

SURFACTANT-DIRECTED NANOSPONGE ZEOLITE WITH UNIFORM MESOPORES SUPPORTING COBALT NANOPARTICLES AS A FISCHER-TROPSCH CATALYST

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Fischer-Tropsch (FT) synthesis is one of important catalytic process that produces liquid fuels from a mixture of H₂ and CO. In the FT synthesis process, cobalt nanoparticles (Co NPs) are used as catalysts due to its high CO converting activity and high yield of long-chain linear hydrocarbons with limited formation of oxygenates and aromatics. To obtain the maximum catalytic activity, Co NPs are often supported on γ -Al₂O₃ owing to strong metal-support interaction. However, Co/ γ -Al₂O₃ catalyst exhibited an unselective distribution of product hydrocarbon chain lengths, according to the Anderson-Schultz-Flory model. Recently, the product selectivity could be increased to a desired range of chain lengths when zeolite was used as a support for Co NPs. However, the zeolite-based catalysts exhibited much lower CO conversion, as compared to the conventional alumina-based catalysts due to low dispersion of Co NPs. Very recently, nanosponge zeolites with MFI, beta, MTW and MRE-type framework (namely, NSZ) were hydrothermally synthesized via a surfactant-directed synthesis route.¹ These zeolites were composed of disordered network of ultrathin (~ 5 nm) thick zeolitic frameworks having a sharp distribution of mesopore diameters centered at 4 nm. In this work, we investigated the NSZ as a supporting material of Co NPs for FT synthesis reaction. The highly mesoporous texture (high surface area and large pore volumes) of NSZ was suitable for supporting Co NPs with a narrow distribution of particle diameters centered at 4 nm. The Co/NSZ exhibited high stability of the Co NPs against particle growth, and there was accordingly high catalytic conversion of carbon monoxide to hydrocarbons and long catalytic lifetime in the FT synthesis reaction. The high CO conversion without significant deactivation over the Co/NSZ catalyst means that the Co NPs were supported with optimum diameters, and were stably retained in the mesopores of the NSZ sample. Additionally, the Co/NSZ exhibited high selectivity for branched hydrocarbons in the gasoline range (C₅-C₁₁), as compared to conventional alumina-based catalysts. This high selectivity could be attributed to hydroisomerization reaction in the extremely thin zeolite frameworks that provided short diffusion path lengths for branched hydrocarbons.² Further works were performed on the details of the FT synthesis using Co/NSZ catalyst, such as the effects of mesopore size, zeolite acidity and Co content, in order to improve the catalytic performance. The NSZs provided new opportunities as advanced catalysts for bi-functional catalytic applications that require both high dispersion of metal nanoparticles and strong acidity of zeolite frameworks.

References:

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