Combined steam and CO_2 reforming of methane for syngas production over carbon-resistant boron-promoted Ni/SBA-15 catalysts

Tan Ji Siang[a], Thong L.M. Pham[b], Nguyen Van Cuong[c], Pham T.T. Phuong[d], Nguyen Huu Huy Phuc[e], Quang Duc Truong[f], Dai-Viet N. Vo[a,g,*]

[a] Faculty of Chemical & Natural Resources Engineering, University Malaysia Pahang, Lebuhraya Tun Razak, Gambang 26300, Pahang, Malaysia
[b] Institute of Research and Development, Duy Tan University, 03 Quang Trung, Danang, Viet Nam
[c] Faculty of Chemical Engineering, Industrial University of Ho Chi Minh City, 12 Nguyen Van Bao St., Go Vap, Ho Chi Minh City 7000, Viet Nam
[d] Institute of Chemical Technology, Vietnam Academy of Science and Technology, 1 Mac Dinh Chi Str., Dist.1, Ho Chi Minh City, Viet Nam
[e] Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology, 1-1 Hibarigaoka, Tempaku, Toyohashi, Aichi 441-8580, Japan
[f] Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Katahira 2-1-1, Aoba-Ku, Sendai 980-8577, Japan
[g] Centre of Excellence for Advanced Research in Fluid Flow, Universiti Malaysia Pahang, 26300 Gambang, Kuantan, Pahang, Malaysia

ARTICLE INFO

Keywords:
Boron promoter
Bi-reforming of methane
Mesoporous silica
Ni/SBA-15 catalyst
Synthetic gas

ABSTRACT

The unpromoted and B-promoted 10%Ni/SBA-15 catalysts synthesized via sequential incipient wetness impregnation approach were assessed for combined steam and CO_2 reforming of methane (CSCRM) at various reaction temperatures of 973–1073 K and stoichiometric feed composition. An expected and noteworthy drop in mean NiO crystallite size and BET surface area with boron promotion from 1% to 5%B loading could be due to the agglomeration of B_2O_3 particles and deboration reaction during calcination and hence blocking mesopores of SBA-15 support at elevated B composition. The complete NiO reduction to metallic Ni^0 form was achieved during H_2 activation and the reduction temperature of NiO phase was shifted towards higher temperature with B-addition owing to enhancing interaction between the acidic B_2O_3 and basic NiO phases. For all reaction temperature employed, 3%B appeared to be the optimal promoter loading in terms of reactant conversions and 3%B-10%Ni/SBA-15 catalyst revealed the greatest H_2 yield (69.4%) at 1073 K. In addition, CH_4 and CO_2 conversions were enhanced about 23.2% and 32.4%, correspondingly with rising reaction temperature from 973 to 1073 K. Ratio of H_2 to CO varied from 1.26 to 2.71 and the desired H_2/CO ratio of about 2 favored for Fischer-Tropsch synthesis was achieved on 3%B-10%Ni/SBA-15 sample at 973 K. Boron promoter suppressed graphitic carbon formation and the amount of carbonaceous deposition was reduced about 4 times. Noticeably, 3%B-10%Ni/SBA-15 was also resilient to metallic Ni^0 re-oxidation throughout CSCRM.