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PII: S0169-4332(15)00043-4
DOI: http://dx.doi.org/doi:10.1016/j.apsusc.2015.01.032
Reference: APSUSC 29467

To appear in: *APSUSC*

Received date: 20-9-2014
Revised date: 12-12-2014
Accepted date: 5-1-2015

Please cite this article as: M. Pudukudy, Z. Yaakob, Z.S. Akmal, Direct decomposition of methane over SBA-15 supported Ni, Co and Fe based bimetallic catalysts, *Applied Surface Science* (2015), http://dx.doi.org/10.1016/j.apsusc.2015.01.032

Direct decomposition of methane over SBA-15 supported Ni, Co and Fe based bimetallic catalysts

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Abstract

Thermocatalytic decomposition of methane is an alternative route for the production of COx-free hydrogen and carbon nanomaterials. In this work, a set of novel Ni, Co and Fe based bimetallic catalysts supported over mesoporous SBA-15 was synthesized by a facile wet impregnation route, characterized for their structural, textural and reduction properties and were successfully used for the methane decomposition. The fine dispersion of metal oxide particles on the surface of SBA-15, without affecting its mesoporous texture was clearly shown in the low angle X-Ray diffraction patterns and the transmission electron microscopy (TEM) images. The Nitrogen sorption analysis showed the reduced specific surface area and pore volume of SBA-15, after metal loading due to the partial filling of hexagonal mesopores by metal species. The results of methane decomposition experiments indicated that all of the bimettalic catalysts were highly active and stable for the reaction at 700°C even after 300 minutes of time on stream (TOS). However, a maximum hydrogen yield of ~56% was observed for the NiCo/SBA-15 catalyst within 30 minutes of TOS. A high catalytic stability was shown by the CoFe/SBA-15 catalyst with 51% of hydrogen yield during the course of reaction. The catalytic stability of the bimetallic catalysts was attributed to the formation of bimetallic alloys. Moreover, the deposited carbons were found to be in the form of a new set of hollow multi-walled nanotubes with open tips, indicating a base growth mechanism, which confirm the selectivity of SBA-15 supported bimetallic catalysts for the formation of open tip carbon nanotubes. The Raman spectroscopic and thermogravimetric analysis of the deposited carbon nanotubes over the bimetallic catalysts indicated their higher graphitization degree and oxidation stability.

Keywords: Hydrogen, Methane decomposition, Bimetallic catalysts, Open tip carbon nanotubes, Base growth mechanism, Raman analysis

1. Introduction

The non-renewable fossil fuels are depleting day by day due to its concomitant usage for energy necessities for all over the world. Therefore, it is crucial to develop an alternative energy source that can replace the non-renewable fossil fuels [1]. Hydrogen is considered to be an alternative promising clean energy carrier to replace the fossil fuel based energy for nearby future [2]. Fuel cells are the main consumers of hydrogen for energy generation. Currently, the industrial scale production of hydrogen is