

# Viscosity building basics in alkyl sulfate systems for cleansing products.

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Cleansing product formulas such as hair shampoo, liquid hand soap and pet shampoos use high foaming surfactants like sodium and ammonium lauryl sulfate. One aspect of the formulation is an appropriate high viscosity for these products. Commonly used thickeners include alkanolamides, betaines and salt. In this paper we will examine and compare the viscosity building response by ammonium lauryl sulfate versus sodium lauryl sulfate using the viscosity builders, alkanolamides, betaine and salt. We will also compare the viscosity building ability of three of the commonly used alkanolamides namely cocamide DEA, cocamide MEA, oleamide DEA and their interaction with betaine and salt for viscosity modification.

Pilot Chemical Company's products used in this study are:

Calfoam <sup>®</sup> ALS-30	Ammonium lauryl sulfate
Calfoam <sup>®</sup> SLS-30	Sodium lauryl sulfate
Calamide <sup>®</sup> C	Cocamide DEA
Calamide <sup>®</sup> MC	Cocamide MEA
Calamide <sup>®</sup> F	Oleamide DEA
Caltaine <sup>®</sup> C-35	Cocamidopropyl betaine

**Note:** All viscosities are measured at 70<sup>o</sup> F, using Brookfield DV-1 + viscometer. The spindle and speed were selected to give the % torque reading 50 – 80

A simple, economy, starting formula for liquid hand soap / pet shampoo can be made with about 10% active lauryl sulfate (Calfoam<sup>®</sup> ALS-30 or Calfoam<sup>®</sup> SLS-30) thickened with 1% cocamide DEA (Calamide<sup>®</sup> C) and 4% salt. The viscosities are as follows.

	<b>Formula # 1</b>	<b>Formula # 2</b>
Water	Q.S to 100%	Q.S to 100%
<b>Calfoam<sup>®</sup> ALS-30</b>	<b>33.3</b>	
<b>Calfoam<sup>®</sup> SLS-30</b>		<b>33.3</b>
Calamide <sup>®</sup> C	1.0	1.0
Sodium chloride	4.0	4.0
Citric acid	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S
<b>Viscosity cp.</b>	<b>19,000</b>	<b>24,000</b>

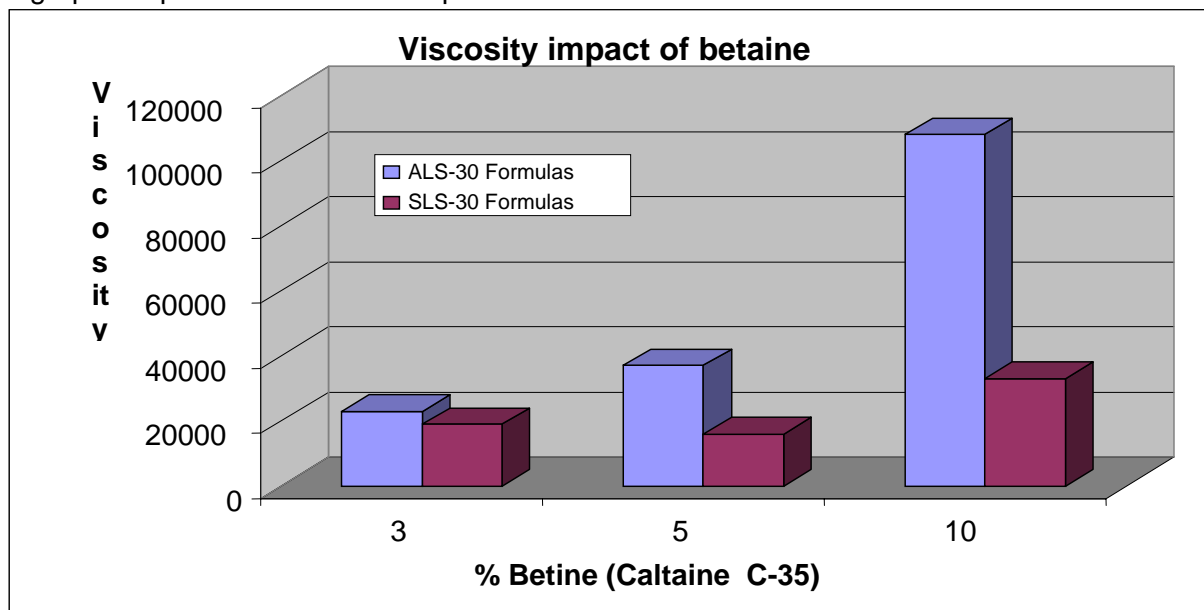
Most formulators would like to add betaine such as Pilot's Caltaine® C-35 (INCI: Cocamidopropyl betaine) to their formula. Caltaine® C-35 is a high foaming, relatively mild, amphoteric surfactant with foam stabilizing and viscosity building properties in personal and pet cleansing formulas based on anionic surfactants such as Calfoam® ALS-30 and / or Calfoam® SLS-30. In above listed formulas 1 & 2 we can see that Calfoam® SLS-30 gave higher viscosity than Calfoam® ALS-30. The situation changes as we introduce Caltaine® C-35 to the formulas. In formulas 3, 4 and 5 we used Calfoam® ALS-30 with 1% Calamide® C and 3, 5 and 10% of Caltaine® C-35, respectively. Sodium chloride was also added to maximize the viscosity.

