

SiC mixed VPO catalyst for the partial oxidation of *n*-butane to Maleic Anhydride

A. H. Kababji, ¹⁾ J. T. Wolan, ^{*1)}

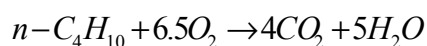
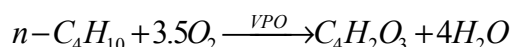
¹⁾ Chemical Engineering Department, University of South Florida, Tampa, FL 33620

* TEL: +813-974-6250, FAX: +813-974-3651, EMAIL: wolan@eng.usf.edu

ABSTRACT

A novel catalyst formula consisting of vanadium phosphorous oxide (VPO) mixed with α -SiC 2 μ m single crystalline particles was formulated and tested for potential use in the partial oxidation reaction of *n*-butane to maleic anhydride. Different commercial SiC powder samples were also used to investigate the intrinsic catalytic selectivity of SiC to produce maleic anhydride in this highly exothermic complex reaction. A fixed-bed catalytic micro-reactor and *in-situ* FTIR were used to evaluate the catalytic system and analyze the product effluent stream. The weight percentage loading of α -SiC in the VPO ranged from 6-90wt%. The best loading range of α -SiC in VPO was found to be 10-50wt%. Pd was used as a promoter in the catalyst system. The highest actual yield of MA in this investigation was obtained using a 1.5wt% Pd promoted 10wt% α -SiC size 2 μ m mixed VPO catalyst system which resulted in a 25% actual yield and 202 STY.

Maleic anhydride (MA) has found applications in almost every field of industrial chemistry. Today almost all the MA in the United States is being produced by the partial oxidation of *n*-butane. Thus the improvement of the process is of great economic and environmental interest. The catalyst used in the production process is a vanadium phosphorous oxide (VPO) catalyst [1-5]. The reaction is highly exothermic and the need to properly support the catalyst, not only for good dispersion but adequate heat dissipation is of crucial importance [1]. To evaluate catalytic activity both mixed and unmixed VPO catalysts were tested. Due to SiC's high heat transfer coefficient, high surface area, resistance to attrition, robustness and possible synergy with the catalyst material itself several types and sizes of SiC powders were investigated [2]. In this study, 2 μ m α -SiC particles showed the best conversion with a loading concentration of approximately 10wt% in VPO. Promoted and unpromoted VPO catalysts were tested with Palladium (Pd) being used as the promoter in this investigation. Selectivity to produce MA is the extent in which the VPO catalyst accelerates the reaction to form this desired product. In this way the VPO catalyst favors the partial oxidation over the complete oxidation of butane as shown in the following reactions respectively:



This selectivity to MA is also affected by temperature, pressure, residence time, contacting pattern and concentration of butane in the reagent flow [3].

REFERENCES

1. M. Ruitenbeek, Thesis, Universiteit Utrecht, (1999).
2. Ledoux, United States Patent 6,660,681 (2003).

- X. Wen and G. Yang, *Development of fluidized-bed catalyst for partial oxidation of n-butane*, *AIChE journal* **49**, 465-470 (2003).
- Bither, United States Patent 4,442,226 (1984).
- M. Abon and J.-C. Volta, *Vanadium phosphorous oxides for n-butane oxidation to maleic anhydride*, *applied catalysis* **157**, 173-193 (1997).

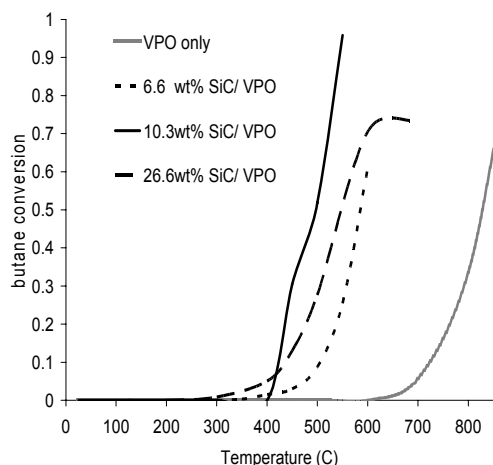


Figure 1: α -SiC 2 μ m/VPO mixtures (lower loadings) used in the partial oxidation of butane to maleic anhydride.

