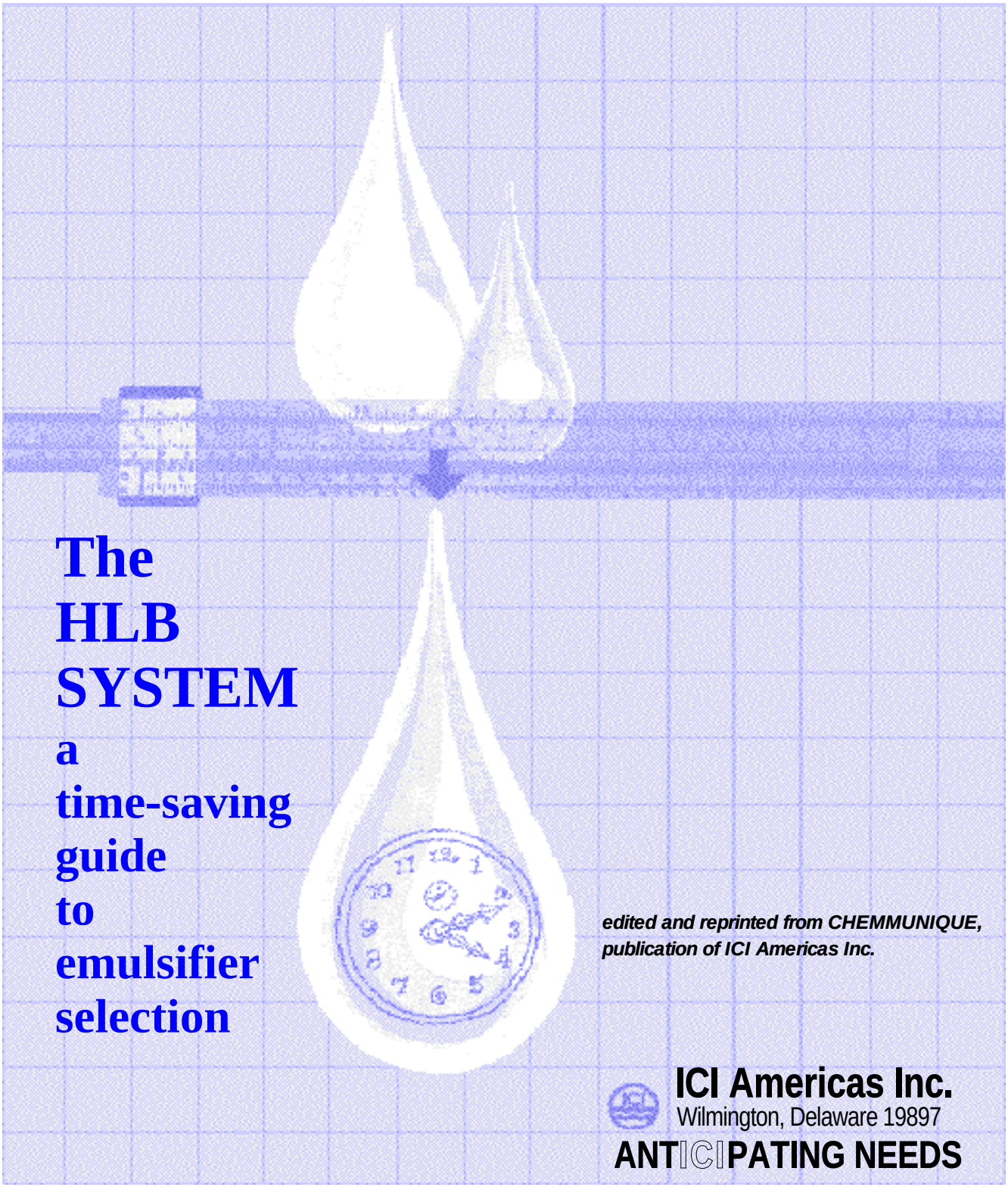

# The HLB SYSTEM

## a time-saving guide to emulsifier selection

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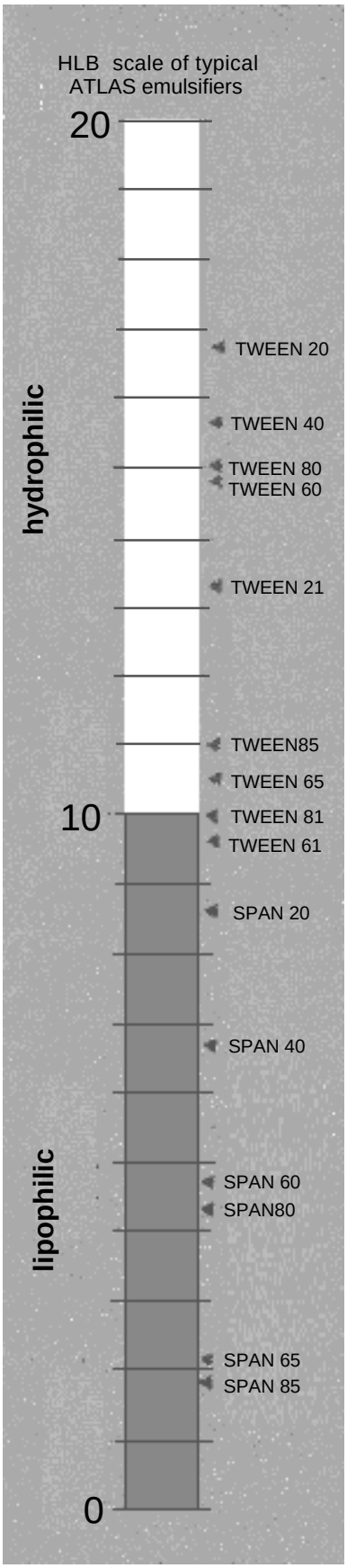
**ANTICIPATING NEEDS**




# CHAPTER 1

*Meaning of HLB*
*Advantages and Limitations*

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WHEN you are faced with the problem of making an emulsion, you have your choice of hundreds upon hundreds of emulsifying agents - well over a hundred just from ICI alone. Out of this welter of products, you have the unenviable task of selecting one or two which will ***satisfactorily emulsify*** your chosen ingredients. You can choose from among hundreds of manufacturers and thousands of surface active agents, according to the 1975 edition of John W. McCutcheon's "Detergents and Emulsifiers"

Your own definition of the words ***"satisfactorily emulsify,"*** as used above, is of course the prime factor in your choice of one emulsifier instead of another.

**What the HLB System Does**

To help save time in emulsifier selection, ICI introduced in the late 1940's a systematic scheme of centering down on the relatively few emulsifiers suitable for any given application. This is called the HLB System - the letters HLB standing for "Hydrophile-Lipophile Balance.

Briefly, the HLB System enables you to assign a ***number*** to the ingredient or combination of ingredients you want to emulsify, and then to choose an emulsifier or blend of emulsifiers having this ***same number.***

At least, this is the principle of the system. In practice, unfortunately, the task is never simple. But the HLB System does provide a useful guide - a series of beacons to steer you through channels where virtually no other markers exist.

