The HLB System

Systematic method for selecting the most effective nonionic emulsifier(s) for any given application

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HLB System Outline

- System history
- HLB definition
- Surfactant structures
- Emulsion types and phenomena
- Three-step surfactant selection method
- HLB requirement determination
- System flexibility
- Summary

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History of the HLB System

The letters HLB stand for

Hydrophile	**Lipophile**	**Balance**
(water compat)	**(oil compat)**	**(Ratio)**

A system invented 54 years ago by
William C. Griffin of the Atlas Powder Company

It was developed for use with NONIONIC surfactants

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HLB System Definition

All nonionic surfactants have an ***HLB Value***

- the higher the number, the more hydrophilic (water soluble)
- the lower the number, the more lipophilic (oil soluble)

Emulsion oils and emulsion applications have specific

HLB Requirements

Matching the ***HLB requirement*** with a surfactant's ***HLB value*** yields optimum performance

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HLB Values of Blended Components

The HLB value of a surfactant blend is the weighted average of the HLBs of the blended surfactants

(ie 50 / 50 blend of HLB 4 w/ HLB 16 = HLB 10)

The HLB requirement of an oil blend is the weighted average of the HLB requirements of the blended components

(ie 50 / 50 blend of Req 10 oil w/ Req 14 ester = Req 12)

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Emulsion Types

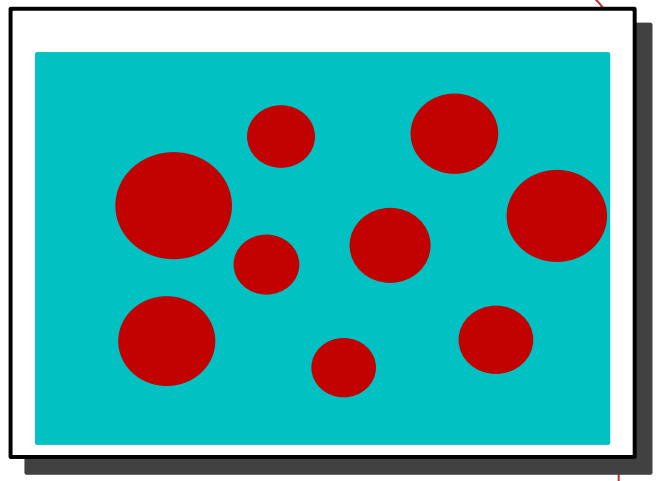
Emulsions are classified as:

oil-in-water (o/w)

the continuous phase is water

dispersed oil droplets

med / high HLB requirement



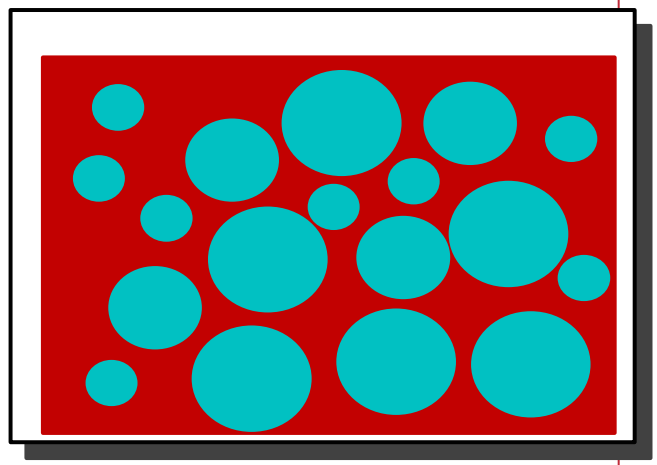
Milk

water-in-oil (w/o) invert

the continuous phase is oil

dispersed water droplets

low HLB requirement



Hand Cream

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How HLB Values of Nonionic Surfactants are Determined

The molecular weight percent Hydrophile (PEG, polyols) of a given nonionic surfactant is simply divided by 5

This yields an HLB range of 1 to 20

mol wt PEG = 600

mol wt lipophile= 400

600 / 1000

60% Hydrophile

60 / 5 = <u>HLB 12</u>

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Examples of matching HLB values to application requirements