	<b>Formula # 3</b>	<b>Formula # 4</b>	<b>Formula # 5</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® ALS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
Calamide® C	1.0	1.0	1.0
<b>Caltaine® C-35</b>	<b>3.0</b>	<b>5.0</b>	<b>10.0</b>
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>23,000</b>	<b>37,000</b>	<b>108,000</b>

Formula 3, 4 & 5 as listed above, when repeated using Calfoam® SLS-30 instead of Calfoam® ALS-30, gave lower viscosities. The difference in viscosities of Calfoam® ALS-30 based formulas (# 3, 4 & 5) versus Calfoam® SLS-30 based formulas (# 6, 7 & 8) grew larger as the amount of Caltaine® C-35 is increased from 3 to 5 to 10%.

	<b>Formula # 6</b>	<b>Formula # 7</b>	<b>Formula # 8</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® SLS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
Calamide® C	1.0	1.0	1.0
<b>Caltaine® C-35</b>	<b>3.0</b>	<b>5.0</b>	<b>10.0</b>
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>19,000</b>	<b>16,000</b>	<b>33,000</b>

A graphic representation of the impact of % betaine is as follows:

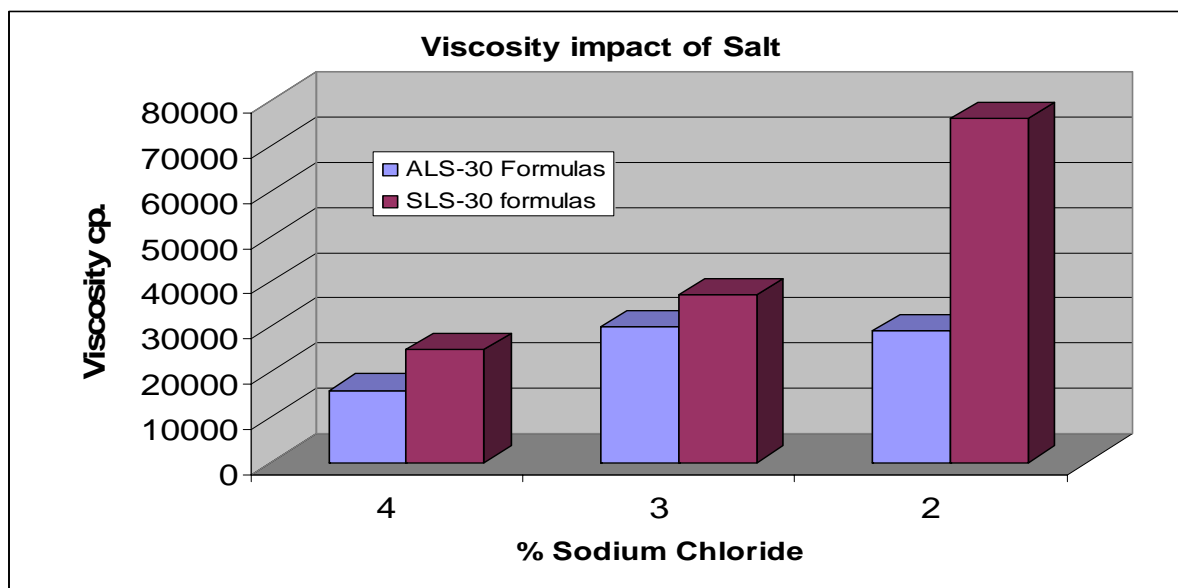


The story gets a little complicated when the amount of salt is increased. One more percentage point of salt was added in the above listed formulas 3, 4, 5 and 6, 7 & 8. Upon increasing the salt, Calfoam<sup>®</sup> ALS-30 based formula viscosity drops. This drop in viscosity increases as the amount of betaine increases in the formulas. For example the difference in viscosity between # 3 and 3A is only 7000 cp. (3% Caltaine C-35) whereas that in # 5 & 5A (10 % Caltaine<sup>®</sup> C-35) is 79,000 cp. In case of Calfoam<sup>®</sup> SLS-30 based formulas the viscosity increases as the amount of salt increases a percentage point. Here again, the rise in viscosity increases as the amount of betaine is increased form 3 to 5 to 10%. It shows that Calfoam<sup>®</sup> SLS-30 and Calfoam<sup>®</sup> ALS-30 have different salt curves and peak viscosities achievable require different amounts of salt, for the systems listed in above formulas. Formulas 3A, 4A & 5A are based on Calfoam<sup>®</sup> ALS-30 whereas 6A, 7A & 8A are based on Calfoam<sup>®</sup> SLS-30.

	<b>Formula # 3A</b>	<b>Formula # 4A</b>	<b>Formula # 5A</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam<sup>®</sup> ALS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
Calamide <sup>®</sup> C	1.0	1.0	1.0
Caltaine <sup>®</sup> C-35	3.0	5.0	10.0
<b>Sodium chloride</b>	<b>4.0</b>	<b>3.0</b>	<b>2.0</b>
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>16,000</b>	<b>30,000</b>	<b>29,000</b>

	<b>Formula # 6A</b>	<b>Formula # 7A</b>	<b>Formula # 8A</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam<sup>®</sup> SLS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
Calamide <sup>®</sup> C	1.0	1.0	1.0
Caltaine <sup>®</sup> C-35	3.0	5.0	10.0
<b>Sodium chloride</b>	<b>4.0</b>	<b>3.0</b>	<b>2.0</b>
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>25,000</b>	<b>37,000</b>	<b>76,000</b>

A graphic representation of the data is as follows:

