PEMULEN™ EZ-4U Polymeric Emulsifier

New Time-Saving Solution For Formulating Smooth O/W Emulsions

Lubrizol

Outline

- Market Trends – Sensitive Skin
- Summary of Main Features and Key Benefits
- Chemistry and Typical Properties
- Mechanism
- Process
- Texture and Sensory
- Low Viscosity Emulsions
- Low pH (pH 4) Systems
- Sun Care
- At-a-Glance Selector Guide

Lubrizol

Formulating for Sensitive Skin

- External factors, such as stress and pollution, have raised the prevalence of sensitive skin
  - Increased consumer awareness of the negative impact of these factors on skin health & wellness
  - Growing trend of products positioned as “hypoallergenic”, “fragrance-free”, “PEG-free”, etc.
- More scrutiny on formulation composition and mildness

There is a need for formulating with ingredients that enable creating milder formulations with simplicity, while keeping required performance.

Source: Euromonitor, Mintel

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Summary of Main Features and Key Benefits

Maintain The Benefits of Pemulen™ Polymeric Emulsifiers:

- **Thicken and stabilize** oil-in-water emulsions at low use level
- Compatibility with a **broad range of oils**
- No HLB calculation required
- Allows for cold or hot processing
- **Refreshing** light sensory with quick-break effect
- Wide **variety of textures** from a shiny, smooth cream to a thin, sprayable lotion
- **PEG-free** and preservative-free; **mild** emulsion stabilizer suitable for sensitive skin applications

Additional Benefits of Pemulen™ EZ-4U Polymeric Emulsifier:

- **Easier to use**, faster to disperse relative to existing polymeric emulsifiers, reducing manufacturing complexity
- **Greater formulation flexibility** through minimized structuring over a wide pH range (4-9) leading to a smooth, appealing texture

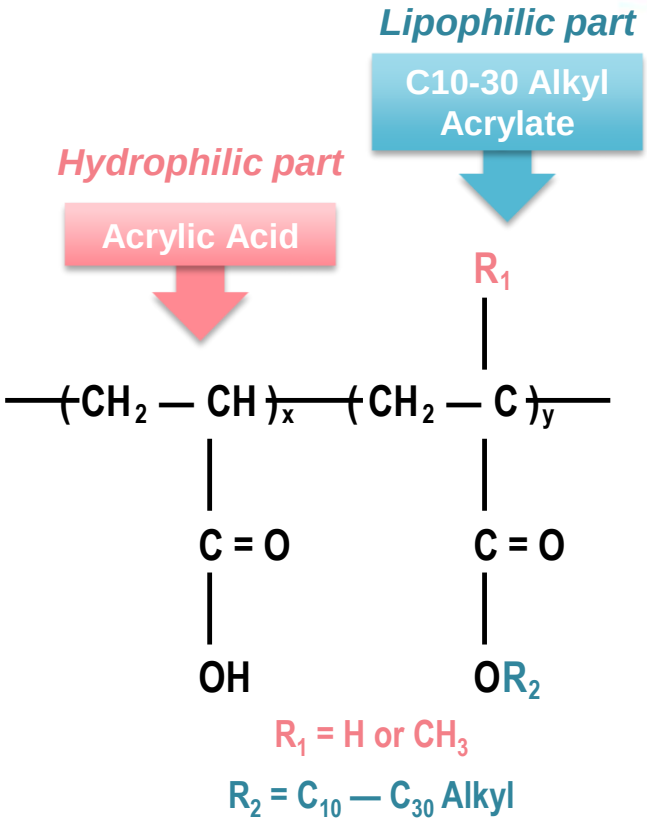
Recommended use level in emulsion: *0.05-0.4 wt%*

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Chemistry and Function

- **Chemistry:** High molecular weight cross-linked copolymers of acrylic acid and C10-30 alkyl acrylate
- **Polymerization Method**
  - Precipitation polymerization
  - Co-solvent (ethyl acetate, cyclohexane)
- **Product Form:** White powder
- **Function:**
  - Thicken, suspend and stabilize O/W emulsion
  - Primary emulsification in emulsions

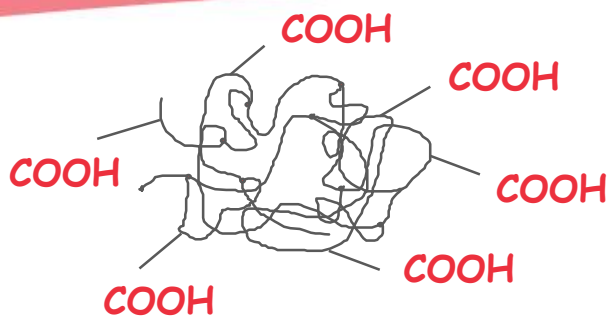


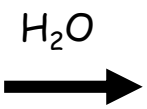
INCI Name: Acrylates/C10-30 Alkyl Acrylate Crosspolymer

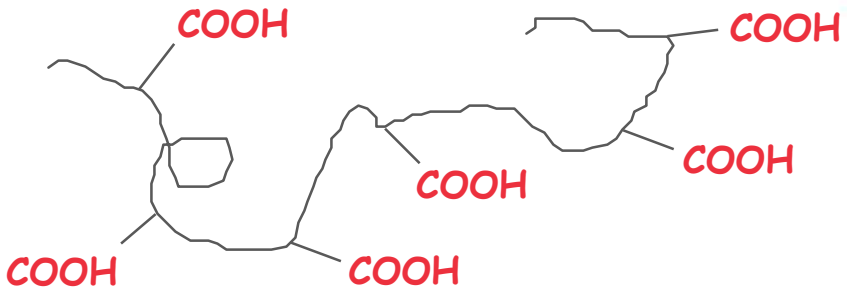
Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Thickening Mechanism





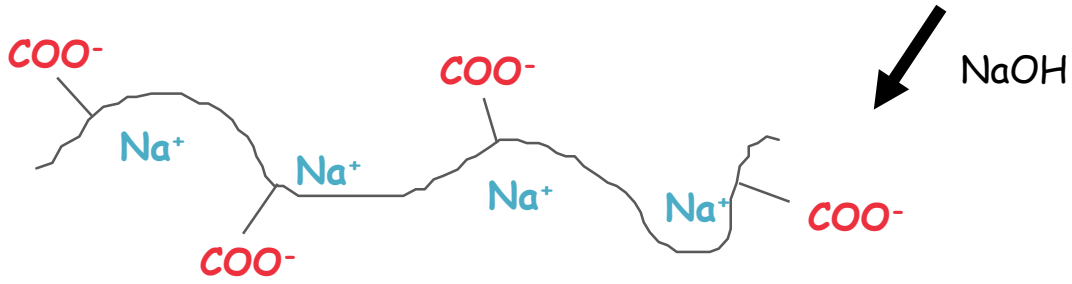


I. Dry Powder

Before contact with water, crosslinked polyacrylic acid is tightly coiled

II. Hydrated Polymer

When dispersed in water, crosslinked polyacrylic acid begins uncoiling

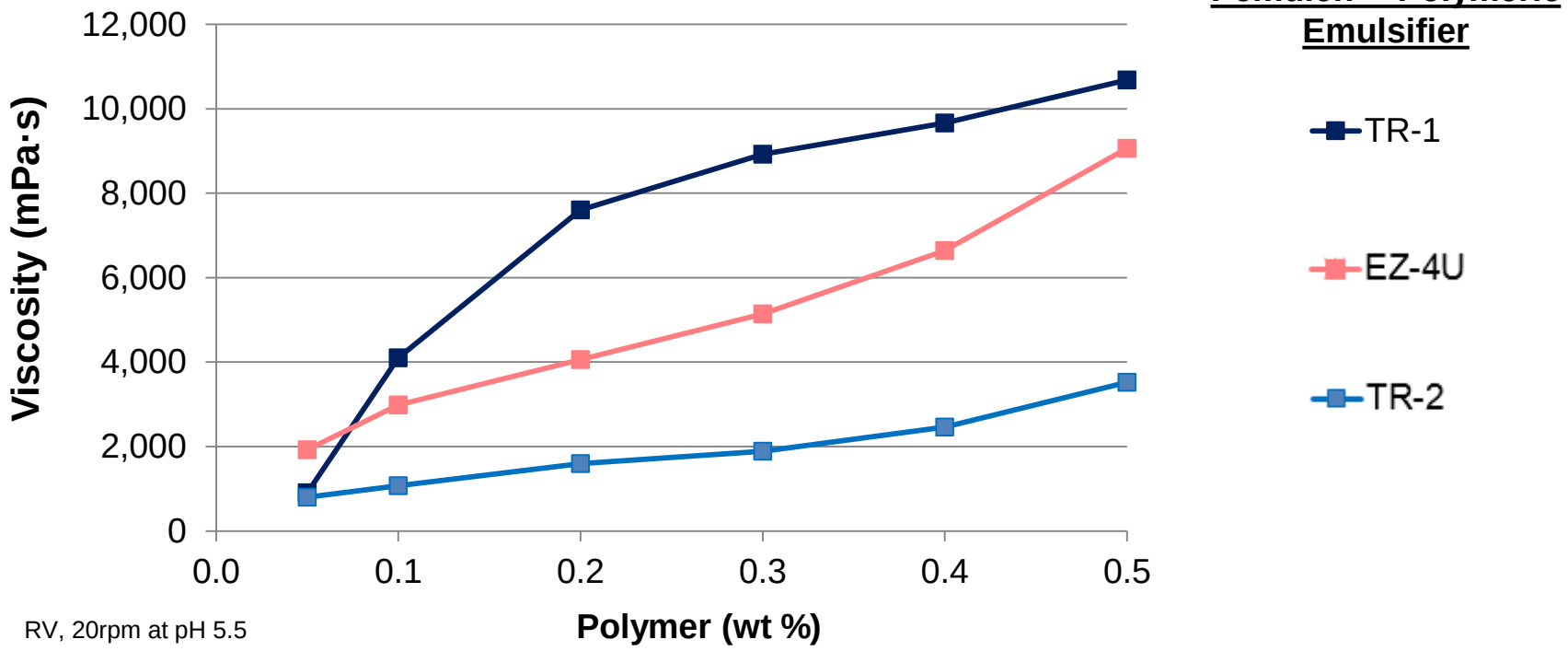


III. Neutralized Polymer

- Neutralization with a base creates negative charges along backbone
- These repulsive forces uncoil polymer into an extended structure

Pemulen™ Polymeric Emulsifiers

Viscosity vs. Concentration Curves (mucilage gel)

