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Green production of PVC from lab to industrialization: Heterogeneous non-mercury catalysts for acetylene hydrochlorination

Hao Xu

Tsinghua University, China

Acetylene hydrochlorination is the main reaction for the dominant process for VCM (vinyl chloride monomer) production from coal resource in mainland China. The traditional activated carbon based mercury catalyst for this reaction causes severe human damage and environmental pollution. Gold is widely considered as the most active metal for acetylene hydrochlorination reaction and copper is the most common metal with cost-effective advantage. The combination of two metals shows the best potential for environmentally friendly non-mercury catalysts. In our study, the performance of Au/Cu catalyst was dramatically enhanced by the introduction of organic ion ligands. Several ligands were studied and trichloroisocyanuric acid (TCCA) was proved to be an effective ligand for preventing Au³⁺ from reduction by acetylene, leading to longer catalyst lifetime. The findings were successfully verified by over 18000 hour's industrial plant-trial evaluation, and the VCM productivity reached 4.2 times comparing to industrial mercury catalyst. Abundant characterization methods including TEM, XRD, TPR, XPS, ICP-AES and nitrogen adsorption-desorption were carried out to reveal the factors which affect the activity and stability of catalysts. Meanwhile, DFT calculation results also illustrated the stability of catalyst is strongly related to the adsorption energy of reactants on the surface of catalysts. Further, reaction and deactivation kinetics of acetylene hydrochlorination reaction was studied and a model was built to simulate the performance of catalyst in long term industrial reactors by limited laboratory data. We have great confidence that the extensive application of non-mercury catalysts can be realized in few years.

Biography

Hao Xu received his Bachelor's degree in 2014 from Tsinghua University, Beijing, China with a major of Chemical and Industrial Biological Engineering. He is currently a PhD candidate in the Department of Chemical Engineering, Tsinghua University, China. He is working on the development of non-mercury catalysts for acetylene hydrochlorination process and corresponding reactor design & simulation. He also devotes himself to the industrialization of the process and the developed catalysts have been working on pilot-trial equipment for over 18000 hours.

472675880@qq.com

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