**Where the HLB System Can Help Most**

Our discussion here will assume that you have had some experience in making emulsions. A complete dissertation on the many factors which influence your choice of emulsifiers would necessarily cover aspects of emulsion technology far beyond the HLB System.

For example, before you can begin making use of the HLB System, you must set up some sort of evaluation system for your "satisfactory" emulsion. Do you want an oil-in-water (O/W) emulsion or a water-in-oil (W/O)? How ***stable*** do you want your emulsion, in storage? -in use? What are your ***cost limits?*** Should your emulsifier be stable toward alkalies, salts, or electrolytes? Must it be non-toxic -or non-irritating to the skin? How about your manufacturing equipment -or the equipment your customer might use in applying your emulsion product-will ease of ***preparation or application*** affect your choice of emulsifier?

Such factors as this may immediately lead you to discard certain types or groups of emulsifiers from further consideration. In any case, they will certainly influence your choice of emulsifiers when you are weighing the relative merits of one emulsion or another in final trials.

**HLB Numbers of Emulsifiers -**
**What Do They Mean?**

In the HLB System, each emulsifier is assigned a numerical value which we call its HLB. The HLB of ICI emulsifiers is shown in all current ICI emulsifier literature, and similar values may be calculated or estimated by various means for any emulsifier. Methods for determining this HLB value are discussed in Chapter 7.

