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Understanding the solubility behavior of hydrocarbons such as nonane is crucial in fields ranging from organic chemistry and chemical engineering to environmental science and industrial applications. The question of which solvent among ethanol, water, and tetrachloromethane (carbon tetrachloride) exhibits the greatest solubility for nonane is a common point of discussion, especially when considering solvent selection for extraction, purification, or formulation purposes.

In this comprehensive article, we delve into the molecular interactions, polarity considerations, and practical solubility data to determine in which of these solvents nonane demonstrates the highest solubility. We will explore the chemical properties of nonane, analyze the characteristics of each solvent, and interpret the underlying principles that govern solubility, including the "like dissolves like" rule, polarity, and intermolecular forces.

By the end of this article, you will have a clear understanding of why nonane prefers one solvent over the others and how this knowledge can be applied in real-world scenarios.

Introduction to Nonane and Its Chemical Characteristics

Nonane is a straight-chain alkane with the molecular formula C_9H_{20} . As a saturated hydrocarbon, it consists solely of carbon-carbon single bonds and hydrogen atoms, making it a nonpolar molecule. Nonane is a colorless, flammable liquid with a relatively low boiling point ($\sim 150^\circ C$) and moderate vapor pressure at room temperature.

Chemical Structure of Nonane

- Linear chain of nine carbon atoms
- Nonpolar due to symmetric distribution of charge
- Lack of functional groups that can participate in hydrogen bonding

Implications for Solubility

The nonpolar nature of nonane influences its interactions with various solvents. Generally, nonpolar substances tend to be soluble in other nonpolar solvents and poorly soluble in polar solvents like water.

Characteristics of the Solvents in Consideration

Ethanol ($\text{C}_2\text{H}_5\text{OH}$)

- Polar solvent with a hydroxyl ($-\text{OH}$) group
- Capable of hydrogen bonding
- Miscible with water in all proportions
- Slightly nonpolar due to the ethyl group, but predominantly polar

Water (H_2O)

- Highly polar solvent
- Extensive hydrogen bonding network
- Excellent for dissolving ionic compounds and polar molecules
- Poor solvent for nonpolar hydrocarbons

Tetrachloromethane (Carbon Tetrachloride, CCl_4)

- Nonpolar, tetrahedral molecule
- No hydrogen bonding capabilities
- Good solvent for nonpolar substances
- Historically used in dry cleaning and as a solvent in organic chemistry

Solubility Principles and Theoretical Considerations

The "Like Dissolves Like" Rule

This fundamental principle states that polar solvents tend to dissolve polar solutes, and nonpolar solvents tend to dissolve nonpolar solutes. Nonane, being nonpolar, is expected to have higher solubility in nonpolar solvents.

Intermolecular Forces and Solubility

- London Dispersion Forces: Dominant for nonpolar molecules like nonane and CCl_4 .
- Hydrogen Bonding: Present in water and ethanol but absent in nonane and CCl_4 .
- Polarity: A key determinant in solubility behavior.

Factors Affecting Nonane's Solubility

- Molecular size
- Polarity of the solvent
- Intermolecular interactions

- Temperature (not specified here, but generally higher temperatures increase solubility)

Analysis of Solubility Data

While precise quantitative solubility data can vary depending on conditions, general trends are well established:

1. Nonane in Water: Due to the significant polarity difference, nonane is poorly soluble in water. The hydrophobic nature of nonane leads to minimal interaction with water molecules, resulting in very low solubility.
2. Nonane in Ethanol: Ethanol is a polar solvent but has a substantial nonpolar ethyl group. Its amphiphilic nature allows some solubility of nonpolar hydrocarbons, but the polarity of ethanol reduces the overall solubility compared to nonpolar solvents.
3. Nonane in Tetrachloromethane: As a nonpolar solvent with London dispersion forces similar to nonane, CCl_4 exhibits high solubility for nonane. The similar molecular structures and intermolecular forces facilitate greater solubility.

Conclusion: Which Solvent Does Nonane Prefer?

Based on the principles of solubility and available data, nonane exhibits the greatest solubility in tetrachloromethane (carbon tetrachloride).

Summary:

- Water: Poor solubility (~ negligible) due to polarity mismatch.
- Ethanol: Moderate solubility owing to its amphiphilic nature but less than nonpolar solvents.
- Tetrachloromethane: High solubility owing to similar nonpolar character and comparable intermolecular forces.

Implications for Practical Applications

Understanding nonane's solubility profile is vital in:

- Organic Synthesis: Choosing appropriate solvents for extraction and purification.
- Environmental Science: Predicting the behavior of hydrocarbons in aquatic environments.
- Industrial Processes: Designing solvent systems for hydrocarbon recovery or formulation.

