

Polyaldo® Polyglyceryl Esters for Leave-On Emulsions

Naturally-Derived Emulsifiers with Viscosity Enhancement Properties



Polyaldo® Polyglyceryl Esters are emulsifiers made from raw materials of 100% plant origin. These non-ionic emulsifiers are highly compatible with different emollients, silicones, and co-emulsifiers, helping to create stable oil-in-water emulsions. Furthermore, Polyaldo® Polyglyceryl Esters are Ecocert approved, making them the smart choice for natural concepts and PEG-free formulations.

Technologies Highlighted in this brochure:

- Polyaldo® 6-2-S [INCI: Polyglyceryl-6 Disterate]
- Polyaldo® 10-1-S [INCI: Polyglyceryl-10 Stearate]
- Polyaldo® 10-1-O [INCI: Polyglyceryl-10 Oleate]
- Polyaldo® 10-2-P [INCI: Polyglyceryl-10 Dipalmitate]

What Are the Polyaldo® Polyglyceryl Esters?

The Polyaldo® Polyglyceryl Esters are ester emulsifiers with a wide range of hydrophilic-lipophilic characteristics. These surfactants, made via esterification of a polyglycerol and a fatty acid, form a molecule which contains a hydrophilic head group and hydrophobic tail group.

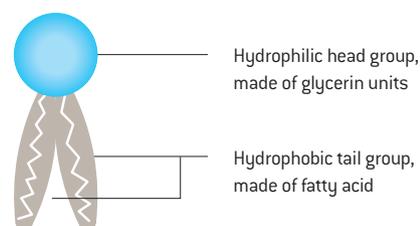


Fig. 1
Model of a Polyaldo® Polyglyceryl Ester molecule.

The hydrophilic head group of the polyglyceryl ester molecule is made of polyglycerol units. The polyglycerol molecule is created by polymerizing naturally-derived glycerin, under controlled conditions, to a specific molecular weight. The glycerin used to make the polyglycerol is derived from naturally sourced coconut oil or palm oil. RSP0 certified palm oil is available for manufacturing of Polyaldo® Polyglyceryl Esters.

The fatty acid represents the lipophilic tail group of the polyglyceryl ester. When the polyglycerol and fatty acid are esterified, they form a non-ionic emulsifier great for creating stable, oil-in-water emulsions for skin and hair care applications.

Polyaldo® Polyglyceryl Ester Nomenclature

Lonza's tradename for a polyglyceryl ester is Polyaldo®. Each polyglyceryl ester product manufactured by Lonza has a three character suffix, beginning with two numerical values and ending with a letter of the Roman alphabet. The first numerical value represents the degree of polymerization of the polyglycerol molecule. It is the number of glycerin units which have been reacted with each other to form the polyglycerol chain. The second numerical value represents the degree of esterification of the polyglyceryl ester. It is the number of fatty acid molecules which have been reacted with the polyglycerol chain.

The last character is a letter of the Roman alphabet. This represents the type of fatty acid used in the esterification process. The Polyaldo portfolio utilizes stearic, oleic, palmitic, and lauric acid as the fatty acids of interest, however, Lonza has the capability to use other fatty acids.

To best understand the nomenclature, we will review Polyaldo® 6-2-S (INCI: Polyglyceryl-10 Distearate) as an example. The suffix for this product contains a "6", a "2", and the letter "S". Based on the nomenclature guidelines above, the characters represent the following:

- 6 => a polyglycerol made up of six (6) units of glycerin
- 2 => the degree of esterification is two (2) and is reflected in the fatty acid as a "distearate"
- S => stearic acid is used as the fatty acid for esterification

Why Consider Polyaldo® Polyglyceryl Esters?

