

SOLUBILITY ENHANCEMENT TECHNIQUE: A REVIEW**Ayushi Sharma*¹, Sunil Patidar², Sachin Lodhi³ and Ayushi Goswami⁴**

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ABSTRACT

Solubility is a fundamental concept in chemistry with widespread applications across scientific disciplines. It refers to the ability of a substance, the solute, to dissolve in another substance, the solvent, forming a homogeneous mixture known as a solution. This review provides an overview of solubility's key principles, factors influencing it, and its significance in various fields. understanding solubility is essential for predicting how substances interact and behave in different environments. The nature of the solute and solvent, temperature, pressure, and the presence of other solutes are critical factors influencing solubility. Polar solutes tend to dissolve in polar solvents, while nonpolar solutes dissolve in nonpolar solvents. Temperature

often increases the solubility of solids but can decrease the solubility of gases. Pressure plays a notable role in the solubility of gases in liquids, as described by Henry's law. solubility finds extensive applications. In pharmaceuticals, it impacts drug formulation, affecting the bioavailability and effectiveness of medications. In environmental science, understanding the solubility of pollutants in water helps assess water quality and pollution levels. Material science benefits from solubility principles when designing new materials and controlling crystallization processes. Solubility also influences chemical reactions, particularly those involving dissolved reactants or products. In conclusion, solubility is a cornerstone concept in chemistry with profound implications for various scientific realms. Its effects are evident in everyday scenarios, from dissolving substances in beverages to complex drug delivery systems. A comprehensive understanding of solubility is crucial for advancing knowledge, optimizing processes, and addressing challenges across disciplines.

INTRODUCTION

Solubility refers to the ability of a solute (typically a solid) to dissolve in a solvent (typically a liquid) to form a homogeneous mixture known as a solution. When a solute dissolves in a solvent, its individual particles become dispersed uniformly throughout the solvent, resulting in a stable and transparent solution.

Solubility is a fundamental property in chemistry and plays a crucial role in various natural and industrial processes, including pharmaceuticals, chemistry, environmental science, and more. It is governed by several factors, including temperature, pressure, and the nature of the solute and solvent. Here are some key points related to solubility:

Saturated Solution: When the maximum amount of solute has dissolved in a given amount of solvent at a particular temperature and pressure, the solution is said to be saturated. Any additional solute added will not dissolve, and it will remain undissolved at the bottom of the container.

Unsaturated Solution: If a solution contains less solute than the maximum amount it can dissolve at a specific temperature and pressure, it is considered unsaturated. There is still room for more solute to dissolve.

Supersaturated Solution: In some cases, it is possible to create a supersaturated solution by dissolving more solute than would typically be possible at a given temperature. Supersaturation can occur when a solution is heated and then allowed to cool slowly without any additional solute crystallizing out. Such solutions are unstable and can spontaneously crystallize if disturbed.

Solubility Curve: For many substances, the relationship between solubility and temperature can be represented graphically by a solubility curve. The curve shows the maximum amount of solute that can dissolve in a specific amount of solvent at different temperatures.

Polarity and Solubility: Generally, "like dissolves like." Substances with similar polarity tend to dissolve well in each other. Polar solutes dissolve well in polar solvents, and non-polar solutes dissolve well in non-polar solvents.

SOLUBILITY ENHANCEMENT TECHNIQUES

There are several solubility enhancement techniques used to improve the dissolution rate and bioavailability of poorly water-soluble drugs. These techniques aim to increase drug solubility and ultimately enhance drug delivery and therapeutic effectiveness. Below is a review of some commonly employed solubility enhancement techniques:

Particle Size Reduction (Milling, Micronization): Particle size reduction is a commonly employed technique in various industries, including pharmaceuticals, food, chemicals, and materials science. The process involves reducing the size of solid particles to enhance specific properties or improve the performance of materials. Two common methods of particle size reduction are milling and micronization.

Milling: Milling is a mechanical process that involves the breaking down of solid materials into smaller particles by applying mechanical forces. The primary goal of milling is to reduce the particle size and increase the surface area of the material. This, in turn, can lead to improved dissolution rates, increased reactivity, enhanced bioavailability, and better handling characteristics.

The milling process can be conducted using various equipment, including ball mills, hammer mills, colloid mills, and fluid energy mills. Each type of mill has its own advantages and is suitable for specific applications. In a ball mill, for example, the material is placed in a rotating cylinder with metal balls, and the impact and friction between the balls and the particles cause size reduction. Hammer mills involve the use of high-speed hammers to shatter and grind the material.

