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Multifunctional polymer for skin and sun care

ABSTRACT

Repair, protect and moisturise are the key consumer requirements in skin care. The components that help achieve these claims are often either monovalent or multivalent electrolytes, such as salts of alpha hydroxy acids, sodium pyrrolidone carboxylic acid (sodium PCA), phenylbenzimidazole sulfonic acid (PBSA), etc. However, it is difficult to formulate with these actives since they tend to have a negative effect on the viscosity, texture and stability provided by commonly used traditional anionic rheology modifiers.

Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside, is a multifunctional polymer based on acrylate chemistry that enables the formulation of smooth and elegant emulsions containing high levels of electrolytic active ingredients by offering excellent efficiency as a thickener, stabiliser, and primary or auxiliary emulsifier, with improved electrolyte tolerance and unique sensory properties. It offers excellent viscosity building and yield value across a range of polymer solids providing stabilisation and suspension properties in finished formulations ranging from low viscosity lotions to high viscosity creams.

As a technology driven company, Lubrizol Advanced Materials strives to provide differentiated solutions and innovative products that help formulators respond quickly and effectively to the fast paced and complicated challenges of skin care product development.

This new polymer with the designated INCI name: Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside, is an inverse emulsion based on acrylic acid, which is partially neutralised with sodium hydroxide prior to polymerisation. With the polymer's lightly crosslinked and highly branched structure, it offers excellent rheology modification, suspension and stabilisation. It also contains very low levels of a naturally derived high HLB emulsifier, which offers the ease of making oil-in-water emulsions by simply adding the material to water with agitation. It contains a light carrier oil phase that offers broad flexibility in sensory modification. With the proper selection of product components combined with expertise in the acrylate technology, this new polymer is designed to offer best-in-class performance in emulsification, co-emulsification, stabilisation and rheology modification of oil-in-water emulsion systems as compared to commonly used competing technologies in the market. With its improved electrolyte tolerance, it offers ease in formulating with electrolytic actives in functional claims-driving skin care products. It has a normal dispersion pH of 6.5-7.5.

Although this polymer offers excellent potential in different applications, this paper will focus primarily on its fit in skin care and sun care applications, particularly in the presence of challenging actives and high electrolyte systems.

Methods and materials

General performance (viscosity and yield value)

The performance of Polymer A (Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside) was compared in water dispersion to other commercially available inverse emulsion polymers and thickeners listed in Table 1 below.

Viscosity and yield value

Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside has been evaluated over a range of polymer concentrations in water, measuring both viscosity and yield value. These measurements have been made using a Brookfield Model DVII+ Viscometer. The polymer is dispersed into water with agitation using a Heidolph mixer with a two-inch diameter marine propeller blade. Agitation is set at 1800 rpm and the material is allowed to mix for 30 minutes. When mixing is stopped, the sample is set in a 25˚C water bath for one hour.

A viscosity (mPa·s) reading is directly taken based on the value provided by a

Table 1: Polymers used in comparative viscosity and yield value performance.

Polymer	INCI Name	Suppliers
A (blue)	Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside	Lubrizol
B (red)	Acrylates/Acrylamide Copolymer (and) Mineral Oil (and) Polysorbate 85	Lubrizol
C (green)	Polyacrylamide (and) C13-14 Isoparaffin (and) Laureth-7	Seppic
D (light blue)	Acrylamide/Sodium Acryloyldimethyltaurate Copolymer (and) Isohexadecane (and) Polysorbate 80	Seppic
E (orange)	Hydroxyethyl Acrylate/Sodium Acryloyldimethyl Taurate Copolymer (and) Squalane (and) Polysorbate 60	Seppic
F (black)	Ammonium Acryloyldimethyltaurate/VP Copolymer	Clariant
G (purple)	Polyacrylate Crosspolymer-6	Seppic
H (yellow)	Ammonium Acrylate/Acrylamide Copolymer (and) Polyisobutene (and) Polysorbate 20	Seppic

fully calibrated viscometer with the appropriate spindle. Brookfield Yield Value (dyn/cm^2) is determined by using the measured viscosity at 0.5 rpm and 1.0 rpm and substituting them into the equation below for Va and Vb, respectively.

Yield Value = (Va – Vb)/100

For emulsion formulations, viscosity and yield value are measured at 25˚C, 24 hours after production or standardisation at room temperature.

Table 2: Screening formulation for sensory evaluation.

	Polymer A (0.50%TS)* Wt%	Polymer C (0.94%TS)* Wt%	Polymer D (0.92%TS)* Wt%
1 Deionised water	97.20	97.70	97.70
2a ■ Polymer A*	2.50		
2b ■ Polymer C*		2.00	
2c ■ Polymer D*			2.00
3 Glydant Plus Liquid	0.30	0.30	0.30
pH (dispersion)	7.34	6.48	5.68
Viscosity (RV, 20 rpm, mPa·s)	25,000	25,150	25,250

**Polymer solids were adjusted appropriately such that equivalent target viscosities could be reached*

Table 3: Compatibility with surface treated micronised titanium dioxide.