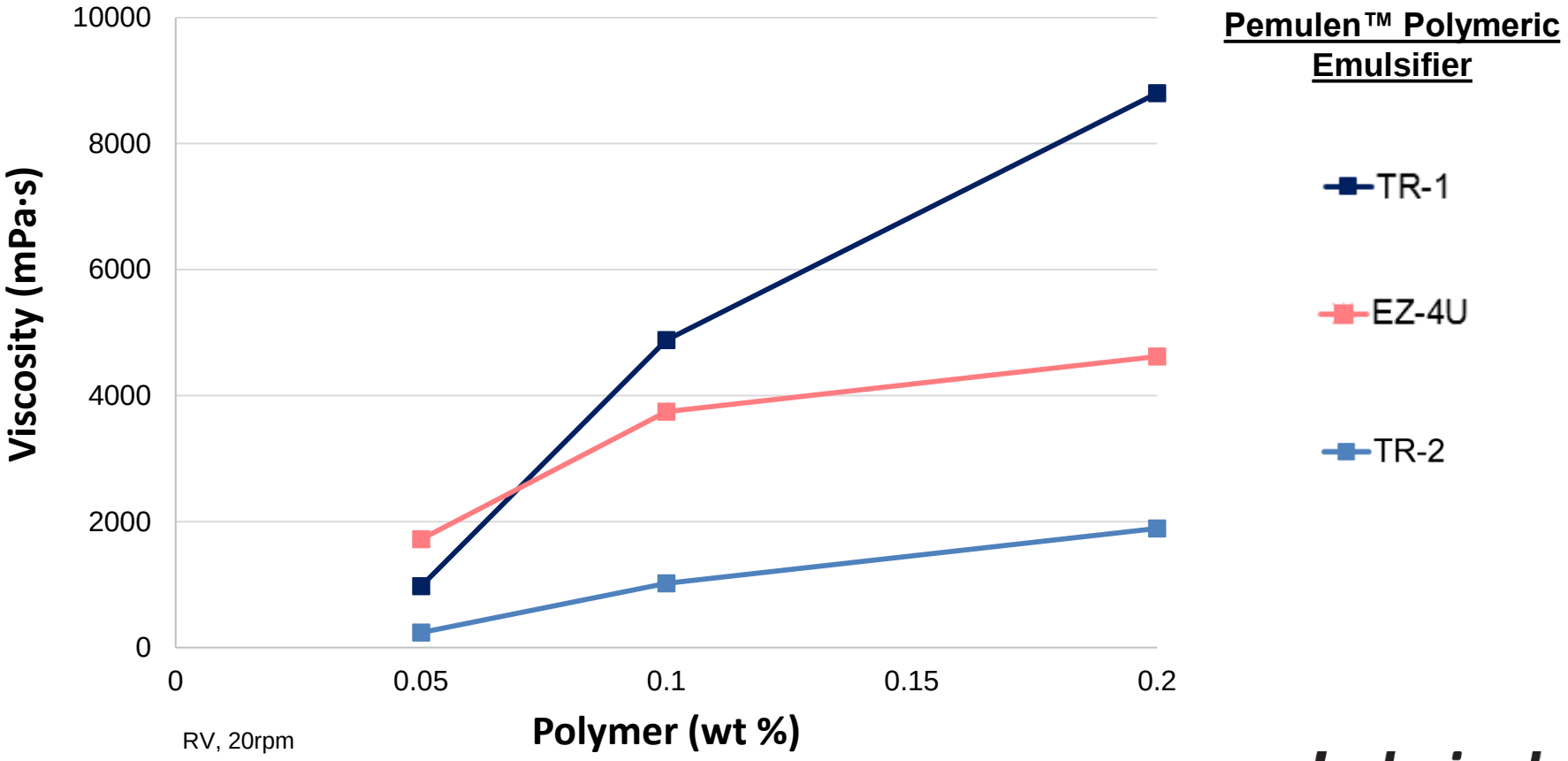


RV, 20rpm at pH 5.5

Pemulen™ EZ-4U Polymeric Emulsifier

Viscosity vs. Concentration Curves (emulsion system)

Emulsion with 20 wt% Caprylic/Capric Triglyceride, pH 5.5

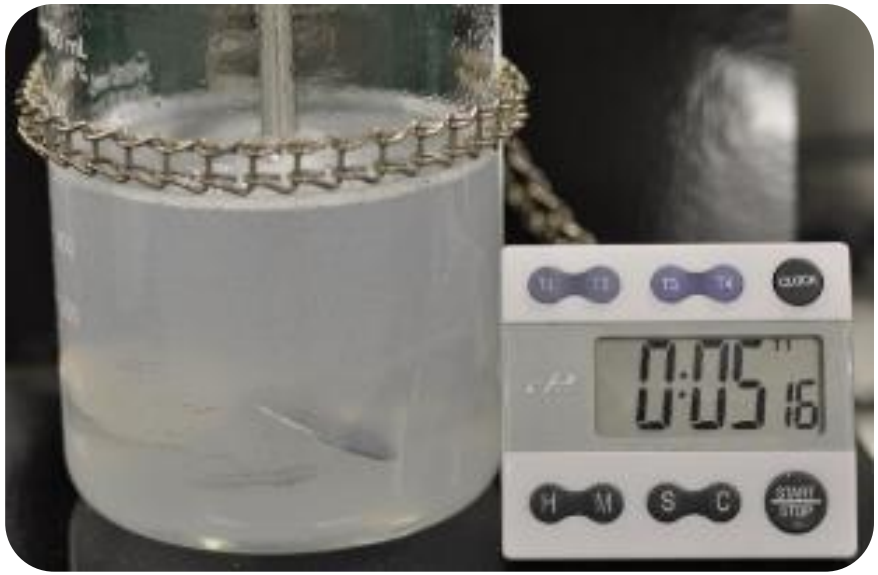


RV, 20rpm

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Process – Dispersion Time



Dispersion Time: Only **5-10 minutes**

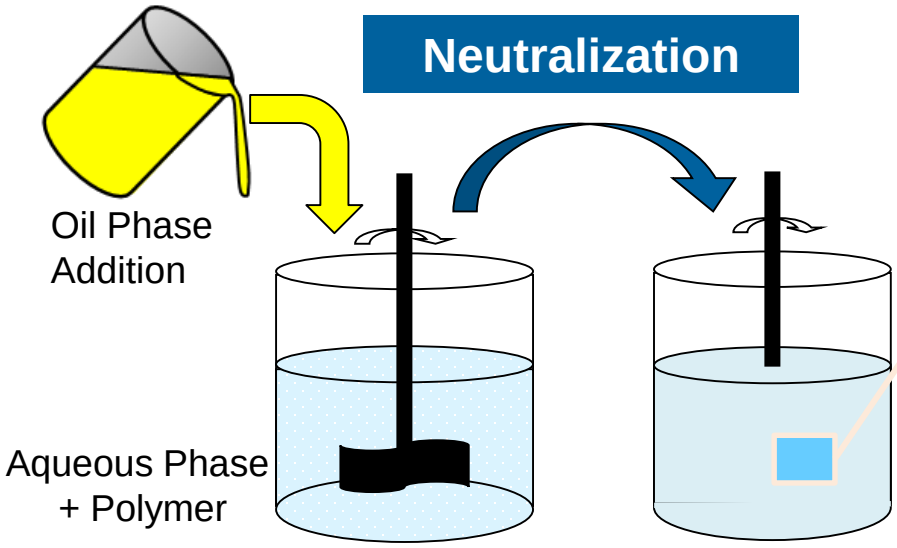
Pemulen™ EZ-4U polymeric emulsifier is SIGNIFICANTLY easier to use

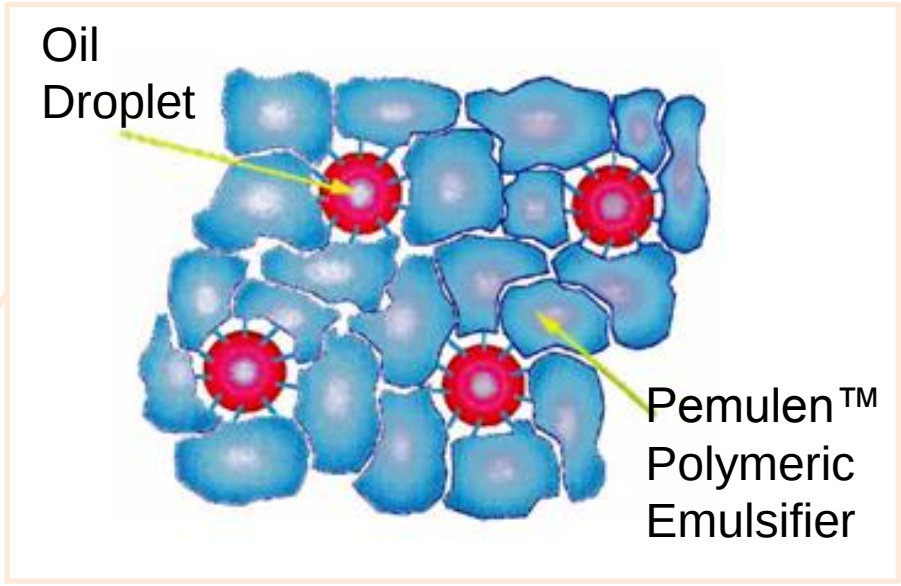
- **Disperses quickly in water**
- **Decreases cycle time & reduces manufacturing costs**

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Emulsion Stabilization Mechanism





Before neutralization:

Little to no emulsification

Upon neutralization:

Emulsification and emulsion stabilization

- Hydrophobic portion anchors oil phase
- Hydrophilic portion stabilizes emulsion in aqueous phase

Pemulen™ EZ-4U Polymeric Emulsifier

Broad Oil Compatibility

Screening Formulation: 10% Oil phase, 0.2% Pemulen™ EZ-4U Polymeric Emulsifier, 0.1% Disodium EDTA, 0.5% Phenoxyethanol, 3% Glycerin, pH 5.5

	Caprylic/Capric Triglyceride	Isohexadecane	Schercemol™ LL ester*	Caprylyl Methicone
X400 Micrographs				
Temperature Stability	Passed 1 month at 50°C	Passed 1 month at 50°C	Passed 1 month at 50°C	Passed 1 month at 50°C

*Lauryl Lactate

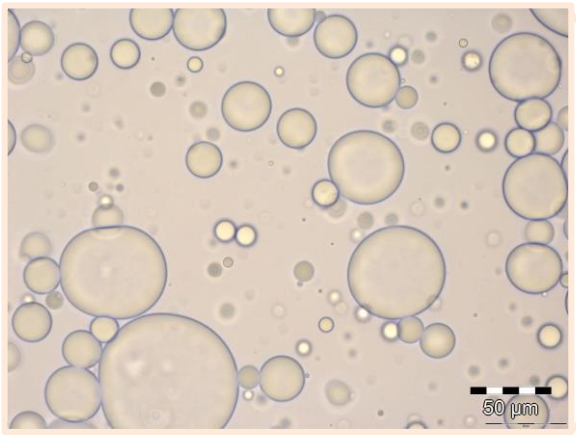
Wide compatibility, with ability to stabilize emulsions independently from required HLB.

