

TSUKAMOTO LAB.

New Chemistry of Quantum-sized Materials



Department of Materials and Environmental Science

Quantum-sized Materials Chemistry

Department of Applied Chemistry, Graduate School of Engineering

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Nanoscience Between Solids & Molecules

Fundamental researches

T. Tsukamoto et al.
Nature Commun. **2018**
Nature Commun. **2018**
Nature Commun. **2019**
Nature Rev. Chem. **2021**
Acc. Chem. Res. **2021**

Synthesis

Theory



Property

Function

Applicational researches

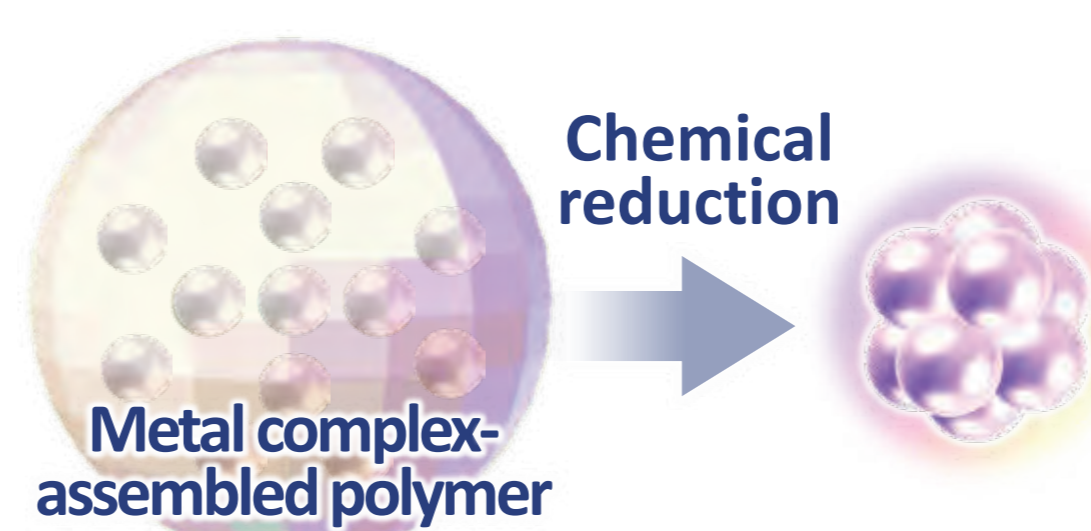
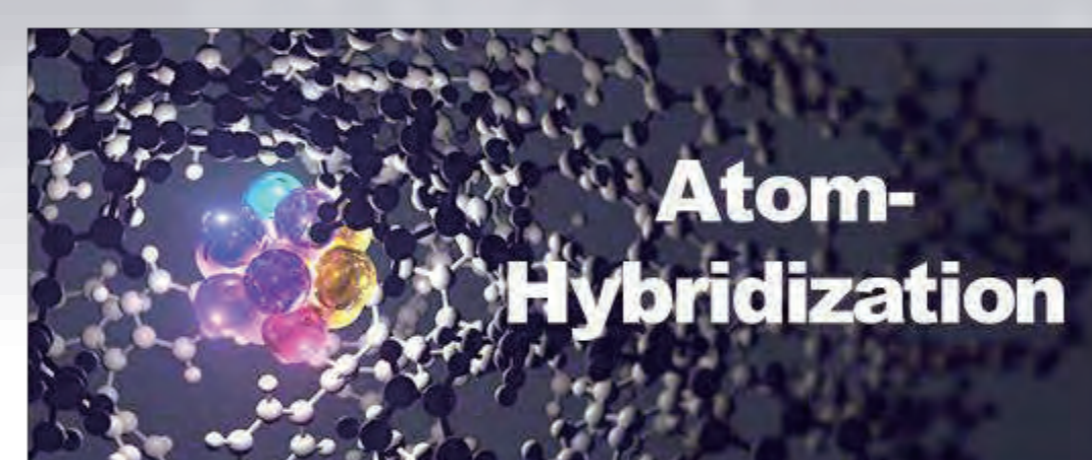
T. Tsukamoto et al.
Angew. Chem. Int. Ed. **2019**
J. Am. Chem. Soc. **2020**
Angew. Chem. Int. Ed. **2020**
Angew. Chem. Int. Ed. **2022**

