IOCS 2025 Conference

The 1st International Online Conference on Separations

15–17 October 2025 | Online

MDPI

Extraction of Thiophene, Indole, Quinoline, and Pyridine from Model Solutions Using a Polyethylene Glycol Methyl Ether/Tetrabutylammonium Bromide Eutectic Solvent

Dmitriy V Lobovich, Grigoriy M Oleshkov, Yulia A Zakhodyaeva, Andrey A Voshkin

Kurnakov Institute of General and Inorganic Chemistry of the Russian Academy of Sciences

INTRODUCTION & AIM

- The tightening of environmental regulations (EURO 5/6) necessitates effective methods for removing S- and N-heterocyclic compounds from petroleum products.
- Traditional methods, such as hydrotreatment, are energy-intensive and destroy valuable components, while conventional extractants like N-methylpyrrolidone (NMP) are insufficiently effective.
- Eutectic solvents (ES) represent a promising environmentally friendly alternative; however, reports on the successful scaling of processes involving them are extremely scarce.
- The aim of the present work was to study the extraction capacity of eutectic solvents based on polyethylene glycol methyl ether (MEPEG) and tetrabutylammonium bromide (TBAB) towards thiophene, quinoline, pyridine, and indole from solutions modeling gasoline, diesel fuel, and kerosene, as well as to scale up the studied processes on a laboratory unit.

METHOD

- Eutectic solvents were synthesized by mixing MEPEG and TBAB in a molar ratio of 3:1 at 60°C for 1 hour.
- The residual concentrations of components in the model solution after extraction were determined by spectrophotometry.
- Pilot experiments were conducted on a laboratory unit consisting of two centrifugal extractors operating in a countercurrent mode.

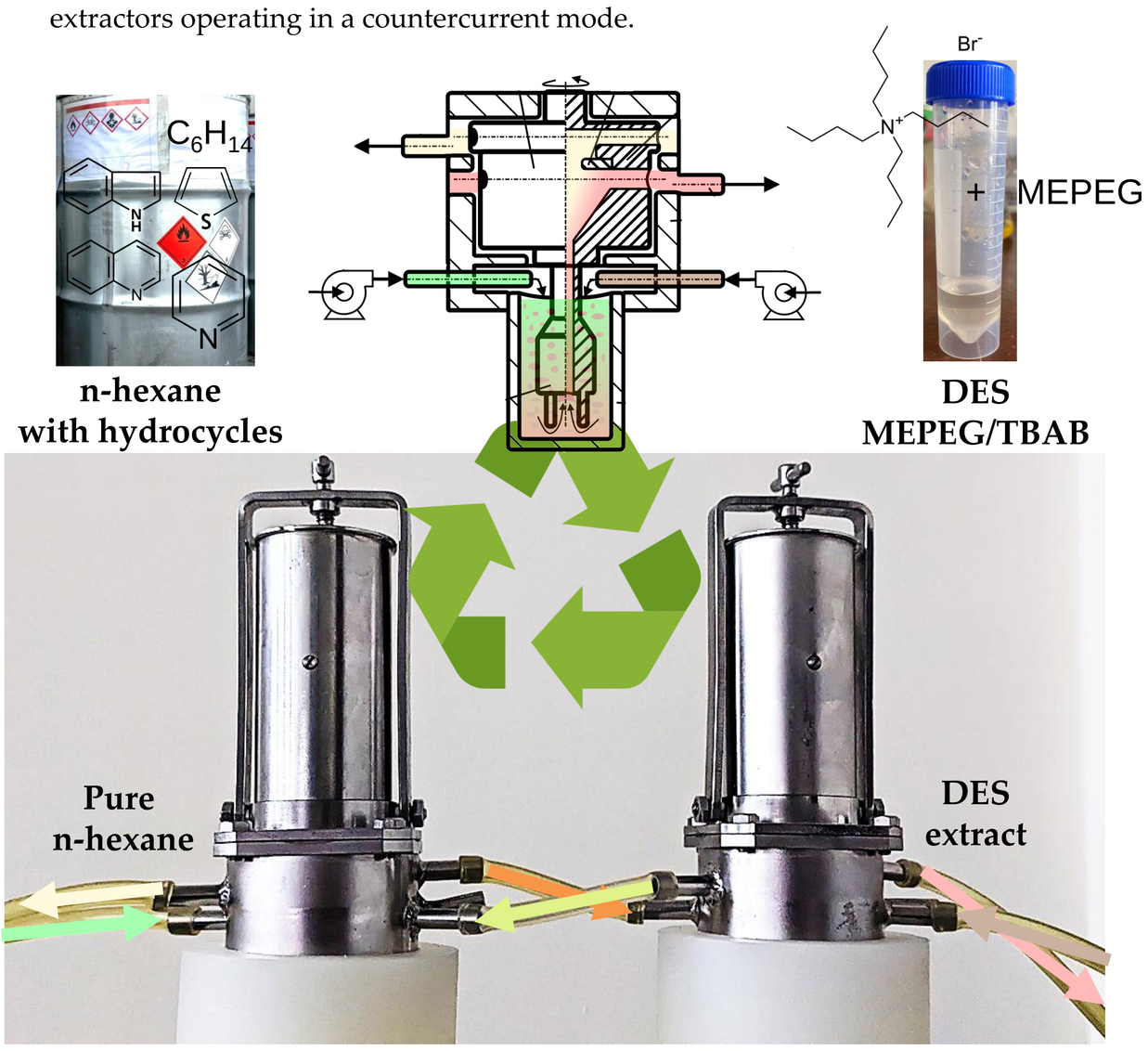

Fig. 1. Laboratory counter-flow extraction system with centrifugal-type apparatuses