- Compatibilizing dissimilar oils
  - Use surfactants with HLB's of 1 to 3
- Formulating water-in-oil emulsions
  - Use surfactants with HLB's 4 to 6
- Wetting powders into oils
  - Use surfactants with HLB's of 7 to 9
- Formulating oil-in-water emulsions
  - Use surfactant blends with HLB's of 8 to12
- Formulating detergent solutions
  - Use surfactants with HLB's of 13 to 15

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The Three-Step System

1) Determine the HLB Requirement of oil
2) Determine the most effective surfactants
3) Determine surfactant concentration required to achieve desired stability / rheology

Required HLB's are accurate to + / - 0.5 HLB units

Reduce black-art dependency

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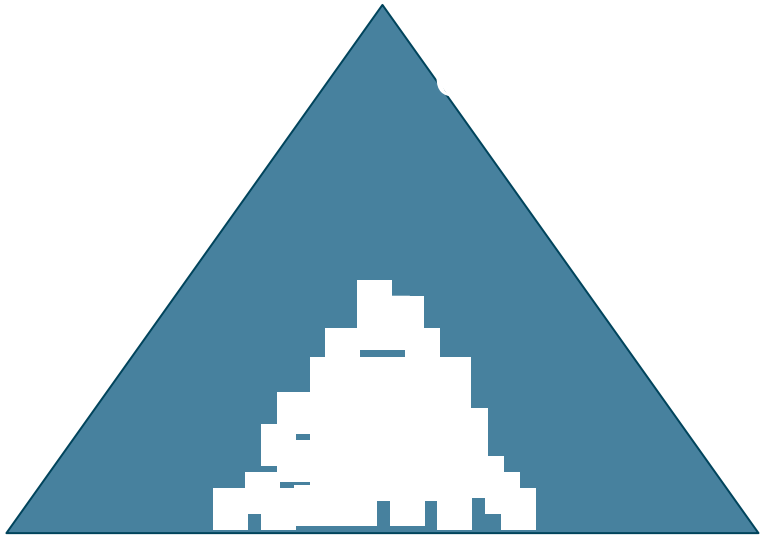
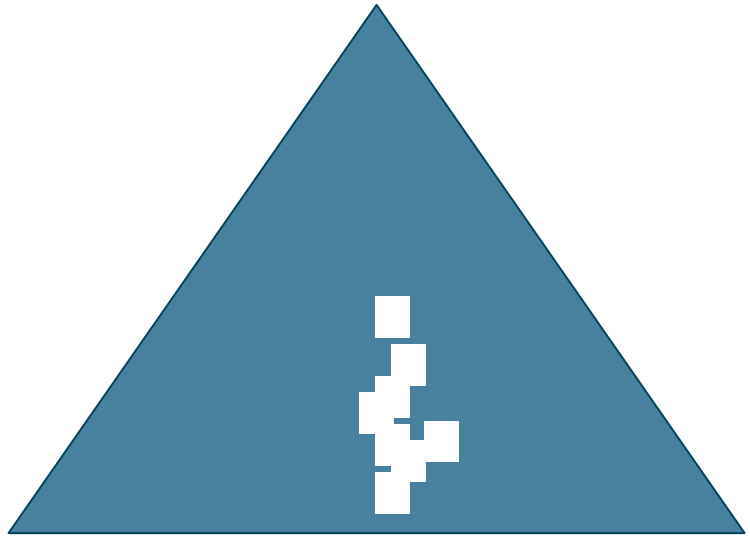
+/- .5 Unit HLB Accuracy
Invert Emulsion Experiment

HLB **6** Surfactant



4% surfactant

HLB **5** Surfactant



9% surfactant

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Typical HLB Requirements for Oils

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

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Determination of HLB Requirement

HLB	Span 80	Tween 80
4	100 %	
6	83 %	17 %
8	65 %	35 %
10	46 %	54 %
12	28 %	72 %
14	9 %	91 %
15		100 %