"Quantum-sized materials," which are ultra-small nanoparticles (1 nm) undergoing the remarkable quantum size effect, are expected to exhibit unique properties not found in conventional materials. In our laboratory, we investigate the science of new material group located at the boundary between solids and molecules by fusing experimental and theoretical approach.

★ Experimental Design of Quantum-sized Materials

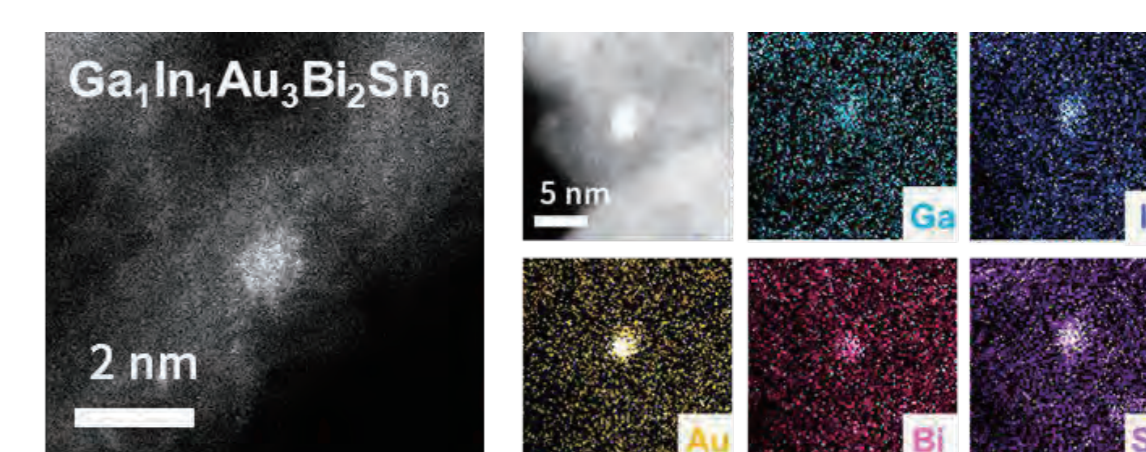
Development of new synthetic method

In our laboratory, we are developing techniques to synthesize the **quantum-sized materials with controlled atomicity and element composition** by utilizing the nano-sized reaction fields inside polymer capsules. By applying this method, we have succeeded in discovering **physical and chemical properties unique to quantum-sized materials**, such as unusual oxidation states and high catalytic abilities.



