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Selective Oxidation of Propane to Acrylic Acid over Multi Metal Oxide Catalyst

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ABSTRACT

The selective oxidation of propane to acrylic acid over a MoVTeNb mixed oxide catalyst, dried and calcined before reaction has been studied under some different reaction conditions using high-throughput instrumentation, which is called nanoflow catalytic reactor.
The rapid evaluation of catalysis is an indispensable technology for the success of combinatorial chemistry. A small-sized, easily operating screening is desirable for parallel settings, which dramatically shorten the evaluation time.
Nanoflow catalytic reactor that contains 12 tubular quartz reactors equipped with an on-line two gas chromatographers can decrease the analysis time by factor of about 12 compared to traditional test equipment (single continuous fixed-bed reactor). In addition, the catalyst powder or small catalyst particles (size up to 100 micron) can be exposed to gaseous reactant mixture, which passes the catalyst bed in the plug-flow mode. Reproducibility and reliability of the nanoflow catalytic reactor are also illustrated for the selective oxidation of propane to acrylic acid over MoVTeNb mixed oxide catalysts, and showed very good results (errors are lower than 10%).
The effects of the preparation methods on the catalytic performance of the MoVTeNb mixed oxide catalyst in selective oxidation of propane to acrylic acid were also investigated. Preparation methods can play significant roles in catalytic performance of these catalysts. In addition, further treatment such as dilution and leaching process can also play significant roles in their catalytic performance. The dilution of the MoVTeNb mixed oxide catalyst leads to increase the selectivity to acrylic acid, and the leaching process with water also leads to increase the selectivity to acrylic acid. Consequently, these processes lead to increase the acrylic acid yield. The reaction condition of selective oxidations of propane to acrylic acid, such as the gas hourly space velocity (GHSV), oxygen-propane ratio, water (steam) concentration, and reaction temperature, has also been studied. The best acrylic acid yield is achieved by oxidation of propane over MoVTeNb diluted-leached 24h catalyst at 683 K, GHSV of 1200h^{-1}, and molar ratio propane/oxygen/nitrogen/steam of 1/2.2/17.8/9.

The reaction kinetics for the selective oxidation of propane to acrylic acid over diluted MoVTeNb mixed oxide catalyst has also been investigated. The disappearance of propane is first order with respect to hydrocarbon and partial order (0.24) with respect to oxygen. The selective oxidation of propane to propylene follows the Langmuir-Hinshelwood mechanism. Deep oxidation of propane to carbon dioxide is first order with respect to hydrocarbon, and partial order (0.21) with respect to oxygen. The selective oxidation of propane to acrylic acid is half order with respect to hydrocarbon and partial order (0.11) with respect to oxygen, while water does not participate directly in propane transformation.

Keyword: **selective oxidation of propane, acrylic acid, high-throughput experimentation, mixed metal oxide catalyst, reaction kinetics**