Lubrizol

Performance Optimization

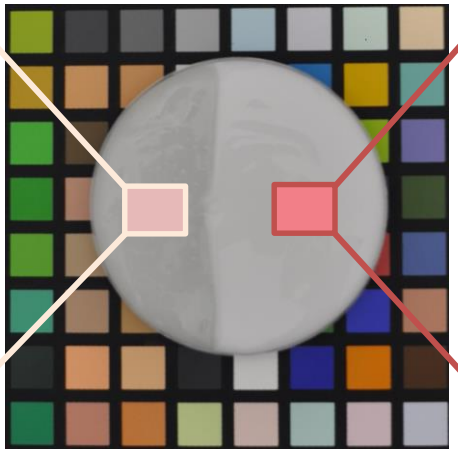
Comparison to Emulsion with Co-Emulsifier – Oil Droplet Size

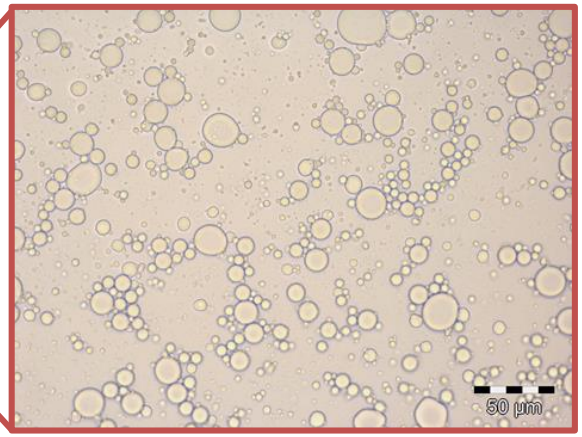
Due to their minimal surface activity, the use of a Pemulen™ polymeric emulsifier as the sole emulsifier typically yields emulsions with an oil droplet size of 20-200µm.



50µm

0.2 wt.% Pemulen™ EZ-4U Polymeric Emulsifier,
20 wt.% Schercemol™ 318 Ester,
pH 5.5-6.0





50µm

0.2 wt.% Pemulen™ EZ-4U Polymeric Emulsifier,
0.5 wt% Glucamate™ SSE-20 Emulsifier,
20 wt.% Schercemol™ 318 Ester,
pH 5.5-6.0

Adjustment of the droplet size result in a whiter, more stable product. It is recommended to use with a co-emulsifier.

Micrograph pictures magnification X 400

Lubrizol

Texture & Sensory

Pemulen™ EZ-4U Polymeric Emulsifier

Compatibility with Fatty Alcohols and Co-Emulsifiers

		INCI Name	Weight %
A	1.	Deionized Water	77.20
	2.	**Polymeric Emulsifier**	**0.20**
	3.	Glycerin	3.00
	4.	Disodium EDTA	0.10
B	5.	Caprylic/Capric Triglyceride	9.00
	6.	**Cetearyl Alcohol**	**2.00**
	7.	**Glyceryl Stearate**	**2.00**
C	8.	NaOH (18 wt% Solution)	Qs pH 5
	9.	Phenoxyethanol	0.50

Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Pemulen™ Polymeric Emulsifiers

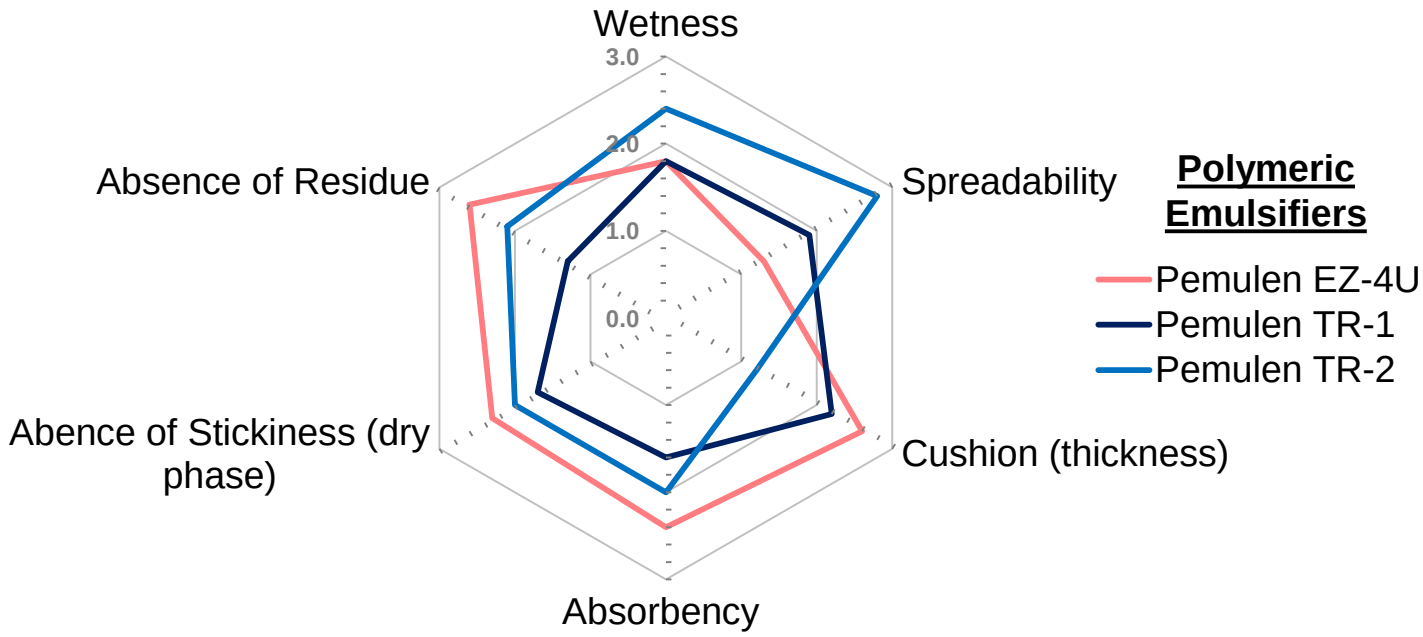
TR-1 EZ-4U TR-2

Greater formulation flexibility through significant improvement in minimizing structuring effect vs. traditional Pemulen™ polymeric emulsifiers in presence of fatty alcohols and co-emulsifiers.

Lubrizol

Sensory Profile of Pemulen™ EZ-4U Polymeric Emulsifier (in mucilage gel)

Evaluation of Pemulen™ EZ-4U, TR-1 and TR-2 polymeric emulsifiers in mucilage gel (polymer dispersed in water)



Forced Rank Testing
(10 panelists)

Pemulen™ EZ-4U polymeric emulsifier has a similar fresh initial feel with wetness, slightly more richness, and lower stickiness and residue vs. traditional Pemulen™ polymeric emulsifiers.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Compatibility with Fatty Alcohols and Co-Emulsifiers

In Shower Moisturizing Body Lotion B-0097(EU)

	INCI Name	Wt %	Trade Name
A	Deionized Water	66.49	
	Phenylpropanol, Propanediol, Caprylyl Glycol, Tocopherol	0.80	
	Carbomer	0.20	**Carbopol® Ultrez 30 Polymer**
	Acrylates/C10-30 Alkyl Acrylate Crosspolymer	0.20	**Pemulen™ EZ-4U Polymeric Emulsifier**
	Glycerin	5.00	
B	Petrolatum	9.00	
	Sunflower (Helianthus Annuus) Seed Oil	5.00	
	Isostearyl Isostearate	3.00	**Schercemol™ 1818 Ester**
	Cetearyl Alcohol	**1.50**	
	Stearyl Alcohol	**1.50**	
C	Sodium Hydroxide（20 wt%）	0.21	
D	Water (Aqua), Xanthan Gum, Caprylyl Glycol, Phenoxyethanol, Glucose, Carrageenan (Chondrus Crispus), Ethylhexylglycerin,	5.00	**Lipomoist™ 2013 Molecular Film**
	Butylene Glycol, Water (Aqua), Acetyl Dipeptide-3 Aminohexanoate	2.00	**Bodyfensine™ Peptide Solution**
E	Fragrance (Parfum)	0.10	Baby Aloe Vera

Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Stabilization of a system containing 3 wt% fatty alcohols with smooth texture.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Compatibility with Fatty Alcohols and Co-Emulsifiers

Mild Moisturizing Facial Cream F-0132(EU)

	INCI Name	Wt %	Trade Name
A	Deionized Water	64.13	
	Acrylates/C10-30 Alkyl Acrylate Crosspolymer	0.15	Pemulen™ EZ-4U Polymeric Emulsifier
	Glycerin	4.00	
	Phenoxyethanol, Ethylhexylglycerin	0.43	
B	Isopropyl Isostearate	7.00	Schercemol™ 318 Ester
	Caprylic/Capric Triglyceride	7.00	
	Cyclopentasiloxane	4.50	
	Sweet Almond (Prunus Amygdalus Dulcis) Oil	4.00	
	Behenyl Alcohol	2.00	
	Methyl Glucose Sesquistearate	0.34	Glucate™ SS Emulsifier
	Tocopheryl Acetate	0.15	
C	Water (Aqua), Glycerin, Calcium Pantothenate, Xanthan Gum, Urea, Caprylyl Glycol, Glucose, Magnesium Lactate, Potassium Chloride, Potassium Lactate, Magnesium Chloride, Sodium Citrate, Citric acid, Ethylhexylglycerin	5.00	Ion-Moist™ Molecular Film
	Glycerin, Water (Aqua), Calendula Officinalis Flower Extract	1.00	Actiphyte™ Calendula GL Botanical Extract
	Fragrance (Parfum)	0.10	Allergen Free Aloe Vera
	Sodium Hydroxide (20% Solution)	0.20	

Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Stabilization at low use levels of this PEG-free mild O/W emulsion containing 2 wt% behenyl alcohol and a co-emulsifier, with smooth texture.

