3D Nanostructured Assembly of 2D Transition Metal Chalcogenide/Graphene as High Performance Electrocatalysts

Authors : Sunil P. Lonkar, Vishnu V. Pillai, Saeed Alhassan

Abstract : Design and development of highly efficient, inexpensive, and long-term stable earth-abundant electrocatalysts hold tremendous promise for hydrogen evolution reaction (HER) in water electrolysis. The 2D transition metal dichalcogenides, especially molybdenum disulfide attracted a great deal of interests due to its high electrocatalytic activity. However, due to its poor electrical conductivity and limited exposed active sites, the performance of these catalysts is limited. In this context, a facile and scalable synthesis method for fabrication nanostructured electrocatalysts composed 3D graphene porous aerogels supported with MoS_2 and WS_2 is highly desired. Here we developed a highly active and stable electrocatalyst catalyst for the HER by growing it into a 3D porous architecture on conducting graphene. The resulting nanohybrids were thoroughly investigated by means of several characterization techniques to understand structure and properties. Moreover, the HER performance of these 3D catalysts is expected to greatly improve in compared to other, well-known catalysts which mainly benefits from the improved electrical conductivity of the by graphene and porous structures of the support. This technologically scalable process can afford efficient electrocatalysts for hydrogen evolution reactions (HER) and hydrodesulfurization catalysts for sulfur-rich petroleum fuels. Owing to the lower cost and higher performance, the resulting materials holds high potential for various energy and catalysis applications. In typical hydrothermal method, sonicated GO aqueous dispersion (5 mg mL^{-1}) was mixed with ammonium tetrathiomolybdate (ATTM) and tungsten molybdate was treated in a sealed Teflon autoclave at 200 $^{\circ}$C for 4h. After cooling, a black solid macroporous hydrogel was recovered washed under running de-ionized water to remove any by products and metal ions. The obtained hydrogels were then freeze-dried for 24 h and was further subjected to thermal annealing driven crystallization at 600 $^{\circ}$C for 2h to ensure complete thermal reduction of RGO into graphene and formation of highly crystalline MoS_2 and WoS_2 phases. The resulting 3D nanohybrids were characterized to understand the structure and properties. The SEM-EDS clearly reveals the formation of highly porous material with a uniform distribution of MoS_2 and WS_2 phases. In conclusion, a novice strategy for fabrication of 3D nanostructured MoS_2-WS_2/graphene is presented. The characterizations revealed that the in-situ formed promoters uniformly dispersed on to few layered MoS_2¬-WS_2 nanosheets that are well-supported on graphene surface. The resulting 3D hybrids hold high promise as potential electrocatalyst and hydrodesulfurization catalyst.

Keywords : electrocatalysts, graphene, transition metal chalcogenide, 3D assembly
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