Determination of Hydrophilic-Lipophilic Balance Value

Ashish Gadhave

Institute of Chemical Technology, Nathalal Parekh Road, Matunga East, Mumbai-400081, Maharashtra, India

Abstract: ***A wide variety of surfactants are available in market therefore one must need to choose suitable surfactant to give maximum effect to final product. Hydrophilic-lipophilic balance (HLB) system enables to choose proper surfactant with ease. Therefore, study of HLB system is very important. This paper reviews the importance of HLB system and methods of calculating it. Further, it also provides the distinction of surfactants application based on their HLB values. This paper would be useful to get easy access to calculations of HLB and would act as a time-saving guide to surfactant selection.***

Keywords: Water, Oil, Surfactants, Hydrophilicity, Lipophilicity

1. Introduction

In past fifty years, there has been a tremendous growth in the field of surfactants. The term surfactants include emulsifiers, wetting agents, suspending agents, detergents, anti-foam compounds and many others [1-5]. Therefore, there classification is very important to choose suitable surfactant to give maximum effect. There has been division according to their ionization, chemical type, by popular (often ambiguous) nomenclature and their behaviour and solubility in water. Among all these classification, the solubility and behaviour based classification is more prominent and widely acceptable throughout the world which is nothing but HLB system.

William Griffin, in the late 1940s, introduced the **H**ydrophilic-**L**ipophilic **B**alance system (**HLB**) as a way of figuring out which emulsifier would work best with the oil phase of an emulsified product [6, 7]. All emulsifiers have a hydrophilic head (water loving) that is generally composed of a water soluble functional group and a lipophilic tail (oil loving) generally composed of a fatty acid or fatty alcohol. The proportion between the weight percentages of these two groups in a surfactant molecule is an indication of the behaviour that may be expected from that product. An emulsifier that is lipophilic in character is assigned a low HLB number and an emulsifier that is hydrophilic in character is assigned a high number. The midpoint is approximately ten and the assigned values have ranged from one to forty.

The theory behind HLB is that emulsifier having low HLB value tend to be oil soluble and materials having high values tend to be water soluble. However, this doesn't always be right, e.g., two emulsifiers may have the same HLB and exhibit different solubility characteristics. Further, one should take a point into consideration that chemical type alone doesn't establish hydrophilic-lipophilic balance. Thus, soaps may range from strongly hydrophilic for sodium laurate to strongly lipophilic for aluminium oleate; esters, ether-esters, and ethers may range from low to high HLB's, sulphates and sulfonates may range from medium to high.

2. Determination of HLB

2.1. Determination of HLB by Calculation

Calculation of HLB value of surfactant is very important in product quality and yield points of view. HLB values can be calculated theoretically or may be determined by experimentally. The experimental method is very long and laborious and was described long back ago by William Griffin in 1949. Formulas for calculating HLB values may be based on either analytical or composition data. For most polyhydric alcohol fatty acid esters approximate values may be calculated with the formula:

$$\text{HLB}= 20\left(1-\frac{S}{A}\right) \qquad (1)$$

Where,
S= saponification number of the ester
A= acid number of the acid

Examples:
i) Atmul 67® glyceryl monostearate (soap free)
S= saponification number, 161
A= acid number of fatty acid, 198

$$\text{HLB}= 20\left(1-\frac{161}{198}\right)= 3.8$$

ii) Tween 20®, polyoxyethylene sorbitan monolaurate *S*= saponification number, 45.5 (mid-point)
A= acid number of fatty acid, 276

$$\text{HLB}= 20\left(1-\frac{45.5}{276}\right)= 16.7$$

Many fatty acid esters do not give good saponification data; for example, tall oil and rosin esters, beeswax esters, lanolin esters. For these a calculation may be based on the formula:

$$\text{HLB}= \frac{E+P}{5} \qquad (2)$$

Where,
E= weight percentage of oxyethylene content
P= weight percentage of polyhydric alcohol content (glycerol, sorbitol)

Example: Atlas G-1441; polyoxyethylene sorbitol lanolin derivative

E= weight percentage of oxyethylene content, 65.1

P= weight percentage of polyhydric alcohol content, 6.7

$$\text{HLB}=\frac{65.1+6.7}{5}=14$$

These formulas are satisfactory for non-ionic surfactants of many types. However, non-ionic surfactants containing propylene oxide, butylene oxide exhibit behaviour which has not been related to composition. In addition, the HLB values of ionic surfactants do not follow a weight percentage basis because even though the hydrophilic portion is low molecular weight the fact that its ionization lends extra emphasis to that portion and therefore makes the product more hydrophilic. For these products, the experimental method must be used. HLB values of some of the surfactants are given in table 1.