	INCI Name	Supplier	Average particle size
1	Titanium Dioxide, Alumina (and) Glycerin	Kemira	<200 nm
2	Titanium Dioxide, Alumina (and) Simethicone	Merck	15 nm
3	Titanium Dioxide (and) Silica	Merck	15 nm
4	Titanium Dioxide (and) Dimethoxydiphenylsilane/ Triethoxycaprylylsilane Crosspolymer (and) Hydrated Silica (and) Aluminum Hydroxide	BASF	<200 nm
5	Titanium Dioxide (and) Diethylhexyl Carbonate (and) Polyglyceryl-6 Polyhydroxystearate	Evonik	10 m

Electrolyte tolerance

To test the polymer's performance against electrolytes, aside from sodium chloride, the following skin care actives are used as sources of electrolytes:

- Sodium PCA (NaPCA), a monovalent salt and a basic component of the natural moisturising factor (NMF). It is commonly used as a moisturising active in skin care applications.
- Zinc PCA (ZnPCA), a divalent salt that is commonly used in cleansing products but now is becoming popular as an active in suppressing sebum and body odour. It is also used as an ingredient in anti-ageing products.

Sensory evaluation at equilibrium pH

The sensory evaluation is conducted by 10-11 trained panellists using forced ranking methodology where the three samples representing the screening formulations (Table 2) are applied at the same time. Evaluation is carried out based on ASTM Method EL-1490-03 which requires the application of 50 µL of the sample on the inner forearm.

Below are the attributes tested:

- **Whiteness**: Appearance in the container.
- **Pick-up**: Ease with which product is taken from container.
- **Peaking**: Degree to which product makes stiff peaks.
- **Wetness**: Amount of water perceived while rubbing.
- **Spreadability**: Ease of moving product over the skin.
- **Absorbency**: Number of rubs the product loses wet feel and perceived to be absorbed into the skin.
- **Slip**: Ease of moving fingers across skin.
- **Stickiness**: Degree to which fingers adhere to the product.
- **Amount of residue**: Amount of product perceived on skin.

Friedman's Analysis of Variance (Friedman ANOVA) is used to determine the statistical differences between the samples.

Formulation 1: Morning Dew Age Defying Moisturizer F-0044.

Containing 0.65 wt% NaPCA, pH6.4-6.6

Part		Ingredient/INCI Name	Wt%
A	1	Deionised water	QS to 100
	2	Butylene Glycol	2.00
	3	Glycerin	2.00
	4	■ Polymer A ■ Polymer C ■ Polymer D ■ Polymer E ■ Polymer F ■ Polymer G ■ Polymer H	0.80 polymer solids
B	5	Diisopropyl Adipate[1]	5.00
	6	Ethylhexyl Palmitate[1]	3.00
	7	Diisopropyl Sebacate[1]	0.85
	8	Isostearyl Neopentanoate[1]	3.00
	9	Isostearyl Hydroxystearate[1]	1.50
	10	Cetyl Alcohol (and) Ceteareth-20[1]	0.40
	11	Tocopherol[2]	0.40
	12	Bisabolol[2]	0.10
C	13	Juglans Regia (Walnut) Seed Extract[3]	4.00
	14	Sodium PCA (50 % active)[4]	1.30
	15	Phenoxyethanol & Ethylhexylglycerin	0.70

Suppliers: 1 Lubrizol 2 BASF 3 Gattefossé 4 Ajinomoto

Emulsification and co-emulsification property

The ability of 5.0 wt% (as supplied) of Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside to emulsify 10.0 wt% oil phase has been evaluated using the following 'oils':

- Hydrogenated polydecene (non-polar, hydrocarbon) (Exxon-Mobil).
- Cetyl ethylhexanoate (medium polar, specialty ester) (Lubrizol Advanced Materials, Inc.).
- Sunflower oil (polar, vegetable oil).

The impact of a co-emulsifier is studied by comparing systems with and without co-emulsifier (0.2 wt% polysorbate 20). All formulations are adjusted to pH 5.5 by the addition of lactic acid.

Thickening/stabilising systems with challenging electrolytic actives

To further evaluate the new polymer's fit in skin care and sun care applications, its ability to thicken and to stabilise systems containing the following actives are studied:

- **Skin whitening actives**: Sodium ascorbyl phosphate and magnesium ascorbyl phosphate are vitamin C derivatives in salt forms that are commonly used as skin lightening actives. Quasi-drug application of these materials requires minimum use level of 3.0 wt%.
- **Organic UV filter**: 2-phenylbenzimidazole-5-sulfonic acid (PBSA), a water soluble sunscreen with excellent absorption in the UVB wavelength region. It is commonly used in its neutralised-salt form.
- **Physical sunscreen**: Compatibility test with titanium dioxide (physical sunscreen) is conducted by incorporating 1.0 wt%-2.0 wt% of different types of surface treated micronised titanium dioxide (Table 3) in the screening formulation.

Results and discussion

General performance (viscosity and yield value)

Thickening is an important factor for rheology modifiers since it changes the physical properties of the system and the migration rate of the suspended components.

From the data in Figure 1, we can say that at dispersion pH and lower polymer solid concentrations, Polymer A (Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside), offers the best thickening performance among the materials tested. It shows exceptional efficiency as compared to other commercially available inverse emulsion polymers (examples: Polymer B, Polymer C, Polymer D, Polymer E, and Polymer H).

