Gaseous products of the methane pyrolysis in laser initiated Cr/Al_2O_3 nanoparticle evaporation process in methane-argon medium

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During the last few decades laser initiated evaporation process is widely used to produce nanoparticles and coatings for electrical conductivity and catalytic purposes [1] including hydrogen generation from light alkanes [2]. Laser radiation allows to supply a high density of energy in the reaction zone and to intensify the dissociation and reassociation of the reactant molecules. Consequently, a greater number of different chemical bonds to produce generate a wider range of different products and materials including gaseous products. There are many difficulties associated with gaseous product analysis in laser initiated process of Cr/Al_2O_3 nanoparticles formation in methane-argon medium at low pressure. In this work some solutions for the chromatographic analysis procedure of the gaseous products synthesized during methane pyrolysis in two-phase system gas-nanoparticle are presented and some optimization approaches for intensification of methane pyrolysis stimulated by laser synthesis of catalytically active nanoparticles are proposed.

The laser synthesis of Cr/Al_2O_3 nanoparticles was conducted in own designed evaporation cell in methane-argon medium using continuous gas-discharge CO_2 laser with maximum output power of up to 120 W. The previously prepared tablets of pressed Cr/Al_2O_3 powder was used as evaporation target. The gaseous products of the methane pyrolysis reaction were characterized by chromatographic complex including a LKhM-80 (USSR) chromatograph with NaX nozzle column and a Kristall 5000 chromatograph (Khromatek, Russia) with a capillary column (Agilent Technologies, HP-Al-KCl sorbent). Special sampling system able to capture gas mixture from evaporation cell in real time mode with compensation of chamber vacuum was created. The experiments were carried out using several CH_4/Ar ratios, gas supply configuration and laser settings to optimize pyrolysis process. The main products of pyrolysis were hydrogen (maximal obtained reaction yield was about 4%) and amorphous carbon (soot) without any intermediate hydrocarbons (ethane, propane, acetylene ect.). The experimental parameters variation such as pressure in evaporation cell, methane-argon ratio gives some quantitative variation in products of reaction.

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