



## Modeling, design and operation of pilot plant for two-stage oxidation of methanol into formic acid



I.A. Zolotarskii<sup>a,\*</sup>, T.V. Andrushkevich<sup>a</sup>, G.Ya. Popova<sup>a</sup>, S. Stempel<sup>b</sup>, V.O. Efimov<sup>b</sup>, V.B. Nakrokhin<sup>a</sup>, L.Yu. Zudilina<sup>a</sup>, N.V. Vernikovskaya<sup>a,c</sup>

<sup>a</sup> Borekov Institute of Catalysis SB RAS, Novosibirsk, Russia

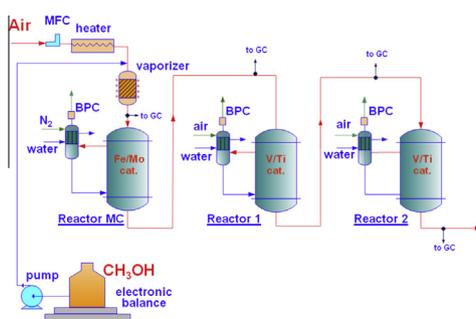
<sup>b</sup> Safe Technologies Inc., St.-Petersburg, Russia

<sup>c</sup> Novosibirsk State University, Novosibirsk, Russia

### HIGHLIGHTS

- Tubular reactor for formaldehyde oxidation into formic acid was modeled.
- Process flowsheet with two reactors for formaldehyde oxidation is favorable.
- Pilot plant for formic acid production is designed and constructed.
- Formic acid yield of 87–88% based on formaldehyde is obtained.
- Methanol consumption is 0.75–0.80 kg per 1 kg of 85% formic acid.

### GRAPHICAL ABSTRACT



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### ABSTRACT

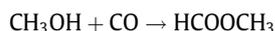
The new technology of formic acid production from methanol is developed. Methanol oxidation into formaldehyde in a tubular reactor with iron-molybdenum catalyst is carried out at the first stage similarly to existing technology of formalin production. Formaldehyde is oxidized into formic acid in a tubular reactor with an appropriate vanadia–titania catalyst at the second stage. Mathematical modeling of the process second stage is performed on basis of the detailed kinetic model. Design parameters and performance of large-scale multitubular reactors were determined and reproduced in the constructed pilot plant with a capacity of 2–3 kg of formic acid per hour. Process feasibility was confirmed by operation of the pilot plant. Formic acid yield at the second stage was shown to be 87–88%. The technology is ready for further scaling up to industrial level.

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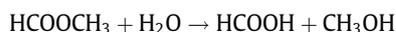
## 1. Introduction

Formic acid is a bulk chemical, its annual production being more than 500 thousand tons. Its major applications include silage and animal feed preservation, leather and tanning accounting for half of world consumption [1]. It is used in production of textiles, formate salts, pharmaceuticals/food chemicals, rubber chemicals (antiozonants and coagulants), catalysts and plasticizers also.

Formerly, formic acid was produced as a byproduct at liquid phase oxidation of butane and light gasoline into acetic acid. Nowadays formic acid is produced commercially by hydrolysis of methyl formate or formamide [2]. Raw material is carbon monoxide. It reacts with liquid methanol forming methyl formate in the presence of a strong base at elevated pressure:



Typical reaction conditions are 80 °C and 40 bar. Hydrolysis of methyl formate gives formic acid and methanol which is recycled.



\* Corresponding author. Tel.: +7 3833269409.

E-mail address: [zol@catalysis.ru](mailto:zol@catalysis.ru) (I.A. Zolotarskii).



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