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Review Article

Investigation of improved applications of deep eutectic solvents in various fields

Mozhdeh Haddadi*

Department of Biochemistry, Faculty of Biological Sciences Tarbiat Modares University, Iran

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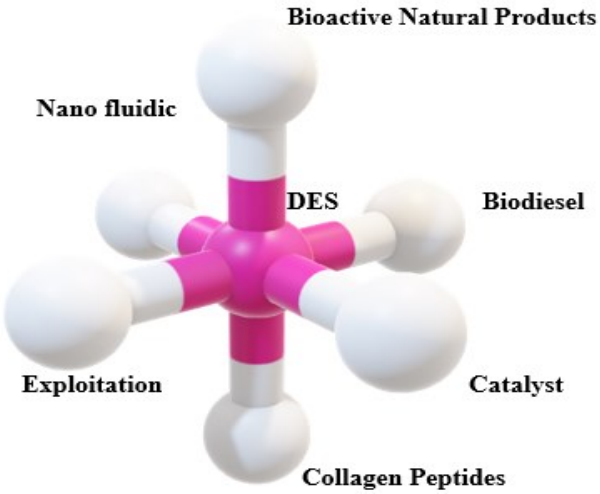
ABSTRACT

In the pharmaceutical arena, the most significant issue is green technology. This is due to the fact that, it decreases the cost of drugs, reducing the environmental influence of the arena and improving the human health and safety. Deep eutectic solvents (DES), a novel kind of green solvent, have some focused attributes such as, low vapor pressure, high thermal stability, low cost, biodegradability, and high viscosity. Green solvent metrics with attention to functionality and environmental, safety, and health influences from a progression and life cycle view are likewise addressed and practical to common and unique solvents. As a developing research field, DESs have previously received important research consideration from chemistry scientists.

Corresponding author, email: m.haddadi@modares.ac.ir (M. Haddadi).
Tel.: +98 9153714942.

Graphical Abstract



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Introduction

DESs include great, nonsymmetric ions that have little reticulation energy and therefore little melting points. They are commonly attained by the elaboration of a quaternary ammonium salt with a metal salt or hydrogen bond donor (HBD). This primary study was extended, and a variety of liquids designed from eutectic combinations of salts and hydrogen bond donors have present been advanced. These solutions were called deep eutectic solvents to separate them from the ionic liquids which include only distinct anions. DESs were used in different field for example metal processing, organic synthesis, extraction and biological transformations. Applications of DES was a solvent or co-solvent, combining the benefits of high solubility of the replacement, non-vaporisation and simple handling [1].

Exploitation of bioactive natural products

Deep eutectic solvents (DESs) are developing solvents for effective exploitation of bioactive mixtures or medicines. This project targeted to expansively assess the possible and efficiency of DESs for exploitation of diverse kinds of natural mixtures from biomass. Li Duan *et al.* revealed that most organized DESs demonstrated to be effective solvents for exploitation of alkaloids; however, minor extractability for anthra quinones. The exploitation volume of DES probably associated with their physical–chemical attributes, containing H-bonding connections, polarity, viscosity, and pH. This research proved that DESs were appropriate green exploitation solvents for optional and effectual extracting bioactive mixtures from biological materials [2].

Dispersive liquid–liquid micro-exploitation

In this research, a novel type of DESs has been manufactured and used as the exploitation solvent in a Scattered liquid–liquid micro-exploitation technique. Some pesticides were used as pattern mixtures and the anticipated micro-exploitation technique was practical for their exploitation and pre-concentration from vegetables and fruit juices previous to gas chromatography- flare ionization detection [3].

Exploitation of polysaccharides

In this work, DESs were anticipated for the ultrasound-helped exploitation of polysaccharides from Dioscorea opposita Thunb. Some DESs were organized for the exploitation of polysaccharides, among which the DES compound of choline chloride and 1,4-butanediol was demonstrated to be appropriate used for the exploitation. The optimal exploitation qualifications could efficiency developed exploitation turnover than those of warm water exploitation and water-based ultrasound-helped exploitation. Thus, DESs were noticeable exploitation solvent replacement to the exploitation of polysaccharides from model matrices [4].

Selective exploitation of collagen peptides

This study investigated an effective and environmental exploitation and dissociation technique of separation of collagen peptides from cod skins based on an innovation stage of green and stable DESs. 6types of DESs were manufactured. According to the attitude of high exploitation efficacy and high purity, ChCl–oxalic acid was designated as the optimal exploitation solvent. The consequences from this research prove that ChCl–oxalic acid is a green, effective and hopeful solvent for exploiting collagen peptides from cod skins [5].

Exploitation of colors from red chili peppers

DESs have been used to exploit bioactive mixtures but there is low practical in exploiting chrysoidine colors.Shuqiang Zhu *et al.* [6] developed a green and effective exploitation technique, containing ultrasonic-supported exploitation of food models with choline chloride/Ethyl glycol (1 : 2) DES for the exploitation of COG, AOG, and AOR. The investigational outcomes displayed the DES as exploiting could suggestion the sufficient improvement with fewer organic solvent expended with the easy function. The technique could be used positively for the examination of illegal additive colors (COG, AOG, and AOR) in solid nutrition [6].