The same data show the versatility and efficiency of Polymer A in thickening different systems of different viscosity profiles. Thickening systems with viscosities lower than 5,000 mPa·s will require less than 0.2 wt% solid of Polymer A.

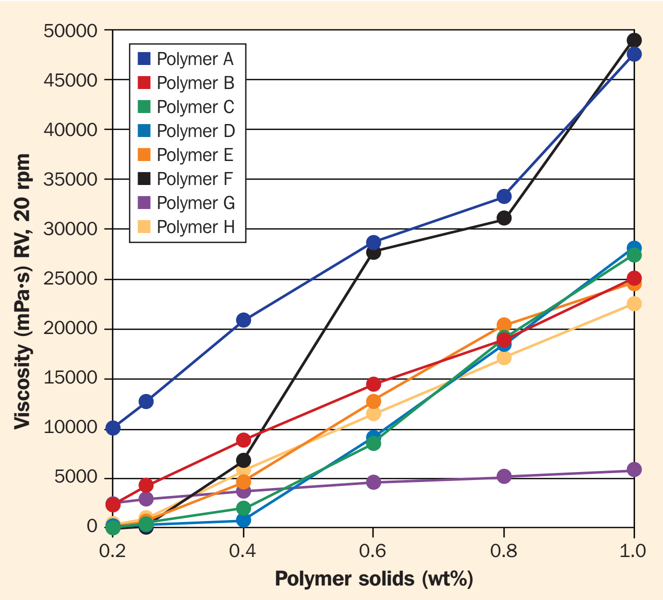

Figure 1: *Viscosity as function of polymer solids at dispersion pH.*

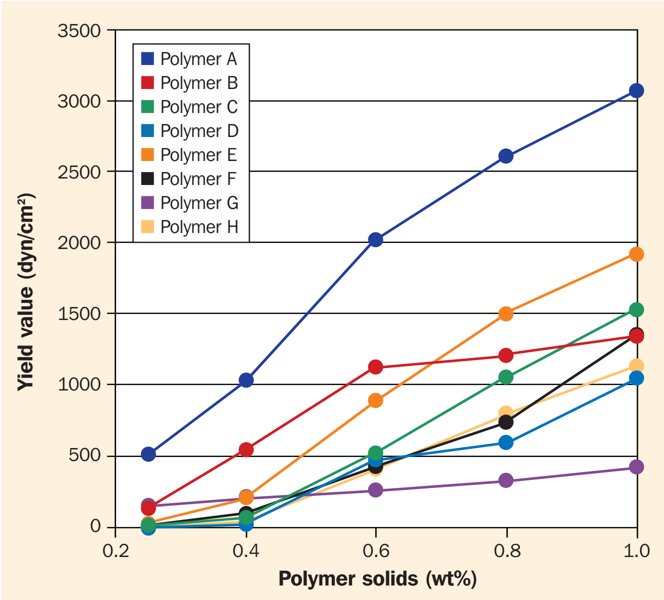

Figure 2: *Yield value as function of polymer solids at dispersion pH.*

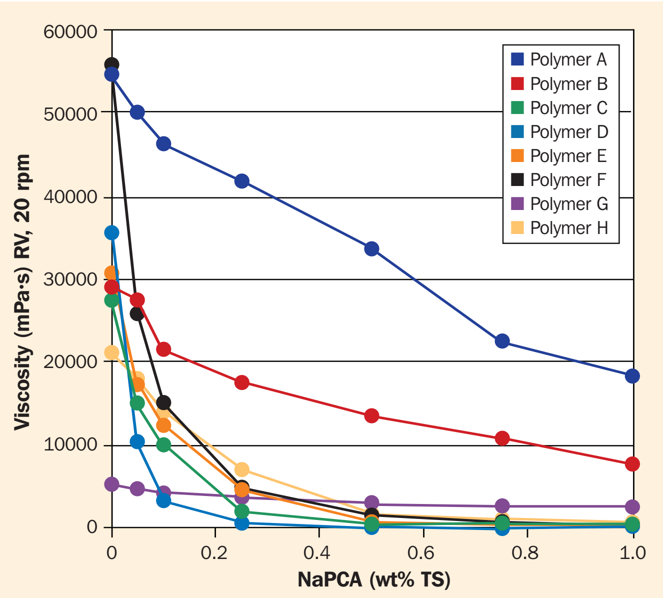

Figure 3: *Comparative electrolyte tolerance of different polymers (1.00 wt% TS) in the presence of NaPCA (dispersion pH).*

