Phosphorus-modified ordered mesoporous $CoAlO_x$ mixed oxides for Fischer-Tropsch synthesis

Yong Min Park, Jong Wook Bae*
School of Chemical Engineering, Sungkyunkwan University (SKKU), Suwon, Gyeonggi-do, 16419, Republic of Korea

* E-mail*: finejw@skku.edu*

As an interest of alternative fuel production from renewable feedstock has been increased gradually, Fischer-Tropsch synthesis (FTS) reaction, which can convert diverse carbon sources into synthetic clean fuels through various reforming processes, has one promising route. Common problems for FTS reaction is catalytic deactivation due to an aggregation of cobalt crystallites by Ostwald ripening mechanism [1]. It was revealed by our previous work that the stability of the ordered mesoporous structures can be improved with a proper structural promoter which resulted in high FTS activity and stability [2]. For example, an ordered mesoporous $CoAlO_x$ mixed oxides with alumina pillaring material in the main frameworks of the mesoporous cobalt grains showed a superior stability in FTS activity [3]. In the present investigation, a phosphorus modified ordered mesoporous $CoAlO_x$ catalyst (denoted as P(x)/CoAl, where x for a wt% of P) was further synthesized, and it showed an enhanced stability and a high production rate of waxy hydrocarbons during FTS reaction. The P-modified mesoporous CoAl was prepared by nanocasting method of cobalt and aluminium precursors into the KIT-6 as hard-template and a subsequent impregnation of phosphorous species with different contents. The mesoporous $CoAlO_x$ with a modification of 0.3wt% P (P(0.3)/CoAl) showed the lowest formation of an inactive cobalt aluminate and a less aggregation of cobalt crystallites from EXAFS and TPR analysis. The suppressed deactivation rate of the P(0.3)/CoAl seems to be attributed to the partial formation of aluminum phosphate in the phase of a thermally stable metal–phosphorous oxo-species on the $CoAlO_x$ surfaces. As shown in **Figure 1** and **Figure 2**, the formation of thermally stable metal phosphates can significantly improve the catalytic activity and structural durability of the P/CoAl at an optimal P content under the reductive FTS reaction conditions.

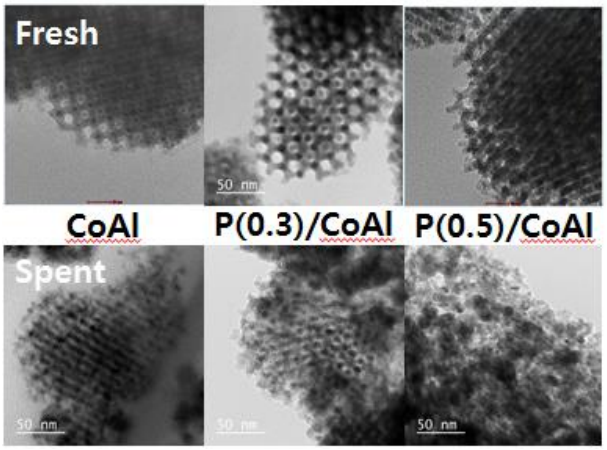

Figure 1. TEM image of ordered mesoporous $CoAlO_x$ before and after FTS reaction

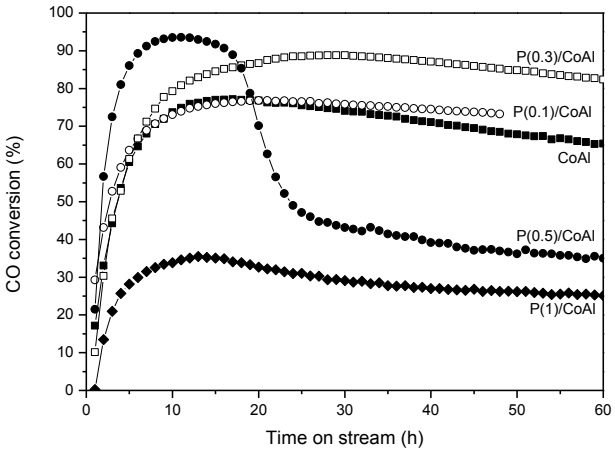

Figure 2. CO conversion with time on stream (h) on the ordered mesoporous $CoAl_x$ at the reaction conditions of T = 230 ℃, P = 2.0 MPa and space velocity = 6000 L/(kg_{cat}·h) at H_2/CO molar ratio of 2

REFERENCES

[1] Andrei Y. Khodakov, Wei Chu, Pascal Fongarland, Chem. Rev., 107 (2007) 1692.
[2] Chang-Il Ahn, Hyun Mo Koo, Mingshi Jin, Ji Man Kim, Taegyu Kim, Young-Woong Suh, Ki June Yoon, Jong Wook Bae, Micropor. Mesopor. Mater., 188 (2014) 196.
[3] Chang-Il Ahn, Yun Jo Lee, Soong Ho Um, Jong Wook Bae, Chem. Commun., 52 (2016) 4820.