Screening of reaction conditions and catalysts for the one-step synthesis of acrylic acid by partial oxidation of propane

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Introduction

- industrial production of acrylic acid: > 10⁴ kg p. a.
- state of the art: two step process propylene to acrolein at high temperature acrolein to acrylic acid at low temperature [1]
- promising alternative: one step synthesis propane to acrylic acid at high temperature catalyst: MoVTeNb mixed oxide catalytically active phase: M1 standard feed: 3% C₂H₈, 6% O₂, 40% H₂O [2]
- goal of presented study: understanding catalytic properties of M1 two main aspects: structure sensitivity of acrylic acid synthesis influence of feed composition

Influence of reaction conditions

- catalytic test in 10-fold parallel reactor
- investigated sample: SN 8612, similar to SN 6059 (same precursor material)
- all reactors at identical temperature, identical feed, identical flow per reactor
- ghsv varied by sample mass variation (sample mass: 300 mg to 12.5 mg)
- samples diluted with SiC (0.9 g to 1.3 g) to give identical volume of catalytic bed
- feed: propane, oxygen, and steam balanced with nitrogen
- ghsv: 2500 to 60000 ml g⁻¹ h⁻¹; H₂O: 10%, 20%, 40%, and 60%; O₂: 3%, 4.5%, and 6%; C₂H₄: constant at 3.0%
- reaction temperature: 370°C, 380°C, and 390°C
- analysed compounds (on-line gas chromatography): propane, propene, acrylic acid, acetic acid, oxygen, carbon monoxide, carbon dioxide, methane (internal standard), nitrogen (inert carrier)

Influence of catalyst morphology

- probing for structure sensitivity by testing phase-pure M1 catalysts of different morphologies
- application of three different synthesis methods to gain three different catalyst morphologies [3]

Conclusions

- phase pure M1 catalysts accessible via three different routes: comparable chemical composition and crystallinity, different morphologies
- probing for structure sensitivity of acrylic acid synthesis by testing catalysts with significantly different S₂O₅/S₃O₅ ratios: no indication for structure sensitivity
- active sites located on basal planes and lateral planes of M1 needles
- higher conversion of propane and S₂O₅/S₃O₅ with increasing steam content
- large influence of C₂H₄O ratio and steam on acrylic acid yield at low ghsv
- large influence of C₂H₄O ratio and steam on activation energy