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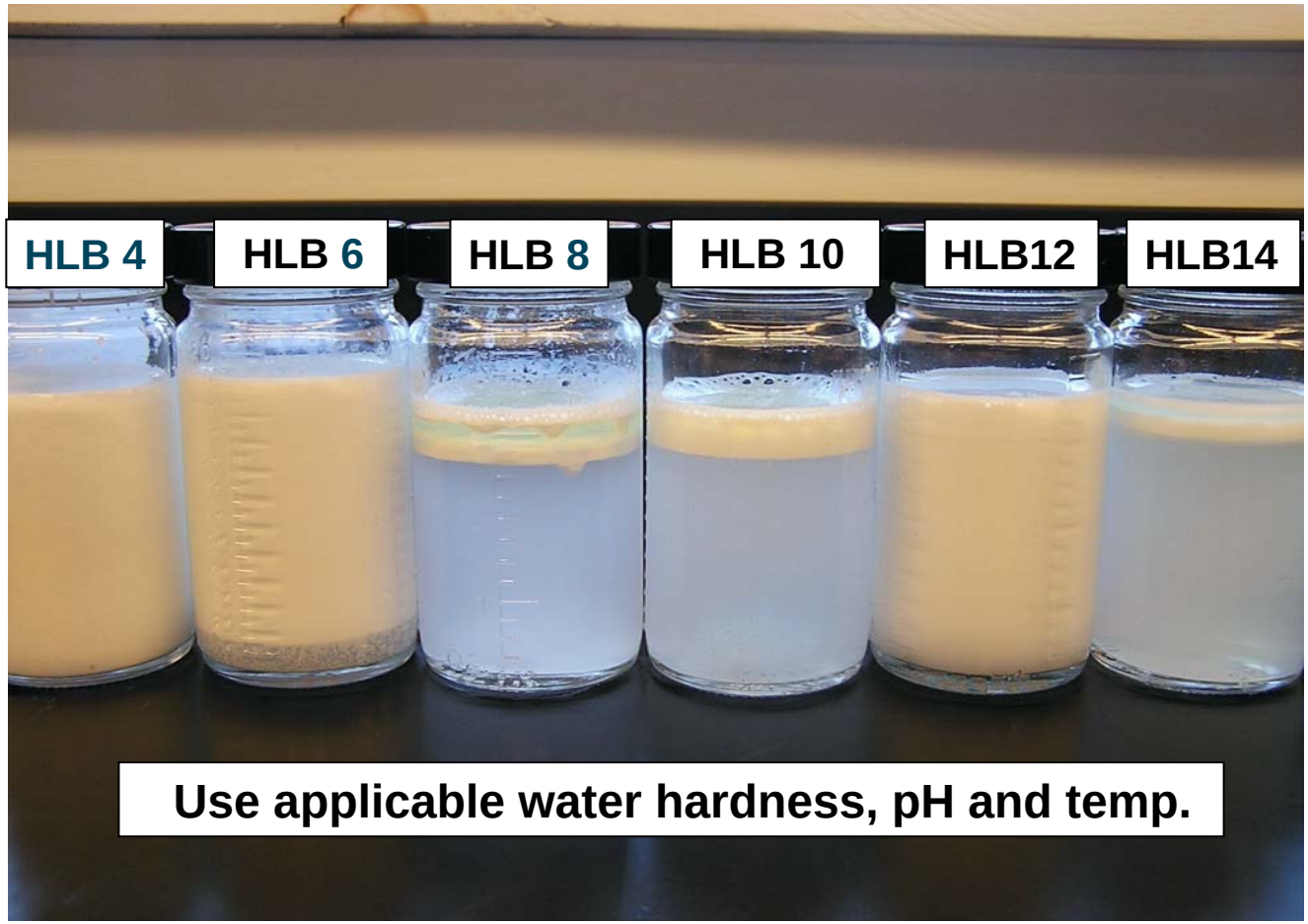
Step 1 - Determine the Required HLB