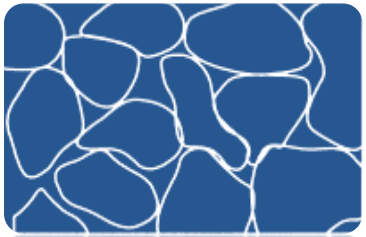
Lubrizol

Low Viscosity Systems

Microgel Thickening Mechanism

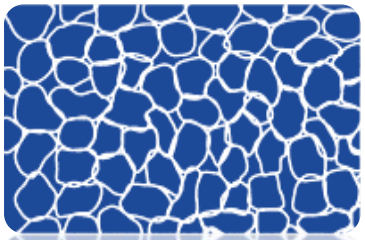
→ **Dilute**

Particles are swollen to equilibrium (c < c*)



→ **Transition Regime**

Particles are swollen to equilibrium (c = c*)

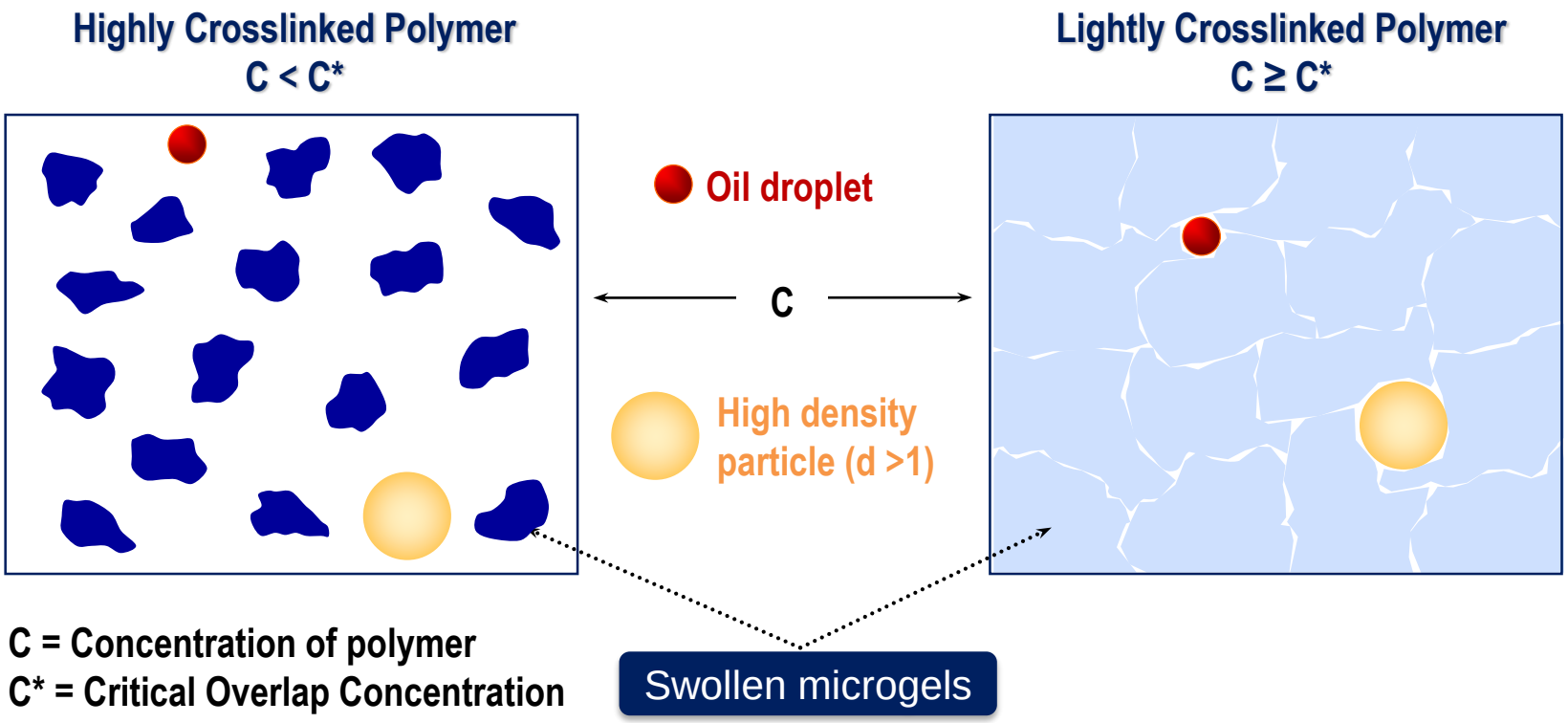


→ **Concentrated**

Particles are swollen to less than equilibrium (c > c*)

c = Concentration of Carbopol® polymer or Pemulen™ polymeric emulsifier
c* = Critical overlap concentration

Stabilization Capability of Lightly and Highly Crosslinked Polymers at Low Use Levels



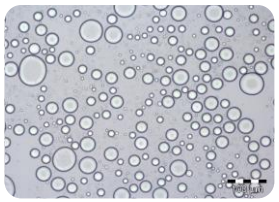
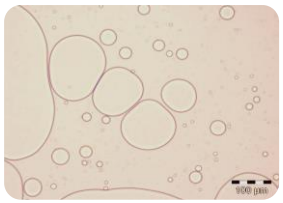
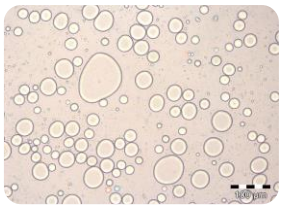
C = Concentration of polymer
C* = Critical Overlap Concentration
d = density

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Efficiency at Low Use levels

Screening Formulation: 0.05 wt% Pemulen™ Polymeric Emulsifier, 20% Caprylic/Capric Triglyceride, pH 5.5

Polymeric Emulsifier	Pemulen™ TR-1	Pemulen™ TR-2	Pemulen™ EZ-4U
24hr Viscosity (mPa·s)	977	237	1,722
24hr Yield Value (dyn/cm^2)	61	5	79
1 month 50°C Viscosity (mPa·s)	Creaming (1 wk)	Creaming (1 wk)	1,284
1 month 50°C Yield Value (dyn/cm^2)	0	0	52
Stability	Failed	Failed	OK
Micrograph pictures X 200			

Pemulen™ EZ-4U polymeric emulsifier offers efficient stabilization at 0.05% with low viscosity, enabling formulation of thin lotions, sprays or wipes.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Benefits in Low Viscosity Emulsions

- **Low viscosity** emulsification and rheology modification at **low use levels**
- **Easy processing** with fast dispersion in water, at cold / hot temperature
- **Excellent suspending** capability
  - Offers visually appealing aesthetics
  - Suspends/stabilizes emollients or particles in the system
- **Efficient cost-in-use**
- **Refreshing** watery quick-break effect with aesthetics evoking enhanced benefits
- **Light sensory** and low residue compared to traditional emulsifiers
  - No negative sensory impact on formulations

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Suspension at Low Use Levels

Gentle Lotion with Oil Pearls for Sensitive Skin F-0131(EU)

	INCI Name	Wt %	Trade Name
A	Deionized Water	Qsp 100	
	Acrylates/C10-30 Alkyl Acrylate Crosspolymer	0.0500	**Pemulen™ EZ-4U Polymeric Emulsifier**
	Sodium Chloride	0.0012	
	Glycerin	2.0000	
	Phenylpropanol, Propanediol, Caprylyl Glycol, Tocopherol	0.8000	
	Glycerin, Water (Aqua), Chamomilla Recutita (Matricaria) Flower Extract	1.0000	**Actiphyte™ Chamomile *Botanical Extract***
B	Sodium Hydroxide (20 wt% Solution)	0.0160	
C	Sesame (Sesamum Indicum) Seed Oil	5.0000	
	Fragrance (Parfum)	0.0500	Sweet Almond Chamomille

Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Pemulen™ EZ-4U polymeric emulsifier enables the stability and suspension of oil droplets in low viscosity systems at only 0.05 wt%.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Suspension at Low Use Levels

Diaper Lotion Protective Spray O-0085(EU)

	INCI Name	Wt %	Trade Name
A	Deionized Water	64.60	
	Glycerin	3.00	
	Phenylpropanol, Propanediol, Caprylyl Glycol, Tocopherol	0.80	
	Acrylates/C10-30 Alkyl Acrylate Crosspolymer	0.20	**Pemulen™ EZ-4U Polymeric Emulsifier**
B	Sweet Almond (Prunus Amygdalus Dulcis) Oil	6.00	
	Diisostearyl Dimer Dilinoleate	2.00	**Schercemol™ DISD Ester**
	Methyl Glucose Dioleate	1.00	**Glucate™ DO Emulsifier**
	Tocopherol	0.50	
C	Sodium Hydroxide (20 wt%)	0.30	
D	Tapioca Starch	11.00	
	Water (Aqua), Glycerin, Calcium Pantothenate, Xanthan Gum, Urea, Caprylyl Glycol, Glucose, Magnesium Lactate, Potassium Chloride, Potassium Lactate, Magnesium Chloride, Sodium Citrate, Citric acid, Ethylhexylglycerin	5.00	**Ion-Moist™ Molecular Film**
	Microcrystalline Cellulose	4.00	**Acticel™ 12**
	Calendula Officinalis Flower Extract	1.00	**Actiphyte™ Calendula GL Botanical Extract**
	Panthenol	0.55	
	Fragrance (Parfum)	0.05	

Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Emulsion stabilization and suspension in an electrolytes-containing system.

