

Role of potassium additive on the catalytic performance of cobalt for CO₂-FTS

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Fischer-Tropsch Synthesis (FTS) using CO₂ (CO₂-FTS) is one of the potential technologies to transform atmospheric CO₂ to a liquid synthetic fuel.¹ Cobalt-based catalysts have been used in FTS, and long-chain hydrocarbons are produced on a commercial scale. On the other hand, the catalyst is known to form methane dominantly (>90%) along with short-chain gaseous hydrocarbons (C₂-C₄) in CO₂-FTS.² Adding potassium in the Co catalyst has been demonstrated to reduce the methane selectivity to 55%, and to increase carbon chain growth to form liquid hydrocarbons (C₅+).³ The promotive effect of K is promising for CO₂-FTS, however still now it has not been clarified in detail yet. In this work, the role of K is investigated by combination of FT-IR, XPS, and STEM from the viewpoints of location and interaction to Co catalysts.

The catalytic activity of K-Co/SiO₂ resulted in a low methane selectivity and a high C₂₋₄ and C₅₊ selectivity. The liquid phase products included not only n-alkanes from C₅ to C₈ but also C₂₊ alcohols and acetic acid. Probe FT-IR and XPS spectra of Co2p regions reveal that potassium keeps the oxidized Co surface even after reduction prior to the FTS. Potassium is possible to exist on the cobalt surface of K-Co/SiO₂, and the oxidized Co surface supplies a weakly basic site for promoting CO₂ adsorption. Therefore, the role of potassium in CO₂-FTS is maintaining the oxidized Co species to promote CO₂ activation by locating on the Co surface.

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Table 1. Catalytic activities for CO₂-FTS at 300 °C under 1 MPa

Catalyst	CO ₂ conversion / %	CO selectivity / %	Hydrocarbon selectivity / %		
			CH ₄	C ₂₋₄	C ₅₊ *
Co/SiO ₂	21	10	90	0.6	9.1
K-Co/SiO ₂	16	31	56	27	16
Co/Na-Y	25	8.9	91	1.0	8.0
Co-Y	3.0	< 0.1	< 0.1	< 0.1	< 0.1

* Including C₂₊ alcohols and acetic acid

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