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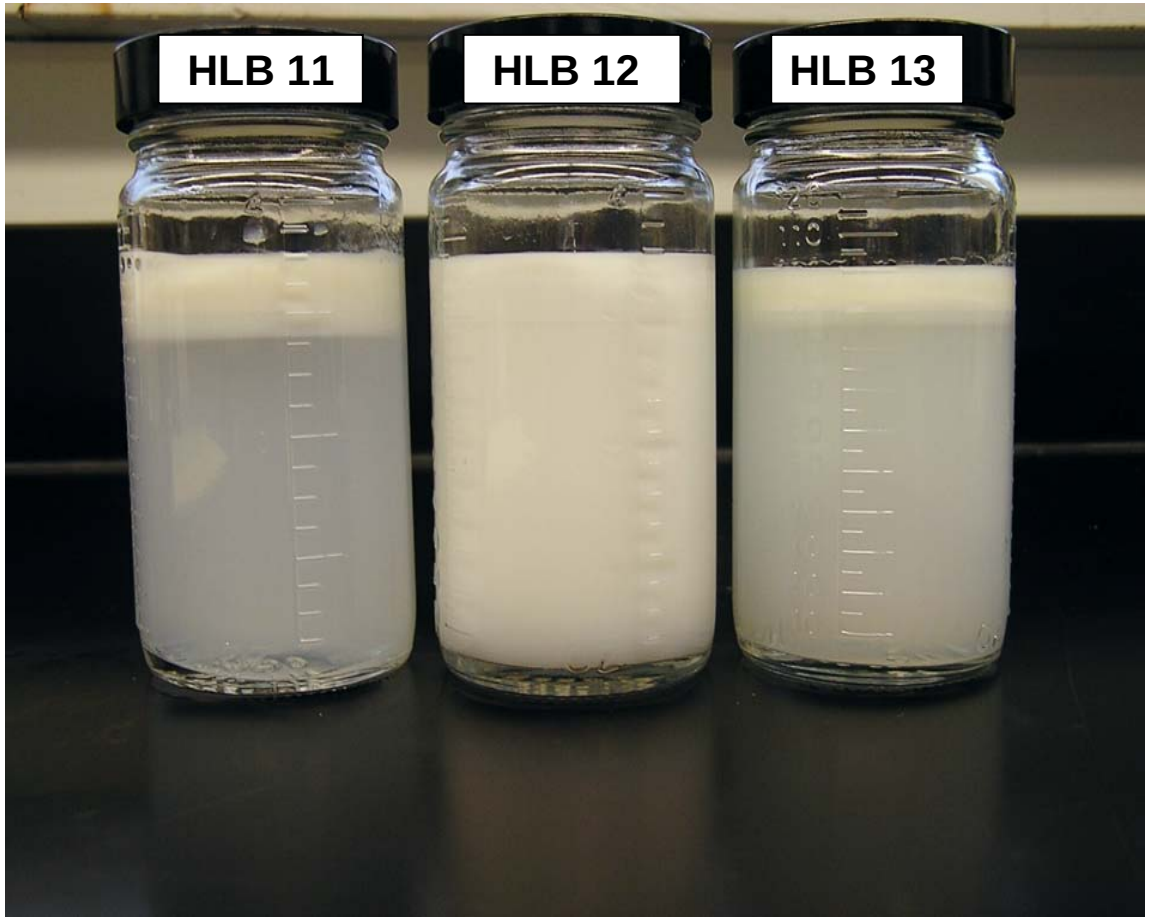
Step 1 - Determine the Required HLB



