

THE HLB SYSTEM

A TIME SAVING GUIDE TO SURFACTANT SELECTION

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uniqema

WHAT DO WE MEAN BY SURFACTANT *SELECTION*



- First - selecting between the available chemical types
 - anionic,
 - Negative charge
 - cationic,
 - Positive charge
 - amphoteric
 - Charge depends on pH
 - Nonionic
 - No charge

WHAT DO WE MEAN BY SURFACTANT *SELECTION*



- Second – once having selected the chemical family
 - You must select a surfactant or surfactant pair with the correct solubility for your unique application

WHAT DO WE MEAN BY SURFACTANT *SELECTION*



- How does surfactant solubility affect performance ?
 - For example (very general rules)
 - You need high water solubility for cleansing and detergency
 - You need medium solubility for spreading and dispersion
 - You need low solubility for invert emulsions and coupling immiscible oils
 - You need a blend of solubilities for O/W emulsions

WHAT DO WE MEAN BY SURFACTANT *SELECTION*



- Is there a way to predict surfactant solubility by merely looking at its chemistry?
 - Yes (for the most part)
 - Almost all “soaps” have medium to high solubility in water & low solubility in oils/fats
 - Almost all anionics such as S.L.S. are highly water soluble & low solubility in oil/fats
 - Almost all cationics and amphotrics are highly water soluble
 - Nonionics’ water solubility can be predicted by their HLB

What do we mean by “HLB”



- All surfactants must have an oil loving portion and a water loving portion or they would not have surface activity
- The ratio of the oil loving portion to the water loving portion is what we call its balance
- We measure this balance based on molecular weight
- “HLB” stands for
 - **H**YDROPHILE / **L**IPOPHILE / **B**ALANCE

What is the HLB “system” story



- The “system” was created as a tool to make it easier to use nonionic surfactants
- In general it applies to nonionic surfactants only
- The basic principle of the system is:
 - Surfactants have an HLB value
 - Applications for surfactants have an HLB requirement
 - Matching the requirement with the value saves time and **money**

What are the common ways of surfactant selection?



- Try what has worked in the past
- ask a co-worker
- use your instinct
- try everything
 - there are thousands available
- **The HLB System**

Why use the HLB System



- It tells us something about the chemistry of the surfactant
- when you know about the chemistry of the surfactant you can predict how it will behave
- being able to predict how a surfactant will behave will save you time (\$\$\$\$\$)

Short background of the HLB System



- It was invented 55 years ago by **William C. Griffin** of the Atlas Powder Company (bought by ICI in 1971)
- The letters HLB stand for
 - **H**ydrophile **L**ipophile **B**alance
- It was / is intended as a large scale road map to good emulsification performance
- It was invented for use with **NONIONIC** surfactants in particular

What is the chemistry of a nonionic surfactant ?



- Each surfactant has a hydrophilic group and a lipophilic group
 - *must have both or it would not be surface active*
- the hydrophilic group is usually a polyhydric* alcohol or ethylene oxide
- the lipophilic group is usually a fatty acid or a fatty alcohol
 - * polyhydric- an alcohol with OH's attached

What is the chemistry - cont.



- The relationship (or balance) between the hydrophilic portion of the nonionic surfactant to the lipophilic portion is what we call

HLB

- All nonionic surfactants have an HLB *Value*

What is the HLB “*system*” ?



- Nonionic surfactants have an HLB “value”
- applications for surfactants have an HLB “requirement”
- matching the HLB “value” of your surfactant with the application “requirement” will give good performance
- it is that simple

How do we determine the HLB “value” of a surfactant ?



- We calculate the water loving portion of the surfactant on a *molecular weight basis* and then divide that number by 5
- this keeps the **HLB** scale smaller and more manageable
 - the working scale is from 0.5 to 19.5
- this number is then assigned to the nonionic surfactant

Here is an example of an HLB value calculation



- our product BRIJ ® 98 INCI name : oleth-20 is a 20 mole ethoxylate of oleyl alcohol
- we calculate the molecular weight of the 20 moles of ethylene oxide (one mole ETO =44)
 - $20 \times 44 = 880$
- we add this number to the molecular weight of the oleyl alcohol
 - $880 + 270 = 1150$ (the mol. wt of BRIJ 98)
- What percentage of 1150 is 880 ?
 - $880/1150 = 76.5\%$
- 76.5% divided by 5 = 15.3
- 15.3 is the HLB value of BRIJ 98



Important to remember !