Traditional emulsifiers, such as PEG-based esters and sorbitan esters, are popular because of their ability to create stable formulations and their ease of use. However, these ester chemistries, which date back to the early 20th century, have not innovated since their creation. In addition, a serious flaw with traditional emulsifiers is with the viscosity of the formulation created. In general, traditional emulsifiers provide a limited range of viscosity, no matter how little or how much of the emulsifier incorporated in formulation. In addition, they require additional support to help build formulation viscosity. Support comes from polymer technologies like carbomer, cellulosic chemistries like hydroxypropyl methyl cellulose, and the inclusion of fatty alcohols like cetyl and stearyl alcohol. Lastly, these traditional emulsifiers are showing their age. They were created when ingredients made from raw materials like ethylene oxide

were not well researched and were generally accepted by the public. Today, consumers are more educated and are moving away from these types of chemistries because of the utilization of ethylene oxide and the potential to contain residual 1,4 dioxane, a well-researched carcinogen.

Polyaldo® Polyglyceryl Esters are different. These naturally-derived esters have been shown to have a direct relationship with the viscosity of the emulsion formed. Lonza has researched this relationship extensively and developed a patent-pending application utilizing Polyaldo® Polyglyceryl Esters for enhanced formulation thickening.

Enhanced Formulation Viscosity with Polyaldo® Polyglyceryl Ester Combinations – Technical Background

Polyaldo® 6-2-S is composed of two parts; a hydrophilic head and hydrophobic tail. The hydrophilic head is composed of six (6) units of glycerin while the hydrophobic tail is made of stearic acid. Polyaldo® 6-2-S is a diester and, therefore, has two hydrophobic tails, making the molecule more hydrophobic than hydrophilic (fig. 2)

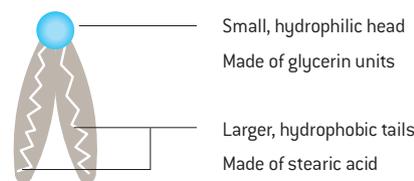


Fig. 2

Visual representation of Polyaldo® 6-2-S (INCI: Polyglyceryl-6 Distearate)

Lonza Inc. has discovered that Polyaldo® 6-2-S performs exceptionally well in the presence of another polyglyceryl ester and fatty alcohol. In our study, Polyaldo® 10-1-S Pastillated, Polyaldo® 10-2-P Pastillated, and Polyaldo® 10-1-0 were evaluated with Polyaldo® 6-2-S. These patent-pending Polyaldo® emulsifier combinations have been shown to outperform traditional emulsifier systems by increasing formulation viscosity and provide formulators with enhanced formulation thickening.

The synergy between Polyaldo® 6-2-S and another Polyaldo® has to do with molecular structures. Polyaldo® 6-2-S has a twin tail molecular structure, with a smaller hydrophilic head and larger hydrophobic tails (fig. 2). When the two Polyaldo® emulsifiers are combined in a formulation, they create a novel order at the oil/water interface (fig. 3). The packing of Polyaldo® emulsifiers creates lamellar structures (fig. 4), ideal structure formations for quality emulsions with increased viscosity and improved stability.

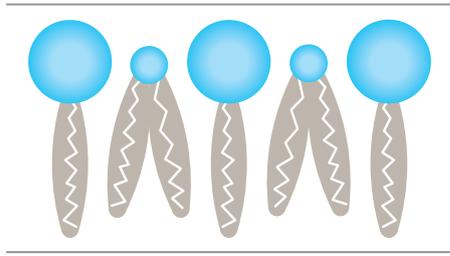


Fig. 3
Molecular packing of Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated

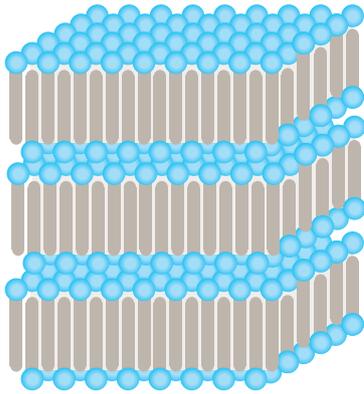


Fig. 4
Utilization of Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated can create an emulsion with lamellar structure

