

Synthesis, characterisation, and performance evaluation of promoted Ni-based catalysts for thermocatalytic decomposition of methane

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ABSTRACT

Thermocatalytic decomposition (TCD) of methane to CO_x free hydrogen and carbon nanofibre (CNF) was investigated over a series of self-designed monometallic Ni catalyst and bimetallic Ni–Cu and Ni–Pd catalysts. The catalysts were synthesised from the wet impregnation method and characterised using a series of complementary techniques include TGA, XRD, BET, TPR, FESEM, TEM, and Raman Spectroscopy. Despite a substantial reduction of surface area in the promoted catalysts, the catalytic activity of the promoted catalyst was enhanced due to the nature of the process which is a metal-catalysed reaction. As a whole, bimetallic Pd–Ni catalyst with a surface area of 2.76 m² g⁻¹ possessed the highest conversion of 77 % after 6 h reaction. The overall TCD reaction was found to be first-order with the calculated activation energy, E_a of 38 kJ mol⁻¹. The methane consumption rates at 1023 K and 1073 K were 0.5 mol s⁻¹g_{cat}⁻¹ and 0.58×10⁴ mol s⁻¹g_{cat}⁻¹ respectively. Meanwhile, the methane consumption rates improved considerably from 0.58 mol s⁻¹g_{cat}⁻¹ to 0.67×10⁴ mol s⁻¹g_{cat}⁻¹ under the methane partial pressure of 41 kPa. The XRD profile of the fresh catalysts revealed that mixed oxides were formed over the surface of the support upon the addition of Cu and Pd to 50 %Ni/Al₂O₃. Moreover, the formation of carbon nanofibers followed both tip and base growth mechanisms as evident from the TEM images. Larger and wider carbon fibres were found in the Pd promoted catalyst.

KEYWORDS

Activation energy; Alloy; Carbon; CNF; Reaction order; TCD

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