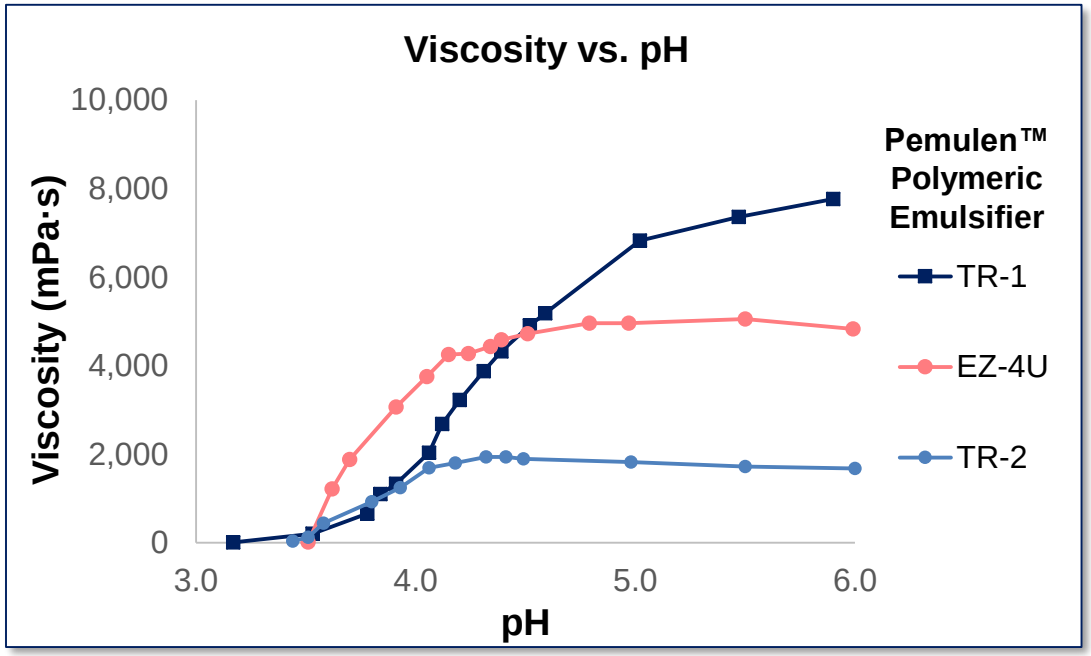
Lubrizol

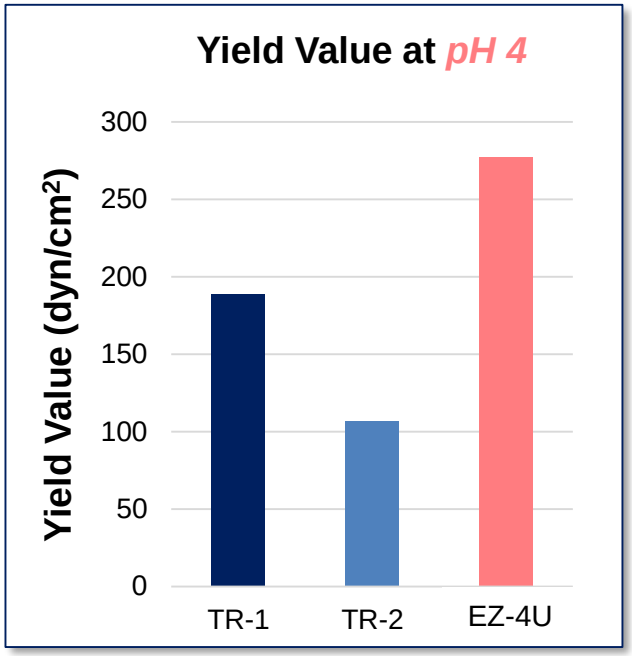
Low pH (pH 4) Systems

Pemulen™ EZ-4U Polymeric Emulsifier

Broader Range of Use – Lower pH

Gels of 0.2% Pemulen™ Polymeric Emulsifiers





Pemulen™ EZ-4U polymeric emulsifier shows improved viscosity and yield value at lower pH ranges enabling for better emulsion stability.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Broader Range of Use – Lower pH

Screening Formulation: 0.2 wt% Pemulen™ Polymeric Emulsifier, 20% Isopropyl Isostearate at ***pH 4.0***

Pemulen™ Polymeric Emulsifier	EZ-4U	TR-1	TR-2
24hr Viscosity (mPa·s)	3,760	2,140	1,000
24hr Yield Value (dyn/cm^2)	256	154	51
Stability	**Passed**	Failed	Failed
1 month 50°C, Viscosity (mPa·s)	3,880	Creaming after 3 weeks	Creaming after 3 weeks
1month 50°C, Yield Value (dyn/cm^2)	200	0	0

✘ Clear aqueous phase at the bottom

Lubrizol

Suncare Benefits and Applications of Pemulen™ Polymeric Emulsifiers

- Increase the stability of the emulsion.
- Eliminate the need for HLB calculations in formulations.
- Suitable for low to high viscosity formulations with good aesthetics.
- Low skin irritation profile due to low concentration or elimination of surfactants.
- Reduce rubbing, soapy feel and reapplication of the product.
- Offer film-forming properties.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Screening Formulation (SPF 30, Emulsifier-free O/W Emulsion)

	INCI Name (Trade Name)	Wt%	Ingredient Function
PART A	Deionized Water	Qsp.	Diluent
	Disodium EDTA	0.10	Chelating Agent
	Polymeric Emulsifier	0.20	Primary Emulsifier
PART B	Glycerin	6.00	Humectant
PART C	Octocrylene (Parsol® 340)	10.00	UV Absorber
	Ethylhexyl Methoxycinnamate (Parsol® MCX)	7.50	UV Absorber
	Ethylhexyl Salicylate (Parsol® EHS)	4.50	UV Absorber
	Butyl Methoxydibenzoylmethane (Parsol® 1789)	3.00	UV Absorber
	C12-15 Alkyl Benzoate	6.00	Solubilizer
PART D	Sodium Hydroxide (18% solution)	qs pH 6	Neutralizer
PART E	Phenoxyethanol	0.50	Preservative

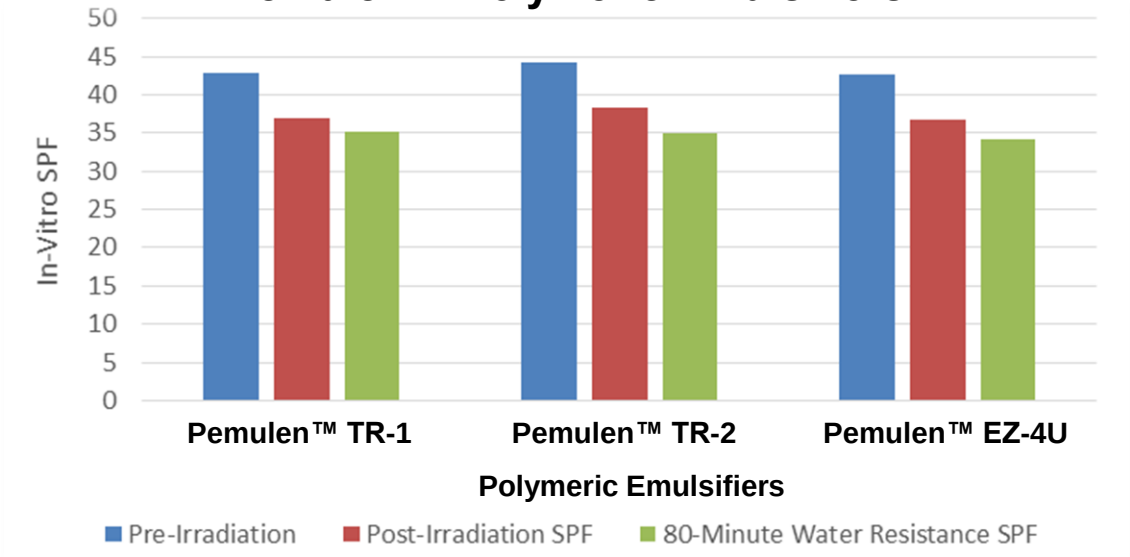
Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Water-resistance in Screening Formulation

In-Vitro SPF of a SPF 30 Emulsifier-Free O/W Emulsion Containing Pemulen™ Polymeric Emulsifiers



% SPF Retained	95%	92%	94%

Similar to Pemulen™ TR-1 and TR-2 polymeric emulsifiers, very water resistant formulations are also easily prepared with Pemulen™ EZ-4U polymeric emulsifier.

Lubrizol

Lubrizol Rheology Modifiers in Sun Care

Benefits	Carbopol® Aqua SF-1 OS Polymer	Novemer™ EC-2 Polymer	Pemulen™ EZ-4U Polymeric Emulsifier	Pemulen™ TR-1 Polymeric Emulsifier	Pemulen™ TR-2 Polymeric Emulsifier	Avalure™ Flex-6 Polymer	Novethix™ L-10 Polymer
Viscosity	Low to Medium	Medium to High	Low to Medium	Medium	Low to Medium	Medium to High	Low to Medium
Suspension	●	●	●	●	●		
Efficiency*			Δ	●	●		
Electrolyte Tolerant	●	●				Δ	
Emulsion Stabilization	●	●	Δ	Δ	Δ	●	●
Compatibility with Fatty Alcohols	●	●	●			●	●
Compatibility with Pigments	Δ but TiO_2 only		● but TiO_2 only		● but TiO_2 only	Δ (TiO_2 and ZnO)	Δ but TiO_2 only
Sensorial	Light, Soft	Cushiony	Light, Fresh	Light, Fresh	Light, Fresh	Cushiony	Light, Fresh
Water-resistance			●**	●**	●**	Δ	

● Recommended
Δ Highly recommended
*Lower use level
**Non re-emulsifiable film

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Conclusions

Pemulen™ EZ-4U polymeric emulsifier features **4 benefits**

- **U**niversal (broad pH and oil compatibility; pH 4-9)
- **U**ltra-smooth – reduced cheese cake effect with fatty alcohols
- **U**se levels as low as 0.05-0.4% with high emulsion stability and ease of processing
- **U**ltimate fresh sensory with light skin feel

Lubrizol

Pemulen™ Polymeric Emulsifiers Selector Guide

	Pemulen™ TR-1 Polymeric Emulsifier	Pemulen™ TR-2 Polymeric Emulsifier	Pemulen™ EZ-4U Polymeric Emulsifier
INCI Designation	Acrylates/C10-30 Alkyl Acrylate Crosspolymer		
PROPERTIES			
Emulsification*	Yes	Yes	Yes
Dispersion Time in Water	Long	Long	Fast
Oil Loading**	Medium	High	High
Emulsion Viscosity (0.2%, pH 5.5) - RV, 20 rpm	medium (8,000 mPa·s)	low (2,000 mPa·s)	medium (5,000 mPa·s)
Effective pH Range	5 - 9	5 - 9	4 - 9
Typical Use Concentration	0.2 - 0.4 wt%***	0.1 - 0.3 wt%***	0.05 - 0.4 wt%***
Compatibility With Fatty Alcohols	Low	Low	High
APPLICATIONS			
Creams, Lotions (moderate oil loading)	•	•	•
Milks, Sprayable Emulsions, Wipes		•	•
Creams, Lotions (high oil loading)		•	•

* Need to be used with a co-emulsifier for optimal stability and aesthetics
** In presence of co-emulsifier; the actual maximum obtainable is formulation dependent
*** In high electrolyte systems, combination with carbomer (Carbopol® homopolymers) is recommended

Lubrizol

Thank you . . .

For more information, samples and/or starting formulations with complete processing instructions and supplier references please contact:

Lubrizol Advanced Materials, Inc.
9911 Brecksville Road
Cleveland, OH 44141
800-379-5389
216-447-5000
www.lubrizol.com/personalcare

Trademarks and Disclaimer

- Carbopol® is a registered trademark of The Lubrizol Corporation or its affiliates
- Acticel™, Actiphyte™, Avalure™, Bodyfensine™, Glucamate™, Glucate™, Ion-Moist™, Lipomoist™, Novemer™, Novethix™, Pemulen™, Promulgen™, and Schercemol™ are trademarks of The Lubrizol Corporation or its affiliates
- Parsol® is a registered trademark of DSM

The information contained herein is being furnished for informational purposes only, upon the express condition that the User makes its own assessment of the appropriate use of such information. While the information contained herein is believed to be reliable, no representations, guarantees or warranties of any kind are made as to its accuracy, suitability for a particular application or the results to be obtained herefrom. Lubrizol Advanced Materials, Inc. ("Lubrizol") cannot guarantee how any products associated with this information will perform in combination with other substances or in User's process. Due to the variations in methods, conditions and equipment used commercially in processing these materials, no warranties or guarantees are made as to the suitability of the information/products for the applications disclosed. Lubrizol shall not be liable and the User assumes all risk and responsibility for, any use or handling of any material beyond Lubrizol's direct control. LUBRIZOL MAKES NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. It is the User's sole responsibility to determine if there are any issues relating to patent infringement of any component or combination of components relating to the supplied information. **Nothing contained herein is to be considered as permission, recommendation, nor as an inducement to practice any patented invention without the permission of the patent owner.**

Back-up slides

General Definition of Polymeric Emulsifiers

- A polymeric O/W emulsifier is an amphiphilic high Mw polymer consisting of a large number of hydrophilic monomers and hydrophobic co-monomers. Emulsion stabilization is achieved at low use level of polymeric emulsifier by effective anchoring of the hydrophobic entities into the oil phase and steric stabilization in the aqueous phase.