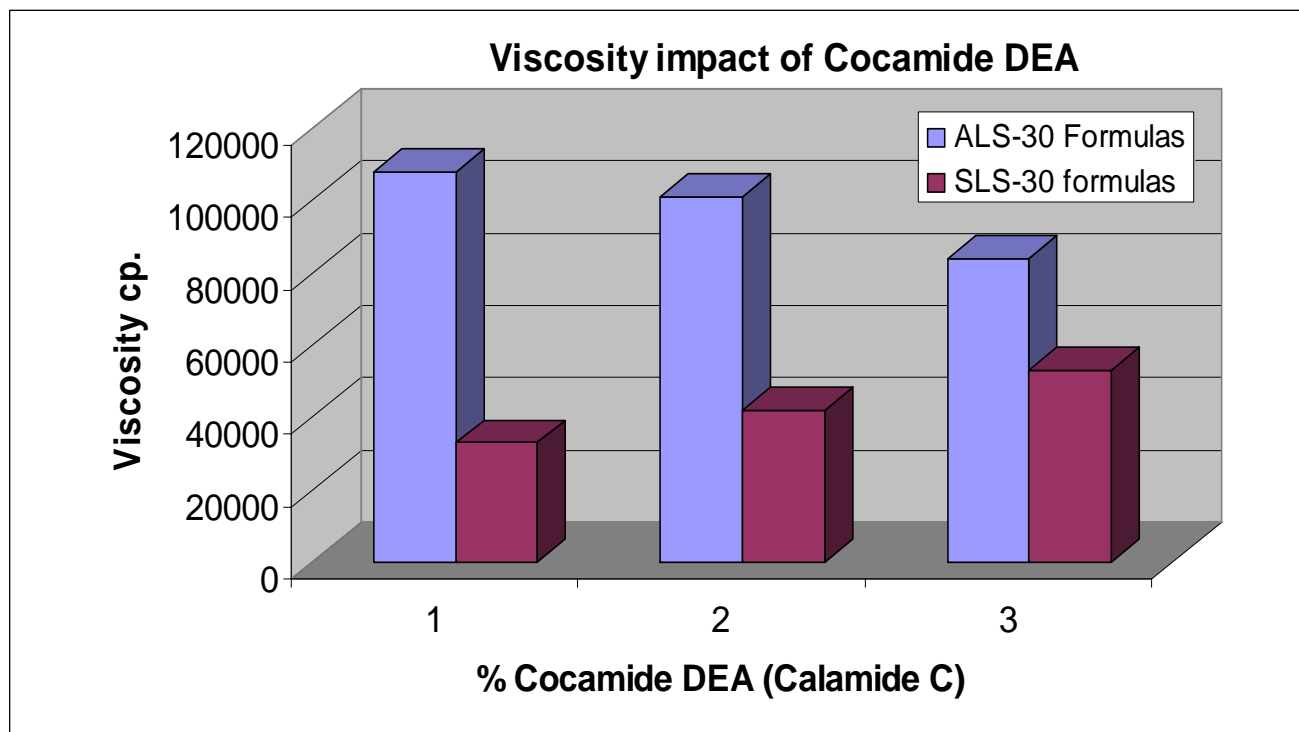


The above listed formulas contain 1% of Calamide® C (Cocamide DEA). Increasing the amount of amide from 1 to 2 to 3% will lower the viscosity of Calfoam® ALS-30 based formulas whereas this increase in the amount of amide will increase the viscosity of SLS-30 based formulas. Also as you increase the amount of amide you will have to decrease the amount of salt in order to achieve the peak viscosity of the system.

Let us see what happens when we increase cocamide DEA from 1% to 2 and then 3% in formulas 5 & 8. These two formulas are based on Calfoam® ALS-30 and Calfoam® SLS-30, respectively with 10% betaine. As we can see Calfoam® ALS-30 based formulas show a viscosity decrease from 108,000 to 101,000 to 84,000 cp. as the Calamide C is increased from 1 to 2 to 3%. Just the opposite happens in Calfoam® SLS-30 based formulas (see Formulas 8, 8B and 8C listed below). Here the viscosity increases from 33,000 to 42,000 to 53,000 cp. as the Calamide® C is increased from 1 to 2 to 3.

	<b>Formula # 5</b>	<b>Formula # 5B</b>	<b>Formula # 5C</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® ALS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
<b>Calamide® C</b>	<b>1.0</b>	<b>2.0</b>	<b>3.0</b>
Caltaine® C-35	10.0	10.0	10.0
Sodium chloride	1.0	0.5	0.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>108,000</b>	<b>101,000</b>	<b>84,000</b>

	<b>Formula # 8</b>	<b>Formula # 8B</b>	<b>Formula # 8C</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® SLS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
<b>Calamide® C</b>	<b>1.0</b>	<b>2.0</b>	<b>3.0</b>
Caltaine® C-35	10.0	10.0	10.0
Sodium chloride	1.0	0.5	0.5
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>33,000</b>	<b>42,000</b>	<b>53,000</b>



So far we have used Calamide<sup>®</sup> C (cocamide DEA) in our formulas. Let us now use Calamide MC (cocamide MEA) and compare its viscosity building properties with those of Calamide<sup>®</sup> C. The formulas and viscosities are listed below.

<b>Formula #</b>	<b>1</b>	<b>2</b>	<b>1C</b>	<b>2C</b>
Water	to 100%	to 100%	to 100%	to 100%
<b>Calfoam<sup>®</sup> ALS-30</b>	<b>33.3</b>		<b>33.3</b>	
<b>Calfoam<sup>®</sup> SLS-30</b>		<b>33.3</b>		<b>33.3</b>
<b>Calamide<sup>®</sup> DEA</b>	<b>1.0</b>	<b>1.0</b>		
<b>Calamide<sup>®</sup> MC</b>			<b>1.0</b>	<b>1.0</b>
Sodium chloride	4.0	4.0	4.0	4.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>19,000</b>	<b>24,000</b>	<b>17,000</b>	<b>20,000</b>

