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A TEM Study of Silica-Supported Cobalt-Based Fischer-Tropsch Synthesis Catalysts

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Understanding and controlling materials' properties (e.g., selectivity, activity, etc.) under industrially relevant (process) conditions is of significant interest to both academia and industry. Morphological and chemical characterization via TEM techniques continues to provide critical insights into these issues. In recent years, new developments in "ex-situ" TEM protocols have yielded important contributions to this knowledge base.[1,2]

One process that remains academically interesting and industrially important is Fischer-Tropsch synthesis (FTS). In FTS, natural gas is converted to hydrocarbon liquids.[3] Cobalt-based catalyst systems are highly desirable due to their relatively low water-gas shift and good C_{5+} selectivity.[3] In this study, we examine the microstructural changes observed in a silica-supported cobalt-based FTS catalyst prior/subsequent to exposure to high conversion conditions.[4]

A fresh silica-supported cobalt-based catalyst (Figure 1a) was observed to have numerous, small metal particles (Figure 1b). After extended exposure to high CO conversion conditions, TEM observations revealed mixed metal oxide formation (Figure 2), a phase not previously observed in the same catalyst exposed to moderate CO conversion conditions (Figure 3). This mixed metal oxide phase has been reported by previous investigators studying cobalt-silica systems under hydrothermal conditions.[5,6] Our "ex-situ" TEM studies showed that a 1.2 MPa H_2 treatment at ≥400 ^{o}C converted the mixed metal oxide back to cobalt metal particles (Figure 4).

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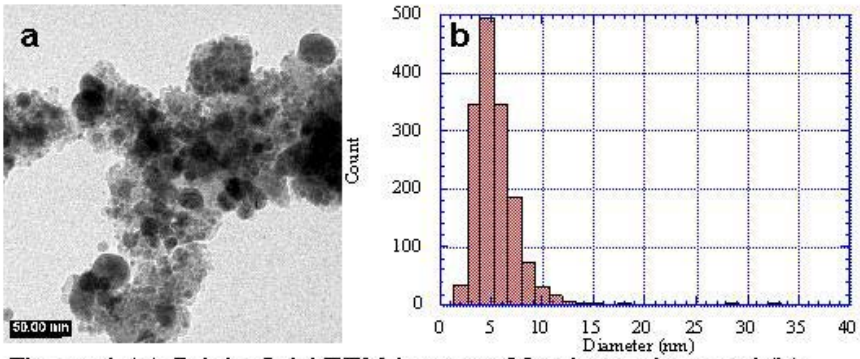

Figure 1:(a) Bright field TEM image of fresh catalyst and (b) corresponding metal particle size distribution histogram.

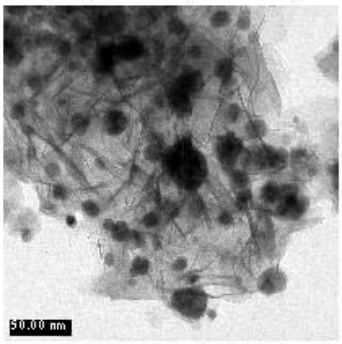

Fig. 2: Bright field TEM image of catalyst exposed to high CO conversion conditions.

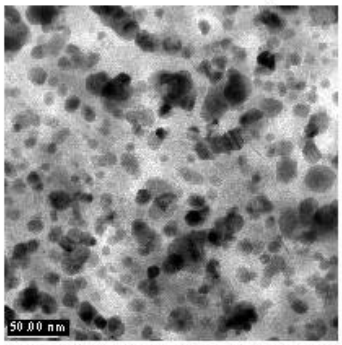

Fig. 3: Bright field TEM image of catalyst exposed to moderate CO conversion conditions.

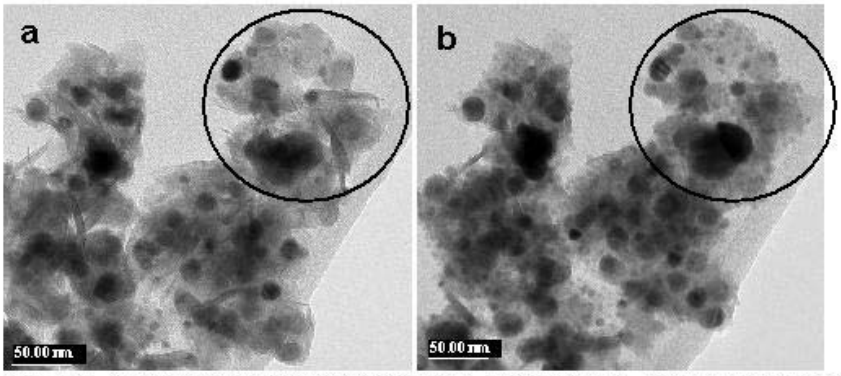

Figure 4: Bright field TEM images of catalyst exposed to high CO conversion conditions (a) prior and (b) subsequent to 12 h 420 ^{o}C H_2 treatment at 0.1 MPa.

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