Oil-Loving and Water-Loving Natural Health Ingredients

Dr. Petro P. Czupiel, PhD

Abstract

Ingredients can be categorized into water-loving (hydrophilic) and oil-loving (lipophilic) groups, with the former dissolving in water at concentrations above 125 mg/L and the latter requiring concentrations below 125 mg/L. By examining the dominant molecules, we can identify whether an ingredient is water-loving or oil-loving, with six chemical groups (alcohols, acids, and nitrogen-containing amines) facilitating the dissolution of water-loving ingredients and seven chemical groups (single, double, and triple bonded carbons, 5- and 6-membered rings, ketones, and ethers) enabling oil-loving ingredients to dissolve in oil. This understanding is exemplified by sugar (sucrose), which has a water solubility of 2,100,000 mg/L, and turmeric (curcumin), which has a water solubility of 3 mg/L. Pharmaceutical companies have developed water-compatible formulations to enhance the solubility of oil-loving ingredients, but the current market for natural health ingredients (NHIs) lacks effective delivery systems, missing an opportunity to realize their full potential. NanoPrime Labs bridges this gap by leveraging pharmaceutical expertise to create more efficient uptake of NHIs, unlocking their maximum potential for consumers.

1. Introduction

Since the dawn of human civilization, the ability to identify safe and palatable ingredients has been crucial for shaping communities' diets and culinary preferences.[1] Throughout history, certain ingredients have risen to prominence due to their unique flavor profiles or ability to enhance the taste of other ingredients. Interestingly, many of these popular ingredients share a common trait: they readily dissolve in water, classifying them as hydrophilic (water-loving) ingredients. On the other hand, ingredients that resist dissolution in water are typically lipophilic (oil-loving). This paper aims to provide a comprehensive guide for distinguishing between these two categories, empowering individuals to make informed decisions about the ingredients they use and consume.

2. Water-Loving and Oil-Loving Natural Health Ingredients

The majority of safe-to-ingest ingredients are water-loving, providing immediate benefits on the tongue. These ingredients effortlessly dissolve in water at concentrations greater than 125 mg/L, such as sucrose, found in sugar, which can reach concentrations over 2,100,000 mg/L.[2] Water-loving ingredients contain hydrophilic chemical groups, allowing them to easily dissolve in water.

On the other hand, oil-loving ingredients easily dissolve in cooking oil but struggle to dissolve in water, with concentrations below 125 mg/L. Curcumin, the active ingredient in turmeric, is a prime example, with a water solubility of just 3 mg/L.[3] Oil-loving ingredients have hydrophobic chemical groups, making them water-fearing.

The pharmaceutical industry has successfully developed formulations to enhance the absorption of oil-loving ingredients, ensuring efficient delivery to the targeted site in the body.[4] However, the natural health industry lags behind, with many oil-loving ingredients packaged in pure powder form, lacking formulation to aid absorption. This results

in subpar products for consumers, missing an opportunity for optimal delivery.

NanoPrime Labs bridges this gap with technology to better deliver oil-loving natural health ingredients into the bloodstream. This paper educates consumers on identifying chemical groups that dissolve ingredients in water or oil, presenting six case examples of water-loving and oil-loving ingredients. By understanding these differences, we can unlock the full potential of ingredients and revolutionize the natural health industry.