- **Main criteria:**
    1. Material has to be polymeric (based on molecular weight)
    2. Has to reduce interfacial tension (amphiphilic)
    3. Has to provide (steric) stabilization

Definition of Pemulen™ Polymeric Emulsifiers

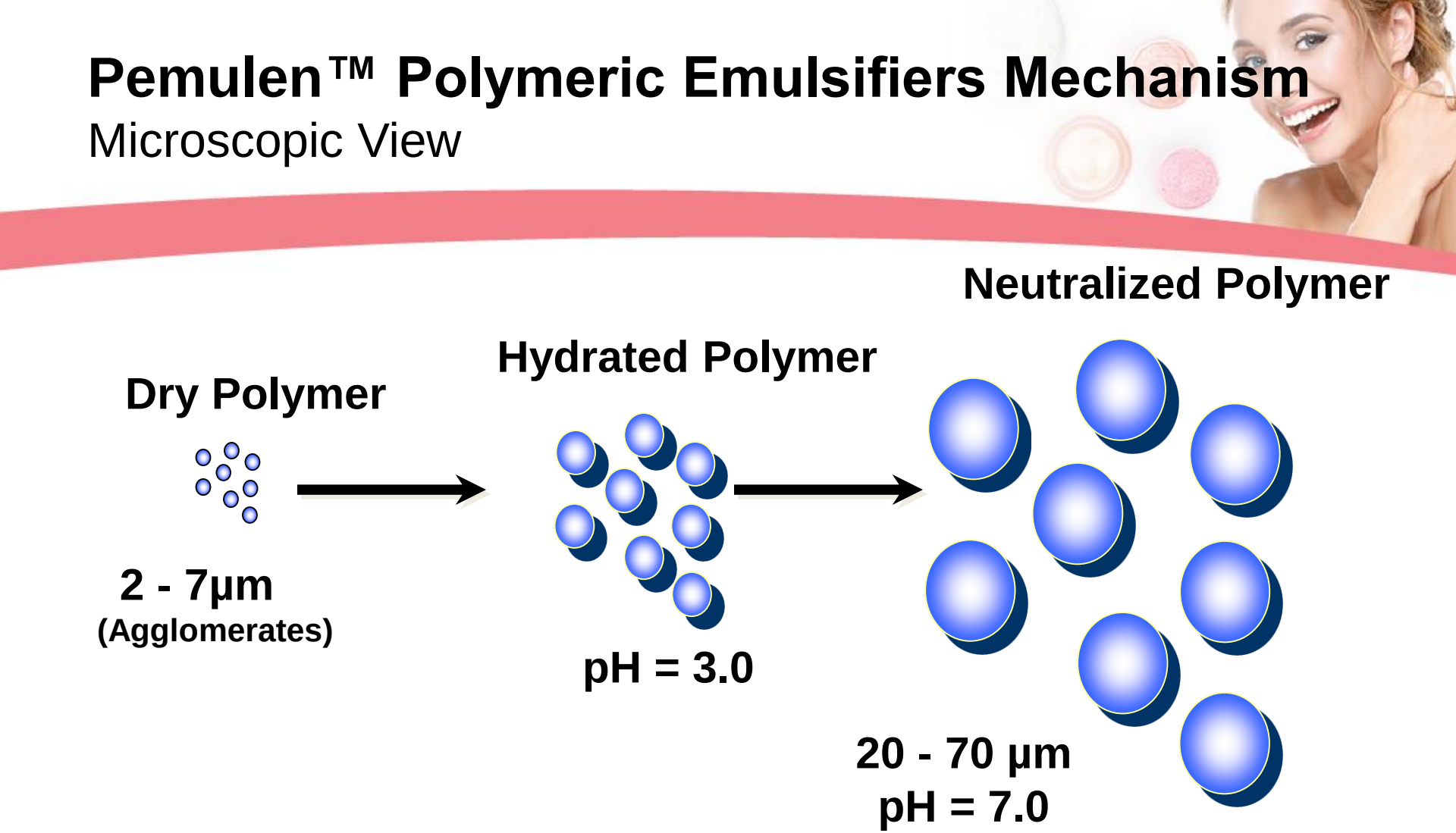
- Water-dispersible amphiphilic molecules enabling O/W emulsion stabilization upon neutralization by mechanical stabilization through space filling of the swollen microgel network and the associative interactions of polymer hydrophobic portions with non-polar and polar lipophilic materials.

- Pemulen™ polymeric emulsifiers are also high molecular weight crosslinked polymers that modify the rheology and texture of an emulsion.

Lubrizol

Pemulen™ Polymeric Emulsifiers Mechanism

Microscopic View



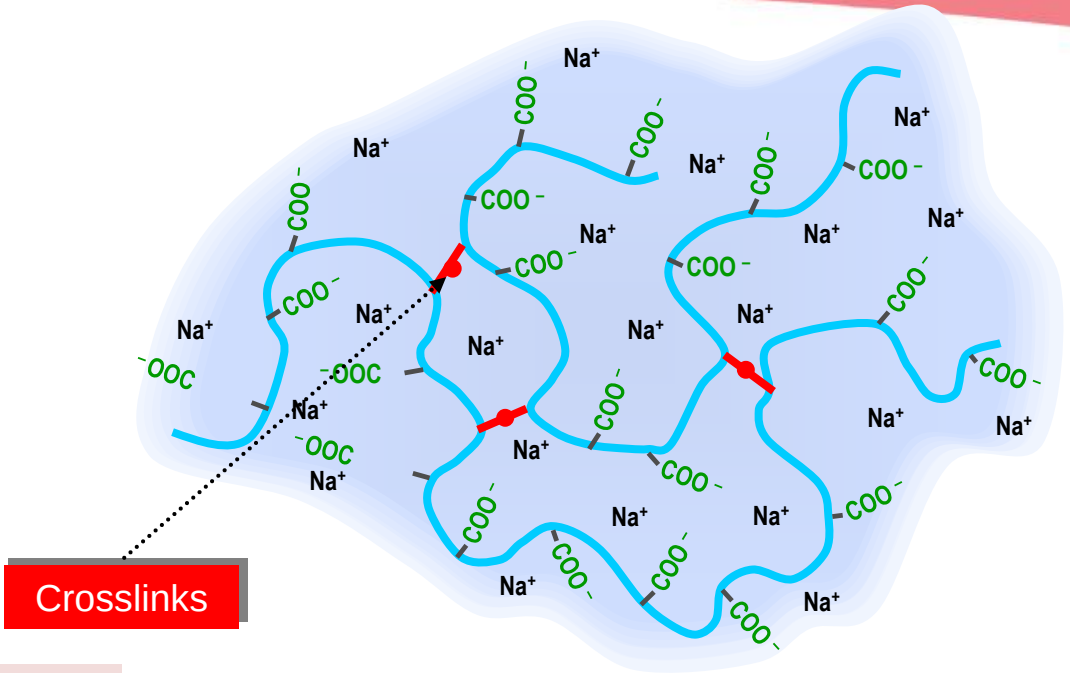
When neutralized in water, Pemulen™ polymeric emulsifiers swell to approximately 1000x their initial volume.

