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GREEN SOLVENTS FOR GREEN TECHNOLOGY

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Abstract
In many industrial processes, large amounts of poisonous and dangerous chemical solvents are used in the reaction systems and other steps. Both the environment and the business are affected by this. So, studying green technology means making new chemicals that are safe for the environment and can be tweaked to be used in business and technology. Supercritical and subcritical fluids, natural and reused solvents, and ionic liquids that are liquid at room temperature all show promise as new ways to make solvents. Here is a list of what these solvents are, how they are used, and whether or not they could be used as totally green industrial solvents.

Keywords: Solvents; Research & Development; · Waste minimisation; · Sustainable development;

Introduction

Solvents are responsible for 60% of industry emissions and 30% of all volatile organic compound emissions in the world [1]. The EU's environmental policy and rules for 2010–2050, which focus on lowering the use of risky solvents in industry, show that P.T. Anastas's idea of "green chemistry" has moved beyond academia. [2] Solvents are needed to break up things, move mass and heat, change the structure of things, split them, and clean them. So, green solvent development focuses on replacing solvents made from petroleum with solvents made from natural resources and replacing solvents that are dangerous with safer ones. Water is the best fluid, and both emulsion polymerization and hydrodistillation use it. Many organic and organometallic drugs do not dissolve in water, which makes them less useful [3]. So, ionic liquids that are liquid at room temperature, fluids that are supercritical or subcritical, and natural or reused solvents are the most promising new solvents.

Solvency and solvents

Solvency, solvents, and solutions are used every day, from making a cup of coffee (and adding sugar and washing the cup) to washing hair in the shower, from putting on and taking off nail polish to rinsing an apple under the tap before eating it, from painting to taking soluble painkillers for headaches. A solution or a way out? What's the difference between a gel, a mix, a suspension, and a solution? So, solutions and solvents are important in many areas of chemistry [4], such as phase behaviour, the nature of solids, liquids, and gases, and the properties of mixtures that are mostly liquids and solids. Dissolving has to do with Van der Waals forces, ionic and dipolar forces, hydrogen, and charge transfer. The liquid has a big effect on the rate and temperature of a process [5].

Ionic liquids

Ionic liquids (ILs) have been of interest to scientists and businesses for 15 years [6]. ILs are organic salts that dissolve at temperatures below 100°C. They are beneficial to technology and the environment because to their low volatility, in flammability, and chemical, thermal, and electrical safety. Solvents may be modified to meet particular requirements [7,8] because to the fact that they are composed of ionic species [often a bulky organic action and an organic or metal anion]. There are already over 50,000 academic articles and over 5,000 patents in the field of ILs.

Usage, waste, and pollution of solvents

The environment and other factors are affected by pollution, chemical use, and excessive water use. This long-standing pastime originally made use of less-than-ideal solvents including benzene, 4-carbon disulphide, and carbon tetrachloride before upgrading [9,10]. Due to their toxicity, flammability, and ability to produce peroxide, industrial users are

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reducing their reliance on chemicals like diethyl ether, di-isopropyl ether, hexane, and ethylene glycol dimethyl ether. (Table 1): Industrial usage of solvents is common.

Solvent extraction	Hydrometallurgy Waste water treatment
Cleaning	Metal degreasing Dry cleaning
Formulations	Dispersant Lubricant
Coatings	Paints Varnishes
Chemicals production	Reaction medium Product purification

Table 1 Lists many common applications for solvents

Natural and renewable sources of solvents

Glycerol can be used in place of petroleum-based solvents because natural component solvents (such as deep eutectic solvents and cholinium-based ILs) and renewable source solvents (such as glycerol, methanol, ethanol, esters, 2-methyl-tetrahydrofuran, and hydrocarbon solvents) are safer, more environmentally friendly, and biodegradable. Glycerol is nontoxic, biodegrades, and may be reused [11,12,13].The majority of volatile organic compounds contribute to environmental degradation and fire hazards. It was formerly believed that natural solvents, such as cholinium-based ILs (described in section X) and deep eutectic solvents, were environmentally friendly because of the low toxicity of their constituent components or ions. Studies [14-16] confirmed this. The greatest research and curiosity have been put into deep eutectic fluids and glycerol replacements. They have potential as environmentally friendly solvents, as shown by this research.