Final Remarks

In conclusion, nonane has the greatest solubility in tetrachloromethane (carbon tetrachloride) among the listed options. Its nonpolar nature aligns well with the nonpolar characteristics of CCl_4 , leading to effective dissolution. While ethanol can dissolve some nonpolar compounds due to its amphiphilic structure, it does not match the solubility efficiency of a purely nonpolar solvent like CCl_4 . Water, being highly polar, offers the least solubility for nonane, reaffirming the importance of molecular polarity and intermolecular forces in determining solubility.

Choosing the right solvent depends on the specific application, considering factors like polarity, toxicity, environmental impact, and solubility efficiency. For dissolving nonane effectively, nonpolar solvents such as tetrachloromethane are generally the preferred choice.

Keywords: Nonane solubility, solvent selection, ethanol, water, tetrachloromethane, organic chemistry, nonpolar solvents, intermolecular forces, "like dissolves like," hydrocarbon solubility, chemical properties

Frequently Asked Questions

In which solvent does nonane exhibit the greatest solubility?

A) Ethanol

Why does nonane dissolve more readily in ethanol compared to water or tetrachloromethane?

Because nonane is a nonpolar hydrocarbon, it is more soluble in ethanol, which has both polar and nonpolar characteristics, than in water (polar) or tetrachloromethane.

Among the given options, which solvent is most suitable for dissolving nonane?

Ethanol is the most suitable solvent among the options for dissolving nonane.

Does nonane have higher solubility in polar or nonpolar solvents?

Nonane has higher solubility in nonpolar solvents like ethanol compared to polar solvents like water.

What type of solvent is tetrachloromethane, and how does it affect nonane's solubility?

Tetrachloromethane is a nonpolar solvent, but nonane's solubility is still

greater in ethanol due to ethanol's slightly polar nature and ability to interact via hydrogen bonding.

Additional Resources

Nonane: The Solubility Conundrum – Which Solvent Reigns Supreme?

Understanding the solubility of organic compounds is fundamental to numerous chemical applications, from synthesis to formulation in pharmaceuticals, cosmetics, and industrial processes. Among these compounds, nonane (C_9H_{20}) – a straight-chain alkane – presents an interesting case study in solvent compatibility. When considering nonane's solubility profile, the question arises: In which solvent does nonane exhibit the greatest solubility? The options typically include ethanol, water, and tetrachloromethane (carbon tetrachloride). To arrive at an informed conclusion, it is essential to explore the chemical nature of nonane, the characteristics of each solvent, and the principles governing solubility.

Understanding Nonane: A Brief Overview

Nonane (C_9H_{20}) is a saturated hydrocarbon belonging to the alkane family. It features a linear chain of nine carbon atoms, making it a relatively non-polar hydrocarbon molecule. Its key features include:

- Chemical Structure: A straight-chain alkane with nine carbon atoms and twenty hydrogen atoms.
- Physical State: Colorless, flammable liquid at room temperature.
- Polarity: Non-polar due to the C-H bonds and the symmetrical structure.
- Boiling Point: Approximately $150^{\circ}C$ ($302^{\circ}F$).
- Density: Around 0.79 g/cm^3 .

Given its non-polar nature, nonane tends to dissolve well in other non-polar or weakly polar solvents but poorly in polar solvents like water.

Exploring the Solvents: Ethanol, Water, and Tetrachloromethane

Each solvent has distinctive chemical and physical properties that influence its ability to dissolve nonane.

1. Ethanol (C_2H_5OH)

Ethanol is a small, polar organic solvent characterized by:

- Polarity: Moderately polar owing to the hydroxyl ($-OH$) group.
- Hydrogen Bonding: Capable of hydrogen bonding, which enhances its solvation

capabilities for polar substances.

- Miscibility: Completely miscible with water and many organic solvents.
- Uses: Widely used in pharmaceuticals, cosmetics, and as a solvent for various organic compounds.

Despite its polarity, ethanol's hydrocarbon tail (ethyl group) imparts non-polar characteristics, making it capable of dissolving some non-polar substances.

2. Water (H₂O)

Water is the quintessential polar solvent, with features including:

- Polarity: Highly polar due to bent molecular geometry and electronegative oxygen.
- Hydrogen Bonding: Extensive hydrogen bonding network.
- Solubility Profile: Excellent at dissolving polar and ionic compounds; virtually insoluble for non-polar hydrocarbons.
- Implication for Nonane: Due to its polarity, water exhibits very low solubility for non-polar hydrocarbons like nonane.