Micronization: Micronization is a specialized form of milling that targets reducing particle size to the micrometer or sub-micrometer range. It is particularly relevant in the pharmaceutical industry, where the bioavailability of poorly soluble drugs can be significantly improved by reducing their particle size to the micron level.

Micronization is often achieved using technologies like air jet milling, spiral jet milling, or bead milling. In air jet milling, compressed air or gas is used to create a high-velocity stream that impacts and fractures the particles, reducing them to the desired size. Spiral jet mills employ a similar principle but with the addition of a classifier to separate particles of

different sizes. Bead milling involves the use of small beads as grinding media in a dispersion medium to achieve particle size reduction.

Benefits of Particle Size Reduction (Milling and Micronization)

Improved dissolution rates and solubility, leading to enhanced bioavailability of pharmaceuticals.

Increased surface area, which can enhance reactivity in chemical reactions and improve material properties.

Homogenization of mixtures, ensuring uniformity in the final product.

Better flow properties, facilitating handling and processing of materials.

Control over particle size distribution, leading to tailored properties for specific applications.

It's important to note that while particle size reduction offers various benefits, it may also present challenges, such as potential degradation of heat-sensitive materials during the process or the need for proper handling to prevent contamination. Additionally, the choice of milling or micronization technique depends on the specific requirements of the application and the properties of the materials involved.

Amorphous Solid Dispersions (ASDs): Amorphous Solid Dispersions (ASDs) are advanced drug delivery systems used in the pharmaceutical industry to enhance the solubility and bioavailability of poorly water-soluble drugs. Many drugs with therapeutic potential have poor solubility in water, which can lead to limited dissolution and reduced absorption upon administration, thereby impacting their therapeutic efficacy. Amorphous solid dispersions offer an effective solution to overcome these challenges.

Formation of Amorphous Solid Dispersions: Amorphous solid dispersions are typically prepared by dispersing a poorly water-soluble drug (the active pharmaceutical ingredient, API) in a water-soluble carrier matrix (often referred to as the polymer). The drug is converted into an amorphous form, meaning its molecular arrangement lacks the regular, crystalline structure typically observed in solid materials.

Solid Lipid Nanoparticles (SLNs) and Nanostructured Lipid Carriers (NLCs): Solid Lipid Nanoparticles (SLNs) and Nanostructured Lipid Carriers (NLCs) are both advanced

drug delivery systems used to enhance the solubility, stability, and bioavailability of lipophilic (fat-soluble) drugs. They are part of the larger family of lipid-based nanoparticles and have several advantages over traditional drug delivery systems. Let's explore each of these systems:

Nanoemulsions and Microemulsions: Nanoemulsions and microemulsions are both types of emulsions, which are colloidal dispersions of two immiscible liquids (usually oil and water) stabilized by surfactants. However, they differ in their droplet size and overall appearance.

SUMMARY AND CONCLUSION

Solubility is the ability of a solute to dissolve in a solvent, forming a homogeneous mixture known as a solution. It is a fundamental property in chemistry and plays a crucial role in various natural and industrial processes, including pharmaceuticals, chemistry, and environmental science. Solubility is governed by factors such as temperature, pressure, and the nature of the solute and solvent. Key points related to solubility include saturated, unsaturated, and supersaturated solutions. solubility enhancement techniques are used to improve the dissolution rate and bioavailability of poorly water-soluble drugs. Common methods include particle size reduction (milling, micronization), which involves breaking down solid materials into smaller particles using mechanical forces. Benefits of particle size reduction include improved dissolution rates and solubility, increased surface area, homogenization of mixtures, better flow properties, and control over particle size distribution. amorphous Solid Dispersions (ASDs) are advanced drug delivery systems used in the pharmaceutical industry to enhance the solubility and bioavailability of poorly water-soluble drugs. Amorphous solid dispersions are prepared by dispersing a poorly water-soluble drug in a water-soluble carrier matrix, converting the drug into an amorphous form. solid Lipid Nanoparticles (SLNs) and Nanostructured Lipid Carriers (NLCs) are advanced drug delivery systems used to enhance the solubility, stability, and bioavailability of lipophilic drugs. These systems are part of the larger family of lipid-based nanoparticles and have several advantages over traditional drug delivery systems. In summary, solubility is a crucial property in various industries, including pharmaceuticals, chemistry, and environmental science. Techniques like particle size reduction, ASDs, and emulsions can be employed to improve drug delivery and therapeutic effectiveness.

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