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Interfacial Behaviour and Compatibility of Synthetic Oil Based Mud with Ionic Liquids

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Abstract

Waste management is a sustainable development issue globally as valuable materials that are yet to be discovered are limited by waste treatment infrastructure. Drilling wastes are toxic due to heavy metals and hydrocarbons in the mixture, thus categorised as hazardous. Novel options must be investigated to explore the recovery of the hydrocarbons despite other established treatment methods. Hence, this study investigates the interfacial behaviour and compatibility of unused drilling fluid in the synthesised 1-propyl-3-methylimidazolium bromide ionic liquid (propyIMIMBr-IL). The findings reveal that the unused drilling fluid and ionic liquids give a heterogeneous mixture that separates into an upper oil layer and a lower ionic liquid for recovery and characterisation by the Fourier-transformed infrared (FTIR). This recovery of drilling fluid from ionic liquid and drilling fluid simulated mixture is a process that can be advanced during drilling waste management to study the chemical reactions and maximise the recovery potentials of propyIMIMBr-IL.

Keywords: Drilling fluid, Material recovery, Oil and gas wastes, Ionic liquid, Recycling

Introduction

Imidazolium-based ionic liquids comprise cations and anions critical in oil recovery and compatible with extraction efficiency (Semnani et al., 2022). Oil recovery during drilling operations is an important aspect of a novel compliance programme. Due to the cationic and separation prospects in synthesising ionic liquids and their efficiency in material recovery and interfacial analysis, they can enhance and increase collaboration in prioritising initiatives to meet regulatory expectations (Nandwani et al., 2017). During the extraction of oils from an oil-solid mixture, the molecular structure of the ionic liquids facilitates the separation process in different petroleum production processes (Song et al., 2023). Scientists typically combine conventional solvents like toluene with ionic liquids to recover oil due to their different solubility parameters (Hou et al., 2022). The application of ionic liquids in recycling is a perspective of green production that proffers effective solutions in the recycling industry and industrial development (Shi et al., 2024)

Synthetic Oil Based Fluid and Molten Salts

Drilling fluid is important to the exploration and production industry and forms one of the most significant waste volumes. Many studies have thus investigated various treatment methods that have shown prospects for recycling (Pereira et al., 2022). Just as synthetic oil-based fluids are critical to drilling operations, ionic liquids are vital for extraction. Ionic liquids are room-temperature molten salts with unique physical and chemical properties and have been widely used as lubricant additives. (Zhou & Qu, 2017). A critical aspect of sustainable development is balance, which means responsibly sharing development and economic activities to minimise pollution and conserve resources. The natural resources required to sustain lives are increasing; hence, a novel way non-renewable resources like fossil fuels can be conserved is through recycling and reuse (Meenakshi, 2012).

Influence of Material Recovery in Environmental Protection

Some toxic chemicals produced by petroleum products have increased environmental pollution levels. Thus, improving environmental policies and an integrated environmental management approach will enable environmental protection and strategic implementation of selected measures to reduce risks (Glibovytska et al., 2023). Environmental policies are the key drivers of strategic green measures influencing sustainable practices. The influx of hazardous substances into the environment increases risk and uncertainties that threaten environmental protection (Bolaji et al., 2023). Effective environmental policies stimulate the use of environmentally friendly and innovative technologies aimed at environmental protection whilst enhancing social and economic development. Thus, emissions are significantly reduced, and more effective green initiatives ensure the rational use of resources (Davydenko et al., 2023). Removing contaminants from soils and organic wastes needs to be optimised by further investing in the recyclability and reusability of ionic liquids (Fu et al., 2025). Ionic liquids are organic salts and next-generation solvents that can be synthesised, having low flammable characteristics with negligible vapour pressure. As a catalyst in a mixed chemical medium, ionic liquids can interact with the target contaminant for extraction and have been tailored to proffer remedial solutions for removing environmental pollutants (Gujjala et al., 2024).

Materials and Method

Investigating the value of ionic liquid application on the recovery of synthetic oil-based mud (SOBM) for reuse required a different examination of the interaction between the SOBM and the propylMIMBr-IL. The SOBM was obtained from the thermal desorption unit outlet of one of the waste management contractors in Rivers State. The reagents for analysis were purchased from Fisher Scientific UK, and the recovery protocol is shown in **Figure 1**. During the experiment, 0.1g of SOBM sample was added to 2g of each propylMIMBr ionic liquid in a flask, and the reaction was stirred to mix. The Fourier-transformed infrared (FTIR) was used to analyse the sample.