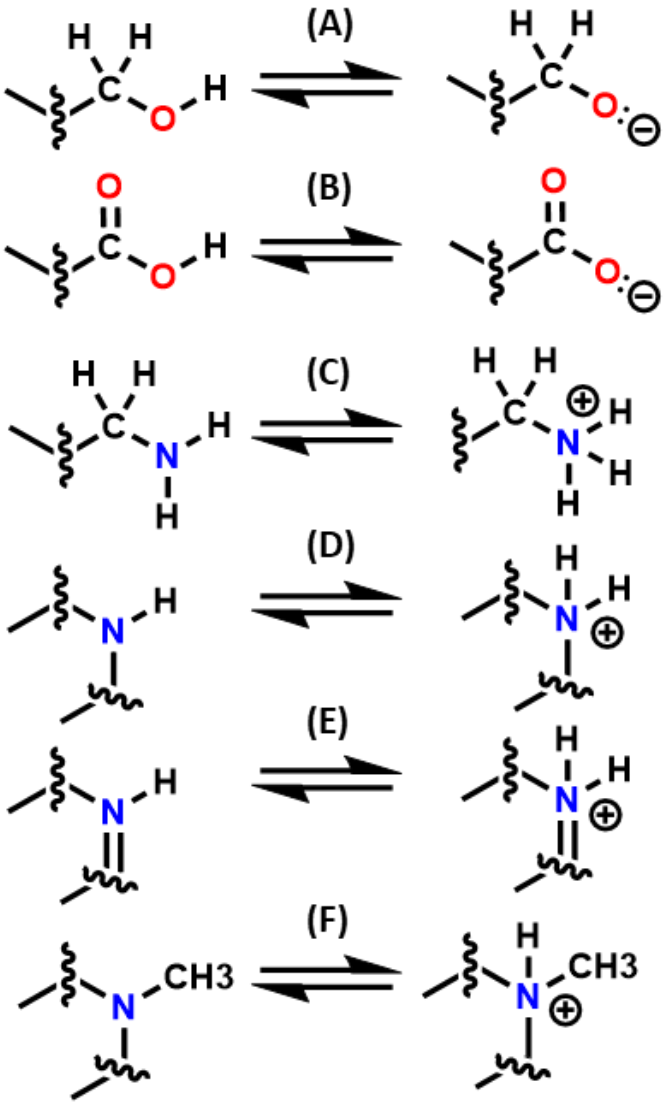

Figure 1. Chemical groups that help ingredients dissolve in water are (A) alcohols, (B) acids, (C) primary amines, (D) and (E) are two types of secondary amines and (F) tertiary amines. Carbon is marked as a C, oxygen is marked as a O, and nitrogen is marked as a N. The structures on the left show the protonated chemical groups while the groups on the right show the deprotonated chemical groups. These two structures exist in equilibrium.

3. How do you determine if an ingredient is water-loving?

Determining whether an ingredient is water-loving or oil-loving begins with identifying its dominant molecule. For instance, sugar's dominant molecule is sucrose, which reveals its water-loving nature. Similarly, turmeric's dominant molecule, curcumin, indicates its oil-loving properties. But how do we determine if a molecule is water-loving or oil-loving?

Health-conscious consumers seeking natural health ingredients (NHIs) often lack the chemical and biological expertise to make informed decisions. Scientists, on the other hand, can easily identify water-loving or oil-loving ingredients by examining their molecular structure. By investigating the dominant molecule in an ingredient, we can observe the chemical groups that facilitate dissolution in water, indicating water-loving properties.

Five key chemical groups that aid dissolution in water are alcohols, acids, and primary, secondary, and tertiary amines (**Figure 1**). These groups exist in equilibrium, with protonated and deprotonated forms. Protonated groups have a hydrogen atom (labeled "H"), while deprotonated groups lack it. **Figures 1(A)** and **1(B)** show how oxygen in alcohol and acid can be deprotonated, existing as a negative charge (-). **Figures 1(C-F)** illustrate how primary, secondary, and tertiary amines can be protonated, existing as a positive charge (+). This equilibrium enables these chemical

groups to dissolve in water, making them essential to identify when studying dominant molecules.

By recognizing these chemical groups and their equilibrium, we can determine if an ingredient is water-loving or oil-loving. This knowledge empowers consumers to make informed decisions about NHIs, ensuring they choose products that meet their health and wellness needs.

