Dry reforming of methane over Ni/dendritic fibrous SBA-15 (Ni/DFSBA-15) : optimization, mechanism, and regeneration studies

Chi Cheng Chong[a,b], Yoke Wang Cheng[a,b], H. D. Setiabudi[a,c], N. Ainirazali[a], Dai-Viet N. Vo[d], B. Abdullah[e,f]

[a] Faculty of Chemical and Process Engineering Technology, College of Engineering Technology, Universiti Malaysia Pahang, Gambang, 26300, Kuantan, Pahang, Malaysia

[b] Centre for Biofuel and Biochemical Research, Institute of Self-Sustainable Building, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Perak, Malaysia

[c] Centre of Excellence for Advanced Research in Fluid Flow, Universiti Malaysia Pahang, Gambang, 26300, Kuantan, Pahang, Malaysia

[d] Center of Excellence for Green Energy and Environmental Nanomaterials (CE@GrEEN), Nguyen Tat Thanh University, 300A Nguyen Tat Thanh, District 4, Ho Chi Minh City, 755414, Viet Nam

[e] Chemical Engineering Department, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Malaysia

[f] Center of Contaminant Control and Utilization (CenCoU), Institute of Contaminant Management for Oil and Gas, University Teknologi PETRONAS, 32610, Bandar Seri Iskandar, Perak, Malaysia

ABSTRACT

Dendritic fibrous type SBA-15 (DFSBA-15) was recently discovered with its outstanding catalytic performance and coke resistance as compared to the conventional SBA-15. The operating conditions for dry reforming of methane (DRM) over 10Ni/DFSAB-15 were optimized by using response surface methodology (RSM), followed by stability and regeneration study. Characterization results (TEM and FESEM) confirmed the homogenous distribution of NiO particles with no morphological change in spherical DFSBA-15 upon Ni addition. Process parameters, such as reaction temperature (X_1, 700 °C–900 °C), gas hourly space velocity (X_2, 15,000 mL/g.h – 35,000 mL/g.h), and CH_4/CO_2 ratio (X_3, 1–3) were studied over CO_2 conversion (Y_1), CH_4 conversion (Y_2), and H_2/CO ratio (Y_3). The optimal reaction conditions were found at X_1 = 794.37 °C, X_2 = 23,815.022 mL/g.h, and X_3 = 1.199, with Y_1 = 95.67%, Y_2 = 93.48%, and Y_3 = 0.983. The in-situ FTIR studies of adsorbed CH_4, CO_2, and $CH_4 + CO_2$ confirmed the formation of unidentate carbonate, bidentate carbonate, and linear carbonyl species as intermediate species. 10Ni/DFSBA-15 presented good reproducibility by using both regeneration medium (air and CO_2/N_2) with two-fold regeneration by air as compared to CO_2/N_2. It was proven that the synthesized 10Ni/DFSBA-15 was appreciably stable and prone to be regenerated by air for DRM under optimal conditions.

KEYWORDS

Response surface methodology; Central composite design; Methane dry reforming; Ni/DFSBA-15; Optimization; Regeneration

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