TABLE 1. CATALYSTS AND PROCESS CONDITIONS FOR ISOBUTYLENE SYNTHESIS

Source	Temperature	Pressure	C_4 Yield mole %	$i\text{-}C_4H_8$ Selectivity	WHSV	Feed Ratios	Catalyst
1	200 °C	0.68 atm	0.087%	—	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	250 °C	0.68 atm	0.088%	—	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	300 °C	0.68 atm	1.05%	—	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	350 °C	0.68 atm	11.11%	97.1%	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	400 °C	0.68 atm	12.23%	88.4%	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	450 °C	0.68 atm	5.38%	56.8%	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	400 °C	10.0 atm	7.42%	—	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
1	400 °C	21.0 atm	5.98%	96.4%	2300 1/hr	$CO\text{-}H_2$ (1:3)	ZrO_2
					Residence Time		
2	425 °C	35 atm	4.6%	—	0.237 min	$CO\text{-}H_2$ (1:1)	ZrO_2
2	425 °C	35 atm	4.1%	—	0.158 min	$CO\text{-}H_2$ (1:1)	ZrO_2
2	425 °C	35 atm	3.4 %	—	0.119 min	$CO\text{-}H_2$ (1:1)	ZrO_2
2	425 °C	35 atm	5.9%	—	0.237 min	$CO\text{-}H_2$ (1:1)	ZrO_2
2	400 °C	35 atm	3.5%	—	0.246 min	$CO\text{-}H_2$ (1:1)	ZrO_2
2	375 °C	35 atm	1.7%	—	0.256 min	$CO\text{-}H_2$ (1:1)	ZrO_2
2	350 °C	35 atm	0.6%	—	0.266 min	$CO\text{-}H_2$ (1:1)	ZrO_2
			C_4 Yield weight %	i-n ratio	W/F (g cat hr/mol)		
3	240 °C	1.5 MPa	24%	6.8	7.0	$CO\text{-}H_2$ (2:3)	HY + 2% Ru
3	240 °C	1.5 MPa	22%	10	7.0	$CO\text{-}H_2$ (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	1.5 MPa	31%	6.5	14	$CO\text{-}H_2$ (2:3)	HY + 2% Ru & HY + 2% Pt
3	240 °C	1.5 MPa	17%	7.5	7.0	$CO\text{-}H_2$ (2:3)	HY + 0.5% Ru + 2% Pt
3	240 °C	1.5 MPa	31%	9.3	7.0	$CO\text{-}H_2$ (2:3)	HY + 1% Ru + 2% Pt
3	240 °C	1.5 MPa	1.6%	0.2	7.0	$CO\text{-}H_2$ (2:3)	HY + 4% Ru + 2% Pt
3	240 °C	1.5 MPa	18%	0.3	7.0	$CO\text{-}H_2$ (2:3)	HY + 8% Ru + 2% Pt
3	240 °C	0.2 MPa	20%	1.7	12.5	$CO\text{-}H_2$ (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	0.8 MPa	23%	3.7	12.5	$CO\text{-}H_2$ (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	1.5 MPa	19%	5.2	12.5	$CO\text{-}H_2$ (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	2.1 MPa	13%	2.5	12.5	$CO\text{-}H_2$ (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	5.1 MPa	8%	1.5	12.5	$CO\text{-}H_2$ (2:3)	HY + 2% Ru + 2% Pt