Alternatives for solvent

Fumes may be reduced or eliminated altogether by using alternative solvents. Major advancements in reaction engineering and process technology are required to eliminate the use of harmful chemicals and other pollutants. Substituting chemicals for solvents is an option. Although (i) is the more common choice in industry, efforts are being made by both business and academia to improve the efficiency and quality of the search for suitable alternatives to traditional industrial liquids. Academics often use (ii) when they have access to financing from private companies. Reduced emissions of harmful chemicals is essential for long-term viability. Fluids and process systems derived from biomass are therefore being

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developed in industry and academia. Both "Solvents from other renewable sources" and "Bio solvents or bio-derived solvents" investigate this.

Guides for solvents from the pharmaceutical sector

The production of pharmaceuticals requires a lengthy chemical process and a liquid or solvent mixture. Interstate separation and cleaning is accomplished with the use of solvents. This is what causes the pharmaceutical industry's very high E-factor (kg/kg) of garbage to valuable output [17]. As a result of the costs and consequences, individuals are looking for solutions to reduce waste and pollution.

Selection of solvents and their creation: an empirical database and computer techniques

Selecting solvents in a methodical manner might potentially enhance chemical intuition and knowledge. Creating molecular species with desired physical or chemical properties and/or mapping chemical "space" using quantitative data for groupings of molecular molecules are two of the primary methods [18]. Many studies [19] have been conducted on so-called "green" compounds. The solute and solvent both have a role in determining how the solvent behaves. Experiments and extensive study on this connection have been conducted in both industry and academia by people like Snyder, Hildebrand, Hansen, Gutmann, Winstein, Reichardt, Kamlet, Taft, Abrahams, Katritzky, and Marcus.

Solvents and the environment

Solvents may be found in a wide variety of forms and are notoriously difficult to replicate. Research and development (R&D) in both industry and academia has moved slowly and unevenly. This is a complete summary of events. In the past, "green" reaction liquids were the primary emphasis of green chemistry; now, however, it is more about the source, method of use, level of control, and final disposal of the fluid that matters. Efforts made early on to improve occupational health by reducing the use of solvents reduced exposure to the most harmful compounds. People who worried about the environment advocated for solvent reduction in the 1970s and 1980s. Substitutes were offered at first because they were more readily available.

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Green solvents: novel and repurposed using previously used materials

According to the data collected by John Andraos (2013), the efficiency of technology, worker safety, and environmental consequences cannot be simultaneously matched.20 Therefore, it is important to consider factors other than a liquid's chemical qualities when deciding how much waste it will produce. In fact, these analyses may reveal that producing a product or intermediate using a "green" solvent is more inefficient and wasteful of resources than producing the same thing using a "non-green" solvent. "Green" or solvent-free solutions are favored in green chemistry research [20, 21]. Similar research may be found in [22, 23,24]. However, much of the written material emphasizes purported advantages that are "greener," "cleaner," "harmless," "environmentally friendly," "environmentally benign," "environmentally green," "environmentally acceptable," "eco-friendly," and "sustainable" without supporting evidence from toxicology or ecotoxicology. The industrial scale is seldom discussed in published works.