4. How do you determine if an ingredient is oil-loving?

The previous section introduced the concept of identifying chemical groups that facilitate the dissolution of water-loving ingredients. This section will delve into identifying chemical groups observed in oil-loving ingredients, employing a similar method of investigating the dominant molecule in an ingredient. **Figure 2** reveals some of the chemical groups that enable molecules to dissolve in oil, including single, double, and triple bonded carbons, 5-membered carbon rings with two double bonds, or 6-membered carbon rings with three double bonds, ketones, and ethers. The structures are presented in two formats: the Kekulé formula on the left and the line formula on the right, both conveying the same meaning but represented differently.

Unlike the chemical groups in **Figure 1**, those in **Figure 2** cannot protonate or deprotonate in water and prefer to exist in oily environments. Therefore, it is crucial to understand the types of chemical groups present in the dominant molecule of ingredients to determine whether they are water-loving or oil-loving. This knowledge enables us to identify the solubility properties of ingredients and make informed decisions about their use.

5. Examples of water-loving and oil-loving ingredients

We must now identify these chemical groups in molecules found in common ingredients

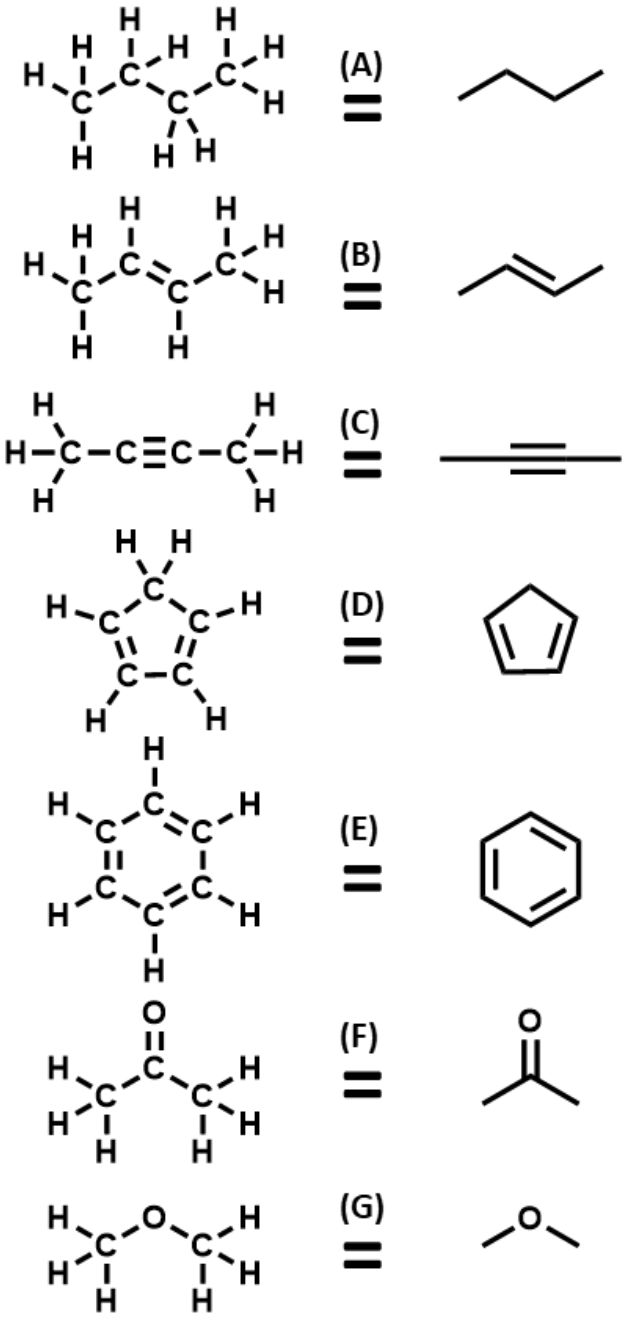

Figure 2. Chemical groups that help ingredients dissolve in oil are (A) single bonded carbons, (B) an example of double bonded carbons, (C) an example of triple bonded carbons, (D) 5-membered carbon ring with two double bonds , (E) a 6-membered carbon ring with three double bonds, otherwise known as benzene, (F) ketones and (G) ethers. These structures can be shown in two ways where the Kekulé formula is shown on the left and the line formula is shown on the right.

