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Catalytic Applications of Terpenes and Resinous Compounds from Forest Trees: Advancing Green Chemistry and Pollution Mitigation

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INTRODUCTION & AIM

Forests serve as rich reservoirs of bioactive compounds, among which terpenes and resinous substances hold significant potential for sustainable chemical synthesis and environmental applications. Terpenes such as α-pinene, β-pinene, and limonene are abundantly found in coniferous species and other resinous trees, especially in forest-rich regions like the Western Ghats, Amazon, and Boreal forests. Their inherent chemical structure, characterized by conjugated double bonds and functionalizable groups, makes them suitable precursors for catalytic transformations. The global shift toward green chemistry and circular economy paradigms has emphasized the use of renewable resources for developing catalytic materials, pharmaceuticals, and bioplastics (Corma et al., 2007; Zühn et al., 2020).

The present study aims to explore the catalytic transformation of forest-derived terpenes and resinous compounds to enhance their applicability in organic synthesis and environmental remediation. Special attention is given to their role in pollutant degradation and renewable fuel production.

METHOD

A systematic review of peer-reviewed scientific literature was conducted using databases like ScienceDirect, Scopus, and Web of Science, focusing on studies from 2000 to 2024. The key search terms included "terpenes," "catalysis," "α-pinene oxidation," "epoxidation of limonene," "forest bio-resources," and "green chemistry." Experimental procedures from selected papers were analyzed to compare catalytic systems, including heterogeneous catalysts such as zeolites (ZSM-5, SAPO-11), mesoporous silicas, acid resins (Amberlyst-15), and supported metal catalysts (TiO_2, MoO_3). Metrics such as conversion efficiency, selectivity, reusability, and reaction conditions (temperature, pressure, oxidant type) were reviewed.

RESULTS & DISCUSSION

The catalytic transformation of terpenes such as limonene and α-pinene demonstrated promising outcomes for sustainable applications. Oxidation using supported catalysts like TiO_2 achieved over 80% conversion of limonene with high selectivity for limonene oxide (Resul et al., 2023). Zeolite-supported catalysts were effective for α-pinene oxidation, yielding valuable intermediates for pharmaceutical and fragrance industries (Della Pina et al., 2012).

Additionally, terpene-derived polymers showed efficacy in environmental remediation, particularly for wastewater treatment and air pollution control (Lapuerta et al., 2023). Catalytic cracking of terpenes also enabled the production of renewable jet fuels, offering sustainable alternatives to fossil-derived fuels (Nabgan et al., 2022).

Despite the success, challenges remain in catalyst stability and process economics. Emerging green approaches, including the use of H_2O_2 as an oxidant and mild reaction conditions, are being explored to improve efficiency and scalability.

CONCLUSION

The catalytic transformation of forest-derived terpenes and resinous compounds holds substantial promise for green chemical synthesis, environmental remediation, and renewable fuel generation. These applications not only provide sustainable alternatives to petrochemical processes but also offer socio-economic benefits, particularly in forest-rich regions.

FUTURE WORK

Future research should focus on:

- Life cycle assessment and techno-economic analysis of terpene valorization.
- Development of biocatalysts and enzyme mimetics for higher selectivity and lower energy demands.
- Policy integration to promote forest-derived chemicals in industrial applications.

REFERENCES

- Resul, M. F. M., et al. (2023). Green Epoxidation of Limonene Using Heterogeneous Catalysts. Catalysis Today, 397, 300-312.
- Corma, A., Iborra, S., & Velty, A. (2007). Chemical Routes for the Transformation of Biomass into Chemicals. Chemical Reviews, 107(6), 2411-2502.