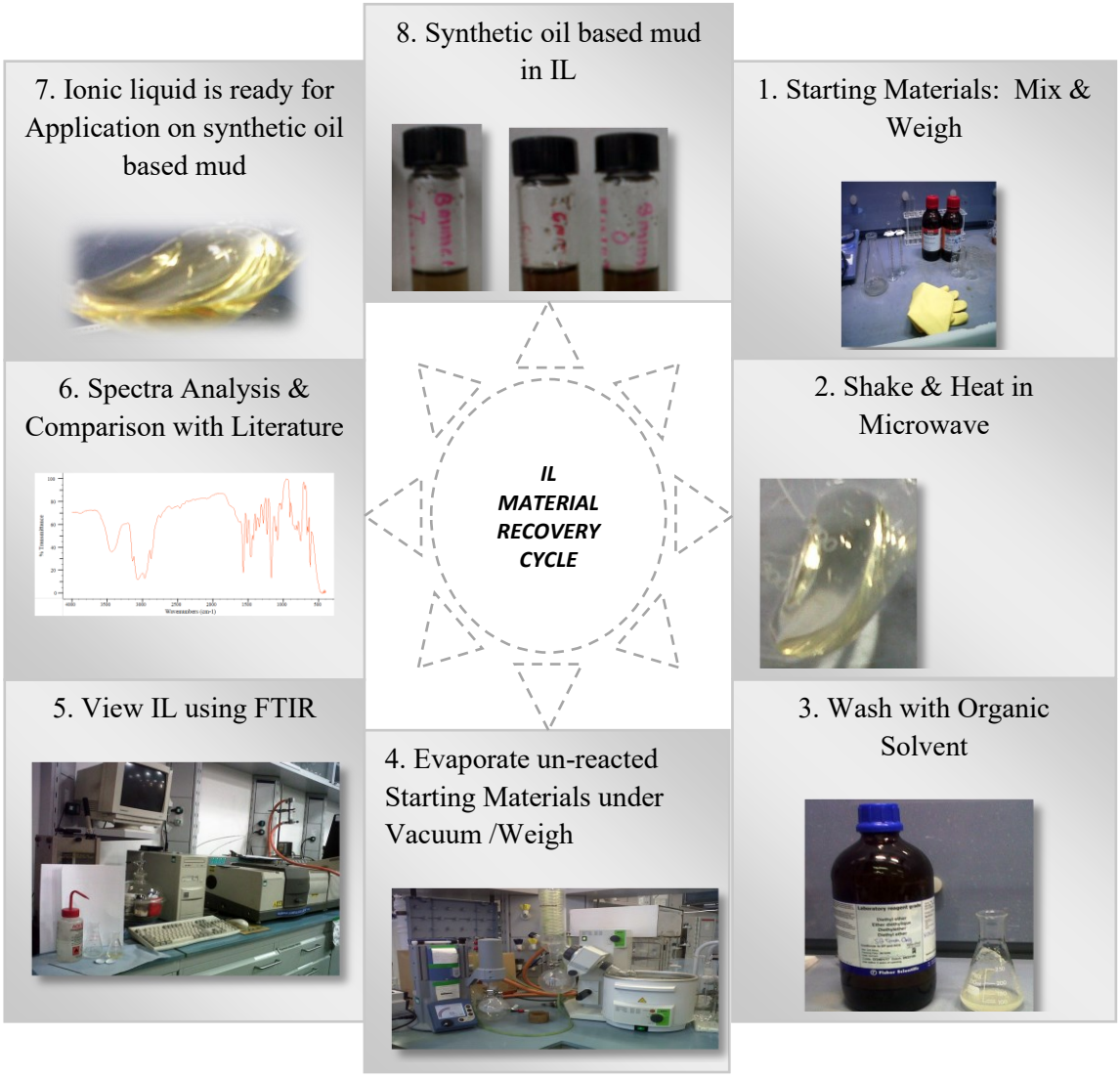


Figure 1: The steps in the protocol for material recovery from SOBM using IL

RESULT

The finding showed that the mixture separated into a two-phase oil separation from a SOBM-ionic liquid mixture, giving a heterogeneous mixture separating an upper oil layer and a lower ionic liquid layer. The simulated mixture of the SOBM and propylMIMBr-IL spectra shows that the peaks between 3000 and 3200cm^{-1} (as circled) suggest the presence of an aromatic structure. In contrast, the extended peak (as circled) at 3398cm^{-1} suggests that the ionic liquid has extracted the SOBM.

The double bond region (1500-2000cm^{-1}) showed the presence of aromatic compounds extracted at 1600cm^{-1} as circled in **Figure 2**.

