in International waters	+44(0) 1235239670

For Health related calls, contact Momentive Performance Materials at +1.518.233.2500 (English only).

DO NOT WAIT. Phone if in doubt. You will be referred to a specialist for advice.

Customer Service Centers

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F +1 607 786 8309

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cs-na.silicones@momentive.com

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