Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-023-26288-8

SUSTAINABLE ENERGY FOR BETTER SOCIAL, ENVIRONMENTAL AND ECONOMIC RETURNS

A review on natural based deep eutectic solvents (NADESs): fundamentals and potential applications in removing heavy metals from soil

Zhi Ying Lai[1] · Chung Loong Yiin[1,2] · Serene Sow Mun Lock[3] · Bridgid Lai Fui Chin[4,5] · Nur Syuhada Ahmad Zauzi[1] · Sherena Sar-ee[1]

Received: 29 November 2022 / Accepted: 1 March 2023

Abstract

Natural based deep eutectic solvent (NADES) is a promising green solvent to replace the conventional soil washing solvent due to the environmental benign properties such as low toxicity, high biodegradability, high polarity or hydrophilicity, and low cost of fabrication process. The application of NADES is intensively studied in the extraction of organic compounds or natural products from vegetations or organic matters. Conversely, the use of the solvent in removing heavy metals from soil is severely lacking. This review focuses on the potential application of NADES as a soil washing agent to remove heavy metal contaminants. Hydrophilicity is an important feature of a NADES to be used as a soil washing solvent. In this context, choline chloride is often used as hydrogen bond acceptor (HBA) whereby choline chloride based NADESs showed excellent performance in the extraction of various solutes in the past studies. The nature of NADES along with its chemistry, preparation and designing methods as well as potential applications were comprehensively reviewed. Subsequently, related studies on choline chloride-based NADES in heavy metal polluted soil remediation were also reviewed. Potential applications in removing other soil contaminants as well as the limitations of NADES were discussed based on the current advancements of soil washing and future research directions were also proposed.

Keywords Natural based deep eutectic solvent · Green solvent · Heavy metal · Soil washing

Introduction

Industrialization and urbanization that are promoted in many countries including Malaysia to improve life quality and economic capabilities aid in soil pollution. Soil pollution is a result of high concentrations of contaminants that exceed the naturally occurring level in soil. Common soil contaminants include metals and metalloids, pesticides, asbestos, and petroleum hydrocarbons. Soil remediation activities increase due to the increasingly severe soil pollution. Referring to the data disclosed by Gao et al. (2022), the number of publications about soil remediation increased from 627 to 2749 between 2001 and 2020 in top 15 nations (Fig. 1), indicating the rising demand of soil remediation.

Soil remediation is carried out with various methods, namely physical process, chemical process, the combination of both, and bioremediation method. Referring to Grifoni et al. (2022), the evolution of soil remediation industry is toward green technology and sustainability. Among different chemical methods, Raffa et al. (2021) and Rashid et al.

Responsible Editor: George Z. Kyzas

✉ Chung Loong Yiin
clyiin@unimas.my

[1] Department of Chemical Engineering and Energy Sustainability, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, Malaysia

[2] Institute of Sustainable and Renewable Energy (ISuRE), Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, Malaysia

[3] CO2 Research Center (CO2RES), Department of Chemical Engineering, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Malaysia

[4] Department of Chemical and Energy Engineering, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009 Miri, Sarawak, Malaysia

[5] Energy and Environment Research Cluster, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009 Miri, Sarawak, Malaysia

Published online: 14 March 2023