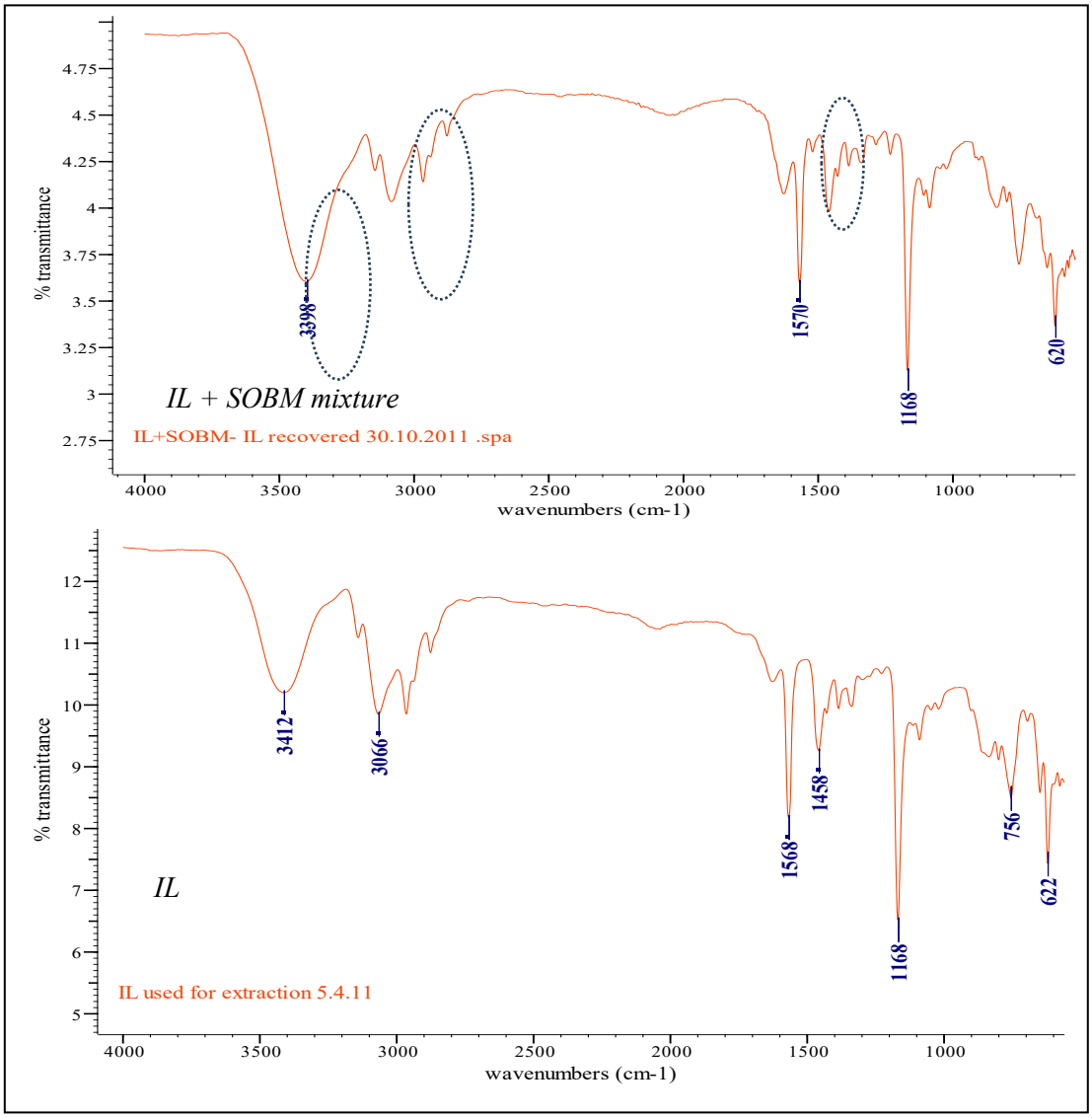


Figure 2: Simulated mixture of the SOBM and propylMIMBr-IL

DISCUSSION

Ionic liquids can be designed to maximise the cation and anion combination in dissolving a wide diversity of materials; hence, they have become the new, target-oriented reaction media for developing new processes for reuse (Siedlecka et al., 2011). The application of ionic liquids in the upstream petroleum industry is relatively new, though there is evidence of the application of ionic liquids in oil

recovery. The findings from this study show that ionic liquids can be adapted to separate SOBMs from a mixed waste stream. Thus, these processes will require further research to establish a protocol for applying ionic liquids in the upstream oil industry (Sulemana & Ghosh, 2017). Also the recovery of ionic liquids after the material extraction is also critical. Some options include membrane separation, distillation, aqueous two-phase extraction and crystallisation (Zhou et al., 2018).

CONCLUSION

The propyIMIMBr-IL is compatible with SOBMs due to their aromatic bonds. SOBMs are valuable to the upstream petroleum industry, so extending the protocol developed in this study to investigate the scope of ionic liquids in removing contaminants such as organic compounds that can be explored for contamination is crucial.

RECOMMENDATION

Ionic liquids offers a lot of opportunities in the petroleum sector. Considering the fact that it is recyclable, this study recommends further investigation of the material recovery protocol to expand the process of material extraction and reuse.

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