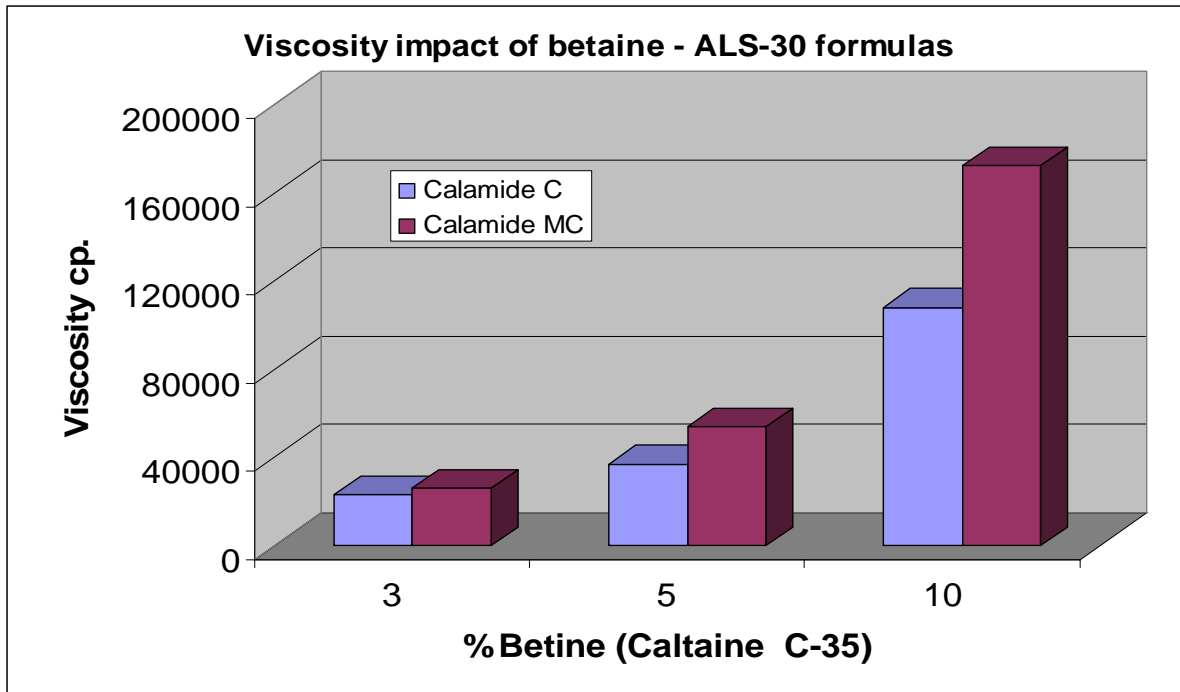
Previously we have seen that the introduction of betaine will increase the magnitude of viscosity difference in these formulas. Here again the difference in viscosity in Calamide<sup>®</sup> C formulas versus Calamide<sup>®</sup> MC formulas increases as the amount of betaine increases.

**Calfoam® ALS-30 Formulas**

	<b>Formula # 3</b>	<b>Formula # 4</b>	<b>Formula # 5</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® ALS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
<b>Calamide® C</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
<b>Caltaine® C-35</b>	<b>3.0</b>	<b>5.0</b>	<b>10.0</b>
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>23,000</b>	<b>37,000</b>	<b>108,000</b>

	<b>Formula # 3C</b>	<b>Formula # 4C</b>	<b>Formula # 5C</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® ALS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
<b>Calamide® MC</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>26,000</b>	<b>54,000</b>	<b>172,000</b>

A graphic representation of the above listed data is as follows:

