

Influence of rare-earth and bimetallic promoters on various VPO catalysts for partial oxidation of n-butane.

ABSTRACT

Vanadium phosphorous oxide (VPO) catalyst was prepared using dihydrate method and tested for the potential use in selective oxidation of n-butane to maleic anhydride. The catalysts were doped by La, Ce and combined components Ce + Co and Ce + Bi through impregnation. The effect of promoters on catalyst morphology and the development of acid and redox sites were studied through XRD, BET, SEM, H₂-TPR and TPR_n reaction of n-butane/He. Addition of rare-earth element to VPO formulation and drying of catalyst precursor by microwave irradiation increased the full width at half maximum (FWHM) and reduced the crystallite size of the Vanadyl hydrogen phosphate hemihydrate (VOHPO₄ · 1/2 H₂O, VHP) precursor phase and thus led to the production of final catalysts with larger surface area. The Ce doped VPO catalyst which, assisted by the microwave heating method, exhibited the highest surface area. Moreover, the addition of promoters significantly increased catalyst activity and selectivity as compared to undoped VPO catalyst in the oxidation reaction of n-butane. The H₂-TPR and TPR_n reaction profiles showed that the highest amount of active oxygen species, i.e., the V⁴⁺—O⁻ pair, was removed from the bimetallic (Ce + Bi) promoted catalyst. This pair is responsible for n-butane activation. Furthermore, based on catalytic test results, it was demonstrated that the catalyst promoted with Ce and Bi (VPOD1) was the most active and selective catalyst among the produced catalysts with 52% reaction yield. This suggests that the rare earth metal promoted vanadium phosphate catalyst is a promising method to improve the catalytic properties of VPO for the partial oxidation of n-butane to maleic anhydride.

Keyword: Vanadium-phosphorus oxide; Rare-earth dopant; Bimetallic promoter; Microwave irradiation; Temperature programmed reaction; n-Butane oxidation.