A Solution Contains Naphthalene (c10h8) Dissolved In Hexane (c6h14) At A Concentration Of 13.51 % Naphthalene

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Introduction

A solution containing naphthalene (C10H8) dissolved in hexane (C6H14) at a concentration of 13.51% naphthalene presents an interesting case study in organic chemistry, particularly in the fields of solvent-solute interactions, solution concentration calculations, and practical applications in industry and research. Naphthalene, a polycyclic aromatic hydrocarbon, is widely known for its distinctive smell and historical use as a moth repellent. Hexane, a nonpolar solvent derived from petroleum, is commonly employed in organic synthesis and extraction processes due to its excellent ability to dissolve nonpolar compounds like naphthalene.

Understanding the properties of this specific solution is crucial for chemists and industrial practitioners who rely on precise concentrations for applications ranging from chemical analysis to manufacturing processes. This article delves into the chemistry behind the solution, explores how the concentration is determined, and highlights its practical significance in various fields.

Understanding Naphthalene and Hexane

Properties of Naphthalene (C10H8)

Naphthalene is a crystalline, aromatic hydrocarbon composed of two fused benzene rings. Its chemical and physical properties include:
- Molecular weight: 128.17 g/mol
- Melting point: 80.2°C
- Boiling point: 218°C
- Solubility: Insoluble in water but highly soluble in organic solvents like hexane, benzene, and ethanol
- Uses: Mothballs, precursor in the manufacture of phthalic anhydride, and as a solvent in chemical research

Properties of Hexane (C6H14)

Hexane is a colorless, volatile liquid characterized by:
- Molecular weight: 86.18 g/mol

- Boiling point: 68.7°C
- Melting point: -95°C
- Solubility: Virtually insoluble in water; excellent solvent for nonpolar substances
- Uses: Extraction of vegetable oils, cleaning, and as a solvent in laboratories

Concentration of Naphthalene in the Solution

Defining the 13.51% Naphthalene Concentration

The concentration of 13.51% naphthalene in hexane indicates that in every 100 grams of the solution, approximately 13.51 grams are naphthalene, with the remaining 86.49 grams being hexane. This percentage can be expressed in various ways, such as:
- Weight/weight percent (w/w%)
- Molar concentration (molarity), which requires calculating moles of each component
- Volume/volume percent (v/v%), especially relevant if dealing with liquids by volume

For most laboratory and industrial purposes, the weight/weight percentage provides a straightforward measure of concentration.

Calculating the Composition of the Solution

To understand the mixture's composition, consider a hypothetical total mass of the solution, for example, 100 grams:
- Naphthalene: 13.51 grams
- Hexane: 86.49 grams

Alternatively, for molar calculations:
- Moles of naphthalene = 13.51 g / 128.17 g/mol ≈ 0.105 mol
- Moles of hexane = 86.49 g / 86.18 g/mol ≈ 1.003 mol

This ratio indicates that the solution is predominantly hexane, serving as an excellent solvent for naphthalene.

Preparation of the Solution

Steps to Prepare a 13.51% Naphthalene Solution

1. Gather Materials:
- Pure naphthalene crystals
- Analytical grade hexane
- Precise weighing scale

- Volumetric flask or mixing container
- Stirring rod or magnetic stirrer

2. Calculate Required Quantities:
- Decide on the total volume or mass of the solution to prepare.
- Use the percentage to determine how much naphthalene and hexane are needed.

3. Dissolution Process:
- Weigh out the calculated amount of naphthalene.
- Add hexane gradually to the naphthalene in the container.
- Stir until the naphthalene is completely dissolved.

4. Storage:
- Store the solution in a tightly sealed container.
- Keep it away from light and heat to prevent degradation.

Applications of Naphthalene-Hexane Solutions

Industrial Uses

Solutions of naphthalene in hexane are utilized in various industrial applications:
- Chemical Manufacturing: As a solvent in the synthesis of dyes, plastics, and other aromatic compounds.
- Extraction Processes: For isolating and purifying aromatic hydrocarbons.
- Analytical Chemistry: Used as calibration standards in chromatography and spectroscopy.

Laboratory and Research Applications

In research settings, precise naphthalene solutions are essential for:
- Studying solubility and dissolution kinetics.
- Performing spectroscopic analysis (UV-Vis, IR).
- Developing analytical methods for detecting aromatic hydrocarbons.

Safety Considerations

Handling naphthalene and hexane requires adherence to safety protocols due to their toxicity and flammability:
- Use gloves and protective eyewear.
- Work in a well-ventilated area or fume hood.
- Avoid inhalation of fumes.
- Store chemicals away from open flames and heat sources.