Source	Temperature	Pressure	C_4 Yield weight %	i-C_4H_8 Selectivity	W/F g cat hr/mol	Feed Ratios	Catalyst
3	240 °C	1.5 MPa	22%	10.0	7.0	CO-H2 (2:3)	HY+2%Ru+2%Pt
3	240 °C	1.5 MPa	21%	3.6	18.0	CO-H_2 (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	1.5 MPa	18%	1.4	33.0	CO-H_2 (2:3)	HY + 2% Ru + 2% Pt
3	270 °C	1.5 MPa	11%	1.1	12.5	CO-H_2 (2:3)	HY + 2% Ru + 2% Pt
3	290 °C	5.1 MPa	6%	0.1	12.5	CO-H_2 (2:3)	HY + 2% Ru + 2% Pt
3	240 °C	1.5 MPa	23%	1.7	12.5	CO-H_2 (2:3)	$SiO_2Al_2O_3$ + 2% Ru + 2% Pt
3	240 °C	1.5 MPa	—	—	12.5	CO-H_2 (2:3)	HM + 2% Ru + 2% Pt
3	240 °C	1.5 MPa	24%	1.2	12.5	CO-H_2 (2:3)	CaY + 2% Ru + 2% Pt
			C_4 Yield mmol/g cat hr				
4	240 °C	1.5 MPa	2.05	7.1	12.5	CO-H_2 (2:3)	DAHY + 2% Pt + 0.1% 1-octene
4	240 °C	1.5 MPa	0.012	3.4	12.5	CO-H_2 (2:3)	DAHY + 2% Ru
4	240 °C	1.5 MPa	0.77	3.7	12.5	CO-H_2 (2:3)	DAHY + 2% Ru +0.1% 1-octene
4	240 °C	1.5 MPa	0.54	3.8	12.5	CO-H_2 (2:3)	DAHY+ 2%Ru+2%Pt
4	240 °C	1.5 MPa	1.27	4.6	12.5	CO-H_2 (2:3)	DAHY + 2% Ru + 2% Pt + 0.1% 1-octene
4	240 °C	1.5 MPa	1.05	10.4	12.5	CO-H_2 (2:3)	DAHY + 0.1% 1-octene
4	240 °C	1.5 MPa	1.24	5.9	12.5	CO-H_2 (2:3)	DAHY + 2% Ru + 2% Pt+0.1% 1-undecene
4	300 °C	1.5 MPa	1.34	1.6	12.5	CO-H_2 (2:3)	DAHY + 2% Ru + 2% Pt + 0.1% 1-undecene
4	240 °C	1.5 MPa	0.23	3.8	12.5	CO-H_2 (2:3)	DAHY+2%Ru+2%Pt
4	300 °C	1.5 MPa	0.39	1.3	12.5	CO-H_2 (2:3)	DAHY + 2% Ru + 2% Pt

Source	Temperature	Pressure	g C_4/m^3 Feed	i-C_4 Selectivity Total i-C_4)	% i-C_4H_8 of i-C_4(Total)	Feed Ratios	Catalyst
5	450 °C	150 atm	18.2	88%	—	$CO-H_2$ (1.2:1)	ThO_2
5	450 °C	150 atm	11.0	82%	—	$CO-H_2$ (1.2:1)	ZrO_2
5	450 °C	150 atm	1.6	81%	—	$CO-H_2$ (1.2:1)	CeO_2
5	450 °C	150 atm	4.7	59%	—	$CO-H_2$ (1.2:1)	Al_2O_3
5	400 °C	150 atm	8.4	87%	—	$CO-H_2$ (1.2:1)	ThO_2
5	450 °C	0 atm	—	—	—	$CO-H_2$ (49:41)	ThO_2
5	450 °C	6 atm	—	—	—	$CO-H_2$ (43:48)	ThO_2