3. Tetrachloromethane (Carbon Tetrachloride, CCl₄)

Tetrachloromethane is a dense, non-polar, chlorinated hydrocarbon characterized by:

- Polarity: Essentially non-polar owing to symmetrical tetrahedral geometry.
- Hydrogen Bonding: Lacks hydrogen bonding capability.
- Solvent Behavior: An excellent solvent for non-polar organic molecules.
- Uses: Historically used as a solvent in dry cleaning, as a refrigerant, and in chemical synthesis.

Given its non-polar nature, tetrachloromethane is often used as a solvent for hydrocarbons.

Analyzing Solubility Principles: The "Like Dissolves Like" Rule

A fundamental principle in chemistry, "like dissolves like," offers insight into solubility behavior:

- Polar solvents tend to dissolve polar or ionic compounds.
- Non-polar solvents tend to dissolve non-polar compounds.

Applying this principle:

- Nonane, being non-polar, will have higher solubility in non-polar solvents.
- Ethanol, being polar but containing a non-polar hydrocarbon tail, can dissolve some non-polar substances but not as efficiently as non-polar solvents.

- Water, being highly polar, will have minimal solubility for non-polar hydrocarbons like nonane.
- Tetrachloromethane, being non-polar, should dissolve nonane very well.

Comparative Examination of Nonane's Solubility in the Given Solvents

Let's evaluate each solvent in terms of nonane's solubility:

1. Nonane in Ethanol

While ethanol can dissolve some hydrocarbons, its polarity limits its ability to dissolve non-polar compounds like nonane effectively. Experiments and literature data suggest:

- Moderate solubility.
- Partial miscibility at room temperature.
- Solubility tends to be lower than in fully non-polar solvents, but better than in water.

Summary: Nonane is somewhat soluble in ethanol, but it does not represent the maximum.

2. Nonane in Water

Due to the stark polarity difference:

- Nonane exhibits extremely low solubility in water.
- The solubility is practically negligible, often less than 0.01 g/100 mL.
- Water's extensive hydrogen bonding network and polarity prevent non-polar hydrocarbons from dissolving.

Summary: Water is an ineffective solvent for nonane, with negligible solubility.

3. Nonane in Tetrachloromethane (Carbon Tetrachloride)

Given their shared non-polar characteristics:

- Nonane is highly soluble in tetrachloromethane.
- The solubility is near complete, with nonane readily dissolving in CCl_4 .
- This solvent is often used as a standard for dissolving non-polar hydrocarbons.

Summary: Tetrachloromethane offers the greatest solubility for nonane among the three solvents.

Scientific Evidence and Practical Insights

Empirical data, including solubility tables and experimental observations, support the conclusion:

- Nonane dissolves readily in non-polar solvents like hexane, benzene, and tetrachloromethane.
- When compared, tetrachloromethane exhibits the highest solubility for nonane.
- Ethanol, being somewhat polar, dissolves nonane to a lesser degree.
- Water, due to its polarity, is essentially insoluble for nonane.

Key Data Point: Literature indicates that nonane's solubility in tetrachloromethane approaches complete miscibility, with solubility values close to 100% under standard conditions.

Conclusion: Which Solvent Does Nonane Prefer?

Based on the principles of solubility, empirical data, and chemical reasoning, tetrachloromethane (carbon tetrachloride) stands out as the solvent in which nonane exhibits the greatest solubility.

Final Verdict:

- A) Ethanol: Moderate solubility, but not maximal.
- B) Water: Negligible solubility.
- C) Tetrachloromethane: Highest solubility, near complete miscibility.

Answer: C) Tetrachloromethane

Implications and Practical Considerations

Understanding nonane's solubility profile has practical implications:

- Industrial Extraction: Non-polar solvents like CCl_4 are ideal for dissolving and extracting nonane from mixtures.
 - Chemical Reactions: Reactions involving nonane are best conducted in non-polar solvents to ensure solubility.
 - Safety and Environmental Impact: Given the toxicity of tetrachloromethane, alternatives like hexane or other hydrocarbons are often preferable, but for theoretical purposes, CCl_4 demonstrates the highest solubility.
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Final Thoughts

In the realm of organic solvents, the compatibility between a solvent and a compound hinges on their polarity and molecular interactions. Nonane, as a non-polar hydrocarbon, naturally gravitates toward non-polar solvents. Tetrachloromethane, sharing this non-polar character, provides an ideal medium for nonane to dissolve extensively. While ethanol offers some solubility due to its hydrocarbon tail, it falls short compared to tetrachloromethane. Water, the polar prototypical solvent, remains largely incompatible with nonane, reaffirming that "like dissolves like" remains a guiding principle in chemistry.

In essence, when seeking the maximum solubility for nonane, tetrachloromethane is unequivocally the solvent of choice.

Nonane Has The Greatest Solubility In Which Solvent A Ethanol B Water C Tetrachloromethane D

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