- The **HLB** value is an indication of the solubility of the surfactant
- the lower the **HLB** value the more lipophilic or oil soluble the surfactant is
- the higher the **HLB** value the more water soluble or hydrophilic the surfactant is
- this surfactant solubility property is an indicator of its likely end use



Important to remember, cont.

- **HLB values are calculated for nonionic surfactants only**
- the **HLB** value is the molecular weight percent of the water loving portion of the nonionic surfactant - divided by five
- What does it mean when you hear of an anionic with an “HLB” for 40 or so?
 - This number is a relative or comparative number and not a mathematical calculation

Examples of matching **HLB** values to application needs



- mixing unlike oils together
 - use surfactants with HLB's of 1 to 3
- making water-in-oil emulsions
 - use surfactants with HLB's of 4 to 6
- wetting powders into oils
 - use surfactants with HLB's of 7 to 9
- making self emulsifying oils
 - use surfactants with HLB's of 7 to 10
- making oil-in-water emulsions
 - use surfactant blends with HLB's of 8 to 16
- making detergent solutions
 - use surfactants with HLB's of 13 to 15
- for solubilizing oils (micro-emulsifying) into water
 - use surfactant blends with HLB's of 13 to 18

What is a *required* HLB as opposed to an *HLB value* ?



- Each lipophilic ingredient used in O/W emulsions has what we call a “required” HLB
- these “required” HLB’s have been determined by a simple experiment
- a list of these “required” HLB’s is available from us
 - see our HLB Booklet

Another way to think of “required” HLB



- The HLB value of the surfactant that provides the lowest interfacial tension between
 - Your unique oil phase
 - AND
 - Your unique water phase
- Is your “required” HLB

Some general required HLB rules for O/W emulsions



Class	Required HLB
Vegetable oil family	6
Silicone oils	8-12
Petroleum oils	10
Typical ester emollients	12
Fatty acids and Alcohols	14-15

How do we determine the “required” **HLB** of a lipophilic ingredient?



- We run a simple practical test
 - eight small experiments
- Materials need for this test:
 - an **HLB** “kit”
 - about 200 grams of your oil
 - eight small jars
 - the instructions
 - and a little bit of time

What is an **HLB** “kit” ?