5	450 °C	30 atm	5.7	92%	30%	$CO-H_2$ (49:41)	ThO_2
5	450 °C	75 atm	—	—	—	$CO-H_2$ (49:41)	ThO_2
5	450 °C	150 atm	18.6	88%	24%	$CO-H_2$ (49:41)	ThO_2
5	450 °C	300 atm	27.5	85%	4%	$CO-H_2$ (49:41)	ThO_2
5	450 °C	300 atm	30.6	84%	7%	$CO-H_2$ (45:45)	ThO_2
5	450 °C	300 atm	23.9	90%	5%	$CO-H_2$ (41:49)	ThO_2
5	450°C	600 atm	50.0	90%	2%	$CO-H_2$ (40:50)	ThO_2
5	450 °C	1000 atm	36.7	90%	—	$CO-H_2$ (44:47)	ThO_2
5	450 °C	300 atm	25.9	88%	8%	$CO-H_2$ (1:1)	ThO_2
5	475 °C	300 atm	31.1	88%	5%	$CO-H_2$ (1:1)	ThO_2
5	450 °C	300 atm	43.0	87%	10%	$CO-H_2$ (1:1)	ThO_2 + 10% Al_2O_3
5	475 °C	300 atm	60.2	83%	3%	$CO-H_2$ (1:1)	ThO_2 + 10% Al_2O_3
5	450 °C	300 atm	53.3	89%	4%	$CO-H_2$ (1:1)	ThO_2 + 20 % Al_2O_3
5	450 °C	600 atm	62.2	94%	2%	$CO-H_2$ (1:1)	ThO_2 + 20% Al_2O_3
5	450 °C	1000 atm	63.9	86%	5%	$CO-H_2$ (1:1)	ThO_2 + 20% Al_2O_3
5	425 °C	300 atm	30.7	87%	46%	$CO-H_2$ (1:1)	ThO_2 + 40% Al_2O_3
5	450 °C	300 atm	41.6	85%	18%	$CO-H_2$ (1:1)	ThO_2 + 40% Al_2O_3
5	475 °C	300 atm	48.6	88%	6%	$CO-H_2$ (1:1)	ThO_2 + 40% Al_2O3
5	450 °C	300 atm	33.3	84%	5%	$CO-H_2$ (1:1)	ThO_2 + 29% Al_2O_3
5	400 °C	300 atm	21.0	81%	11%	$CO-H_2$ (1:1)	ThO_2 + 20% Al_2O_3
5	450 °C	300 atm	69.5	87%	8%	$CO-H_2$ (1:1)	ThO_2 + 20% Al_2O_3
5	475 °C	300 atm	77.0	90%	2%	$CO-H_2$ (1:1)	ThO_2 + 20% Al_2O_3
5	450 °C	600 atm	67.9	91%	6%	$CO-H_2$ (1:1)	ThO_2+ 20% Al_2O_3

Source	Temperature	Pressure	g C_4/m^3 Feed	i-C_4 Selectivity (Total)	% i-C_4H_8 of i-C_4	Feed Ratios	Catalyst
5	425 °C	300 atm	26.2	67%	—	CO-H_2 (1:1)	ThO_2 + 20% Al_2O_3
5	450 °C	300 atm	26.0	90%	—	CO-H_2 (49:41)	ThO_2
5	450 °C	300 atm	13.0	92%	—	CO-H_2 (49:41)	ThO_2 + 0.6% K_2CO_3
5	450 °C	300 atm	70.0	87%	8%	CO-H_2 (49:41)	ThO_2+20% Al_2O_3
5	450 °C	300 atm	77.0	87%	8%	CO-H_2 (49:41)	ThO_2+20% Al_2O_3 +0.2% K_2CO_3
5	450 °C	300 atm	95.0	90%	5%	CO-H_2 (49:41)	ThO_2 + 20% Al_2O_3 + 0.6% K_2CO_3
5	450 °C	300 atm	16.0	63%	—	CO-H_2 (49:41)	Al_2O_3
5	450 °C	300 atm	3.0	67%	—	CO-H_2 (49:41)	Al2O3 + 3% K2CO3
5	450 °C	300 atm	2.5	76%	6%	CO-H_2 (41:49)	ZnO
5	450 °C	300 atm	36.4	87%	3%	CO-H_2 (40:50)	ThO_2 + 25% ZnO