Template synthesis using nanocapsules

Development of Precise Template synthesis

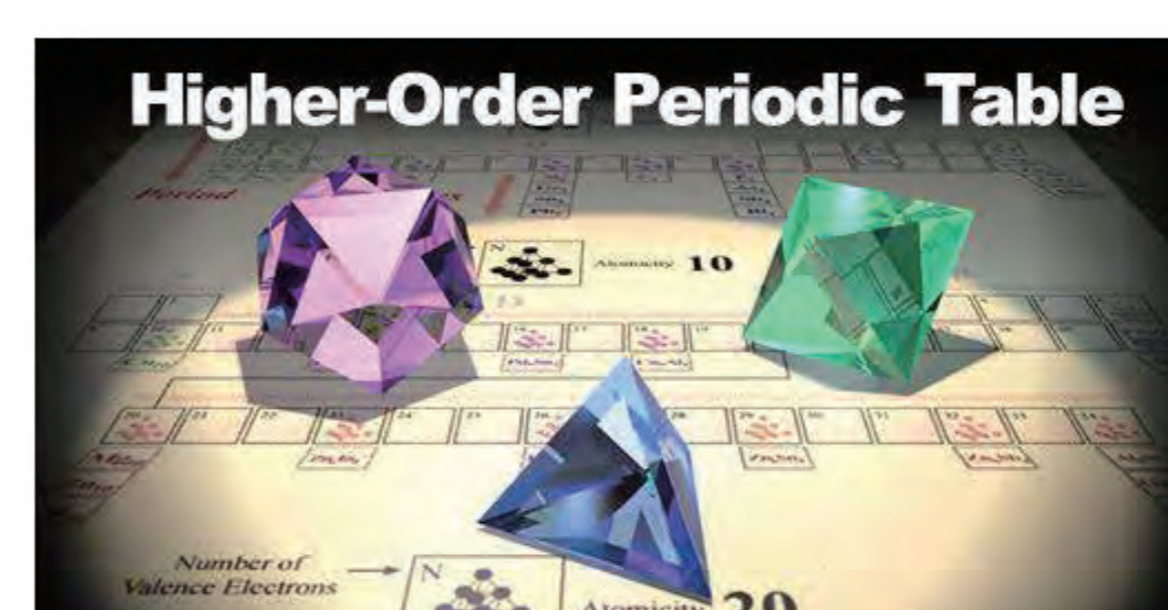
[*Nature Communications* 2018]

1 nm particle composed of 5 metal elements

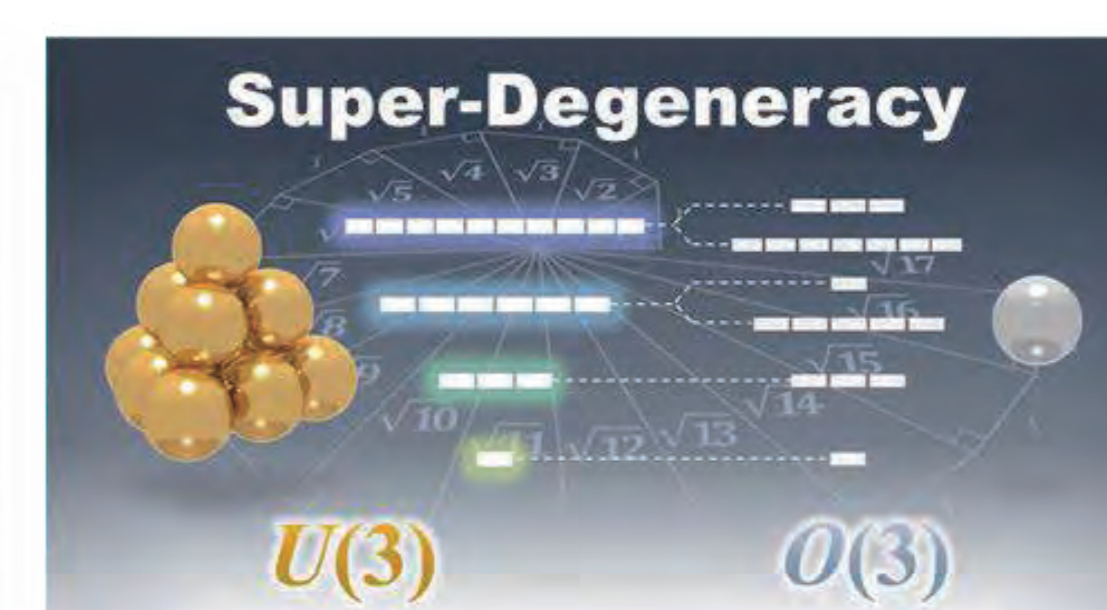
★ Theoretical Design of Quantum-sized Materials

Development of new design theory

In our laboratory, we are developing a new theory that simply predicts structure and property of the quantum-sized materials by combining computational chemistry and group theory. We have succeeded in finding the **periodicity in molecular properties** in such materials, and in discovering the first-ever **chemical substances with anomalously-degenerate electronic states** originating from mathematical factors.



Proposition of
Higher-order periodic table

[*Nature Communications* 2019]

Discovery of
Super-degenerate clusters

[*Nature Communications* 2018]