To confirm the efficacy of combining Polyaldo® 6-2-S with another polyglyceryl ester, a base emulsion was created utilizing Polyaldo® 6-2-S with either Polyaldo® 10-1-S Pastillated, Polyaldo® 10-2-P Pastillated, or Polyaldo® 10-1-0 and compared against a traditional emulsifier system, Steareth-2 and Steareth-21. Steareth-2 and Steareth-21 are considered the gold standard for emulsification and an ideal system to compare the Polyaldo® polyglyceryl ester emulsifier system. The emulsifier systems were used at a 2% use level in the presence of 15% oil phase and 3% fatty alcohol. The emulsions were created under identical conditions and evaluated concurrently.

Enhanced Formulation Viscosity with Polyaldo® Polyglyceryl Esters – Technical Data

Polyaldo® 6-2-S was first evaluated in combination with Polyaldo® 10-1-S Pastillated (INCI: Polyglyceryl-10 Stearate). Polyaldo® 10-1-S Pastillated was a logical starting point for the first evaluation because it contains stearic acid like Polyaldo® 6-2-S.

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated vs. Traditional Emulsifier Base

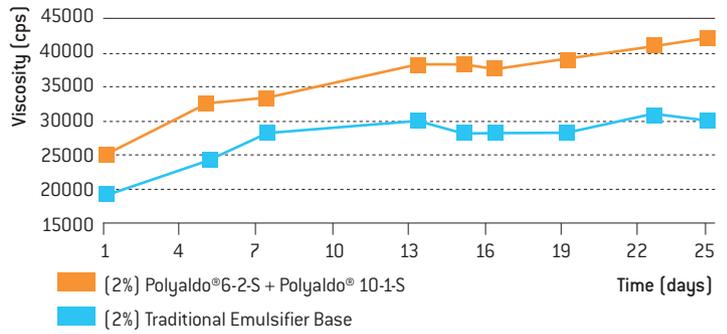


Fig. 5
Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated formulation versus a traditional emulsifier system (Steareth-2 + Steareth-21)

The results in figure 5 show the emulsion base made with Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated had a higher average viscosity compared to the traditional emulsifier system, where the combined Polyaldo® emulsifier system had a 30% higher overall viscosity. The improvement in viscosity provided by the Polyaldo® emulsifier system is a solution for formulators dealing with lackluster emulsion bases without having to increase the use level of costly rheology modifiers.

While the improvement in viscosity is an excellent benefit for using the Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated emulsifier system, it represents only one formulating situation. Lonza went a step further and analyzed the effect other ingredients may have on the viscosity of the emulsion. The following components of the formulation were adjusted to analyze the effect they may have on the overall emulsion:

- Adjust the emulsifier use level - reduce emulsifier by half
- Adjust the fatty alcohol use level - reduce fatty alcohol by half
- Change the oil phase/emollients

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated vs. Traditional Emulsifier Base at 1% Use Level

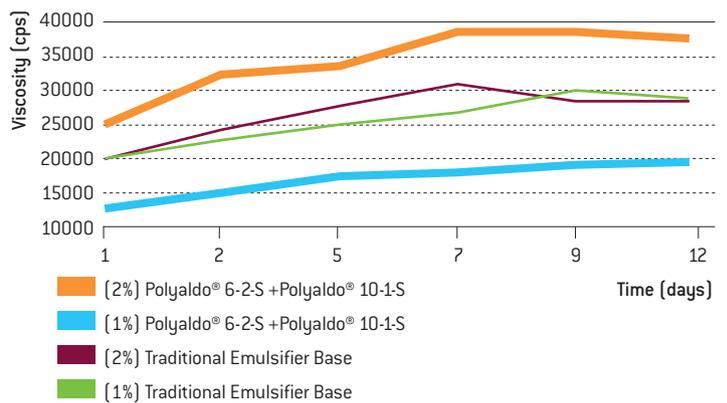


Fig. 6
Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated formulation versus a traditional emulsifier base (Steareth-2 + Steareth-21) when the emulsifier system is reduced by 50% (1.00% total emulsifier use level)

The results from figure 6 show when the Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated emulsifier system is reduced by 50%, there is a direct impact to the formulation viscosity, reducing viscosity an average of 50%. Compare this to the traditional emulsifier system, which reduced viscosity by only 4% on average. In addition, the traditional emulsifier system is unstable in long-term accelerated stability evaluations. The Polyaldo® 6-2-S and Polyaldo® 10-1-S passed long-term accelerated stability.