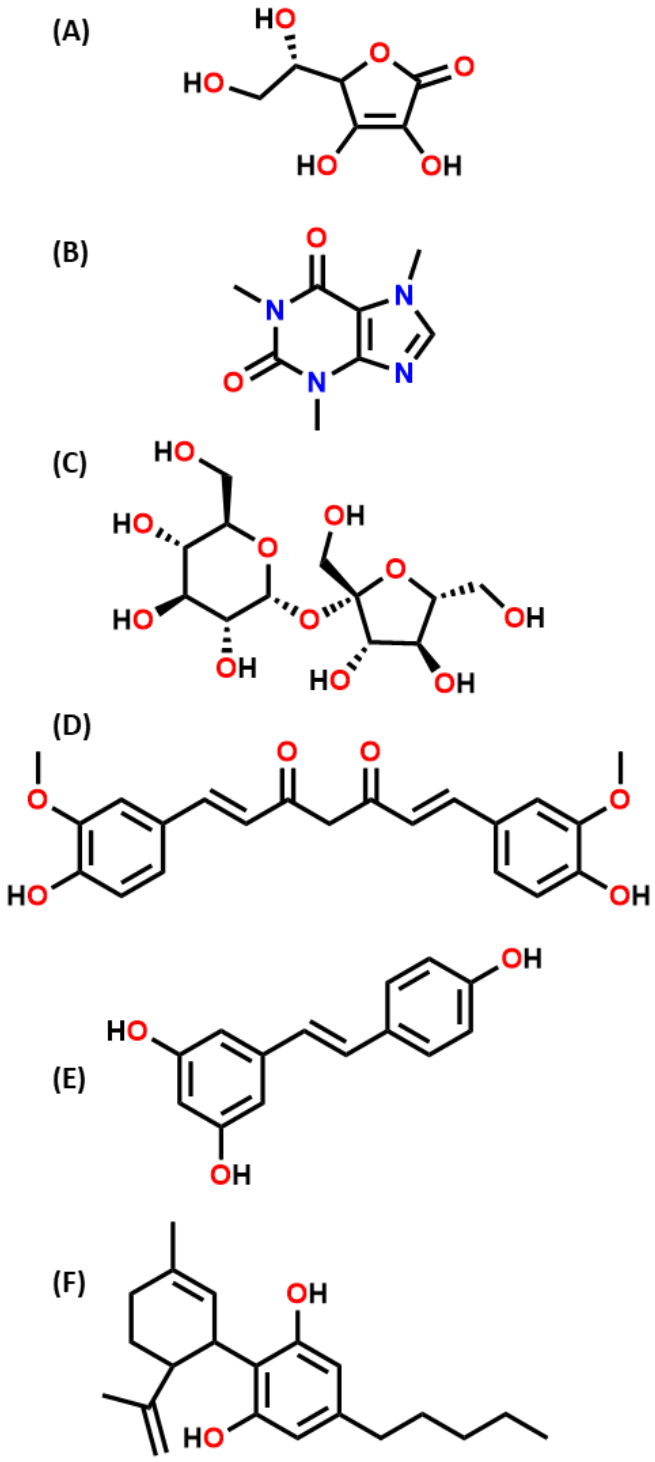

Figure 3. Chemical structures of water-loving and oil-loving ingredients includes: (A) Vitamin C, (B) caffeine, (C), sucrose, (D) curcumin, (E) resveratrol, and (F) cannabidiol (CBD).

to help us understand if a molecule is water-loving or oil-loving. As shown in **Figure 3**, three water-loving molecules - vitamin C, caffeine, and sucrose - and three oil-loving molecules - curcumin, resveratrol, and cannabidiol (CBD) - are illustrated. This section will investigate what makes these molecules water-loving or oil-loving.

