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Optimization of bi-metallic (Fe–Co) catalyst on kaolin support for carbon nanofiber growth in a CVD reactor

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Abstract

This study focused on the development of Fe–Co/kaolin catalyst by a wet impregnation method. Response surface methodology was used to study the influence of operating variables such as drying temperature, drying time, mass of support and stirring speed on the yield of the catalyst. The catalyst composite at best synthesis conditions was then calcined in an oven at varied temperature and time using 2^2 factorial design of experiment. The catalyst with optimum surface area was then utilized to grow carbon nanofiber (CNF) in a chemical vapour deposition (CVD) reactor. Both the catalyst and CNF were characterized using high-resolution scanning electron microscopy, high-resolution transmission electron microscopy, thermogravimetric analysis (TGA), X-ray diffraction (XRD) and X-ray photoelectron spectroscopy. On the influence of operating variables on the yield of catalyst, the results showed that an optimum yield of 96.51% catalyst was obtained at the following operating conditions: drying time (10 h), drying temperature (110 °C), stirring speed (100 rpm) and mass of support (9 g). Statistical analysis revealed the existence of significant interactive effects of the variables on the yield of the catalyst. The HRSEM/XRD/BET/TGA analysis revealed that the particles are

well dispersed on the support, with high surface area (376.5 m^2/g) and thermally stable (330.88 °C). The influence of operating parameters on the yield of CNF was also investigated and the results revealed an optimum yield of 348% CNF at the following operating conditions: reaction temperature (600 °C), reaction time (40 min), argon flow rate (1416 mL/min) and acetylene/hydrogen flow rate (1416 mL/min). It was found from statistical analysis that the reaction temperature and acetylene/hydrogen flow rates exerted significant effect on the CNF yield than the other factors. The contour and surface plots bi-factor interaction indicated functional relationship between the response and the experimental factors. The characterization results showed that the synthesized CNF is thermally stable, twisted and highly crystalline and contain surface functional groups. It can be inferred from the results of various analyses that the developed catalyst is suitable for CNF growth in a CVD reactor.

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