

# Composite catalysts constructed by coordination polymers with phase transitions

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Heterogeneous catalysts composed of multiple functional species are known as composite catalysts. Coordination polymers (CPs)/metal-organic frameworks (MOFs) are candidates as platforms of composite catalysts because CPs immobilize functional species in their pores and on their surfaces. Recent reports indicate that several classes of CP/MOFs exhibit reversible crystal-to-liquid transformation upon heating, and this behavior opens a new direction for the design of composite catalysts.

[Zn(HPO<sub>4</sub>)(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>](imidazolium)<sub>2</sub> is in the liquid phase at above the melting point (155 °C) and in the glassy state by rapid cooling to room temperature. We dissolved metalloporphyrin in the CP liquid and fabricated composite glass membranes using a knife-coating technique. The transparent glass membrane showed photocatalytic CO<sub>2</sub> reduction ability in the presence of a sacrificial electron donor, without unexpected light scattering due to the grain boundary-free structure.<sup>1</sup>

Alloys of two different CPs are promising as composite catalysts, since practical composite catalysts are alloys of multiple metals or metal oxides, such as Pt-Ru and CeO<sub>2</sub>-ZrO<sub>2</sub>. The physical properties of the alloys are discussed using phase diagrams. We have demonstrated the construction of binary phase diagrams of phase transition CPs. Three types of binary phase diagrams of Ag<sup>+</sup>-based coordination polymers were constructed, and all diagrams showed eutectic phenomena induced by ligand exchange reactions at the interface of the two constituents.<sup>2</sup>

## References:

1. H. Izu, H. Tabe\*, Y. Namiki, H. Yamada, S. Horike\*, "Heterogenous CO<sub>2</sub> Reduction Photocatalysis of Transparent Coordination Polymer Glass Membranes Containing Metalloporphyrins", *Inorg. Chem.* **2023**, *62*, 29, 11342–11349.
2. K. Atthawilai, H. Tabe\*, K. Ohara, K. Kongpatpanich, S. Horike\*, "Binary Phase Diagrams of Coordination Polymers with Eutectic Behaviors", *J. Am. Chem. Soc.* **2025**, *147*, 6, 5140–5148.

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#### 【Professional carrier】

- July 2021 – Current  
Program-Specific Junior Associate Professor, KUIAS-iCeMS, Kyoto University
- January 2019 – June 2021  
Special Appointment Lecturer, Research Center for Artificial Photosynthesis, Osaka City University
- April 2017 – December 2018  
Special Appointment Research Associate, Graduate School of Engineering, Osaka City University
- May 2015 – March 2017  
IP administrator of Kyoto University, Kansai TLO, Co., Ltd.
- April 2012 – March 2015  
Research Fellow for Young Scientists, Japan Society for the Promotion of Science

#### 【Education】

- May 2015 Ph.D. in Engineering, Kyoto University, Japan  
Supervisors: Prof. Susumu Kitagawa and Prof. Takafumi Ueno
- March 2012 M. Eng., Kyoto University, Japan
- March 2010 B. Eng., Kyoto University, Japan

#### 【Recent papers】

- K. Atthawilai, H. Tabe, K. Ohara, K. Kongpatpanich, S. Horike, “Binary Phase Diagrams of Coordination Polymers with Eutectic Behaviors”, *J. Am. Chem. Soc.* **2025**, *147*, 6, 5140–5148.
- Y. Seki, T. Nakazono, H. Tabe, Y. Yamada, “Enhanced catalytic activity of solubilised species obtained by counter-cation exchange of  $K\{Co^{II}_{1.5}[Fe^{II}(CN)_6]\}$  for water oxidation”, *Chem. Sci.* **2024**, *15*, 16760–16767.
- H. Izu, H. Tabe, Y. Namiki, H. Yamada, S. Horike, “Heterogenous CO<sub>2</sub> Reduction Photocatalysis of Transparent Coordination Polymer Glass Membranes Containing Metalloporphyrins”, *Inorg. Chem.* **2023**, *62*, 29, 11342–11349.
- H. Tabe, Y. Seki, M. Yamane, T. Nakazono, Y. Yamada, “Synergistic Effect of FeII and MnII Ions in Cyano-Bridged Heterometallic Coordination Polymers on Catalytic Selectivity of Benzene Oxygenation to Phenol”, *J. Phys. Chem. Lett.*, **2023**, *14*, 158–163.

#### 【Selected awards】

- Special Lectures from Outstanding Young Scientists, The 105<sup>th</sup> CSJ annual conference (Osaka), March 2025
- Lecture Award, The 95<sup>th</sup> CSJ annual conference (Tokyo), March 2015
- Poster Award, The 1<sup>st</sup> young scientists forum on biorelevant chemistry, September 2013