The combined Polyaldo® emulsifier is directly connected with the viscosity of the emulsion and provides the formulator a variable (in this case, the emulsifier use level) of the formulation to help fine tune the formulation aesthetics to create the ideal formulation base.

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated vs. Traditional Emulsifier Base by Reducing Fatty Alcohol Use Level

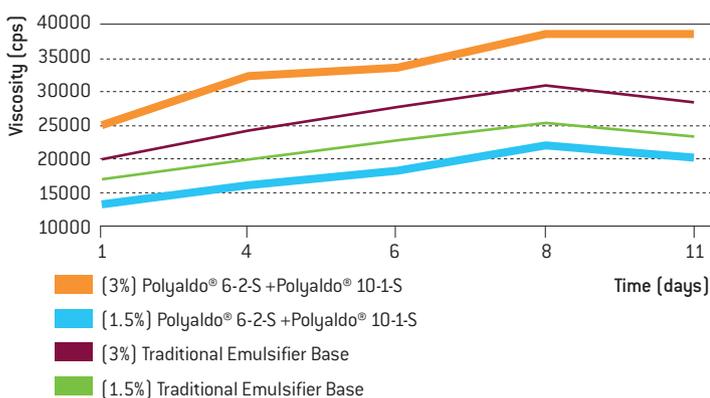


Fig. 7

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated formulation versus a traditional emulsifier system (Steareth-2 + Steareth-21) when the fatty alcohol is reduced by 50% (1.50% use level)

Fatty alcohol is incorporated into a formulation as a rheology modifier. They are used to thicken emulsions and increase viscosity. As such, the reduction of the fatty alcohol use level should reduce the viscosity of the formulation and is reflected in figure 7. However, when the fatty alcohol is reduced by 50%, there is a more substantial impact to the viscosity of the Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated emulsifier system compared to the traditional emulsifier system. On average, there is a 38% reduction in viscosity of the combined Polyaldo® emulsifier system versus a 13% reduction in the traditional emulsifier system. The combined Polyaldo® emulsifier system provides another variable (fatty alcohol use level) a formulator can adjust and hone to create the targeted product form.

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated vs. Traditional Emulsifier Base with Different Triglycerides

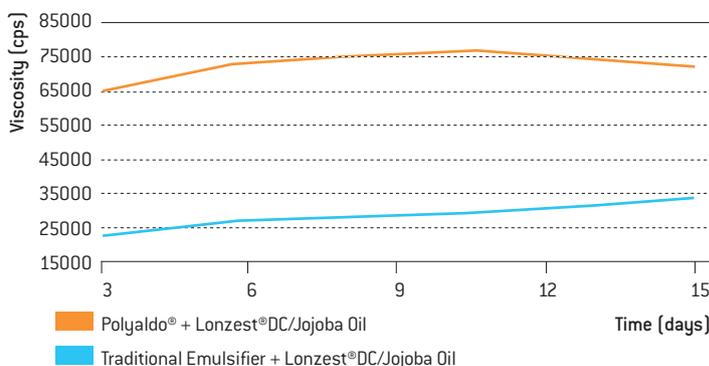


Fig. 8

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated formulation versus a traditional emulsifier base (Steareth-2 + Steareth-21) when the oil phase/emollients are changed*