Table 1: Calculated HLB values

Name	*Chemical Designation*	*Type*	*HLB Value*
Span 85	Sorbitan trioleate	Nonionic	1.8
Atlas G-1706	Polyoxyethylene sorbitol beeswax derivative	Nonionic	2
Emcol PO-50	Propylene glycol fatty acid ester	Nonionic	3.4
Span 60	Sorbitan monostearate	Nonionic	4.7
Span 40	Sorbitan monopalmitate	Nonionic	6.7
Atlas G-2800	Polyoxypropylene mannitol dioleate	Nonionic	8
Span 20	Sorbitan Monolaurate	Nonionic	8.6
Brij 30	Polyoxyethylene lauryl ether	Nonionic	9.6
Tween 85	Polyoxyethylene sorbitan trioleate	Nonionic	11
Atlas G-2133	Polyoxyethylene lauryl ether	Nonionic	13.1
Tween 80	Polyoxyethylene sorbitan mono-oleate	Nonionic	15
Tween 40	Polyoxyethylene sorbitan monopalmitate	Nonionic	15.6
Myrj 51	Polyoxyethylene monostearate	Nonionic	16
Myrj 52	Polyoxyethylene monostearate	Nonionic	16.9
Atlas G-263	N-cetyl N-ethyl morpholinium ethosulfate	Cationic	27

2.2. HLB Prediction using Water Solubility

The solubility of non-ionic surfactants in water can usually be used as a guid in approximating their hydrophilic-lipophilic balance and their usefulness (Table 2). This method is only a guide and serves as a basis for HLB estimation. This method is considered more accurate than the calculation method (mentioned in 2.1 sections).

Table 2: Water Solubility and HLB [8].

Water Solubility	*HLB Range*
No dispersability in water	1-4
Poor dispersability	3-6
Milky dispersion after	6-8
Stable milky dispersion	8-10
Translucent to clear	10-13
Clear solution	13+

3. Determination of HLB "Requirement"

HLB "requirement" is the amount of surfactant required to make an oil to remain in solution. Variation of the proportion of the blended emulsifiers has been preferred to obtain best results. When two emulsifiers of known HLB are thus blended for use with a given oil there is an optimum ratio that gives best emulsification and the HLB at this ratio is said to be the required HLB for the oil (to give that type of emulsion, whether O/W, W/O solubilisation, etc.). This is expressed by the equation 3:

$$\text{HLB}_{\text{oil}} = \frac{W_A X\ HLB_A + W_B X\ HLB_B}{W_A + W_B} \qquad (3)$$

Where, W_A= the amount (weight) of the 1st emulsifier *(A)* used.

W_B= the amount (weight) of the 2nd emulsifier *(B)* used at the optimum ratio giving the best emulsion.

HLB_A, HLB_B= the assigned HLB values for emulsifiers *A* and *B*.

HLB_{oil}= the "required HLB" of the oil for the type of emulsion being studied.

4. Applications of Surfactants depending on HLB

The HLB system is very useful to distinguish the surfactants according to their applications. Generally, the applications for nonionic surfactants within the following HLB ranges are as follows (Table 3):

Table 3: Application of surfactants depending on HLB range

HLB Range	*Application*
4-6	w/o emulsifiers
7-9	wetting agents
8-18	o/w emulsifiers
13-15	detergents
10-18	solubilizers

5. Conclusions

The HLB system, though it does not indicate the overall efficiency of the surfactant, it does tell "what it will do" i.e. what kind of an emulsion or product to expect. By so doing, it enables us to compare various chemical types of surfactants at their optimum balance. The HLB system appears to be suitable for all types of problems employing surface active agents.

References

[1] Kaci M., Meziani S., Arab-Tehrany E., Gillet G., Desjardins-Lavisse I., Desobry S. Emulsification by high frequency ultrasound using piezoelectric transducer: Formation and stability of emulsifier free emulsion. Ultrason. Sonochem. 2014; 21: 1010-1017.

[2] Sritapunya T., Kitiyanan B., Scamehorn J. F., Grady B. P., Chavadej S. Wetting of polymer surfaces by aqueous surfactant solutions. Colloids Surf. A. 2012; 409: 30-41.

[3] Georgiadou S., Brooks B. W. Suspension polymerization of methyl methacrylate using sodium polymethacrylate as a suspending agent. Chem. Eng. Sci. 2005; 60: 7137-7152.

[4] Chen K., Zhang Q., Chen B., Chen L. Nanocomposite hydrogels with rapid thermal responsibility by using surfactant detergent as template. Applied Clay Sci. 2012; 58: 114-119.

[5] Alfantazi A. M., Dreisinger D. B. Foaming behaviour of surfactants for acid mist control in zinc electrolysis processes. Hydrometallurgy. 2003; 69: 57-72.

[6] Griffin W C. Classification of Surface-Active Agents by “HLB”. J. Soc. Cosmet. Chem. 1949; 1: 311–326.

[7] Griffin W C. Calculation of HLB values of non-ionic surfactants, J. Soc. Cosmet. Chem. 1954; 5: 249–256.

[8] The HLB system- a time saving guide to emulsifier selection. CHEMMUNIQUE (Ed.), (1980). ICI Americas Inc. Delaware, USA.

Author Profile

Ashish Gadhave is pursuing M. Tech degree from Institute of Chemical Technology, Mumbai. He completed his B. Tech degree from same institute. He was working as a project fellow in CSIR-National Chemical Laboratory after completion of bachelor degree. He completed in-plant training in BASF-The Chemical Company.