Chapter 2
The Fundamental Research and Application Progress of 2D Layer Mo(W)S\textsubscript{2}–Based Catalyst

The Mo(W)S\textsubscript{2} based catalysts have been intensively studied by the global scientific community because of their vast implications in oil refining and chemical industry. The last two decades have seen major advances in the detailed understanding about their active sites at the atomic scale, the catalytic reaction mechanism, the interactions between active nanoparticles and supports, and so on. This newly acquired insight has opened up the way to a continual enhancement of the performance of Mo(W)S\textsubscript{2} based catalysts.

Mo(W)S\textsubscript{2} based catalysts are extensively used in the refining process for removal of impurities and enhancement of product quality. The global crude oils are becoming increasingly heavy and rich in heteroatoms (S, N, O, V, Ni, etc.). Meanwhile production of “clean fuels” has been identified a priority to meet more stringent legislation on the limitation of sulfur, olefin and aromatics contents. Facing with this challenge, a lot of efforts have been dedicated to constructing the connection between fundamental principles
and practical application of Mo(W)S₂ catalysts. And catalysts with better activity, selectivity and durability have been designed and developed based on the rich understanding of the synthesizing technique, active structure control and support modulation. And chemical application of Mo(W)S₂ based catalysts have attracted renewed interests owing to the fast advance in the micro-engineering technique in 2D materials which make it possible to finely control the catalytic selectivity. In this chapter, we review the recent advances in the fundamental research and practical application of the 2D layer Mo(W)S₂ based catalyst, and then project their potentials in improvement of the quality of fuels and production of new chemicals.

1. SUPPORTED 2D LAYER Mo(W)S₂ CATALYSTS

Supporting the Mo(W)S₂ nanosheets on a high surface area material is beneficial to increases the number of active sites via enhanced dispersion and distribution of active phases. Meanwhile cheaper support decreases the cost of industry catalysts.

In petroleum and chemical industry, conventionally, the Mo(W)S₂ nanosheets is supported on the alumina support and promoted by Co or Ni co-catalysts. In the sulfiding process before usage, the Mo(W)S₂ active phases are yielded in situ by the sulfidation of the oxidic precursors, which are in advance prepared through three steps, i.e., impregnation, drying and calcination. The almost exclusive use of alumina as support is due to its outstanding textural and mechanical properties and the relatively low cost. However, the undesirable very strong metal-support interaction has urged to introduce new supports.

Recently, ordered mesoporous materials with high surface area, large pore volume, ordered pore structure, and good thermal and mechanical stabilities have been studies as the support of Mo(W)S₂ based nanosheets. They act as host to support the active species and/or behave as a nanoreactor to provide a space for the catalytic reactions. According to the pore symmetry, these meso materials can be classified as 2D (e.g. HMS, SBA-15 and MCM-41) and 3D (e.g. MCM-48, SBA-16, KIT-6, and FDU-12) architectures (Fan et al. 1998). When incorporated into the pores of the support, the active phases will be confined by the pore size and pore structure, evoking interesting modulation of the structural and electronic properties.

When MoS₂ nanosheets were supported on the FDU-12 mesoporous material, with the increasing of Mo loading, the layer structure of MoS₂ active phase transforms from straight to slightly curved then to ring-like and finally
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