Preferential Horizontal Growth of WS_2 Nanosheet on Carbon Nanorod: An Highly Efficient Electrocatalyst for the Hydrogen Evolution Reaction

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Desired material properties in layered transition metal dichalcogenides can be realized by understanding their growth behavior, which is predominantly affected by the growth mechanism and energetics. Particularly for electrocatalytic applications, where porous carbons are predominantly used as conductive support, understanding their growth behavior on porous carbon surfaces is of critical importance. In this work, we synthesized MS_2 (M = Mo or W) nanoplates embedded on porous carbon nanorod arrays (MS_2@OMCs) by limiting their growth space in nanoscale. We found that vertical growth is favored in MoS_2 to generate multiply stacked MoS_2 nanoplates, whereas the horizontal growth is preferred in WS_2 to give rise to monolayer nanoplates. We theoretically explored the energetics of MS_2 according to their growth orientation. The stacking energies for MoS_2 were larger than those for WS_2, confirming the experimental results. We applied WS_2@OMCs as electrocatalysts for hydrogen evolution reaction (HER). WS_2@OMCs exhibit high catalytic activity with a low overpotential of 179 mV *vs.* RHE (at 10 mA cm^{-2}) and low Tafel slope of 63 mV sec^{-1}.