

TABLE 4.1.1: Properties of Alumina Catalysts

Determined by supplier

Catalyst	Supplier	Alumina Phase	Surface Area (m ² /g)	Pore Volume (cc/g)	Loss on Ignition	Sodium Level (wt. % Na ₂ O)
Catapal B	Conoco	gamma	250	0.45	25.8	0.004
Versal GH	LaRoche	gamma	150-290	----	1-3	0.08
Al-3996R	Engelhard	gamma	180	0.64	----	0.05
Versal B	LaRoche	eta	400	----	35	0.1

TABLE 4.2.1: Effect of Catalyst Sodium Level on Isobutene Yield

Conditions: 330 °C, 150 psig, 5 mol % isobutanol in nitrogen, GHSV of 2500 sl/kg-hr

Run #	Catalyst	(wt. % Na ₂ O)	i-BuOH Conv (%)	Yield (basis: moles converted Isobutanol)		
				Isobutene	Linear Butenes	Diisobutyl Ether
11782-88	Catapal B	0.004	99.6	0.913	0.085	0.00
13033-12	Versal GH	0.05	98.7	0.917	0.081	0.00
13033-14	Al-3996R	0.08	99.7	0.908	0.089	0.00
11782-92	Versal B	0.1	98.9	0.920	0.078	0.00

Conditions: 330 °C, 150 psig, 5 mol % isobutanol in nitrogen, GHSV of 6000 sl/kg-hr

Run #	Catalyst	(wt. % Na ₂ O)	i-BuOH Conv (%)	Yield (basis: moles converted Isobutanol)		
				Isobutene	Linear Butenes	Diisobutyl Ether
11782-88	Catapal B	0.004	97.4	0.924	0.076	0.00
13033-12	Versal GH	0.08	95.6	0.919	0.083	0.00
13033-14	Al-3996R	0.05	99.3	0.904	0.094	0.00
11782-92	Versal B	0.1	96.1	0.925	0.071	0.00

TABLE 4.2.2: Operating conditions Necessary to Obtain Identical Conversions for Different Potassium Weight Loadings

Conditions: 5 Mol% Isobutanol in Nitrogen

Run #	Catalyst	Temperature (°C)	Pressure (psig)	GHSV (sl/kg-hr)	% i-BuOH Conversion	Yield (basis: moles converted i-BuOH)		
						Isobutene	Linear Butenes	Diisobutyl Ether
11782-88	Catapal B	290	150	2500	89.3	0.942	0.052	0.004
11782-98	Catapal B 0.2 wt.% K	330	500	2500	89.3	0.938	0.053	0.005
11782-01	Catapal B 0.5 wt.% K	330	150	1600	89.5	0.946	0.045	0.004
11782-98	Catapal B 0.2 wt.% K	330	150	6000	84.3	0.935	0.052	0.008
11782-01	Catapal B 0.5 wt.% K	330	150	2500	84.9	0.946	0.041	0.009
13033-1	Catapal B 0.8 wt.% K	330	150	1200	84.5	0.944	0.039	0.011

TABLE 4.2.3: Effect of Higher Alcohols on the Product Spectrum

Conditions: 330 °C, 150 psig, 5 mol % alcohol in nitrogen, GHSV of 2500 sl/kg-hr

Run # 13033-1

Alcohol Conversion (%): 74.9

<u>Alcohol Feed</u>	<u>Mole%</u>	<u>Feed Molar Selectivity (mole%)</u>	<u>Product Molar Selectivity (mole%)</u>
isobutanol	58.17	2-methyl-1-C3 alcohol/ C4 alcohol: 89.2	2-methyl-1-C3 alkene/C4 alkene: 87.0
1-butanol	7.04	2-methyl-1-C4 alcohol/ C5 alcohol: 80.3	2-methyl-1-C4 alkene/C5 alkene: 70.0
2-methyl-1-butanol	14.88	2-methyl-1-C5 alcohol/ C6 alcohol: 72.3	2-methyl-1-C5 alkene/C6 alkene: 49.3
1-pentanol	3.65	2-methyl-1-alcohol/ total feed: 84.8	2-methyl-1-alkene/total alkene: 76.9
2-methyl-1-pentanol	11.75		
1-hexanol	4.50		

