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Abstract

In order to realize highly efficient, selective, and energy-saving chemical reactions, it is necessary to develop next-generation catalyst technology that can design structures and functions at the atomic level. Polyoxometalates (POMs) are molecular metal oxide clusters that exhibit various physical properties, such as magnetism, dielectric properties, electrical conductivity, optical properties, and catalytic properties. We have developed the precise synthesis method of POMs in organic solvents (Fig. 1). In particular, we didn’t utilized lacunary POMs as simple “templates” but utilized them in concert with the introduced metal atoms, and we explored new methodologies in the design of POMs catalysts, including the development of visible-light-responsive photoredox catalysis and highly efficient concerted catalysis.[1–5] We are also studying on heterogeneous POM catalysts for gas-phase reactions of hydrocarbons.

Precise synthesis of POMs: We have developed the precise synthesis method of POMs by controlling the reactivity of lacunary POMs by changing the protonation state and/or using protecting groups, such as alcohol and pyridine, in organic solvents. We synthesized metal oxide nanoclusters by introducing various transition metals, main group elements, and rare earth metals in one step into the lacunary POMs.[3] We also succeeded in developing a new synthesis method to introduce different metals sequentially in the controlled metal arrangement.[4] In particular, by controlling the magnetic anisotropy and spin states of metal oxide nanoclusters, we have developed materials exhibiting excellent single ion magnet properties and single molecule magnet properties.

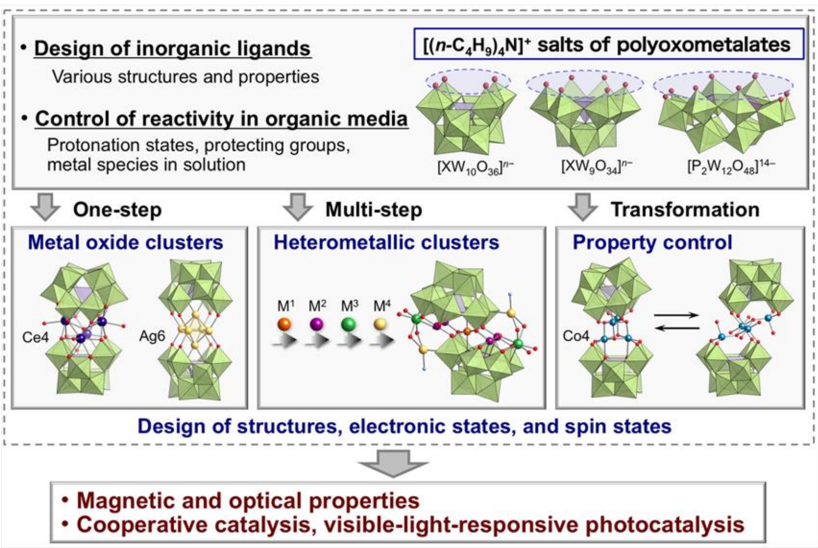

Fig. 1 Development of the precise synthesis method of POMs for functional materials and catalysis.

Development of high-performance POM catalysis: Based on our synthetic methods, we developed a high-performance POM catalysis for various liquid phase reactions. For example, we developed visible-light-responsive redox catalysis for functional group transformations by controlling the electronic states of POMs using the introduced metal atoms and organic substrates (Fig. 2).[5]

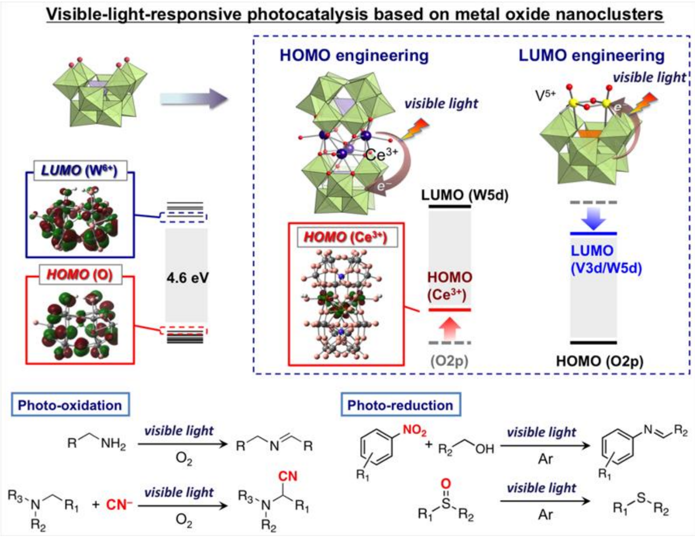

Fig. 2 Visible-light-responsive POM photocatalysis for selective functional group transformations.

Possible collaborations:

• Liquid-phase (photo)catalytic reactions

• Gas-phase catalytic reactions for conversion of hydrocarbons

• Synthesis of various polyoxotungstates and polyoxomolybdates

• Synthesis of solid catalysts based on polyoxometalates

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