The results from figure 8 show when the oil phase/emollients in the formulation are changed, there is, yet again, a direct impact to the viscosity of the Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated emulsifier system compared to the traditional emulsifier system. The purpose of this evaluation is to show how the combined Polyaldo® emulsifier system can improve formulation viscosity by optimizing the oil phase/emollients incorporated. In figure 8, Lonzest® DC (INCI: dicaprylyl carbonate) and jojoba oil emollient system takes full advantage of the combined Polyaldo® emulsifier system, averaging 71,000cps, compared to the original emollients package of caprylic/capric triglycerides and shea butter, which averaged 34,000cps. When utilizing the Lonzest® DC and Jojoba oil emollient package, a formulator can scale back the use level of expensive rheology modifiers, reduce the emulsifier use level, or adjust the fatty alcohol used to achieve the viscosity they want. The traditional emulsifier system, on the other hand, maintained the same viscosity for both oil phase/emollient packages used.

Now that we have evaluated the combination of Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated, our next evaluation will replace Polyaldo® 10-1-S Pastillated with Polyaldo® 10-1-0. Polyaldo® 10-1-0 is composed of ten (10) units of glycerin esterified with oleic acid. Polyaldo® 10-1-0 has a natural affinity for skin because oleic acid is a known component of sebum. Oleic acid has a double bond along the polyglyceryl chain, causing the hydrophobic tail of the molecule to “kick outwards” (fig. 9).

This bend in the tail section creates a trapezoidal packing structure and affects the packing parameters of the emulsion (fig. 10).

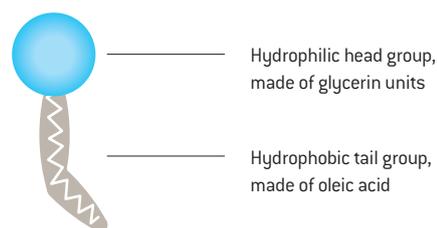


Fig. 9

Visual representation of Polyaldo® 10-1-0 (INCI: Polyglyceryl-10 Oleate)

*Please note: the change in emollients required a change in the ratio of emulsifiers. Please refer to the appendix section for more information.

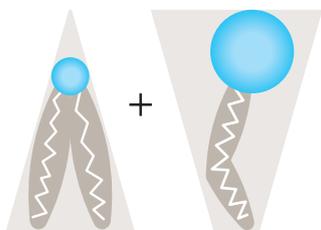


Fig. 10
Visual Representation of Polyaldo® 6-2-S and Polyaldo® 10-1-0

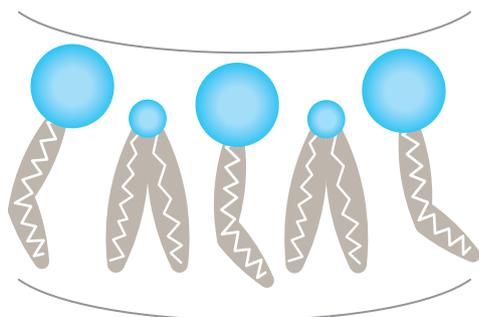


Fig. 11
Molecular packing of Polyaldo® 6-2-S and Polyaldo 10-1-0

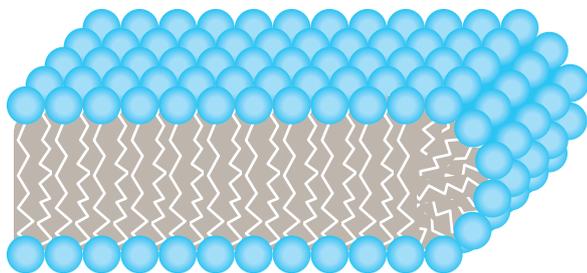


Fig. 12
Utilization of Polyaldo® 6-2-S and Polyaldo 10-1-0 can create an emulsion with curved lamellar structure

When the two emulsifiers are combined into a formulation, they create a unique order at the oil/water interface (fig. 11). The packing of these Polyaldo® emulsifiers creates curved lamellar structures (fig. 12), which are ideal for forming quality emulsions with improved stability but have lower viscosities for products such as sprayable emulsions and cosmetic milks.