The HLB of an emulsifier is an expression of its Hydrophile-Lipophile Balance, i.e. the balance of the size and strength of the hydrophilic (water-loving or ***polar***) and the lipophilic (oil-loving or ***non-polar***) groups of the emulsifier. All emulsifiers consist of a molecule that combines both hydrophilic and lipophilic groups.

An emulsifier that is lipophilic in character is assigned a low HLB number (below 9.0), and one that is hydrophilic is assigned a high HLB number (above 11.0). Those in the range of 9-11 are intermediate.

When two or more emulsifiers are blended, the resulting HLB of the blend is easily calculated. For example, suppose you want to determine the HLB value of a blend comprising 70% of TWEEN 80 (HLB = 15) and 30% Of SPAN 80 (HLB = 4-3). The calculation would be:

| | |
|---|---|
| TWEEN 80 | 70% X 15.0 = 10.5 |
| SPAN 80 | 30% X 4.3 = 1.3 |
| | HLB of blend = 11.8 |

As you will discover in applying the HLB System, the HLB of an emulsifier or blend of emulsifiers is an excellent indication of ***what the emulsifier system will do,*** that is, whether it will make an oil-in-water (O/W) emulsion or a W/O emulsion, or act as a solubilizer for some oil. The HLB of an emulsifier class or blend is also an

indication of the efficiency of chemically-related emulsifiers or of a blended pair of emulsifiers for performing any given emulsifier task.

When you consider a variety of chemical types of emulsifier, and classify them according to structure, each class covers a segment of the HLB range. The efficiency of these classes differs. HLB is not an indication of the relative efficiency of one class to another. This "class efficiency" seems to be related more to chemical structure (that is, whether the emulsifier is a soap, a partial ester, a complete ester, whether the lipophilic group is saturated, etc.) and the relationship of its chemical structure to the chemical structure of the material to be emulsified.

Subsequent chapters in this book will give you some guides to comparison of chemical types when the "ideal" HLB of emulsifier for your application has been determined, although no specific rules have been established for this step in emulsifier selection.

## HLB Related to Solubility

The HLB of an emulsifier is related to its ***solubility***. Thus, an emulsifier having a low HLB will ***tend*** to be oil-soluble, and one having a high HLB will ***tend*** to be water-soluble, although two emulsifiers may have the same HLB and yet exhibit quite different solubility characteristics.

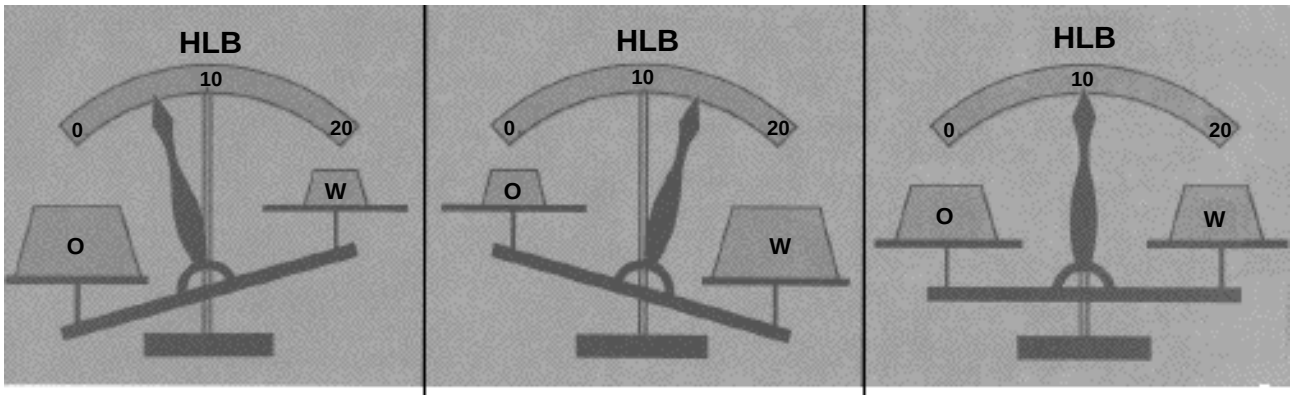
Anyone who works with emulsifiers soon becomes aware of the relationship between the ***solubility*** of an emulsifier and its ***behavior.*** For example, you will use a "water-soluble" emulsifier or blend to make an O/W emulsion, or to solubilize oils, or to obtain detergent action. In other words, you use a "water-soluble" emulsifier when you want your final product to exhibit ***aqueous characteristics,*** i.e. to dilute readily with water. For these purposes, you would rarely use an "oil-soluble" emulsifying system. On the other hand, if you wanted to make a W/O emulsion, or couple watersoluble materials into an oil, or produce some other type of non-aqueous emulsion system, you would choose an oil-soluble emulsifier.