Environmental Impact and Disposal

Both naphthalene and hexane are classified as hazardous substances:
- Avoid environmental release.
- Dispose of waste solutions in accordance with local regulations.
- Use designated disposal containers for organic solvents and chemicals.

Conclusion

A solution containing naphthalene dissolved in hexane at a concentration of 13.51% exemplifies the interplay of solute-solvent chemistry, precise measurement, and application-specific formulation. Understanding the properties of both components, the methods of preparation, and safety considerations ensure effective and responsible use in industrial and research settings. This concentration level offers a balance between maximizing solubility and maintaining manageable handling characteristics, making it a valuable formulation in various chemical processes.

By mastering the details of such solutions, chemists and industry professionals can optimize their processes, ensure safety, and achieve accurate analytical results. Whether used in manufacturing, research, or analytical chemistry, the knowledge of how to prepare and utilize a 13.51% naphthalene in hexane solution is a fundamental aspect of working with aromatic hydrocarbons and their solvents.

Frequently Asked Questions

What is the significance of a solution containing 13.51% naphthalene dissolved in hexane?

A solution with 13.51% naphthalene in hexane indicates a relatively high concentration, which is useful for applications requiring specific solubility or toxicity levels, such as in chemical analysis or industrial processes.

How does the concentration of 13.51% naphthalene affect its solubility in hexane?

At 13.51%, naphthalene is well within its solubility limit in hexane, ensuring the solution remains homogenous. This concentration reflects the capacity of hexane to dissolve naphthalene effectively without precipitation.

What are the potential safety considerations when handling a solution with 13.51% naphthalene in hexane?

Naphthalene is toxic and potentially carcinogenic, and hexane is volatile and flammable. Proper ventilation, protective equipment, and avoidance of ignition sources are essential when handling this solution.

How can the concentration of naphthalene in hexane be accurately determined in such a solution?

Analytical techniques such as UV-Vis spectroscopy, gas chromatography, or gravimetric analysis can be used to accurately measure the concentration of naphthalene in the hexane solution.

In what industrial or research applications might a 13.51% naphthalene in hexane solution be used?

Such solutions are used in organic synthesis, as solvents or intermediates in chemical manufacturing, or in studies related to the environmental impact and toxicity of naphthalene.

Additional Resources

A solution contains naphthalene ($C_{10}H_8$) dissolved in hexane (C_6H_{14}) at a concentration of 13.51%. This seemingly straightforward statement opens up a realm of chemical principles, measurements, and practical considerations that are fundamental to understanding solution chemistry, solubility, and applications in industry and research. Whether you are a student delving into organic chemistry, a professional working with solvents, or an enthusiast exploring chemical solutions, this guide aims to break down the key concepts surrounding such a mixture, providing clarity, detail, and context.

Understanding the Components: Naphthalene and Hexane

Before exploring the nuances of the solution, it’s crucial to understand the individual components involved: naphthalene and hexane.

Naphthalene ($C_{10}H_8$)

- Chemical Nature: Naphthalene is an aromatic hydrocarbon composed of two fused benzene rings. It is a crystalline, solid substance at room temperature with a distinct smell.
- Physical Properties:
- Melting point: approximately 80°C
- Boiling point: approximately 218°C
- Solubility: Sparingly soluble in water but highly soluble in organic solvents like hexane, benzene, and chloroform.
- Uses: Naphthalene is widely used in mothballs, as a precursor to synthetic dyes, and in the production of phthalic anhydride.

Hexane (C_6H_{14})

- Chemical Nature: Hexane is a straight-chain alkane, a saturated hydrocarbon with six carbon atoms.
- Physical Properties:
- Boiling point: about 68.7°C
- Melting point: around -95°C
- Solubility: Non-polar solvent with excellent capacity to dissolve other non-polar compounds, like naphthalene.

- Uses: Hexane is commonly used as a solvent in cleaning, extraction processes, and in laboratories due to its non-polar nature.

The Significance of Concentration: 13.51%

When stating that a solution contains naphthalene dissolved in hexane at a concentration of 13.51%, it refers to the mass/mass percentage (m/m%) or weight percent:

$$
\text{Concentration (w/w%)} = \frac{\text{mass of solute}}{\text{total mass of solution}} \times 100
$$

In this context, 13.51% naphthalene indicates that in every 100 grams of the solution, approximately 13.51 grams are naphthalene, with the remainder being hexane.

Alternative Concentration Measures

- Molarity (mol/L): Number of moles of naphthalene per liter of solution.
- Mass Fraction: Ratio of the mass of naphthalene to total mass.
- Volume Percent: Volume of naphthalene per total volume, less common for solids dissolved in liquids.