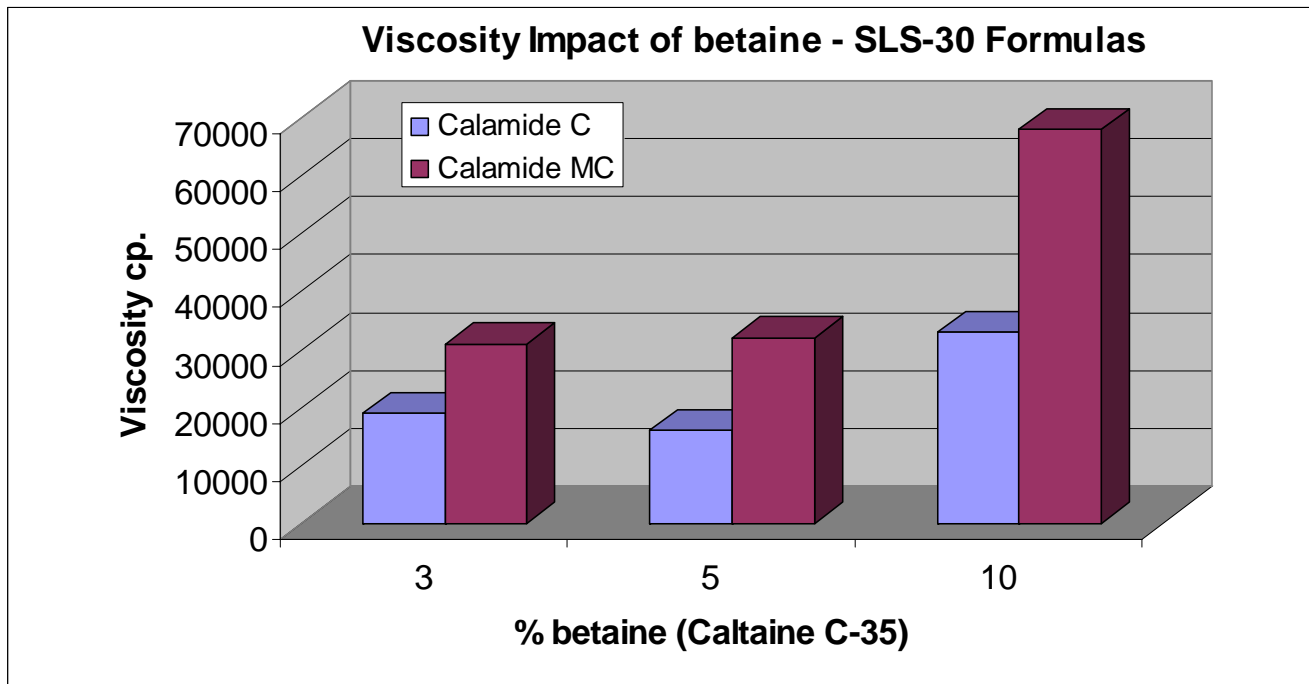


**Calfoam® SLS-30 Formulas**

	<b><u>Formula # 6</u></b>	<b><u>Formula # 7</u></b>	<b><u>Formula # 8</u></b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® SLS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
<b>Calamide® C</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>19,000</b>	<b>16,000</b>	<b>33,000</b>

	<b><u>Formula # 6C</u></b>	<b><u>Formula # 7C</u></b>	<b><u>Formula # 8C</u></b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
<b>Calfoam® SLS-30</b>	<b>33.3</b>	<b>33.3</b>	<b>33.3</b>