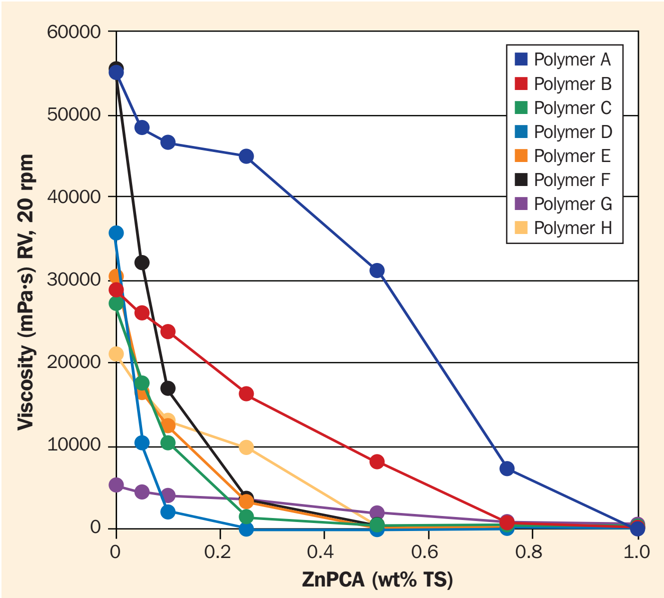

Figure 4: *Comparative electrolyte tolerance of different polymers (1.0 wt% TS) in the presence of ZnPCA (dispersion pH).*

Yield value is considered as a predictive measurement for the suspending power of the system.[1] It is also a good predictor of emulsion stability since an emulsion is a dispersion of minute droplets of one liquid into another in which it is not soluble or miscible.[2]

The data show that at dispersion pH and from 0.2 wt%-1.0 wt% polymer solids, Polymer A offers unmatched yield value when compared to all the benchmarks used in the evaluation. This shows the versatility of Polymer A to provide stabilisation and suspension properties to finished formulations ranging from low viscosity lotions to high viscosity creams.

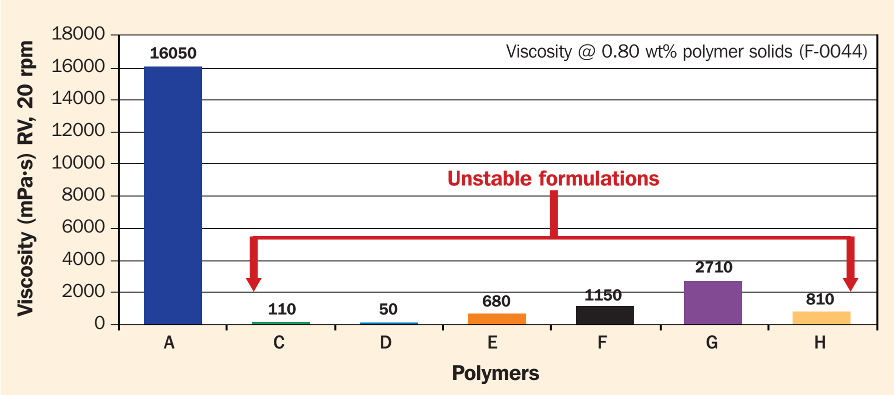

Figure 5: *Comparative thickening performance of different polymers (F-0044).*

Electrolyte tolerance

- **Sodium PCA (NaPCA):** In the presence of NaPCA, Polymer A shows better electrolyte tolerance as compared to the other inverse emulsion polymers used in the study.
- **Zinc PCA (ZnPCA):** In the presence of ZnPCA, Polymer A shows better electrolyte tolerance as compared to the other inverse emulsion polymers used in the study. The rapid drop of viscosity due to the presence of a certain amount of divalent salt may come from:
  - Reduced charge repulsion with a stronger shielding of the charges of carboxylic groups by multi-valent ions.
  - The low dissociation constant of polymeric zinc complexes with carboxylic groups would render the complexes as a cross-linkage and retard the swelling of polyacrylates.
  - The polymer is anchored to the oil droplet by hydrophobic interaction. Such anchoring should theoretically be strengthened by the presence of water-structure-enhancing electrolytes.