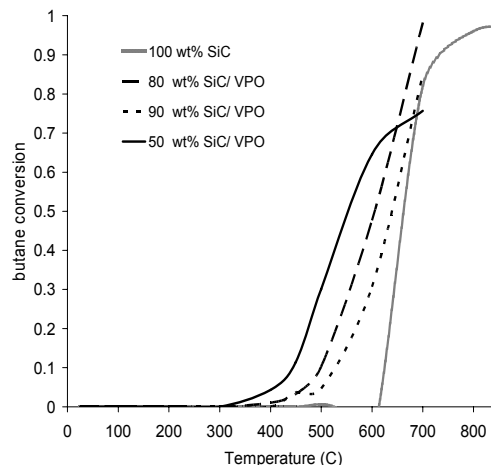


Figure 2: α -SiC 2 μ m/VPO mixtures (higher loadings) used in the partial oxidation of butane to maleic anhydride.

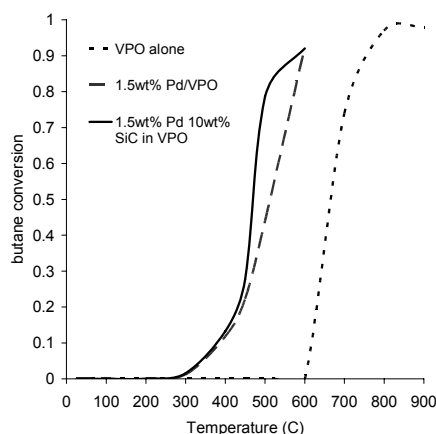


Figure 3: Pd promoted VPO catalyst systems used in the partial oxidation of butane to maleic anhydride.

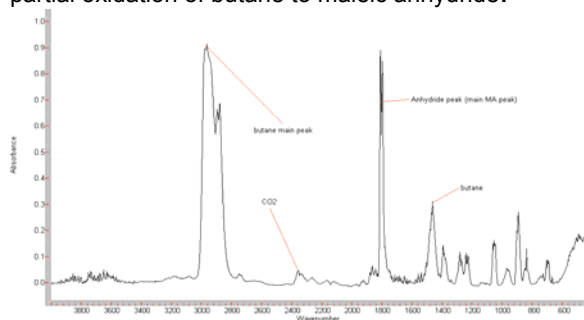


Figure 4: Spectrum at 400°C for a 1.5wt% Pd/ 10.0wt% α -SiC size 2 μ m/VPO catalyst system showing strong MA absorbance and very low CO₂ absorbance.

Sample	Catalyst weight (g)	Total product weight (g)	Total product actual yield (%)*	Space time yield (STY)
VPO only	0.38	0.575	7.20	76
6.6wt% α -SiC 2 μ m /VPO	0.38	0.40	5.01	53
10.3wt% α -SiC 2 μ m /VPO	0.38	0.772	9.67	102
26.6wt% α -SiC 2 μ m /VPO	0.38	0.35	4.38	46
50wt% α -SiC 2 μ m /VPO	0.5	0.25	3.13	25
80wt% α -SiC 2 μ m /VPO	0.5	0.10	1.25	10
90wt% α -SiC 2 μ m /VPO	0.5	0.05	0.62	5
0.5wt%Pd/ VPO	0.5	0.63	7.89	63
1.0wt%Pd/ VPO	0.5	1.40	17.54	140
1.5wt%Pd/ VPO	0.5	1.20	15.04	120
1.5wt%Pd/ 10wt% α -SiC 2 μ m/ VPO	0.5	2.02	25.27	202

Table 1: Actual total product yield and STY results for all catalyst systems used in this study.