Eutectic deep solvents

A new class of liquid salts based on ILs, deep eutectic solvents (DESs) are composed of a hydrogen acceptor, such as a nontoxic quaternary ammonium salt (such as cholinium chloride), and a naturally derived uncharged hydrogen-bond donor, such as amines, sugars, alcohols, and carboxylic acids, in a specific molar ratio. The freezing point of a combination is decreased due to charge delocalization [25]. It is possible to create a liquid at room temperature (Tf = 12°C) by combining urea (133°C) with choline chloride (2-hydroxyethyl-trimethylammonium chloride, 302°C) in a 1:2 molar ratio.103 Because of their similarities to ILs in their inertness, lack of combustibility, high viscosity, and precursor ingredients, some refer to DESs as the fourth generation of ILs. DESs, like ILs, are considered "designer solvents" due to their malleable molecular structure and chemical composition. Environmentally and economically, DESs are a good option since they need few components, are simple to produce, pose no health risks, and endure for many years. [26] First employed in biodiesel, metal electrode position, and electropolishing, choline-based eutectic liquids have now found other applications. Organic synthesis, (bio)catalysis, polymer manufacturing, electrochemistry, nanomaterial’s, separation processes, analysis, medicine, and the extraction of bioactive substances from plants are only some of the 104,105 applications of DESs that have been reported [27]. From 2009-2013, there were 300 DES research articles that discussed these novel solvents. Although DESs may have positive effects on technology, health, and the globe, further research is required to confirm this. The biological applications of solvents produced from choline and sugar include medication delivery systems and bone repair aids. Organic acids, sugars, sugar alcohols, alkanols, amino acids, choline chloride, and betaine are all degraded by DESs at rates 10–100 times faster than water or lipids. Plant products that might be utilized in food, medicine, cosmetics, and agrochemicals could be provided by DESs without the need for costly processing.

Glycerol and it's by products

Due to its abundant supply (10 wt% of total output), low cost, non-toxicity, non-flammability, biodegradability, and promising physical (negligible vapour pressure, stability under typical storage conditions) and chemical properties (high polarity, ability to form strong hydrogen bonds and dissolve a wide range of organic and inorganic compounds, enzymes, and transition metal complexes), in [28] glycerol is being investigated for a variety of potential applications. In organic chemistry, glycerol is helpful because it can be combined with a wide variety of compounds, including some that don't mix well with water but do mix with glycerol. [29-31] Mineral salts, acids, bases, enzymes, and transition metal combinations are all susceptible to destruction by glycerol. Reaction products may be extracted in the liquid-liquid phase since ethers and hydrocarbons don't interact with glycerol. Glycerol's high boiling point (290°C) and great thermal stability allow it to be utilized at high temperatures and then reclaimed by distillation after being contaminated by reaction byproducts [32]. Glycerol's high viscosity (1200 cP at 20 °C) and poor solubility of hydrophobic compounds and gases are well-documented issues. Both co-solvents and temperatures higher than 60 °C have been shown to reduce viscosity [33–36]. Glycerol's hydroxyl groups undergo chemical reactions in very acidic or basic environments, yielding byproducts. Glycerol is a good solvent because it maintains the chemical neutrality of hydroxyl groups [37-39].

Conclusion

The process of dissolving is crucial in chemistry. Liquids are useful in both industry and the household, and they may be made using any branch of chemistry. Substitutes for lost solvent are not as effective as the original. Selecting an appropriate solvent is challenging since it must fulfil several roles. Which liquid you use depends on your application. Maintain a healthy equilibrium between the physical, scientific, economic, scalability, regulatory, safety,

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and environmental objectives. The past ten years have seen significant developments in a variety of solvent types, including ionic liquids, water, supercritical and subcritical fluids (particularly supercritical CO2), and natural and green solvents (deep eutectic solvents, glycerol-derived solvents, etc.).

Despite promising findings, the use of supercritical CO2 extraction units, ionic liquids, and other such solvents is limited by their toxicity, biocompatibility, and difficulty to separate products in water-based processes. There are differences among green chemicals. Consumers make choices based on evidence from the past, as well as cost and environmental considerations. Solvents are essential for purifying, extracting, and separating goods because they slow down the changes that occur during chemical reactions. For this reason, we must conduct a comprehensive economic and environmental impact assessment.

Toxicological, Eco toxicological, environmental, resource depletion, and economic effects on the production chain (from its primary feedstock), formulation, use, and fate or disposal are just some of the factors that should be considered when choosing a sustainable solvent.

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