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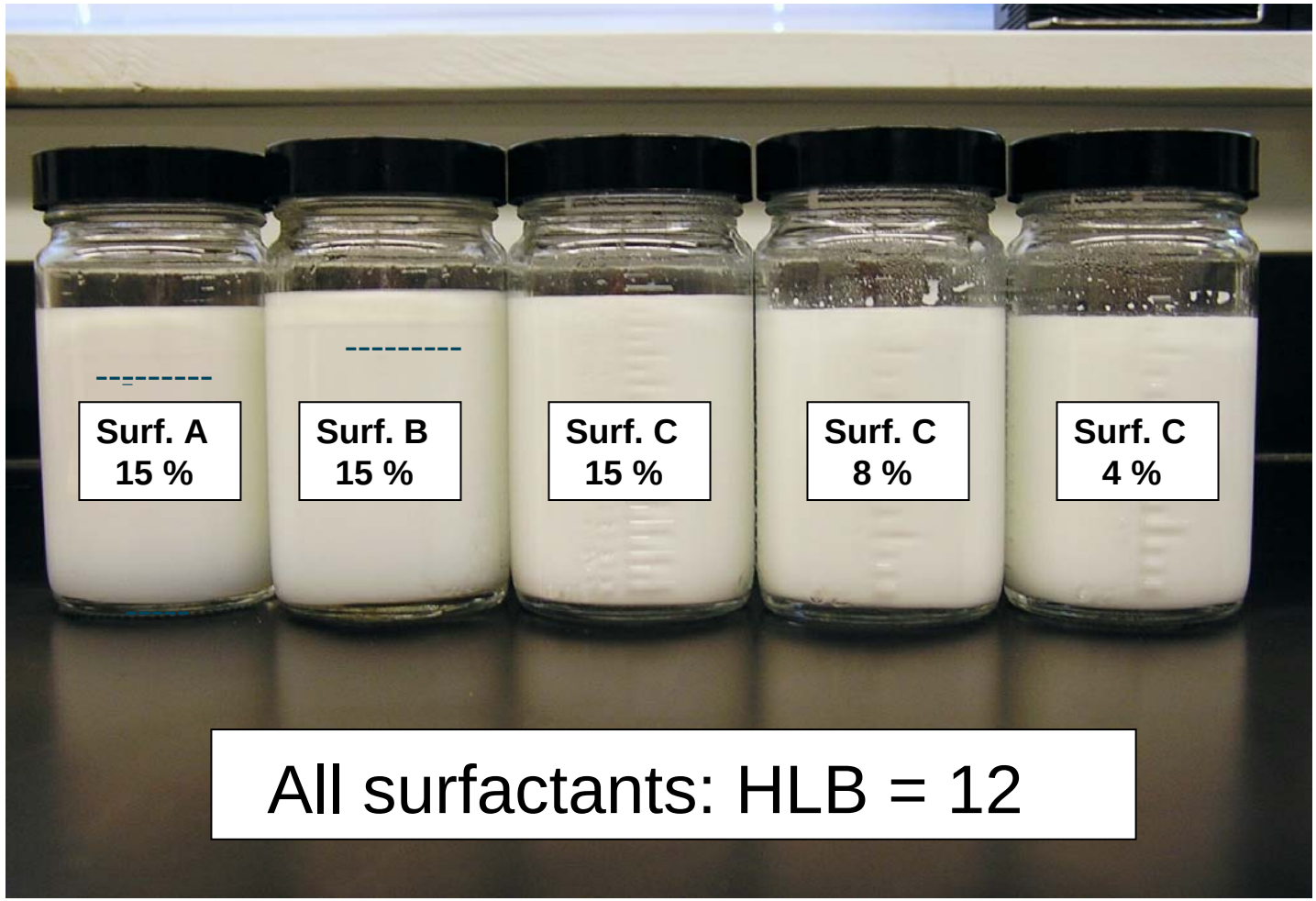
Steps 2 and 3
Select the chemistry….Determine the conc.



