Proceedings of the World Congress on New Technologies (NewTech 2015)
Barcelona, Spain – July 15 - 17, 2015
Paper No. 312

Macrokinetics of Carbon Nanotubes Synthesis by the CVD Method

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Extended Abstract

Carbon nanotubes (CNTs) are finding increasing applications in different areas due to their specific properties such as autoelectronic emission ability, chemical and thermal stability, unique sorption properties, good conductivity, and high strength. Studying basic processes of the CNTs synthesis in order to improve existing technologies and develop new industrial technologies is an actual task nowadays (Li et al., 2008).

Worldwide experience has shown that chemical vapor deposition (CVD) of carbon on the surface of a metal catalyst appears to be the most popular method for synthesizing CNTs during the decomposition of carbonaceous substances (Kumar and Ando, 2010). However, despite the increasing demand for CNTs, there is a lack of theoretical approaches to studying basic processes of the CNTs synthesis by the CVD method. The emphasis is currently placed on performing expensive experimental studies under laboratory and industrial conditions during the development of new technologies and equipment for the CNTs synthesis, which negatively affects the final price of products (Diao et al., 2010).

In this connection, the goal of the present work was to develop and study main processes taking place on the metal catalyst surface during the thermal decomposition of carbonaceous substances in the CNTs synthesis through the CVD method. For that purpose, we proposed an approach based on the assumption that the formation of nanostructures at the micro- or nano-scale level is determined by a set of macro-level parameters (temperature, pressure, flow rate, etc.), and the flow-catalyst external mass transfer is the rate-limiting stage. The latter was examined by means of mathematical modeling. We elaborated an equation which demonstrated a discrepancy of less than 10 % between calculated and experimental data obtained in our current and previous (Melezhyk et al., 2013) studies on the CNTs synthesis from ethanol and a propane-butane mixture over a nickel and magnesium oxides-based catalyst. This fact indicates the adequacy of our model and thus, the possibility of applying the proposed approach for developing and studying principal processes of the CNTs synthesis.

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