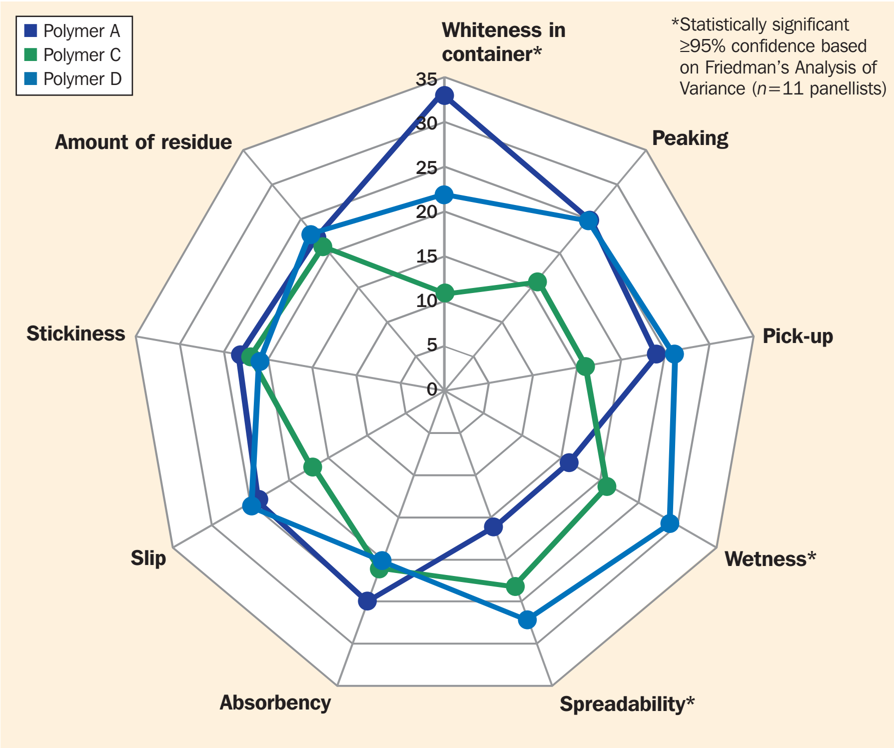

Figure 6: *Sensory profile at equilibrium pH.*

Combining the data from Figures 3 and 4, we can say that Polymer A offers the best in class electrolyte tolerance in the presence of monovalent and divalent salts.

Formulation 1 shows an actual application of the above data in an emulsion containing 0.65 wt% sodium PCA as natural moisturising factor (NMF) active. It is a highly stable formulation that is formulated at pH: 6.4-6.6 with viscosity of 13,000 to 22,000 mPa·s. Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside efficiently stabilises the system and allows the incorporation of sodium PCA without sacrificing its rich glossy white appearance and silky soft after-feel aesthetics.

Formulation 1 shows that the amount of Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside needed to stabilise the emulsion with electrolytes is lower as compared to its aqueous dispersion.

Moreover, this formulation also shows the ability of Sodium Acrylates/Beheneth-

Table 4: Compatibility with surface-treated, micronised titanium dioxide.

	INCI Name	Average particle size	Observations
T-1	Titanium Dioxide, Alumina, Glycerin	<200 nm	Compatibility issue (lumpy)
T-2	Titanium Dioxide, Alumina and Simethicone	15 nm	Compatibility issue (lumpy)
T-3	Titanium Dioxide, Silica	15 nm	Good compatibility (smooth, uniform texture)
T-4	Titanium Dioxide (and) Dimethoxydiphenylsilane/ Triethoxycaprylylsilane Crosspolymer (and) Hydrated Silica (and) Aluminum Hydroxide	<200 nm	Compatibility issue (lumpy)
T-5	Titanium Dioxide (and) Diethylhexyl Carbonate (and) Polyglyceryl-6 Polyhydroxystearate	10 nm	Good compatibility (smooth, uniform texture)

25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside to stabilise the system with 13.75 wt% of oily and oil soluble components in the presence of only 0.40 wt% traditional emulsifier.

To validate if a similar trend in Figure 3 (polymer dispersion in water) will be achieved in emulsion systems, Polymer A is substituted with the other polymers in the screening Formulation 1. Data in Figure 5 demonstrates that in actual electrolyte containing oil-in-water applications, Polymer A will outperform the thickening and stabilising properties of all polymers used in the test. On the other hand, we can say that as compared to the other polymers, a lower amount of Polymer A will be needed to thicken the same system with high levels of electrolytes.

Sensory profile of the polymer at equilibrium pH

Figure 6 shows the differentiated sensory profile of Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside. It creates a good uniform dispersion resulting in a visually elegant emulsion with a very white appearance. It provides good peaking and pick-up with slow break characteristics which gives a less watery, cushiony sensory feel. Moreover, it leaves a non-tacky feel with comparatively low residue.

Emulsification/co-emusification properties

To further characterise the stabilisation provided by Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside, its ability to emulsify 10.0 wt% of different types of oils was evaluated.

Figure 7 shows that Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside alone is capable of emulsifying medium to high polar types of emollients/oils. It creates elegant, white and smooth emulsions with cetyl ethylhexanoate (medium polar) and sunflower oil (high polar). Its ability to impart viscosity to the emulsion also increases as the polarity of the oil phase increases. Both formulations also exhibit excellent stability. Since the polarity of the oil has an impact on the emulsion viscosity and stability, it is recommended to use a co-emulsifier or a co-thickener in emulsions containing low polarity oils.

Using the medium polarity oil cetyl ethylhexanoate (supplier: Lubrizol Advanced Materials, Inc.), we studied the effect of co-emulsifier (polysorbate 20) in the emulsion. In Figure 8, we can see that

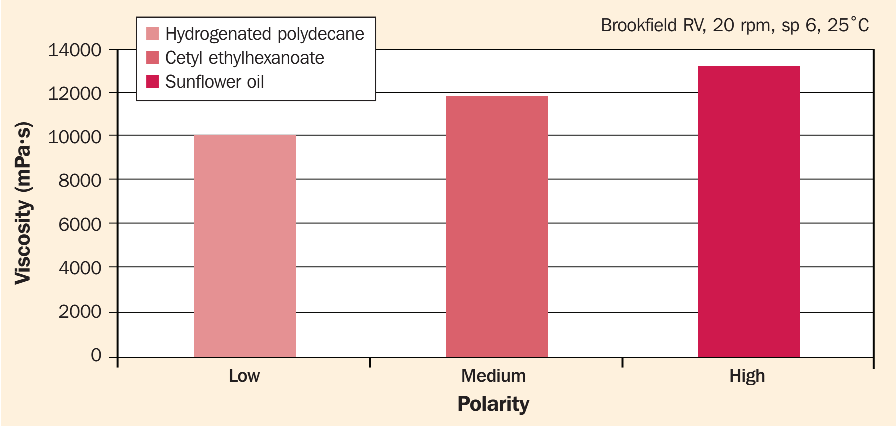

Figure 7: *Emulsification of different types of emollients with different polarities pH 6.5.*