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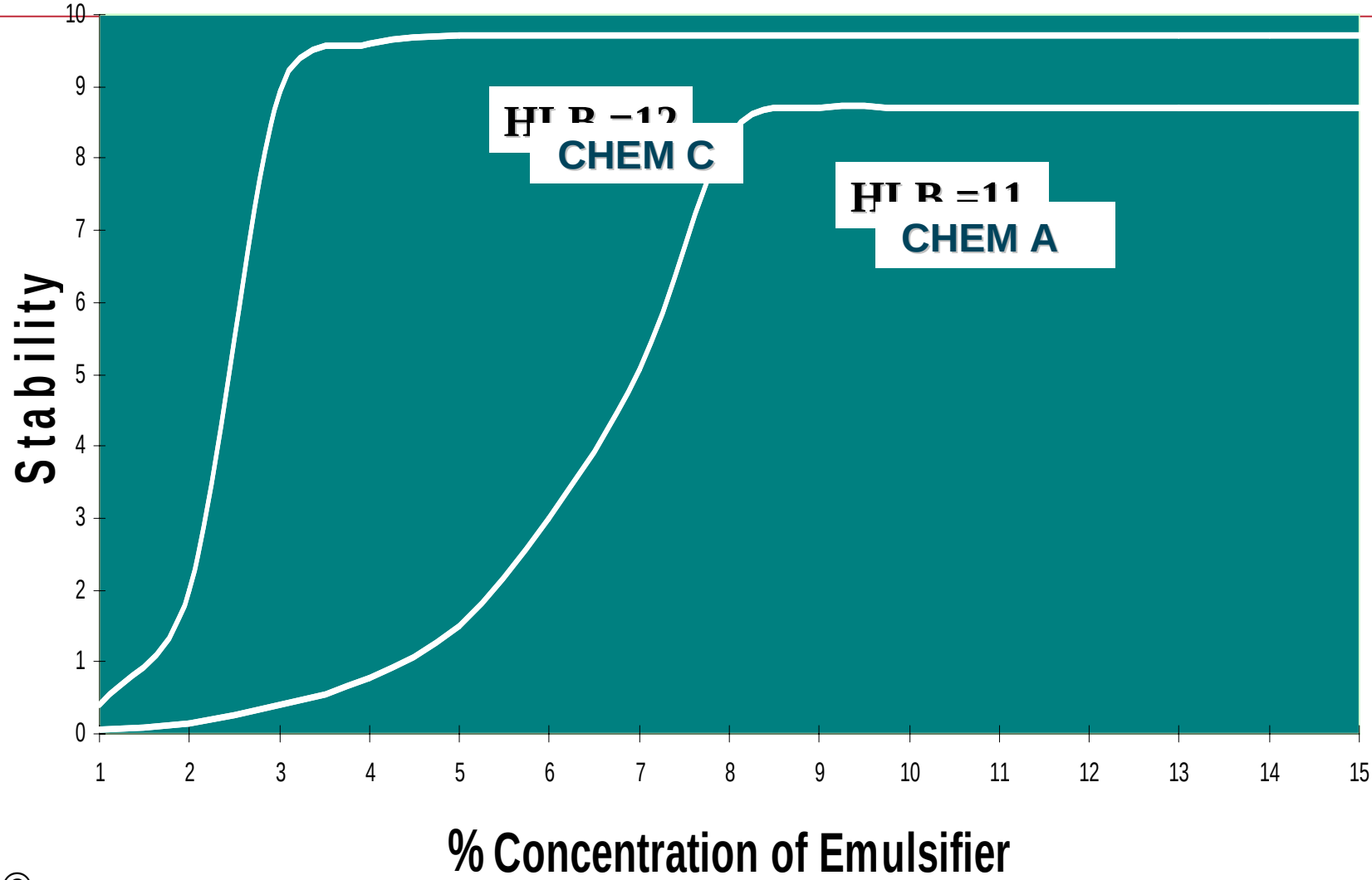
How Stability of Your Emulsion Is Affected by HLB and Concentration of Emulsifier