To confirm the efficacy of combining Polyaldo® 6-2-S with Polyaldo® 10-1-0, a study identical to the evaluation of Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated was conducted. The Polyaldo® 6-2-S + Polyaldo® 10-1-0 emulsifier system was compared against a traditional

emulsifier system, Steareth-2 and Steareth-21. The emulsifier systems were used at a 2% use level in the presence of 15% oil phase and 3% fatty alcohol. The emulsions were created under identical conditions and evaluated concurrently.

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-0 vs. Traditional Emulsifier Base

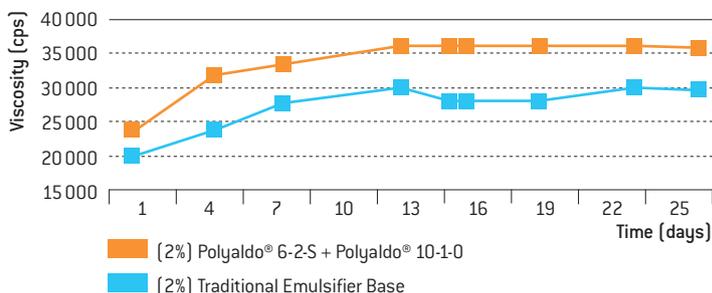


Fig. 13
Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-0 formulation versus a traditional emulsifier system (Steareth-2 + Steareth-21)

The results in figure 13 show the emulsion base made with Polyaldo® 6-2-S and Polyaldo® 10-1-0 had a higher viscosity compared to the traditional emulsifier system. The combined Polyaldo® emulsifier system had a 23% higher overall viscosity compared to the traditional emulsifier system, a perceivable difference.

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-0 vs. Polyaldo® 6-2-S + Polyaldo® 10-1-S Emulsion Bases

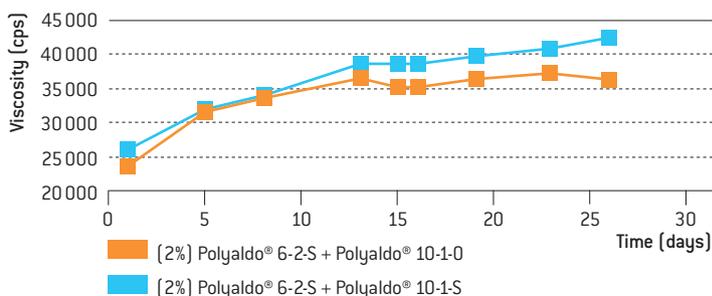


Fig. 14
Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-1-0 formulation base versus Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated formulation base

When comparing the Polyaldo® 6-2-S + Polyaldo® 10-1-0 base to the first polyglyceryl ester combination [Polyaldo® 6-2-S + Polyaldo® 10-1-S Pastillated], the Polyaldo® 6-2-S + Polyaldo® 10-1-0 base has an average lower viscosity (fig. 14).

The last study evaluated the combination of Polyaldo® 6-2-S with Polyaldo® 10-2-P Pastillated. Polyaldo® 10-2-P Pastillated is composed of ten (10) units of glycerin esterified with palmitic acid (fig. 15). This twin tailed emulsifier, when compared to Polyaldo® 6-2-S, has a relatively large hydrophilic head versus its hydrophobic twin tails, which forms an inverted trapezoid packing structure (fig. 16).

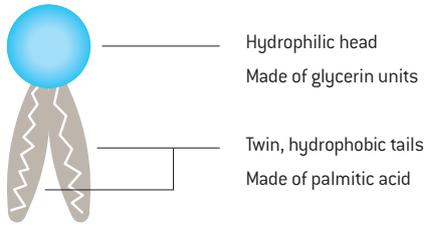


Fig. 15
Visual representation of Polyaldo® 10-2-P Pastillated (INCI: Polyglyceryl-10 Dipalmitate)

