Coupled engineering and chemical approach to the design of a catalytic structured reactor for combustion of VOCs: Cobalt oxide catalyst on knitted wire gauzes

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Highlight:
- Model of gauze reactor is presented and the impact of axial dispersion discussed.
- Cobalt oxide catalyst is layered on wire gauze surface using plasma technique.
- Raman, XPS and XRD proved presence of about 5 nm CoO spinel crystallites.
- Kinetics of n-hexane catalytic combustion is studied in a gradientless reactor.
- Modelling is validated by experiments performed in large laboratory reactor.

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Abstract:
A structured reactor was built from stacked catalytic knitted wire gauzes. The cobalt oxide catalyst was deposited on the wire gauze surface using the plasma enhanced metal-organic chemical vapour deposition method. The Raman scattering, electron diffraction and photoelectron emission analyses of the catalyst surface evidenced the formation of a cobalt oxide spinel with crystallites of about 5 nm. The results of kinetic studies of VOC combustion (using n-hexane as a probe molecule) performed in a gradientless reactor allowed determining the reaction order and activation energy for this catalytic reaction. It has been proved that reaction follows first order kinetics. Two reactor models (plug-flow and plug-dispersions) were compared and the simpler plug-flow one is recommended due to the negligible influence of axial dispersion. Experiments were performed in a large laboratory reactor (temperature up to 873 K, gas stream up to 10 m^3/h STP) for catalytic conversion of VOCs (n-hexane). The model validation has shown satisfactory accuracy with maximum and average errors of 12% and 4%, respectively.

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1. Introduction

Catalytic combustion seems to be the most successful remedy for the removal of many types of 'combustible' species from exhaust gases. Combustible emissions containing a diverse variety of chemicals, called Volatile Organic Compounds (VOCs), constitute a vital environmental problem worldwide. A typical end-pipe VOC emission is characterised by a very low concentration of the organ-