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MATERIAL RECOVERY AND SUSTAINABILITY IN PRACTICE USING IONIC LIQUID

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ABSTRACT

Material recovery is essential to sustainable development and has gained attention over the years. This study investigates the use of 1-butyl-3-methylimidazolium chloride ionic liquid (butylMIMCl-IL) as a mechanism for the recovery of hydrocarbons from simulated contaminated soil. The methodology used in this study are literature review and experimental research to determine the recovery potential of the selected ionic liquids and the adaptability of material recovery mechanisms to businesses to adapt the reusable option to their operation. The findings revealed that the butylMIMCl-IL recovered the target contaminants successfully from the mixture. The study

Introduction

Sustainable development is a lasting solution to environmental impacts. Failure to resolve the usage of natural resources can deplete the resource base. Thus, this emphasises the need to set up structures that can aid the accomplishment of the goal of sustainable use. This requires orientation to technological developments in implementing a mechanism that is beneficial socially, economically and environmentally, and sustained (Tatiya, 2011). Over-extraction and resource

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concluded that the adaptability of novel solvents will require a cost-benefit analysis to determine the best approach at what stage of operations the management will need strategic planning to adopt a reuse option.

Keywords: Ionic liquid, recycling, reuse, recovery, sustainability.

Exploitation of raw materials can lead to poor sustainability performance hence waste management policies help sectors to meet their environmental responsibilities (National Environmental Commission, 2011).

Waste Reduction and Environmental Management

Techniques for waste management, reducing pollution and consumption of natural resources tend to be very specific in nature. These wastes can be transformed into inputs where they are broken down into harmless substances. Waste minimisation comprises disposal with recovery, which is a life-cycle approach. The disposal of waste without treatment or recovery can lead to enormous negative effects on the environment, especially if such waste contains toxic components. Toxics can be ategorized into different groups such as the known and latent. The known group comprises pollutants considered tentatively problematic and are enlisted by regulation, requiring further actions to either prioritise or include them in a watchlist. While the latent comprises wastes yet to be established as toxic due to limited information or studies to justify their long-term effects. In all this, the challenge is how companies can track the hazardous components of their materials, correctly capture their volume and communicate to the regulatory bodies overseeing the management process (Antweiler, 2014).

Adapting to Material Recovery Options

At every level of the life cycle of a product, industries and regulatory agencies are faced with the challenge of how to protect the environmental and social

resources at a cost. The regulatory capacity and the established infrastructure to help corporate organizations protect the environment will foster monitoring and compliance. To adapt to material recovery, many industries will require equipment modification to achieve a reduction in waste or reuse, thus this may require new capital investments. Hence, a broad range of possible options for companies to adapt to reuse options that are practicable and economically viable, though desirable will require adequate planning and funding (Hardisty, 2010).

Cost Recovery through Recycling

The recycling of materials can employ the local people. Improving corporate policies and integrating community expectations during environmental management can facilitate sustainable development, especially in developing countries (Barrow, 1999). A cost-benefit analysis of adapting novel innovations that foster reuse or recycling is critical for large-scale infrastructure and requires strategic planning (Petts, 1999). Despite the cost, the environmental sustainability of business operations can be improved and with a series of experimental efforts, the effect of different stages of operations that emit pollutants can be put under control (Aland & Banhazi, 2013).

Recovery Process Using Ionic Liquids

Ionic liquids are molten salts used mainly for extraction, and it's considered as a solution for recovering and separating hazardous components from a mixed waste stream, for recycling (Inman et al., 2022). The reliability of sustainable principles is at the heart of most business operations as technical and environmental performances are priorities in innovative practices (Christensen & Panoutsou, 2022) and compliance to emission standards across the life cycle of operations (Panoutsou et al., 2020). Recovery and recycling technologies are vital in the removal of organic pollutants from a one-phase or multiple-phase mixture (Khoo et al., 2024).

MATERIALS AND METHOD

To synthesis the butylMIMCl ionic liquid, the reagents, 1-methylimidazole (5.0 g, 0.06mol) and 1-chlorobutane (7.5 g, 0.08 mol) were mixed and heated by microwave for a total duration of 3min 20s at 50, 30, 20, 40, 60-sec intervals at 40, 60, 20,20, 20 % microwave power, respectively. This heating pattern was repeated two more times before washing the reaction mixture (25 mL×5) with ethyl acetate to remove any unreacted starting material. Residual ether was evaporated *in vacuo* and the IL was isolated as a viscous pale yellow liquid in 73% yield.

To test the synthesised ionic liquid for material extraction, treated drill cuttings were obtained from the outlet of a thermal desorption unit of waste management contractors in Port Harcourt Nigeria. Reagents for analysis were purchased from Fisher Scientific UK. To 1g of treated drill cuttings was added 2g separately of the butylMIMCl ionic liquid left for 6 hours without applying heat. A two-phase separation of oil from the cutting residue was observed with clear clean cutting at the base of the conical flask. It was observed that the butylMIMCl ionic liquid separated the oils on the contaminated soil (drill cuttings) in a very clear liquid. The Fourier transform infrared spectroscopy (FTIR) method was adopted to characterise and interpret the reaction.