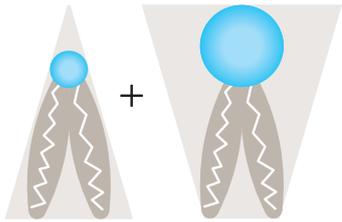


Fig. 16
Visual Representation of Polyaldo® 6-2-S and Polyaldo® 10-2-P Pastillated

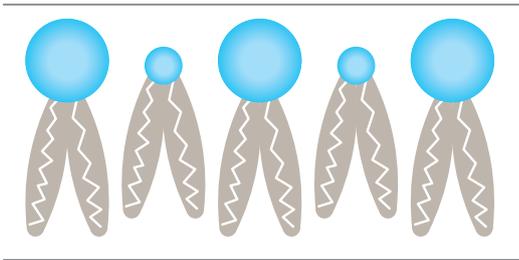


Fig. 17
Molecular packing of Polyaldo® 6-2-S and Polyaldo 10-2-P Pastillated

When the two emulsifiers are combined into a formulation, they create a unique order at the oil/water interface (fig. 17). The packing of these Polyaldo® emulsifiers creates multi-layered lamellar structures (fig. 18), which are ideal for forming quality emulsions with high viscosity and excellent long-term stability.

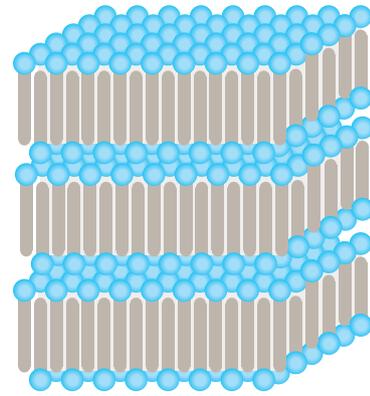


Fig. 18
Utilization of Polyaldo® 6-2-S and Polyaldo 10-2-P Pastillated can create an emulsion with multi-layered lamellar structure

As before, to confirm the efficacy of combining Polyaldo® 6-2-S with Polyaldo® 10-2-P Pastillated, a study identical to the evaluation of Polyaldo® 6-2-S and Polyaldo® 10-1-S Pastillated was conducted. The Polyaldo® 6-2-S + Polyaldo® 10-2-P Pastillated emulsifier system was compared against a traditional emulsifier system, Steareth-2 and Steareth-21. The emulsifier systems were used at a 2% use level in the presence of 15% oil phase and 3% fatty alcohol. The emulsions were created under identical conditions and evaluated concurrently.

Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-2-P Pastillated vs. Traditional Emulsifier Base

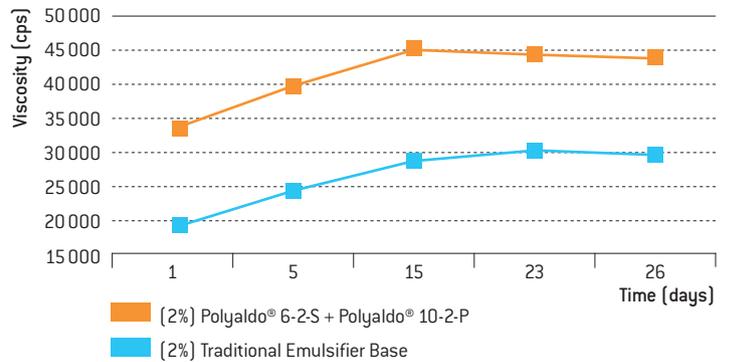


Fig. 19
Evaluation of Polyaldo® 6-2-S + Polyaldo® 10-2-P Pastillated formulation versus a traditional emulsifier system (Steareth-2 + Steareth-21)

The results in figure 19 show the emulsion base made with Polyaldo® 6-2-S and Polyaldo® 10-2-P Pastillated had a higher average viscosity compared to the traditional emulsifier system, with the combined Polyaldo® emulsifier system had a 58% higher overall viscosity. The improvement in viscosity provided by the Polyaldo® emulsifier system makes it an ideal base for cold creams and intensive skincare products, formulations which require higher viscosities. The combination of Polyaldo® 6-2-S and Polyaldo® 10-2-P Pastillated emulsifier system is a superior solution for formulators when viscosity is a necessity for their formulations.