Recognition of flavonoids

Asma Nisar DESs created of ChCl-glycerol (1:2) were applied for the exploitation and separation of flavonoid such as rutin, gallic acid, and quercetin from Catharanthus roseus herbal fragments, flower petal, leaves, root, and stem [7]. Catharanthus roseus has multiple operative important therapeutic attributes like anticancer, antidiabetic, antimicrobial, antioxidant, and etc. expenditures. Currently, profits have been growing in DESs based on ChCl and their operative expenditures in exploitation and isolation of mixtures from pharmaceutical herbal. Flavonoids [8, 9], aromatics [10], chalcones [11], and saponins [12] are the positive mixtures being exploited and isolated by using DESs from pharmaceutical herbal, and DESs exploitation prepare more effective exploitation than other solvents. The sepration of rutin, gallic acid, and quercetin in DES exploitation admitted desirable outcomes, and this is owing to the foundation of hydrogen bonds connecting flavonoids (rutin, gallic acid, and quercetin) and DES ingredients. The HPLC is a methodical technique, which was found to be great system for designation of rutin, gallic acid, and quercetin expending DES exploitation from herbal sections of Catharanthus roseus. Therefore, this technique can be practical for the qualitative and also quantitative investigation of rutin, gallic acid, and quercetin. Additionally, the technique was found to be easy, fast and effectual.

Eco-friendly environmental protection

With growing anxieties over health and eco-friendly factors of pesticides, the research for environmentally admissible replacements has boosted [13]. Herbal secondary metabolites emerge in the perspective as an adsorbent solution for green produce defense. Several of these insecticidal metabolites, nevertheless, are crystalline solids with confined solubility which might possibly hinder marketable construction.Sanae Mouden and *et al*. demonstrated the impression of (NDES) natural deep eutectic solvents for increasing solubility and sustainability of such mixtures. The idea, ideologies and instances of green pest regulator explained here suggestion a novel group of eco-friendly tools planned to support and approve maintainable farming [14].

Stability and thermophysical researches based carbon nanotube nanofluidic

Microfluidic and nanofluidic systems are prevailing in several areas of experimental knowledge. Therefore, a novel kind of base fluid recognized as DESs is recommended in this study as a possible alternative for the conventional base fluid caused by their unique solvent attributes for instance low vapor pressure, high thermal sustainability, biodegradability and nonflammability. Sustainability of the nanofluids were specified expending both qualitative and quantitative method. Furthermore, thermo-physical attributes for example thermal conductivity,

particular heat, viscosity and density were reconnoitered [15].

Facilitate lignocellulosic biomass utilization and conversion

Great dependence on simple oil for energy expenditure outcomes in the prompt necessity to discover and progress substitute renewable sources. Important hopeful ways are the alteration of biomass such as biofuels and chemicals. The presentation of DESs in 2004 expected a significant volume of consideration through various research arenas, mainly in biomass processing. The helpfulness of DESs in breaking down the unmanageable structure in biomass highpoints its impression on the alteration of biomass into different value-added products [16]. As novel uses develop in the arena of biomass purifying and valorization, suitable solvent expansion and usage will aid in viable performance [17].

Improved solubility of lignin monomeric pattern mixtures and practical

The factors of DES constituents, concentration and temperature, were assessed. The consequences indication aqueous solutions of DES to be a novel stage of influential solvents wherever both the hydrogen bond donor (HBD) and the hydrogen bond acceptor (HBA) synergistically collectivity to growth the solubility of the lignin pattern mixtures. The consequences revealed that the solubility of the practical lignins and their monomers in DES aqueous solutions is motivated by a hydrotropic mechanism, now accepted by dynamic light scattering that is here detected for the first time with DES as hydrotropes [18].

Papermaking process

Some greatly major investigation and expansion within the industry has newly led to an exciting detection that might remove the essential for water in the papermaking process altogether. DESs, manufactured by herbals, could open an approach to manufacturing pulp at low temperatures and at atmospheric pressure needing a lot fewer energy and no water. Expending DES, any kind of biomass could be dissolved into lignin, cellulose and hemicellulose with least energy, releases and remains. They could also be utilized to improve the cellulose from waste. It was reported that DES is a hopeful solvent for wood delignification and the manufacture of a novel source of lignin with hopeful probable practical [19].

Biodiesel

In this research deep eutectic solvent containing ChCl) as salt and CA, glycolic acid and ethane-1,2-diol as hydrogen donor was reported as co-solvent for alteration of feed oil to biodiesel, also demonstrated to be impressive in recovering the yield of biodiesel. The synthesized choline chloride-DES demonstrated to be impressive in recovering efficiency of biodiesel and so can be used as a substitute to ionic liquids. In summary, the synthesized DES acted efficiently as co-solvents through purification progression of biodiesel [20].

Role of catalyst

Newly, other part of DESs displayed up, as a catalyst in various category of reactions. Acid type catalysis containing Lewis and Brønsted category acids were the irreversible catalysts for most of the organic reactions. category 3-15 metal chlorides are named Lewis acids. Electron-pair acceptor with presence of a metal in the combination of DES prepares it Lewis acidic feature.

Although various metal salts are used in DES provision, the DES including HCl and $ZnCl_2$ is

widely used as Lewis acid catalyst. As acid catalyst the use of DESs has numerous advantages for example the application at non-toxicity, stoichiometric quantity, feasibility of the improvement, alike or higher catalytic impact than the acid itself alone, the recyclability without an important loss of activity. Consequently, DESs can easily be observed as substitute catalysts to the typical ones [21].

Conclusions

Green technology is possibly significant impression which plays a character to realize the global sustainable development. Currently the world requires a novel serious innovation, which may result in an improved environment. The basic impartial of the study is to recognize the condition of the innovative green products for today's global market and also try to recognize the negative influence of non-green products. It benefits for the sustainable development. Solvents are the necessary mixtures of chemical and pharmaceutical industries. The study also throws a light on future research opportunities. With the growing knowledge of the environmental problems, researchers displayed great endeavor to substitute toxic component with less or non-toxic ones.

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