<b>Calamide® MC</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>31,000</b>	<b>32,000</b>	<b>68,000</b>

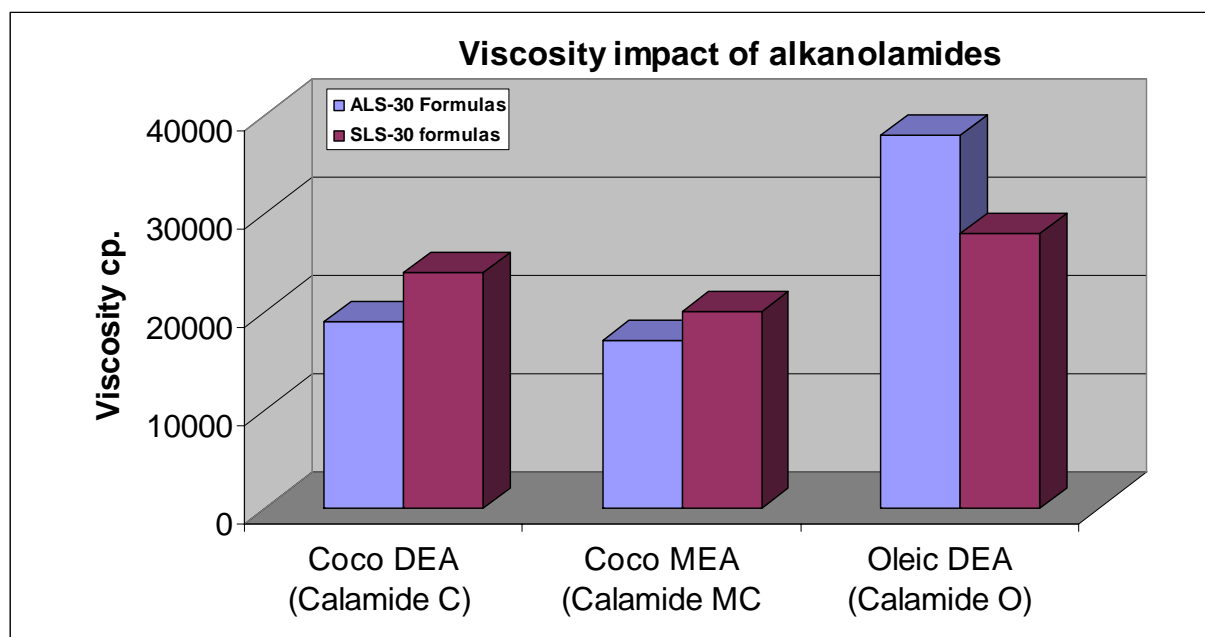
A graphic representation of the above listed data is as follows:



Lastly we used Calamide® F (INCI: Oleamide DEA) as the amide part of the formula to increase the viscosity of the system. Compared to Calamide® C or Calamide® MC, Calamide® F built the highest viscosities, generally speaking. A full comparison of the formulas based on all three amides is listed as follows.