- The following formulas were used to determine the required number of extraction stages for deep purification of fractions:

$$\frac{C_n}{C_0} = \frac{1-\frac{\lambda}{D}}{\frac{D^n}{\lambda}-\frac{\lambda}{D}} \qquad Pu,\% = \frac{C_i}{\Sigma C} * 100\% \qquad D = \frac{C_{ES}^i}{C_{org}^i} \qquad \lambda = \frac{V_{org}}{V_{ES}}$$

C - concentration of the target component, D - distribution coefficient, Pu - purity of the target component in the respective phase, n - extraction stage, V – phase volume

RESULTS & DISCUSSION

Table 1. Results of two-stage countercurrent purification of model hydrocarbon fraction solutions in an extractor cascade

Thiophene	Indole	Quinoline	Pyridine
85,92%	99,99%	99,23%	99,65%

- The process carried out in two extraction stages shows good agreement with the results of mathematical modeling.
- A calculation was performed to determine the number of stages required to reduce the content of contaminating components to 1 ppm.

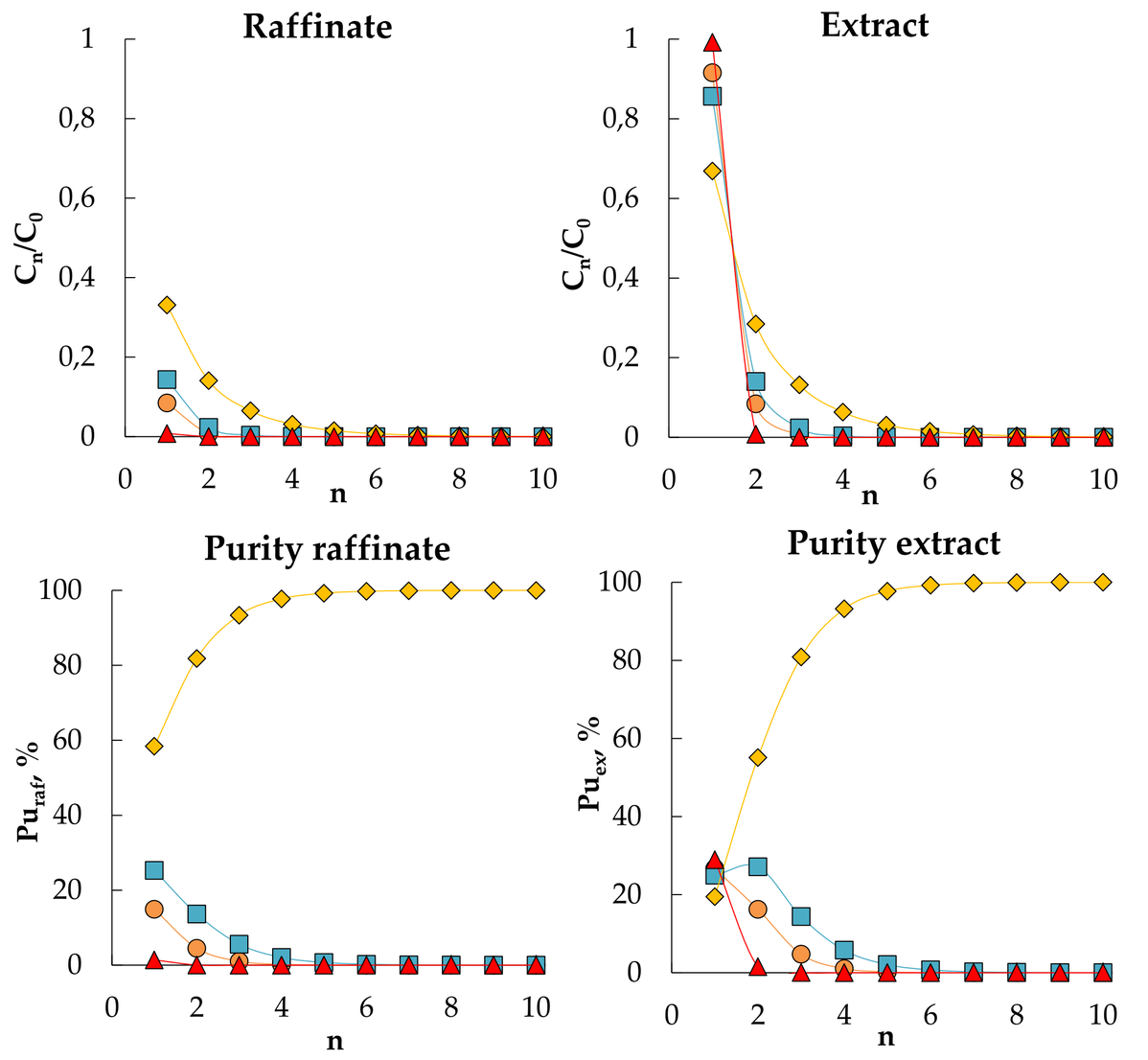

Fig. 2. Calculated results for the multistage deep extraction purification of a hydrocarbon fraction containing thiophene (yellow diamond), pyridine (blue square), quinoline (orange circle), and indole (red triangle),

CONCLUSION

A eutectic solvent based on water-soluble polymers was tested for the first time on an extraction unit, demonstrating high efficiency in the extractive purification of petroleum products. The two-stage extraction process on the unit showed good agreement with the results of the mathematical model. Further calculations showed that six extraction stages are sufficient to reduce heterocyclic compounds to 1 ppm.

REFERENCES

1. Lobovich, D. V., et al. *Theoretical Foundations of Chemical Engineering* **2023**, *57*, 1276–1291
2. Lobovich, D. V., et al. *Processes 2024, Vol. 12, Page 488* **2024**, *12*, 488