Lubrizol

Crosslink Density

Molecular View after Dispersion and Neutralization

Crosslink density helps dictate gel particle structure



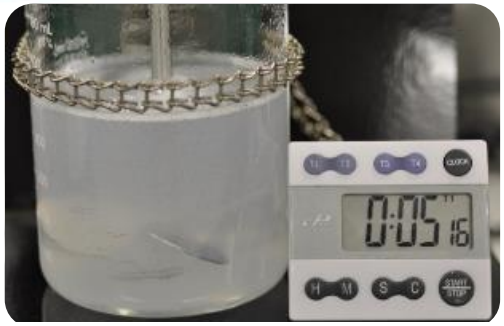
Lightly Crosslinked Polymer

- Large soft particles
- Pemulen™ Polymeric Emulsifiers

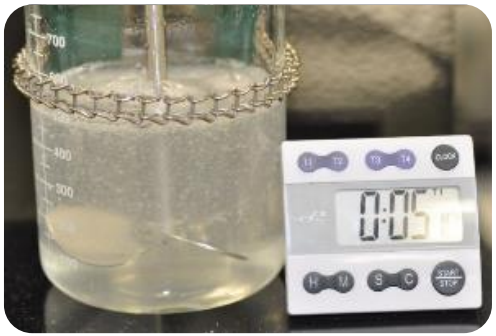
Lubrizol

Pemulen™ Polymeric Emulsifier

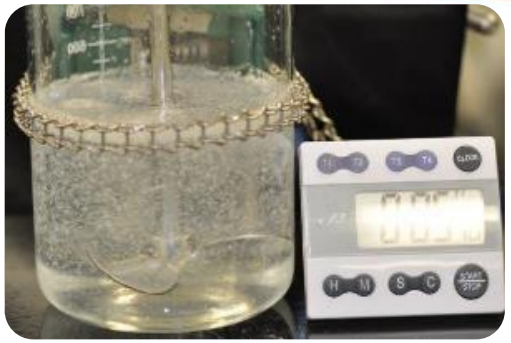
Dispersion Time Comparisons



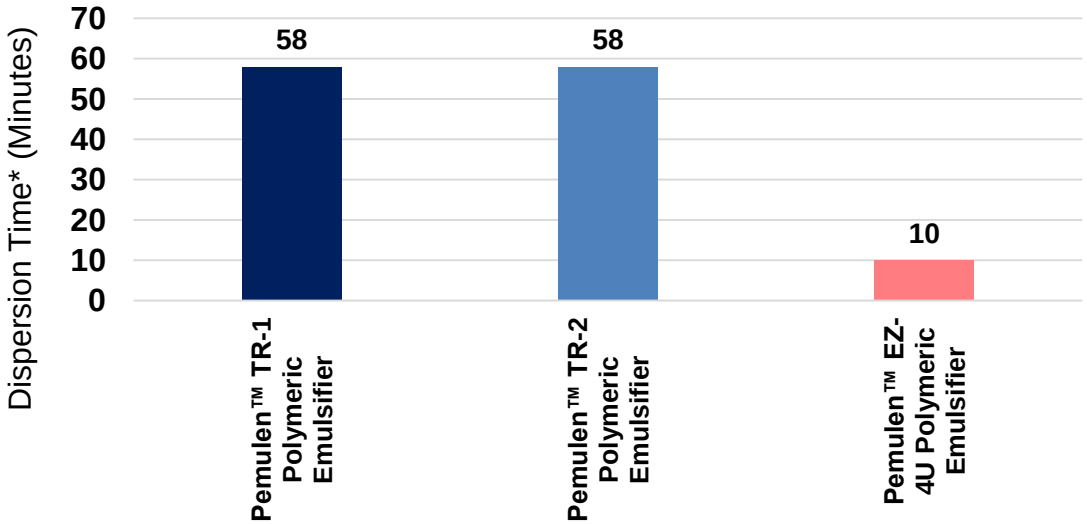
Pemulen™ EZ-4U Polymeric Emulsifier



Pemulen™ TR-1 Polymeric Emulsifier



Pemulen™ TR-2 Polymeric Emulsifier



* 0.25% polymer dispersion using propeller mixing at 400-600rpm

Pemulen™ Polymeric Emulsifier

Processing Guidelines

Order of Addition

- There is no significant differences between direct or indirect method. When using indirect method (Pemulen™ EZ-4U Polymeric Emulsifier added first in the oil phase) the viscosity is a little bit higher (around 10% higher)
- Stability is good in all cases, and the sensory is very similar

Neutralization Before or After Emulsification

- There is no significant differences between neutralization before or after emulsification.
- Stability is good in all cases and the sensory is very similar.

Processing Temperature

- There is no significant differences between cold and hot processes.
- Stability is good in all cases and the sensory is very similar.

Shear Forces

- Ultra-Turrax®* homogenizer is recommended to reduce the oil droplet size to optimize emulsion aesthetics.
- Used homogenizer preferably before neutralization.
- Rotation speed and timing should be carefully adjusted to minimize viscosity decrease.
- Stability is good in all cases when using Ultra-Turrax at 5,000 – 10,000 – 15,000 rpm .

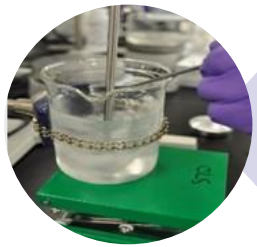
*Ultra-Turrax® is a registered trademark of IKA

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Cold Processing of Simple Emulsion

	Traditional Polymeric Emulsifiers **71** min. process time	**Pemulen™ EZ-4U Polymeric Emulsifier** **21** min. process time
STEP 1* water, polymer, glycols Part A	Mixing Time 60 minutes	Mixing Time **10 minutes**
STEP 2 Oil phase components	Mixing Time 1 minutes	Mixing Time 1 minutes
STEP 3 Neutralization and preservatives	Mixing Time 10 minutes	Mixing Time 10 minutes



Time saving
-70%

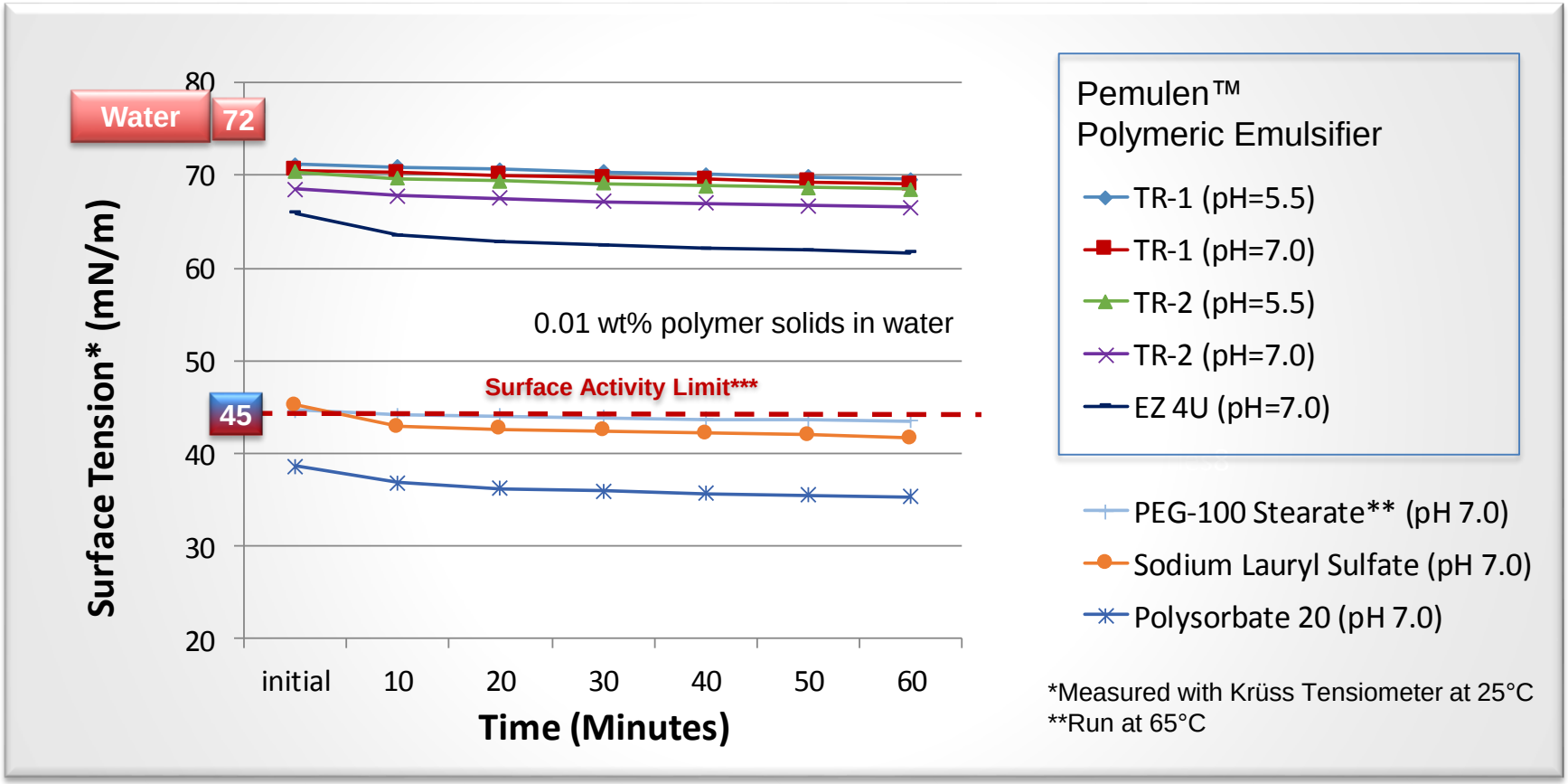
RESULT

*propeller mixing at 400-600rpm

Lubrizol

Surface Activity

Pemulen™ Polymeric Emulsifiers vs. Traditional Emulsifiers



*Measured with Krüss Tensiometer at 25°C
**Run at 65°C

Pemulen™ polymeric emulsifiers show minimal surface activity.

***Definition as stated in the World Customs Organization- Explanatory Notes (chapter 34)

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Efficiency at High Oil Levels (40%)

Screening Formulation: 0.20 wt% polymeric emulsifier, 40% Oil at pH 5.50

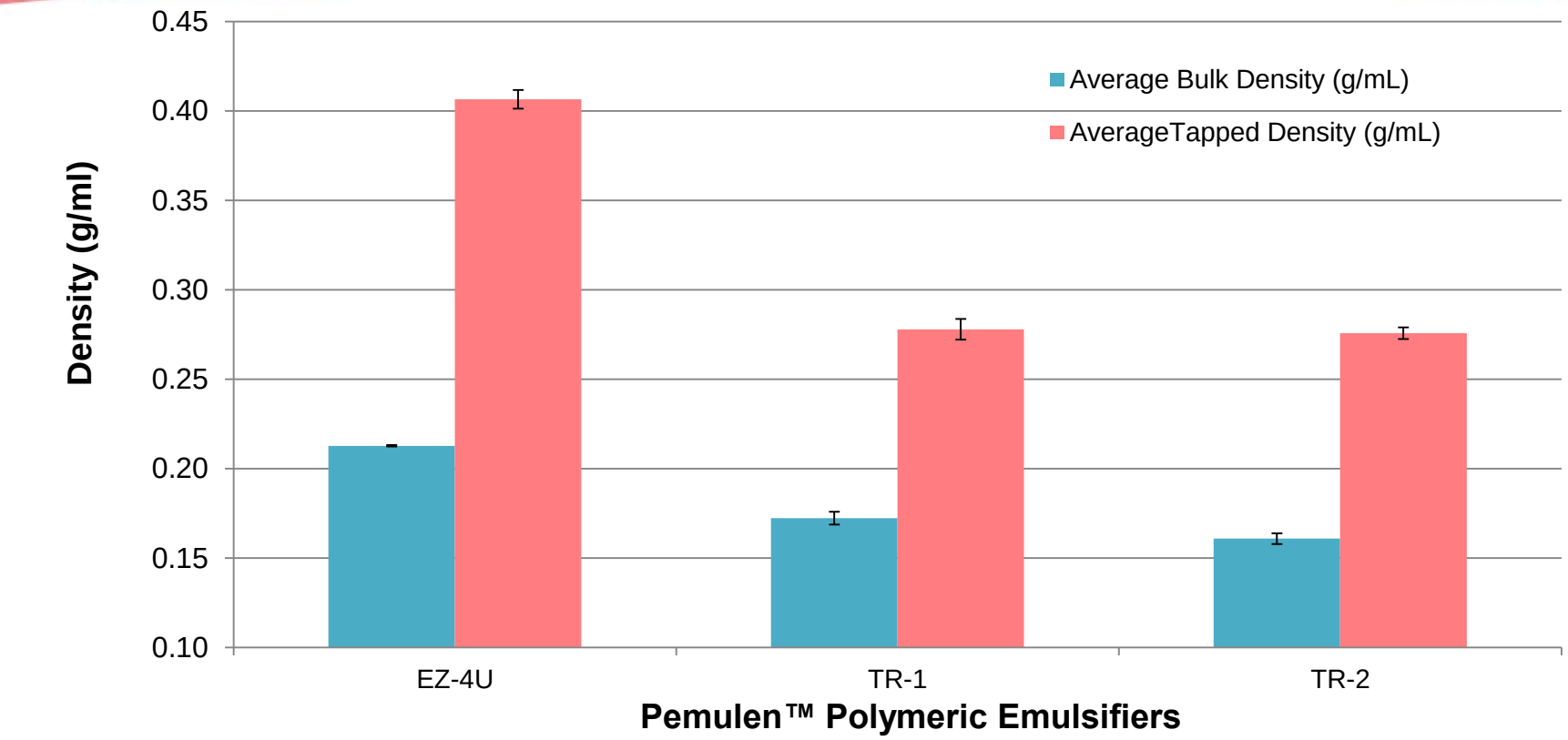
	Caprylic/Capric Triglyceride				Isohexadecane			
Pemulen™ Polymeric Emulsifier	24hr Viscosity (mPa·s)	24hr Yield Value (dyn/cm²)	1 month 50°C Viscosity (mPa·s)	1 month 50°C Yield Value (dyn/cm²)	24hr Viscosity (mPa·s)	24hr Yield Value (dyn/cm²)	1 month 50°C Viscosity (mPa·s)	1 month 50°C Yield Value (dyn/cm²)
TR-1	13,140	992	10,920	824	12,160	884	10,260	760
TR-2	3,010	115	2,685	109	2,815	134	2,840	124
EZ-4U	8,320	590	7,520	352	8,700	560	7,760	424

Pemulen™ EZ-4U polymeric emulsifier shows comparable stabilization of emulsions with high oil loading relative to benchmarks.