Vitamin C, as shown in **Figure 3(A)**, contains a 5-membered ring and six oxygens, with four alcohol chemical groups that can deprotonate and protonate, making it water-loving. The solubility of vitamin C in water is 330,000 mg/L, a high number that explains why eating tangerines and oranges provide us with vitamin C.[5]

Caffeine, in **Figure 3(B)**, has a 6-membered ring, a 5-membered ring, two oxygens, and four nitrogens, including a secondary amine and three tertiary amines, which deprotonate and protonate, making it water-loving. The solubility of caffeine in water is 21,600 mg/L, a high number that allows coffee and espresso drinkers to get their caffeine fix quickly and efficiently.[6]

Sucrose, in **Figure 3(C)**, contains a 6-membered ring, a 5-membered ring, and eleven oxygens, with eight alcohol chemical groups that can deprotonate and protonate, making it water-loving. The solubility of sucrose in water is 2,100,000 mg/L, a high number that allows for quick dissolution in drinks and desserts.

Curcumin, in **Figure 3(D)**, has two 6-membered rings with three double bonds each, two double bonds, and six oxygens, with two ketones, two ethers, and two alcohol chemical groups, but the oil-loving components dominate, making it oil-loving. The solubility of curcumin in water is 3 mg/L, a low number that explains why turmeric is added to cooking oil.

Resveratrol, in **Figure 3(E)**, contains a double bond, two 6-membered rings with three double

bonds each, and three oxygens, with an alcohol chemical group, but the benzene rings and double bond make it oil-loving. The solubility of resveratrol in water is 30 mg/L, a low number that makes water-solubility a major problem.[7]

CBD, in **Figure 3(F)**, has a 6-membered ring with three double bonds, two double bonds, and two oxygens, with alcohol chemical groups, but the benzene and double bonds make it oil-loving. The solubility of CBD in water is 0.06 mg/L, a very low number that makes delivery in edibles, beverages, or capsules extremely difficult.[8] NanoPrime Labs holds the technology to overcome these solubility issues and efficiently deliver these molecules for therapeutic purposes.

6. How does the pharmaceutical industry formulate oil-loving ingredients?

Despite the challenges, the pharmaceutical industry has successfully developed water-compatible formulations to dissolve oil-loving ingredients in water. In fact, approximately 40% of approved active pharmaceutical ingredients (APIs) and 90% of APIs in the discovery pipeline are hydrophobic, poorly soluble in water, and oil-loving. However, the pharmaceutical industry has overcome this obstacle through research and innovation.

Appropriate formulations are crucial to efficiently deliver oil-loving natural health ingredients (NHIs) into our bloodstream. If not properly formulated, oil-loving NHIs may not be effectively absorbed, leading to reduced efficacy. The connection between the poor water solubility of oil-loving NHIs and their delivery in the body is a critical topic, explored in our next white paper, "Pharmacokinetics and Bioavailability of Oil-Loving Ingredients."

7. Conclusion

Most safe-to-ingest ingredients known to humans are water-loving, characterized by an immediate taste sensation on the tongue upon consumption. Water-loving ingredients readily dissolve in water at concentrations above 125 mg/L, whereas oil-loving ingredients dissolve at concentrations below 125 mg/L. Identifying the dominant molecules in ingredients helps classify them as water-loving or oil-loving. Six chemical groups facilitate dissolution of water-loving ingredients in water, including alcohols, acids, and amines. Conversely, seven chemical groups enable oil-loving ingredients to dissolve in oil, including single, double, and triple bonded carbons, 5- and 6-membered rings, ketones, and ethers.

Investigating three water-loving and three oil-loving molecules revealed the reasons behind their solubility in water or oil. Pharmaceutical companies have successfully developed water-compatible formulations to enhance the solubility of oil-loving ingredients in water. However, the current market for natural health ingredients (NHIs) lacks effective delivery systems, missing an opportunity for consumers to fully benefit from NHIs. NanoPrime Labs leverages pharmaceutical expertise to optimize NHI delivery into the bloodstream, ultimately benefiting consumers.

8. References

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