<b>Formula #</b>	<b>1</b>	<b>2</b>	<b>1C</b>	<b>2C</b>	<b>1F</b>	<b>2F</b>
Water	to 100%	to 100%	to 100%	to 100%	to 100%	to 100%
Calfoam® ALS-30	33.3		33.3		33.3	
Calfoam® SLS-30		33.3		33.3		33.3
<b>Calamide® C</b>	<b>1.0</b>	<b>1.0</b>				
<b>Calamide® MC</b>			<b>1.0</b>	<b>1.0</b>		
<b>Calamide® F</b>					<b>1.0</b>	<b>1.0</b>
Sodium chloride	4.0	4.0	4.0	4.0	4.0	4.0
Citric acid	pH 5.5	pH 5.5	pH 5.5	pH 5.5	pH 5.5	pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>19,000</b>	<b>24,000</b>	<b>17,000</b>	<b>20,000</b>	<b>38,000</b>	<b>28,000</b>

A graphic representation of the data listed above is as follows:



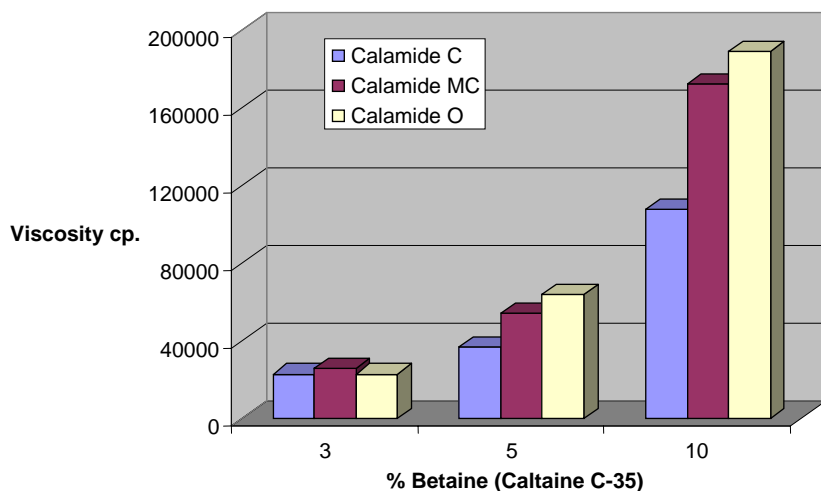
**Calfoam® ALS-30 Formulas**

	<b><u>Formula # 3</u></b>	<b><u>Formula # 4</u></b>	<b><u>Formula # 5</u></b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
Calfoam® ALS-30	33.3	33.3	33.3
<b>Calamide® C</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>23,000</b>	<b>37,000</b>	<b>108,000</b>

	<b><u>Formula # 3C</u></b>	<b><u>Formula # 4C</u></b>	<b><u>Formula # 5C</u></b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
Calfoam® ALS-30	33.3	33.3	33.3
<b>Calamide® MC</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>26,000</b>	<b>54,000</b>	<b>172,000</b>

	<b><u>Formula # 3F</u></b>	<b><u>Formula # 4F</u></b>	<b><u>Formula # 5F</u></b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
Calfoam® ALS-30	33.3	33.3	33.3
<b>Calamide® F</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>23,000</b>	<b>64,000</b>	<b>189,000</b>