Conditions: 330 °C, 150 psig, 5 mol % alcohol in nitrogen, GHSV of 1050 sl/kg-hr

Run # 13033-1

Alcohol Conversion (%): 84.5

<u>Alcohol Feed</u>	<u>Mole%</u>	<u>Feed Molar Selectivity (mole%)</u>	<u>Product Molar Selectivity (mole%)</u>
isobutanol	58.17	2-methyl-1-C3 alcohol/ C4 alcohol: 89.2	2-methyl-1-C3 alkene/C4 alkene: 87.5
1-butanol	7.04	2-methyl-1-C4 alcohol/ C5 alcohol: 80.3	2-methyl-1-C4 alkene/C5 alkene: 59.5
2-methyl-1-butanol	14.88	2-methyl-1-C5 alcohol/ C6 alcohol: 72.3	2-methyl-1-C5 alkene/C6 alkene: 39.8
1-pentanol	3.65	2-methyl-1-alcohol/ total feed: 84.8	2-methyl-1-alkene/total alkene: 74.0
2-methyl-1-pentanol	11.75		
1-hexanol	4.50		

TABLE 4.2.4: Effect of Methanol on the Product Spectrum

Conditions: 330 °C, 33 psig, GHSV of 1600 s/kg-hr

Run #	Feed	i-BuOH in N ₂ (mole%)	i-BuOH Conv (%)	Yield (basis: moles converted Isobutanol)			
				Isobutene	Linear Butene	Diisobutyl Ether	Methyl isobutyl Ether
13033-7	pure isobutanol	5.1	92.2	0.944	0.049	0.002	----
13033-7	2 moles isobutanol/ 1 mole methanol	4.2	92.1	0.900	0.045	0.001	0.049

TABLE 4.3.1: Effect of Impeller Speed on Reaction Rate

Conditions: 310 °C, 500 psig, 5 Mol% Isobutanol in Nitrogen, GHSV 11500 sl/kg-hr

Run #	Stirrer Speed (RPM)	Isobutanol Conv (%)	Isobutene Rate (gmole/kg-hr)	Yield (basis: moles converted Isobutanol)		
				Isobutene	Linear Butenes	Diisobutyl Ether
13033-14	300	58.6	17.4	0.884	0.050	0.058
13033-14	600	67.2	18.5	0.906	0.052	0.034
13033-14	800	70.6	19.9	0.907	0.055	0.028
13033-14	1200	74.3	20.8	0.913	0.058	0.022
13033-14	2000	73.3	20.6	0.909	0.057	0.024

TABLE 4.3.2: Effect of Water on the Reaction Rate

Conditions: 290 °C, 150 psig, 5 mol % isobutanol in nitrogen, GHSV of 6000 sl/kg-hr

Run #	Feed	i-BuOH Conv (%)	Isobutene Rate (gmole/kg-hr)	Yield (basis: moles converted Isobutanol)		
				Isobutene	Linear Butenes	Diisobutyl Ether
13033-14	pure isobutanol	79.9	11.3	0.924	0.059	0.012
13033-20	3 moles isobutanol/ 1 mole water	72.1	9.4	0.924	0.055	0.016
13033-20	3 moles isobutanol/ 2 moles water	55.1	7.6	0.902	0.047	0.044

Conditions: 310 °C, 150 psig, 5 mol % isobutanol in nitrogen, GHSV of 6000 sl/kg-hr

Run #	Feed	i-BuOH Conv (%)	Isobutene Rate (gmole/kg-hr)	Yield (basis: moles converted Isobutanol)		
				Isobutene	Linear Butenes	Diisobutyl Ether
13033-14	pure isobutanol	95.5	13.1	0.919	0.079	0.000
13033-18	3 moles isobutanol/ 1 mole water	86.3	11.5	0.926	0.067	0.004
13033-20	3 moles isobutanol/ 2 moles water	77.7	11.1	0.923	0.062	0.009