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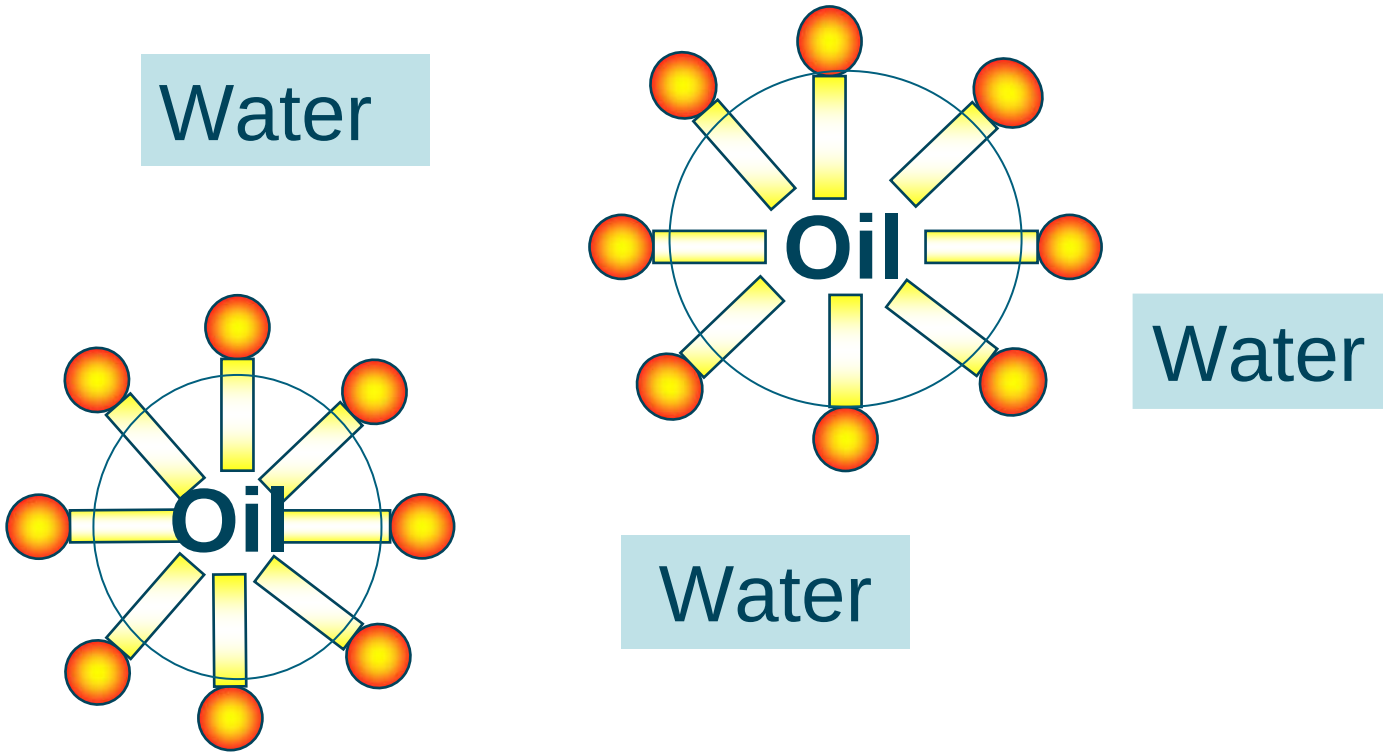
Rule of thumb……



Surfactant "wide blends" are generally more effective than using a single surfactant

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A Personal Experience

a.m.

Taking a “shortcut”

>>>>>>> 3 hours of ***100% failure***

<u>Lunch time contemplation</u>

p.m.

HLB System to the rescue

>>>>> 1 hour ***100% success***

Incomplete information

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Complete System Flexibility

Tech Service Story

Any number of components can be added to the oil
before the HLB requirement is determined

ie corrosion inhibitors
biocide package
anionic emulsifiers
lubricity / EP adds

Formulation "Surfactant Pivot Pair"

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Anionic HLB Values

Apparent anionic HLB values

When used in combination with nonionics, they behave as if……..

TEA Oleate	HLB 12
Na Oleate	HLB 18
K Oleate	HLB 20
Sulfonates	HLB 4 to 7

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HLB / Water Dispersibility Relationships

HLB 1- 4	No dispersibility
HLB 3 - 6	Poor dispersibility
HLB 6 - 8	Milky after shake
HLB 8 - 10	Stable milky dispersion
HLB 10 - 13	Translucent to clear
HLB 13+	Clear solution

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Summary

HLB System predicts how oils and surfactants will likely interact

Surfactants have HLB values

- the higher the number - the more hydrophilic
- the lower the number - the more lipophilic

Required HLB's are accurate to + / - 0.5 HLB units !!

Oils and applications have HLB requirements

Matching the surfactant HLB value with the HLB requirement will yield ***optimum performance / cost***