### Viscosity response - % betaine and quality of alkanolamide



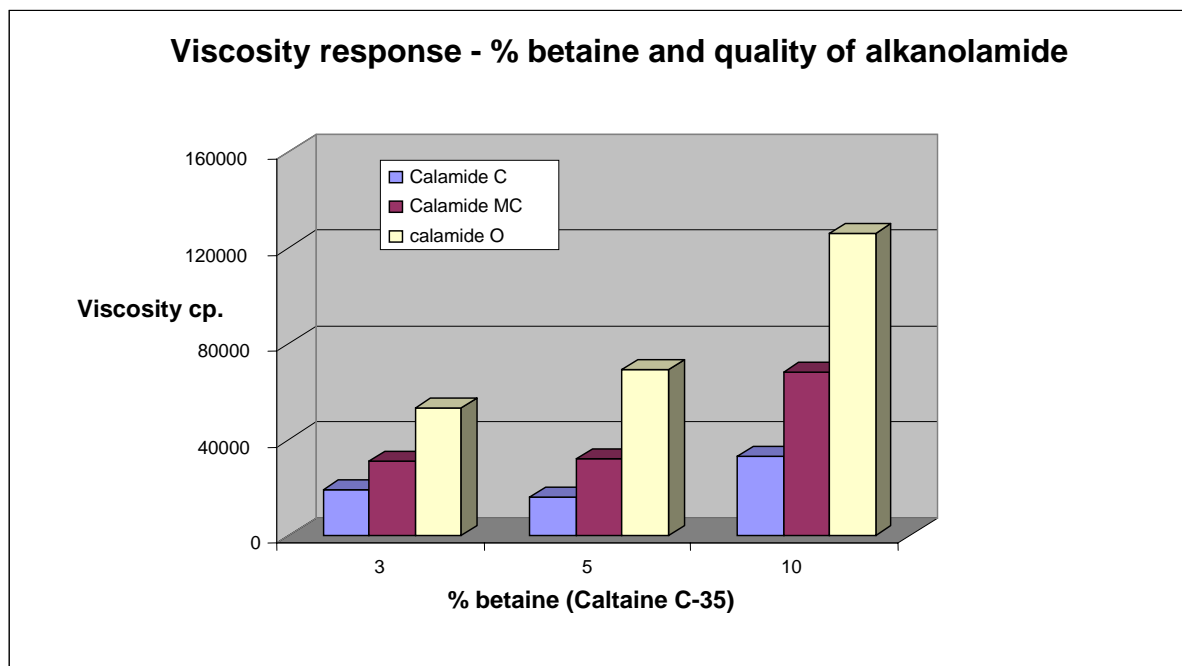
### Calfoam® SLS-30 Formulas

	<u>Formula # 6</u>	<u>Formula # 7</u>	<u>Formula # 8</u>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
Calfoam® SLS-30	33.3	33.3	33.3
<b>Calamide® C</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>19,000</b>	<b>16,000</b>	<b>33,000</b>

	<u>Formula # 6C</u>	<u>Formula # 7C</u>	<u>Formula # 8C</u>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
Calfoam® SLS-30	33.3	33.3	33.3
<b>Calamide® MC</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine® C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>31,000</b>	<b>32,000</b>	<b>68,000</b>

	<b>Formula # 6F</b>	<b>Formula # 7F</b>	<b>Formula # 8F</b>
Water	Q.S to 100%	Q.S to 100%	Q.S to 100%
Calfoam <sup>®</sup> SLS-30	33.3	33.3	33.3
<b>Calamide<sup>®</sup> F</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
Caltaine <sup>®</sup> C-35	3.0	5.0	10.0
Sodium chloride	3.0	2.0	1.0
Citric acid	to pH 5.5	to pH 5.5	to pH 5.5
Preservatives, dye, perfume	Q.S	Q.S	Q.S
<b>Viscosity cp.</b>	<b>53,000</b>	<b>69,000</b>	<b>126,000</b>

A graphic representation of the data is as follows:



### **Conclusions:**

- 10% active Calfoam<sup>®</sup> ALS-30 or SLS-30 (ammonium or sodium lauryl sulfate) can be thickened with 1% Calamide<sup>®</sup> C (cocamide DEA) and 4% salt to a viscosity of about 20,000 cp.
- Caltaine<sup>®</sup> C-35 (cocamidopropyl betaine) can be incorporated in SLS/ALS – amide – salt systems for further increase in viscosity. The system viscosity can be increased with 3-5% of Caltaine<sup>®</sup> C-35. Very high viscosities, up to 100,000 cp. can be achieved by using about 10% Caltaine<sup>®</sup> C-35. Calfoam<sup>®</sup> ALS-30 based formulas generally give higher viscosities than Calfoam<sup>®</sup> SLS-30 based formulas.
- Calfoam<sup>®</sup> ALS-30 based systems have different salt – viscosity curves than Calfoam<sup>®</sup> SLS-30 based systems. The two systems are also different in peak viscosity salt requirements. Salt requirement for maximum viscosity also depends on the amount of alkanolamide present in the system, among other factors. Generally speaking, as we increase the amount of alkanolamide (keeping ALS/SLS & betaine constant) the requirement for the amount of salt to get the maximum viscosity decreases.

4. Calamide<sup>®</sup> C (Cocamide DEA) & Calamide<sup>®</sup> MC (cocamide MEA), without any Caltaine<sup>®</sup> C-35, produce somewhat similar viscosities in both Calfoam<sup>®</sup> ALS-30 and SLS-30 based systems. With Caltaine<sup>®</sup> C-35, Calamide<sup>®</sup> MC gives much higher viscosities than Calamide<sup>®</sup> C. This difference in viscosity (Calamide<sup>®</sup> C VS. Calamide<sup>®</sup> MC) increases as the amount of Caltaine<sup>®</sup> C-35 increases from 3 to 5 to 10% levels. Calfoam<sup>®</sup> ALS-30 based systems gives considerably higher viscosities than Calfoam<sup>®</sup> SLS-30 based systems.
5. Calamide<sup>®</sup> F (Oleamide DEA) produces significantly higher viscosities than Calamide<sup>®</sup> C or Calamide<sup>®</sup> MC.

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### **About the Author**

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