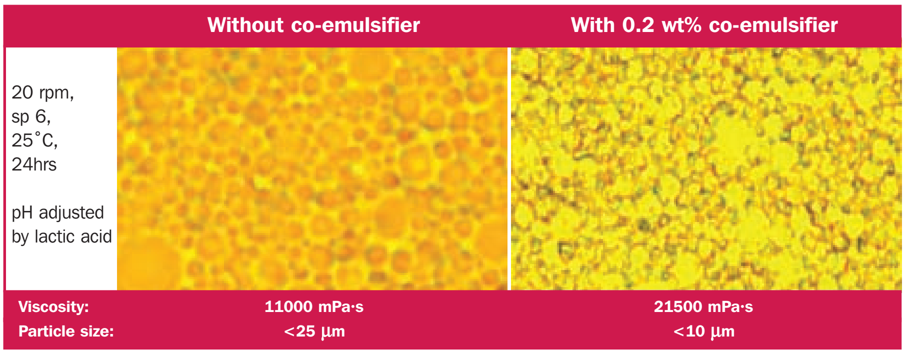

Figure 8: *Effect of co-emulsifier (Polysorbate-20).*

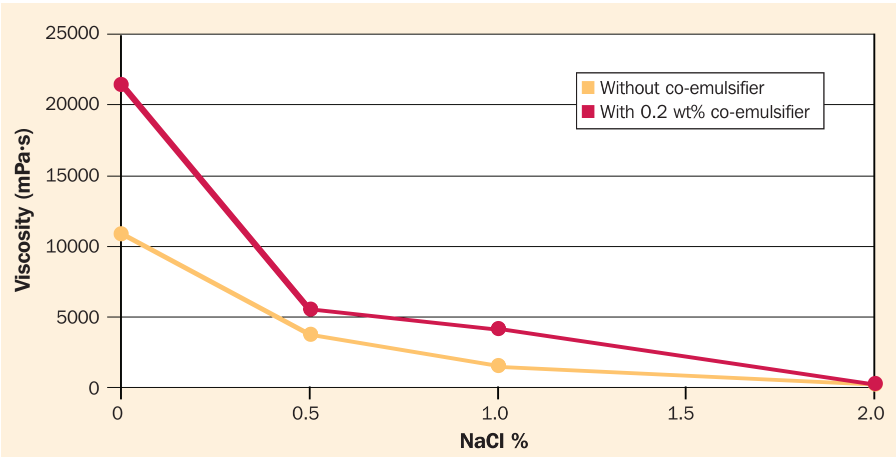

Figure 9: *Effect of co-emulsifier (Polysorbate-20) on the electrolyte tolerance in emulsion.*

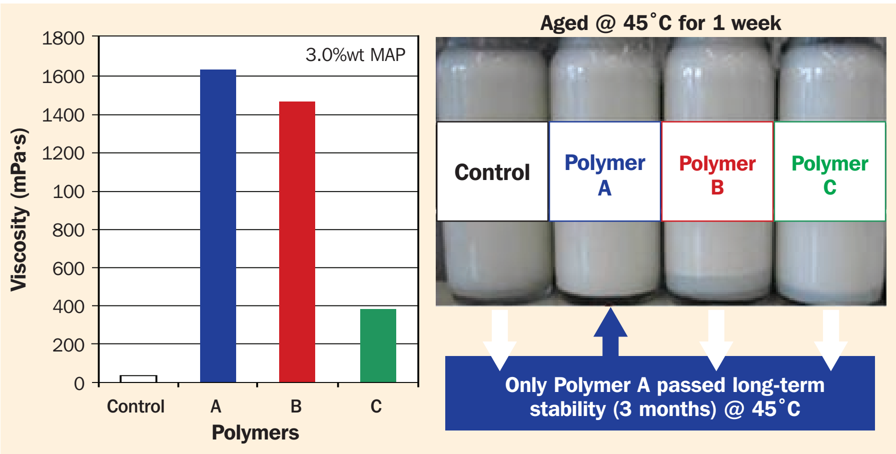

Figure 10: *Comparative viscosity and stability of whitening formulations.*

although Sodium Acrylates/ Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside alone can emulsify the system, the addition of a small amount of co-emulsifier (0.2 wt%) can reduce the emulsion droplet size and increase the viscosity of the system.

To simulate the possible effect of electrolytes in the emulsion, we added NaCl to emulsions (with and without co-emulsifier). The data in Figure 9 shows that in the presence of electrolytes, the addition of high HLB co-emulsifier can optimise the performance of Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside.