From experience, then, you would expect that the functions of emulsifiers might well be classified by HLB, and this is true. Table I shows some interesting general correlations.

**Table 1**

| HLB Range | Use |
|---|---|
| 4-6 | W/O emulsifiers |
| 7-9 | Wetting agents |
| 8-18 | O/W emulsifiers |
| 13-15 | Detergents |
| 10-18 | Solubilizers |

These correlations are based on long experience with ICI emulsifiers, and are amazingly accurate, although certain exceptions have been found. For example, a few excellent detergents have been found in the HLB range 11-13.




When oil-loving groups in surfactant are predominant, HLB is low... for producing water-in-oil emulsions.

When water-loving groups predominate, the surfactant has high HLB and is used for oil-in-water emulsions.

When oil-loving and water-loving groups are fairly well balanced, HLB is intermediate (around 10).

# CHAPTER 2

## *"Required HLB" for Typical Ingredients to be Emulsified*

**The "Required HLB" of an Ingredient**

Through long experience in using the HLB System, ICI emulsion technologists have found that all oils, waxes and other materials likely to be incorporated into emulsions have an individual "Required HLB." For instance, in Table 2A, you will see that the required HLB for a fluid O/W, emulsion of paraffin is 10.

This means that an emulsifier, or blend of emulsifiers, having an HLB of 10 will make a more stable fluid O/W paraffin emulsion than emulsifiers of any other HLB value. It ***does not mean*** that every emulsifier or blend having an HLB of 10 will "work" - you might have an "HLB 10" emulsifier of the "wrong" chemical family (wrong for this purpose, at least). However, you can be assured that when you're working with any certain family of emulsifiers, you will obtain optimum results more quickly if you work in the area of HLB 10, say ± 1. You'd be wasting time to try emulsifier blends at HLB 8 or 13, for example, unless you might happen to be looking for a particular quality ***other than stability*** in your emulsion.

Do not make the mistake of assuming, from this preliminary working data, that you should immediately try all single emulsifiers in the catalog that have an HLB of 10 for your paraffin emulsion. Remember, you can ***blend*** emulsifiers to make any HLB you want, and blends usually work best. In Chapters 5 and 6, emulsifier blends and selection of "chemical families" for trial will be discussed more fully.

It is important to remember that, as noted in Table 2 this HLB of 10 is for a 10-20% paraffin wax fluid O/W emulsion made by propeller mixing. If you want an emulsion of different concentration, composition or viscosity-or made by a different method-its required HLB will likely be different. Differences in supplies and batches of oils and waxes can also result in variations in required HLB.

**Required HLB for Ingredient Blends**

Table 2 gives you some idea of the required HLB values for O/W emulsions of various oils and waxes that you are likely to encounter most frequently. From these values, you can calculate required HLB values for blends of these oils and waxes, each component contributing its share to the whole.

For example, suppose you are making an O/W emulsion textile lubricant. The product might be 30% mineral spirits, 50% cottonseed oil and 20% chlorinated paraffin to be emulsified in water. The required HLB of the combination can be calculated as follows:

| | | | |
|---|---|---|---|
| Mineral Spirits | .....30% | X Req. HLB 14 | = 4.2 |
| Cottonseed Oil | .....50% | X Req. HLB 6 | = 3.0 |
| Chlorinated Paraffin . . | 20% | X Req. HLB 14 | = 2.8 |
| Estimated HLB for emulsifier system | | | .....10.0 |

You should ckeck this estimated value with a few exploratory tests in the range of say 9-11, as shown in Chapter 3, but you know from this calculation

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