

Fundamental Chemistry to the Usefulness: Examples of Triptycenes and Related Compounds

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In 2025 Nobel Prize in Chemistry lecture, “The Usefulness of the Useless — How MOFs Transformed the Concept of Porous Matter,” Professor Susumu Kitagawa emphasized that transformative innovations often arise from research without immediate applications. He showed how long-term “useless” work on porous materials led to metal–organic frameworks (MOFs), now central to energy and environmental technologies. Our work in triptycene chemistry follows this philosophy, evolving from an interest in molecular form and symmetry to functional materials.

Useless Fundamental Chemistry of Triptycene

Triptycene (Trp) is a rigid three-dimensional molecule in which three benzene rings are fused through two sp^3 carbon atoms to form a propeller-like framework. Initially, triptycene chemistry seemed a structural curiosity for theoretical and synthetic exploration, but this apparent “uselessness” motivated us to ask how its unique shape might stabilize unusual bonding environments. We designed a derivative, Trp*, bearing bulky fused-ring substituents on the periphery, whose steric protection enabled isolation of thermally stable but extremely reactive divalent main-group species—germylene, stannylene, and plumbylene ($RTrp^*_2E$; $E = Ge, Sn, Pb$)—each bonded exclusively to aliphatic carbon ligands, providing rare insight into low-valent group 14 chemistry.

Usefulness Applied Chemistry of Triptycene

Triptycene’s rigidity also serves as a design principle in materials chemistry. Using our synthetic heteroatom chemistry, we developed triptycene-based ligands for robust MOFs aimed at hydrogen storage and gas separation. Zinc-based MOFs incorporating two differently sized triptycene ligands were synthesized under solvothermal conditions and showed high porosity, crystallinity, and thermal stability. Notably, MOFs with narrower pores, despite smaller BET surface areas, exhibited higher H_2 and CO_2 adsorption capacities, highlighting how pore geometry can outweigh surface area and how curiosity-driven structural design can lead to practical applications.

Thus, our pursuit of triptycene chemistry resonates deeply with the message of “the usefulness of the useless.” As we trace the path from molecular curiosity to material innovation through molecular technology, we wish to share with you the value of patient, open-ended fundamental research.