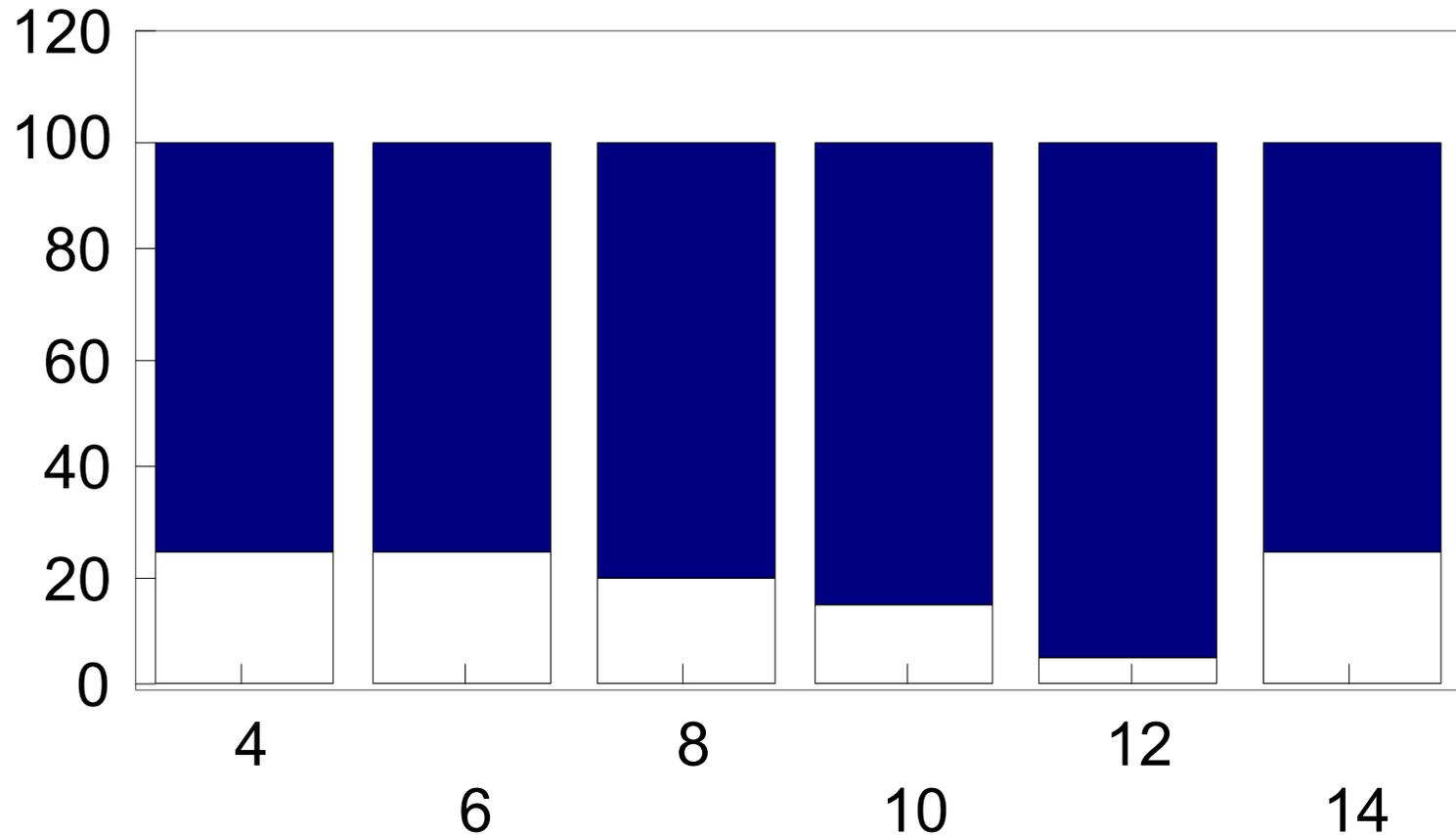
- A series of jars of nonionic surfactant blends
 - HLB 2 8% **SPAN®80** / 92% **SPAN 85**
 - HLB 4 88% **SPAN80** / 12% **SPAN 85**
 - HLB 6 83% **SPAN 80** / 17% **TWEEN® 80**
 - HLB 8 65% **SPAN 80** / 35% **TWEEN 80**
 - HLB 10 46% **SPAN 80** / 54% **TWEEN 80**
 - HLB 12 28% **SPAN 80** / 72% **TWEEN 80**
 - HLB 14 9% **SPAN 80** / 91% **TWEEN 80**
 - HLB 16 60% **TWEEN 20** / 40% **TWEEN 80**

How do we run the practical test to determine a required HLB



- We prepare eight simple emulsions
 - each with the same amount of oil
 - each with the same amount of surfactant but with a different HLB value
 - each with the same amount of water and mixing
- we observe which emulsion appears to be the most stable
 - *stable* - meaning here the one least separated or the one that separates last
- the HLB value of the surfactant used in *this* emulsion is the HLB requirement for that particular oil phase

Separation curves will look something like this



How is knowing the required HLB useful for a formulator



- One you know the required HLB of individual oils it is easy to mathematically calculate the required HLB of a mixture of oils
- knowing the required HLB of an oil or an oil mixture means that you can use the least amount of surfactant to achieve emulsification

Directions for using the HLB system to select surfactants for an O/W emulsion



- Look at your formula
- determine which are the oil soluble ingredients
 - *this does not include the emulsifiers*
- weigh each of the weight percents of the oil phase ingredients together and divide each by the total
- multiply these answers times the required HLB of the individual oils
- add these together to get the required HLB of your unique blend



For example

- A simple O/W lotion formula
 - mineral oil 8 %
 - caprylic/capric triglyceride 2 %
 - isopropyl isostearate 2 %
 - cetyl alcohol 4 %
 - emulsifiers 4 %
 - polyols 5 %
 - water soluble active 1 %
 - water 74 %
 - perfume q.s.
 - preservative q.s.