Understanding the concentration measure is fundamental for calculations, whether predicting solubility limits, preparing solutions, or modeling behavior.

Calculating Composition: From Percent to Mass and Moles

Suppose you want to prepare or analyze a specific amount of this solution. Here's how to approach the calculation.

Example: Preparing 100 grams of the solution

- Mass of naphthalene: 13.51 g
- Mass of hexane: 86.49 g (since total mass = 100 g - 13.51 g)

Moles of each component:

- Naphthalene:
$$
\text{moles} = \frac{13.51\, \text{g}}{128.17\, \text{g/mol}} \approx 0.1053\, \text{mol}
$$

- Hexane:
$$
\text{moles} = \frac{86.49\, \text{g}}{86.18\, \text{g/mol}} \approx 1.003\, \text{mol}
$$

These calculations help in understanding the molar ratio, which is essential in reactions, phase behavior, or when converting between different concentration units.

Solubility and Thermodynamics

Solubility of Naphthalene in Hexane

Naphthalene’s high solubility in hexane stems from their similar non-polar characteristics, following the principle "like dissolves like." At room temperature, naphthalene dissolves readily in hexane, but solubility can vary with temperature.

Factors Affecting Solubility

- Temperature: Increasing temperature generally increases solubility.
- Pressure: While pressure effects are minimal for liquids and solids, they can influence solubility in some cases.
- Impurities: Presence of other substances can alter solubility.

Thermodynamic Considerations

The dissolution process involves enthalpy and entropy changes:

- Enthalpy (ΔH): Typically exothermic or slightly endothermic for naphthalene in hexane.
- Entropy (ΔS): Increases as the solid dissolves into the solvent.

The free energy change (ΔG) determines the spontaneity of dissolution:

$$
\Delta G = \Delta H - T \Delta S
$$

A negative ΔG indicates spontaneous dissolution under given conditions.

Practical Applications and Considerations

Industrial and Laboratory Use Cases

- Extraction and Purification: Naphthalene can be extracted from mixtures using hexane due to its high solubility.
- Formulation of Mixtures: Precise concentration control is vital for producing mothballs or chemical intermediates.
- Analytical Chemistry: Accurate knowledge of concentration aids in spectroscopic analysis, titrations, or chromatography.

Handling and Safety

- Toxicity: Both naphthalene and hexane are hazardous; naphthalene is toxic and potentially

carcinogenic, while hexane is neurotoxic with effects related to inhalation.
- Flammability: Hexane is highly flammable; solutions should be handled away from heat sources.
- Storage: Store in well-sealed containers in a cool, ventilated area, following safety protocols.

Measuring and Preparing the Solution

- Use precise analytical balances for weighing.
- Dissolve naphthalene in hexane under controlled temperature conditions to ensure accurate concentration.
- Use volumetric flasks or graduated cylinders for volume-based preparations if needed.

Analytical and Experimental Techniques

Determining Concentration

- Gravimetric analysis: Weighing components directly.
- Spectroscopic methods: UV-Vis or IR spectroscopy can quantify naphthalene concentration.
- Gas chromatography: Separates and quantifies naphthalene in complex mixtures.

Verifying Stability

- Conduct stability tests over time to ensure concentration remains consistent.
- Note that temperature fluctuations can cause naphthalene to crystallize or precipitate if the solution exceeds solubility limits.

Calculations for Phase Equilibrium and Saturation

Understanding whether a solution is saturated, undersaturated, or supersaturated is crucial:

- Saturated solution: Contains maximum naphthalene at a given temperature.
- Undersaturated: Less naphthalene than maximum; additional dissolves.
- Supersaturated: More naphthalene than equilibrium allows; unstable and may crystallize.

The solubility curve of naphthalene in hexane can be used to determine these states at various temperatures.

Summary and Key Takeaways

- A solution containing naphthalene dissolved in hexane at 13.51% represents a specific, quantifiable mixture with applications in industry and research.
- Understanding the physical and chemical properties of each component informs how the solution behaves under different conditions.
- Accurate calculations of moles, mass, and concentration are essential for preparation, analysis, and quality control.
- Thermodynamic principles govern the dissolution process, affecting solubility and stability.

- Safety considerations are paramount when handling these chemicals, given their toxicity and flammability.
- Analytical techniques enable precise determination of concentration and phase behavior.

Final Thoughts

The mixture of naphthalene in hexane at 13.51% is more than just a simple solution—it's a gateway to understanding fundamental concepts in solution chemistry, thermodynamics, safety protocols, and practical applications. Whether for laboratory research, industrial processes, or educational purposes, mastering the details of such solutions enhances both scientific knowledge and practical capability.

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