Polyaldo® Polyglyceryl Esters – Your Solution for Improved Formulation Viscosity and Enhanced Stability

Lonza's Polyaldo® Polyglyceryl Esters are your emulsifier solution for high-quality formulations with superb viscosity. These naturally-derived, plant-based emulsifiers provide you an EO-free option and an alternative to PEG-based chemistries. The Polyaldo® emulsifier combinations create formulations with excellent stability and enhanced formulation aesthetics.

Appendix

	Triglyceride (required HLB)	Polyaldo® 6-2-S + 10-1-S Pastillated	Polyaldo® 6-2-S + 10-1-0	Polyaldo® 6-2-S + 10-2-P Pastillated
Ratio of Polyaldo (estimated HLB value)	Caprylic/Capric Triglyceride [5]	95/5 [6.15]	95/5 [6.3]	95/5 [6.25]
Quality of Emulsion*	Coconut Oil [5]	+++	+++	+++
	Jojoba Oil [6]	95/5 [6.15]	95/5 [6.3]	95/5 [6.25]
	Petrolatum [7]	+++	+++	+++
	Shea Butter [8]	7/3 [6.9]	5/1 [7]	4.1 [7]
	OMC [8]	+++	++	++
	Safflower Oil [8]	3/7 [8.1]	2/1 [8]	3/2 [8]
	Landolin Oil [9]	+++	+++	+++
	Dimethicone [9]	3/7 [8.1]	2/1 [8]	3/2 [8]
	Mineral Oil [10.5]	+++	++	++
	Dicaprylyl Carbonate [11]	5/95 [8.85]	1/1 [9]	2/3 [6.25]
	Isopropyl Myristate [11.5]	5/95 [8.85]	1/1 [9]	2/3 [6.25]
	Isopropyl Isostearate [11.5]	5/95 [8.85]	1/3 [10.5]	1/9 [10.5]
	Cetyl Alcohol [14]	+	++	+
		5/95 [8.85]	1/5 [11]	5/95 [10.75]
		+++	+++	+++
		5/95 [8.85]	1/11 [11.5]	5/95 [10.75]
		++	+++	++
		5/95 [8.85]	11/1 [11.5]	5/95 [10.75]
		++	+++	+++
		5/95 [8.85]	5/95 [11.7]	5/95 [10.75]
	+++	+++	+++	

Table 1
Solubility of Oils and Emollients in Polyaldo® Polyglyceryl Ester Combinations for Leave-On Emulsions

- * -: separation, clear/transparent bottom section of solution
- +: separation, slightly hazy bottom section of solution, top layer about ¼” of emulsion
- ++: slight separation, hazy bottom section of solution, top layer more than ½” of emulsion
- +++ : no separation, hazy solution throughout sample

Viscosity of Formulation	Ratio of Polyaldo® Polyglyceryl Ester	HLB @95:5	HLB @90:10	HLB @80:20	HLB @70:30	HLB @60:40	HLB @50:50	HLB @40:60	HLB @30:70	HLB @20:80	HLB @10:90	HLB @5:95
Low ~25-40k cps	Polyaldo® 6-2-S : Polyaldo® 10-1-0	6.3	6.6	7.2	7.8	8.4	9.0	9.6	10.2	10.8	11.4	12.0
Moderate ~35-45k cps	Polyaldo® 6-2-S : Polyaldo® 10-1-S Pastillated	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	8.9
High ~40-50k cps	Polyaldo® 6-2-S : Polyaldo® 10-2-P Pastillated	6.3	6.5	7.0	7.5	8.0	8.5	8.9	9.5	10.0	10.5	10.8

Table 2

Guidance for Ratio of Polyaldo® Polyglyceryl Esters for Leave-On Emulsions Based on HLB Values

USA

Lonza Consumer Care
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South Plainfield, NJ 07080
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