Lubrizol

Pemulen™ Polymeric Emulsifier

Bulk Density/Tapped Density

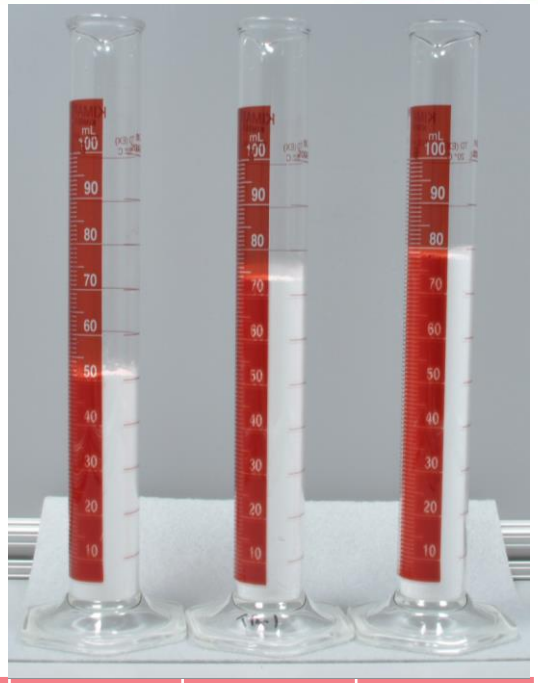


Pemulen™ EZ-4U polymeric emulsifier has higher bulk density than traditional Pemulen™ polymeric emulsifiers, resulting in improved handling and packaging.

Pemulen™ Polymeric Emulsifier

Bulk Density/Dusting

15 g of Polymer



Pemulen™ Polymeric Emulsifier	EZ-4U	TR-1	TR-2
Bulk Density (g/ml):	0.213	0.172	0.161

Pemulen™ EZ-4U polymeric emulsifier has higher bulk density than traditional Pemulen™ polymeric emulsifiers, resulting in improved handling and packaging.

Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

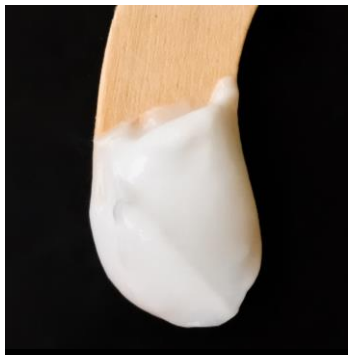
Texture – Reduction of Structuring Effect

"CHEESECAKE" EFFECT EMULSIONS	Wt%
Water	Qs 100
Pemulen™ Polymeric Emulsifier	**0.4**
Schercemol™ NGDO Ester	20
PEG-7 Glyceryl Cocoate	1.0
Promulgen™ D Emulsifier **(Cetearyl Alcohol (and) Ceteareth-20)**	**2.0**
Phenoxyethanol	0.5
NaOH (18% Solution)	QS pH 5

Nothing contained herein is considered as permission, recommendation, nor as inducement to practice any patented invention without the permission of the patent owner.

Pemulen™ TR-1 Polymeric Emulsifier, 24hr RT

Pemulen™ TR-2 Polymeric Emulsifier, 24hr RT



Pemulen™ EZ-4U Polymeric Emulsifier, 3mos RT

Greater formulation flexibility through significant improvement in minimizing cheesecake effect vs. traditional Pemulen™ polymeric emulsifiers in presence of fatty alcohols.

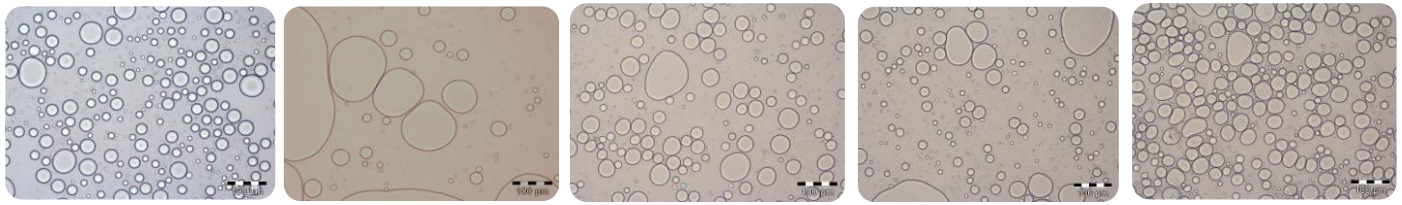
Lubrizol

Pemulen™ EZ-4U Polymeric Emulsifier

Efficiency at Low Use Levels vs. Commercial Benchmarks

Screening Formulation: 0.05 wt% polymeric emulsifier, 20% Caprylic/Capric Triglyceride, pH 5.5

Polymeric Emulsifier	Pemulen™ TR-1	Pemulen™ TR-2	Pemulen™ EZ-4U	Commercial A	Commercial C
24hr Viscosity (mPa·s)	977	237	1,722	3,075	439
24hr Yield Value (dyn/cm^2)	61	5	79	263	17
1 month 50°C Viscosity (mPa·s)	Creaming (1wk)	Creaming (1 wk)	1,284	2,555	Creaming (1 wk)
1month 50°C Yield Value (dyn/cm^2)	0	0	52	165	0
Stability	Failed	Failed	OK	OK	Failed



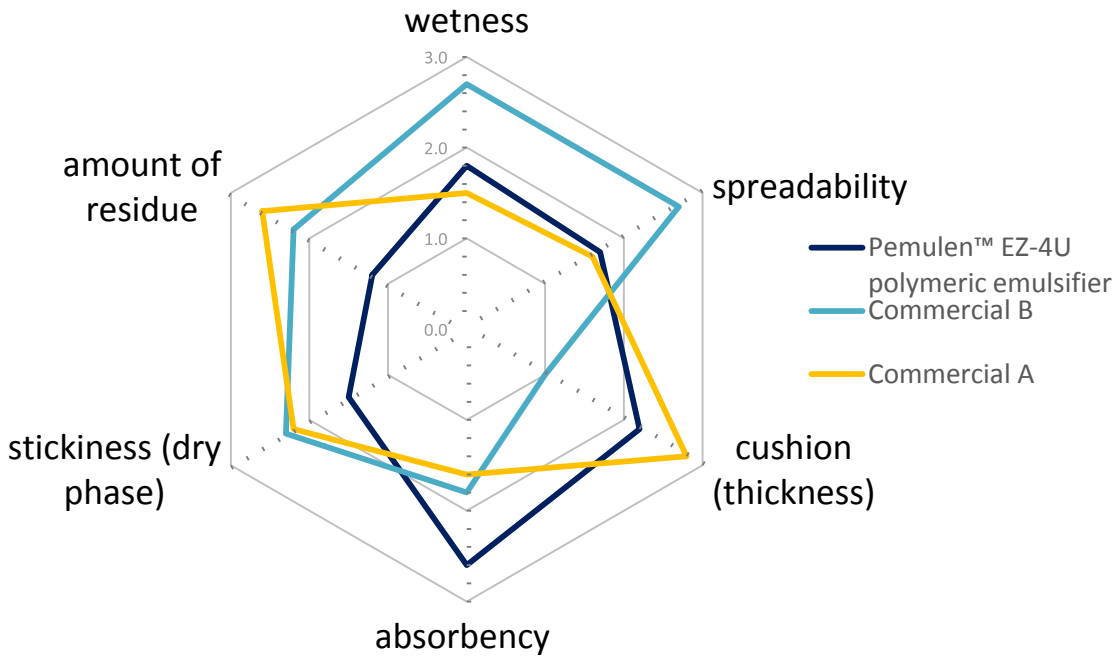
Pemulen™ EZ-4U polymeric emulsifier offers efficient stabilization at 0.05% with low viscosity, enabling formulation of thin milk and lotions.

Lubrizol

Sensory Profile of Pemulen™ EZ-4U Polymeric Emulsifier vs. Commercial Benchmarks

(In mucilage gels)

Evaluation of Pemulen™ EZ-4U, commercial product polymeric emulsifiers in mucilage gel (polymer dispersed in water)



Forced Rank Testing
(10 panelists)

Pemulen™ EZ-4U polymeric emulsifier has a fresh initial feel with lower stickiness and amount of residue vs. commercial benchmarks.

Lubrizol

Competitive Advantage

	Dispersion Time	Structuring Reduction	Refreshing Sensory	Universal Emulsification	Efficiency
Pemulen™ EZ-4U polymeric emulsifier Acrylates/C10-C30 Alkyl Acrylate Crosspolymer	+++	+++	+++	+++	+++
Commercial A Acrylates/Vinyl Isodecanoate Crosspolymer	–	+++	+++	+++	+++
Commercial B Ammonium Acryloyldimethyltaurate/VP Copolymer	~~	+++	+++	–	–
Commercial C Acrylates/C10-C30 Alkyl Acrylate Crosspolymer	~~	+++	+++	~~	~~
Commercial D Acrylates/C10-C30 Alkyl Acrylate Crosspolymer	~~	+++	+++	~~	~~
Commercial E Sodium Polyacrylate	+++	+++	+++	–	–

+++ Excellent ~~ Fair - Poor

Easier to use, more efficient, universal and flexible.

Lubrizol

Miscellaneous

- Regulatory:
  - CFDA, JSQI (Japan), and TGA (Australia) compliant

Lubrizol