Calculations: add up the oil phase ingredients



– mineral oil	8 %
– caprylic/capric triglyceride	2 %
– isopropyl isostearate	2 %
– cetyl alcohol	<u>4 %</u>
»	16
– emulsifiers	4 %
– polyols	5 %
– water soluble active	1 %
– water	74 %
– perfume	q.s.
– preservative	q.s.

Calculations:

divide each by the total to get the contribution to the oil phase



- Mineral oil $8 / 16 = 50\%$
- caprylic/cap. trig. $2 / 16 = 12.5\%$
- isopropyl isostearate $2 / 16 = 12.5\%$
- cetyl alcohol $4 / 16 = 25\%$

Calculations for HLB of this unique blend



Oil phase ingredient	contribution	X required HLB of ingredient	equals
Mineral oil	50.0%	10.5	5.250
Caprylic cap. Trig.	12.5%	5	0.625
Isopropyl isostearate	12.5%	11.5	1.437
Cetyl alcohol	25.0%	15.5	3.875
		Total	11.2

How do we use this information to our advantage?



- We know that as a starting point we should select a surfactant system with an HLB value of ~11.2
- For the surfactant system we recommend that you use a blend of at least two surfactants
 - reason
 - experience has shown the benefit
 - mixtures of a low HLB and a high HLB surfactant give better coverage at the interface
 - a blend of two surfactants is typical

How do we use this information to our advantage? (Cont.)



- The correct HLB value usually translates to superior stability at a lower use level. For example:
 - our unique formula with a surfactant blend at **HLB 11.2** at a 4% use level will most likely give longer stability at elevated temperatures than 5% of a blend at either **HLB 10.2 or 13.2**

Surfactant choice considerations:



- **Chemical type**
 - ester VS ether
 - lipophilic group, e.g. lauryl VS stearyl
- **Physical form**
 - liquid VS solid VS beads
- **FDA “status” (if any)**
 - is there an N. F. monograph
- **Price VS function**
- **Blend VS single surfactant**
- **Efficiency of the surfactant**

A very general recommendation for o/w emulsions



- For topical O/W emulsions (the most common type) we recommend:
 - **nonionics based on stearyl alcohol or stearic acid**
 - the high molecular weight and high melting point of the C-16/18 portion gives superior anchoring in the dispersed oil droplets
 - blends of steareth-2 with steareth-21 are the most useful (in our opinion)
 - these are low and high HLB stearyl alcohol ethoxylates

For Example :

ethoxylated fatty alcohol at HLB 15



Fatty alcohol	Hydrophilic mol. Wt.	Lipophilic mol. Wt.	Total mol. wt.
STEARYL	811	270	1081
OLEYL	805	268	1074
CETYL	726	243	969
LAURYL / DODECYL	559	186	745

How do we calculate HLB value of a surfactant blend ?



- Simple arithmetic, for example:
 - a 50 / 50 blend of steareth-2 and steareth-21
 - **50% times the HLB value of the steareth-2**
 - $0.5 \times 4.9 = 2.45$
 - **50% times the HLB value of the steareth-21**
 - $0.5 \times 15.5 = 7.75$
 - $2.45 + 7.75 = 10.2$



Summary

- HLB is a number system that lets you know how oils and surfactants will likely interact
- Surfactants have an HLB value
 - the higher the number the more hydrophilic
 - the lower the number the more lipophilic
- Oils and applications have an HLB requirement
- Matching the HLB value with the requirement will give good performance
- It is not rocket science
 - ***just a very useful time saving general guide***

How to get in touch with me

(as of March 2004)



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