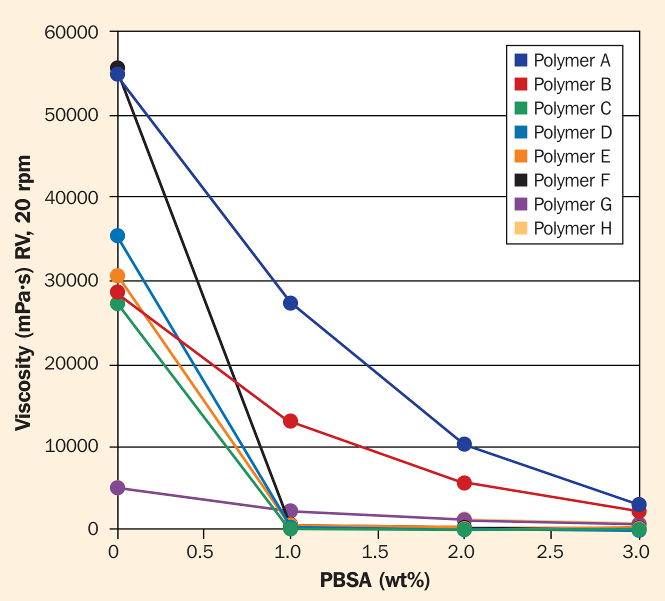

Figure 11: *Effect of PBSA to viscosity (pH 7).*

Performance in the presence of challenging actives

Vitamin C derivative skin whitening actives

It is a common practice to use inverse emulsion polymers as co-emulsifiers and stabilisers for challenging emulsion systems. The polymers are expected to reinforce the emulsifying property of the primary emulsifier and to act as rheology modifiers that will improve the viscosity and stability of the system.

Using the screening formulation in Formulation 1, we evaluated the comparative performance of Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside against other inverse emulsion polymers (Polymer B and Polymer C) in thickening and stabilising an emulsion system containing high levels (3.0 wt%) of magnesium ascorbyl phosphate (MAP), a commonly used active in Japanese Quasi Drug classified skin whitening formulations.

As reflected by the data in Figure 10, Polymer A (Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside) shows better viscosity response as compared to the other polymers in thickening this low viscosity emulsion containing high levels of multivalent salt of ascorbic acid. This could be attributed to the better compatibility of Polymer A to the electrolytes than the other inverse emulsion polymers.

The photographs in Figure 10 show that Polymer A enhances the stability of an emulsion system containing 3.0 wt% magnesium ascorbyl phosphate. Comparing the viscosities and the degrees of separation, the data also shows that the system's good viscosity response to the polymer alone is not enough to stabilise the system. With the presence of separation in the emulsions – Control, Polymer B and Polymer C, it is obvious that Polymer A imparts better co-emulsifying property to the system as compared to the other two inverse emulsion polymers and it improves the stability of the system.

Phenylbenzimidazole sulfonic acid (PBSA)

To balance skin-feel and functionality, many formulators prefer to use the water soluble PBSA in combination with the oil soluble UV filters. However, PBSA must be neutralised to pH 7-8 prior to use or it may revert to its acid form and crystalise, rendering it less effective as a sunscreen active. At pH 7-8, it is available in its salt form which will negatively interact with the polymers, resulting in low viscosity.

Based on the viscosity plotted in Figure 11, Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside shows the best compatibility to neutralised PBSA as reflected by its ability to provide viscosity to the system in the presence of different levels of neutralised PBSA. Most of the polymers tested except Polymers A and B were not able to provide viscosity to the system in the presence of 1.0 wt% PBSA.

To validate the above results in the emulsion system, we used a very easy-to-make cold process formula cream gel with PBSA which contains PBSA (phenylbenzimidazole sulfonic acid). It features Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside as the rheology modifier, emulsion stabiliser, and primary emulsifier with excellent sensory. The performance of the other polymers is tested by substituting similar solids (wt%) of the polymer used in the test formulation formulated at pH 7.1-7.5.

The results in Figure 12 confirm the excellent performance of Polymer A in thickening PBSA containing formulation.

Titanium dioxide

Because of its low potential to cause skin sensitisation, titanium dioxide is still a popular raw material in sun care formulations. However, there are a few factors to be considered in using titanium dioxide such as particle size, shape, surface treatment, compromise between high UVB/UVA protection and low whitening, compatibility with other components, solubility, etc. Since agglomeration and incompatibility with anionic acrylic based polymers are

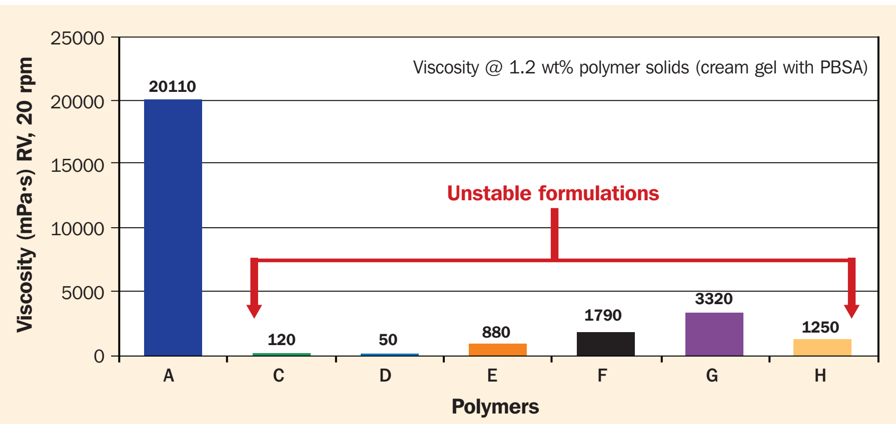

Figure 12: *Polymer thickening performance in cream gel with PBSA.*

common complaints in formulations containing titanium dioxide, we tested the compatibility of Sodium Acrylates/ Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside in formulations containing 1.0-2.0 wt% of micronised, surface treated rutile titanium dioxides that are commonly used in sun care applications at pH 6.0-7.5.