RESULT

The comparative FTIR for the butylMIMCl ionic liquid and the mixture containing the oil-contaminated soils in **Figure 1** show differences in the peak profile (as circled) around the high wave number regions (3200-3500cm^{-1} and 2800-3100cm^{-1}), and double bond region (1900-2200cm^{-1}) suggesting that some organic contaminant from the oil drill cutting has been extracted into the ionic liquid.

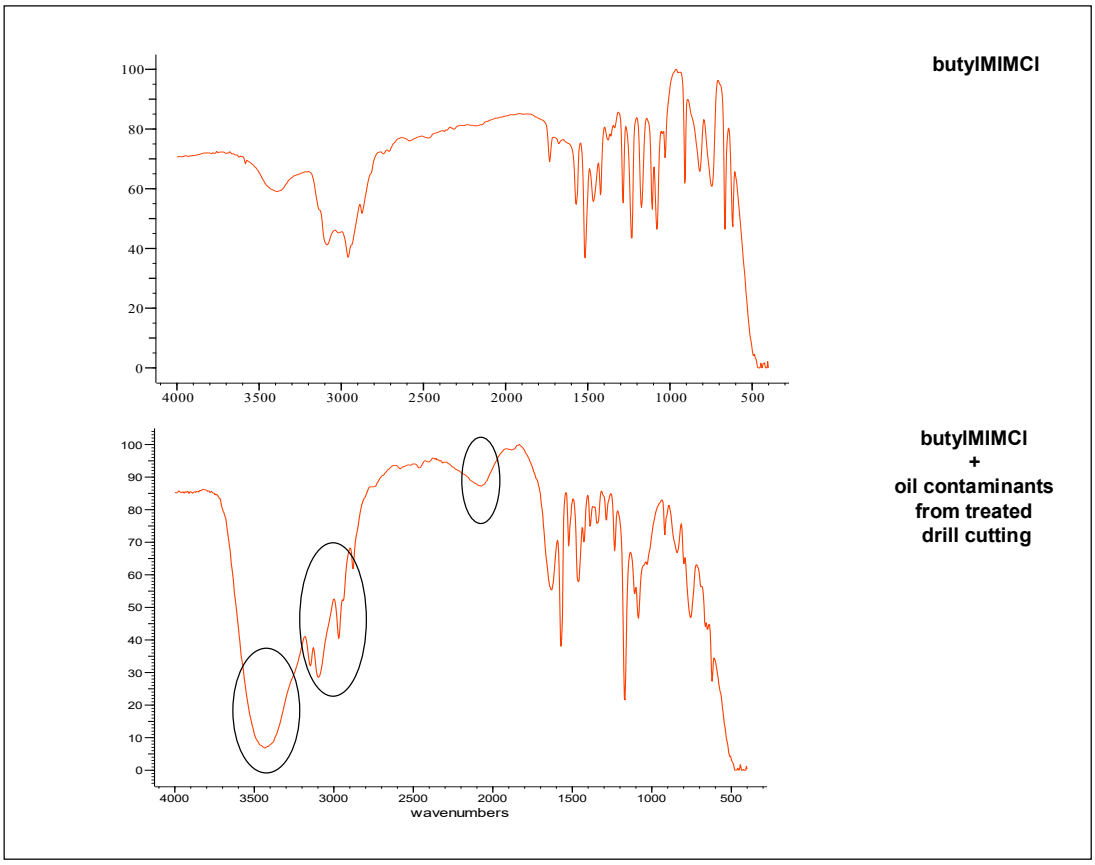

Figure 1: Comparative FTIRs for butylMIMCl and butylMIMCl – treated drill cutting

DISCUSSION

The filtration method is of significance in the recycling of ionic liquids from a mixture. The ionic liquid used in this study, butylMIMCl ionic liquid has been successfully used in other studies, and the membrane filtration method of extraction has been very effective in recovering the target material (Wang et al., 2016). The use of ionic liquid in the extraction of hydrocarbon mixtures is not new (Yu et al., 2024). In this study, the ionic liquid is utilised as a potential green solvent for the management of oily wastes. The scope of ionic liquids as a means of removing contaminated organic materials from soils is an extensive study that requires further investigation with a series of trials to determine the procedures for extraction and protocol for removal.

CONCLUSION

This study highlights the importance of conserving natural resources by adopting sustainable reuse options and mechanisms to reduce the exploitation of natural resources and improve sustainability performance. The novel use of molten salts like ionic liquid is a viable option to address latent toxic components of waste and to protect environmental and social resources. Though this might be difficult due to the cost implication, established protocols such as the membrane filtration method can be easily adapted to recover target materials from complex mixtures for recycling.

RECOMMENDATION

Organic materials can be toxic to the environment. The study recommends improving the separation techniques for oily wastes so that extraction of these organics can become a norm in sustainability practices.

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