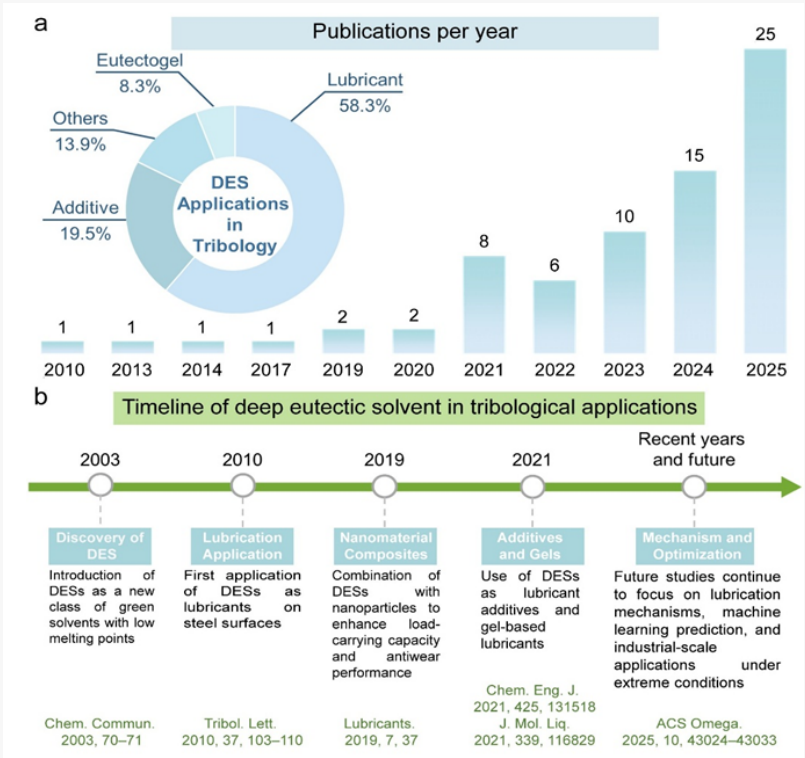
Deep Eutectic Solvents in Tribology - Recent Advances and Future Perspectives

FAYETTEVILLE, GA, UNITED STATES, September 11, 2026 / EINPresswire.com/ -- Industrial advancement and the rapid development of advanced manufacturing have intensified friction and wear issues in mechanical components, leading to equipment failure, energy consumption and waste. Meanwhile, conventional liquid lubricants suffer from limitations such as environmental pollution, high cost, and poor sustainability. Deep eutectic solvents (DESs), as emerging solvent systems, are formed by the hydrogen bonding structure between hydrogen bond acceptors (HBAs) and hydrogen bond donors (HBDs) and have attracted increasing attention as potential next-generation lubricating materials due to their green characteristics, facile preparation, and tunable physicochemical properties.

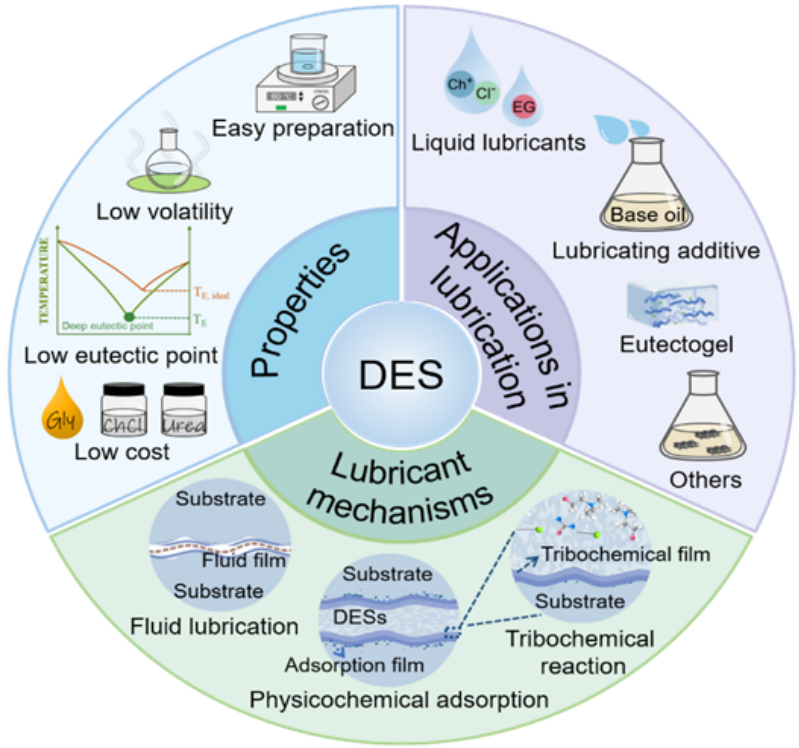


(a) Publication statistics of DES-related tribological studies up to December 2025. (b) Timeline showing the development of DESs and their applications in tribology.

Recent studies have demonstrated the great potential of DESs as both lubricants and lubrication additives in tribological applications. This work systematically summarizes recent progress in DES-based tribological research, including their classification, preparation methods, characterization techniques, and tribological applications. Furthermore, the lubrication performance, underlying mechanisms, current challenges, and future development prospects of DES-based lubricating materials are discussed. This work provides comprehensive insights into the design of environmentally friendly and high-performance DES-based lubrication systems, promoting the development of sustainable lubrication technologies and offering valuable guidance for future tribological research on green DES-based lubricants.

The advanced manufacturing technologies have driven mechanical equipment toward higher

speeds, greater loads, and longer service lifetimes. The intensive and high-frequency operation inevitably leads to friction and wear of mechanical components, compromising their reliability, functionality, and service life, as well as leading to safety issues and causing considerable waste of energy and resources. However, conventional mineral oils and synthetic lubricants still suffer from several inherent limitations, including environmental pollution, high volatility, potential toxicity, and insufficient adaptability under extreme operating conditions. Therefore, the development of green, efficient, and sustainable lubrication materials has become an urgent demand for next-generation mechanical systems.



Development and research trends of DES-based lubricating materials in tribology.

DESs, as a new class of solvents, have emerged as promising candidates for next-generation lubrication systems owing to their tunable molecular structures, low volatility, facile preparation, and unique physicochemical properties. Recent studies have demonstrated that DESs can function not only as high-performance lubricants but also as multifunctional additives and building blocks for advanced lubrication materials. Nevertheless, despite their remarkable potential in tribology, DES-based lubricating materials still face several challenges. These include insufficient understanding of their environmental compatibility, unclear correlations between molecular structures and tribological behaviors, limited knowledge regarding interfacial lubrication mechanisms, and practical constraints associated with large-scale engineering applications.

In this review, the classification, physicochemical characteristics, and lubrication properties of DESs are systematically summarized. The advantages and application progress of DESs as liquid lubricants, lubrication additives, eutectogel lubricants, and other DES-containing lubrication materials are comprehensively discussed. Particular attention is devoted to elucidating the fundamental mechanisms governing their tribological performance, including the formation and evolution of hydrogen-bond networks, interfacial adsorption behaviors, and tribochemical reactions during friction processes. Furthermore, the key factors influencing lubrication efficiency and the challenges associated with practical applications are analyzed, followed by perspectives on future development directions of DES-based lubrication technologies. This review provides a comprehensive understanding of the relationship between DES molecular

design, interfacial interactions, and lubrication performance, offering theoretical insights and technical guidance for the development of high-performance, environmentally sustainable lubrication materials for advanced engineering applications.Liquid lubricants are the primary solution for reducing friction and wear toward the wear-prone areas caused by friction in the machinery.

References

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