With the above observations, caution must be employed in formulating with titanium dioxide. Alumina surface treated and aluminum hydroxide containing titanium dioxide appear to have a negative interaction with Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside, causing the formation of lumpy agglomerates. These findings will help formulators to choose the appropriate type of titanium dioxide to be used in the formulation. Formulation 4 is an example of a sunscreen containing 4.0 wt% of T5 (Titanium Dioxide and Diethylhexyl Carbonate and Polyglyceryl-6 Polyhydroxystearate). The polymer, Sodium Acrylates/Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside co-emulsifies, thickens and stabilises titanium dioxide containing sunscreen.

Conclusion

From the preceding data, it can be concluded that Sodium Acrylates/ Beheneth-25 Methacrylate Crosspolymer (and) Hydrogenated Polydecene (and) Lauryl Glucoside, is an effective, easy-to-use liquid inverse emulsion polymer that offers multifunctional benefits.

It functions as a primary emulsifier or co-emulsifier and at the same time, offers elegant rheology modification to the system. It provides excellent thickening and suspension properties especially in systems containing high levels of electrolytes enabling the development of claims driving formulations that are highly stable and with exceptional elegant sensory. PC

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Formulation 2: Skin Whitening Formulation.

Containing 3.0 wt% Magnesium Ascorbyl Phosphate (MAP) at pH ~7.5

Part		Ingredient/INCI Name	Control Wt%	Trial A/B/C Wt%
A	1	C12-15 Alkyl Benzoate	10.00	10.00
	2	Methyl Glucose Sesquistearate[1]	0.40	0.40
	3	PEG-20 Methyl Glucose Sesquistearate[1]	1.60	1.60
	4	Cetyl Alcohol	2.50	2.50
	5	Tocopherol[2]	0.50	0.50
	6	Deionised water	QS to 100	QS to 100
	7	Glycerin	1.00	1.00
B	8	■ Polymer A ■ Polymer B ■ Polymer C		1.00 polymer solids
C	9	Magnesium Ascorbyl Phosphate (15%)[3]	20.00	20.00
D	10	Sodium Hydroxide (18%)	QS to pH 7.5	QS to pH 7.5
	11	Phenoxyethanol (and) Ethylhexyl Glycerin	0.50	0.50
	12	Fragrance[4]	0.10	0.10

Suppliers: 1 Lubrizol 2 BASF 3 Nikko 4 Givaudan

Formulation 3: Cream Gel.

Containing 2.00 wt% PBSA at pH 7.1-7.5

Part		Ingredient/INCI Name	Wt%
A	1	Deionised water	QS to 100
	2	Butylene Glycol	5.00
	3	Diisopropyl Adipate[1]	4.00
	4	Neopentyl Glycol Diethylhexanoate	2.00
	5	DMDM Hydantoin & Iodopropynyl Butylcarbamate	0.40
B	6	Sodium Hydroxide (18% solution)	0.40
C	7	■ Polymer A ■ Polymer C ■ Polymer D ■ Polymer E ■ Polymer F ■ Polymer G ■ Polymer H	1.20 polymer solids
D	8	Phenylbenzimidazole Sulfonic Acid (20% solution neutralised w/50% NaOH to pH 7.10-7.50)	10.00

Suppliers: 1 Lubrizol 2 Symrise

Formulation 4: Very Water Resistant Sun Protective Body Cream – SPF 20.

SU-0034(LA)

Part		Ingredient/INCI Name	Wt %
A	1	Deionised water	73.40
	2	Disodium EDTA	0.05
	3	Panthenol[1]	0.20
	4	Polyglyceryl-3 Laurate[2]	0.50
B	5	Octocrylene	5.00
	6	Butyl Methoxydibenzoylmethane	2.00
	7	Ethyl Methoxycinnamate	7.00
	8	Benzophenone-3	3.00
	9	Isodecyl Neopentanoate[2]	1.50
	10	Dimethicone PEG-7 Isostearate[2]	0.40
	11	Acrylates C10-30 Alkyl Acrylate Crosspolymer[2]	0.20
	12	Titanium Dioxide (and) Diethylhexyl Carbonate (and) Polyglyceryl-6 Polyhydroxystearate[3]	4.00
C	13	Triethanolamine (99%)	0.20
	14	Methylchloroisothiazolinone (and) Methylisothiazolinone	0.05
	15	Fragrance[4]	0.50
	16	■ Polymer A	2.00

Suppliers: 1 BASF 2 Lubrizol 3 Evonik 4 Cosmat