Two opportunities to optimize performance / cost

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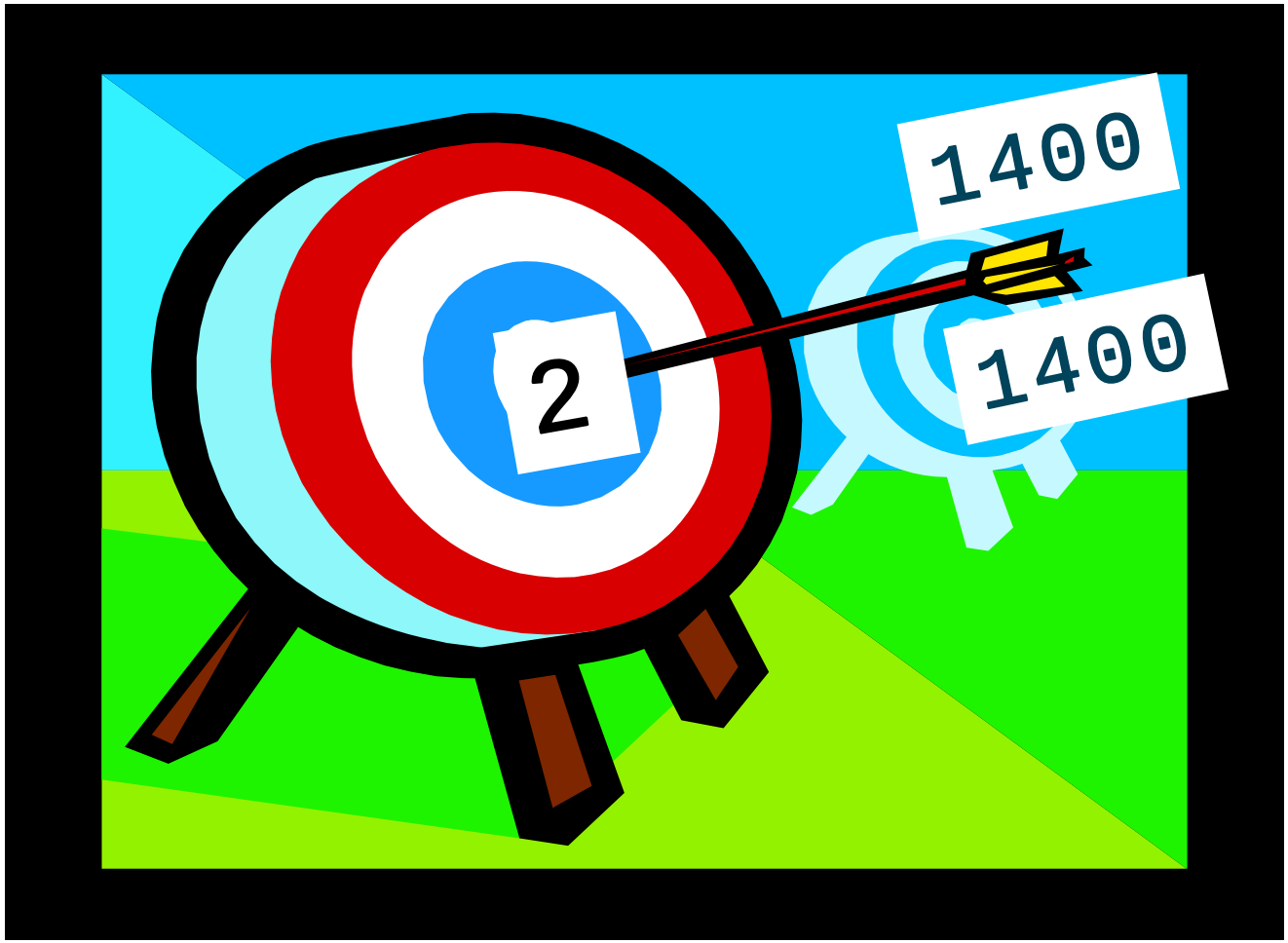
Improve Your Accuracy



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"We're disappointed by the lack of science behind the HLB System, we just use it because it works."

- **Tech Director, major consumer products company**

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Experimental Design
to Achieve Final HLB Balance

Base Components:

Mineral oil
Sulfonate - Mid MW
Sulfonate - Hi MW
K - TOFA – Hi rosin
HLB Balance (8 /12%)
Amine
Coupling agent

HLB Req. ??

Sulfonates (low HLB)

1
2 3
4 5 6
7 8 9 10
11 12 13 14 15
16 17 18 19 20 21
22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37
38 39
47 48 49 50 51 52 53 54 55 56
57 58 59 60 61 62 63 64 65 66
67

>>>> Result: Perfect HLB
>>>> balance established

K-TOFA (high HLB)

Aux Emulsifier (HLB?)

Prospect Points = **13, 16, 21, 33, 40, 44, 62**

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