5	425 °C	150 atm	12.9	90%	—	CO-H_2 (48:42)	ThO_2 + 25% ZnO
5	450 °C	150 atm	18.2	88%	11%	CO-H_2 (48:42)	ThO_2 + 25% ZnO
5	450 °C	150 atm	25.2	89%	—	CO-H_2 (48:42)	ThO_2 + 13% ZnO
5	450 °C	300 atm	22.4	86%	—	CO-H_2 (48:42)	ThO_2 + 25% ZnO
5	425 °C	150 atm	5.9	64%	—	CO-H_2 (49:41)	ZnO + 39% Al_2O_3
5	450 °C	150 atm	22.2	88%	6%	CO-H_2 (49:41)	ZnO + 39% Al_2O_3
5	450 °C	300 atm	30.8	86%	3%	CO-H_2 (41:49)	ZnO + 39% Al_2O_3
5	450 °C	300 atm	28.6	84%	14%	CO-H_2 (41:49)	ZnO + 56% Al_2O_3
5	450 °C	300 atm	36.4	87%	—	CO-H_2 (51:39)	ThO_2+11% Al_2O_3 +30% ZnO
5	450 °C	300 atm	37.2	92%	—	CO-H_2 (56:39)	Cr_2O_3
5	500 °C	300 atm	—	—	—	CO-H_2	Al_2O_3+10%Cr_2O_3
5	400 °C	150 atm	8.5	—	—	CO-H_2 (48:42)	H_3PO_4
5	450 °C	300 atm	19.4	89%	—	CO-H_2	ThO_2+0.25% Fe

Source	Temperature	Pressure	g C_4/m^3 Feed	i-C_4 Selectivity	% i-C_4H_8 of i-C_4	Feed Ratios	Catalyst
5	450 °C	300 atm	24.0	94%	—	$CO-H_2$	ThO_2+1.25% Fe
5	425 °C	300 atm	78.7	87%	11%	$CO-H_2$ (50:50)	ThO_2+20% Al_2O_3
5	375 °C	300 atm	11.0	88%	54%	$CO-H_2$ (50:50)	ThO_2+20% Al_2O_3
6	475 °C	300 atm	78.7	87%	11%	$CO-H_2$	ThO_2+20% Al_2O_3
						Feed ml/min	
7	643 K	69 kPa	—	57%	93%	N_2.DME (91-0.01)	ZrO_2
7	643 K	69 kPa	—	74%	93%	N_2.DME (91-0.43)	ZrO_2
7	643 K	69 kPa	—	77%	100%	N_2.DME (91-0.7)	ZrO_2
7	643 K	69 kPa	—	92%	100%	N_2.DME (91-6.2)	ZrO_2
7	643 K	69 kPa	—	97%	100%	N_2.$CO-H_2$ (18-36-36)	ZrO_2
7	643 K	69 kPa	—	92%	100%	N_2.$CO-H_2$.DME (18-36-36-0.23)	ZrO_2
7	643 K	69 kPa	—	95%	98%	N_2.$CO-H_2$.DME (18-36-36-0.7)	ZrO_2
7	643 K	69 kPa	—	97%	100%	N_2.$CO-H_2$.DME (18-36-36-4.4)	ZrO_2
7	643 K	69 kPa	—	97%	100%	N_2.$CO-H_2$.DME (18-36-36-6.1)	ZrO_2
			C_4 Yield mmol/min				
7	643 K	69 kPa	2.7	97%	100%	N_2.$CO-H_2$.C_2H_4 (20-40-40-1)	ZrO_2
7	643 K	69 kPa	6.0	85%	99%	N_2.$CO-H_2$ (20-40-40)	ZrO_2
7	633 K	69 kPa	2.1	97%	100%	N_2.$CO-H_2$.C_3H_6 (20-40-40-1)	ZrO_2
7	633 K	69 kPa	2.4	36%	97%	N_2.$CO-H_2$ (20-40-40)	ZrO_2
7	643 K	69 kPa	0.1	—	—	N_2.$CO-H_2$.$C_2H_5OC_2H_5$ (20-40-40-0.96)	ZrO_2
7	643 K	69 kPa	9.2	97%	100%	N_2.$CO-H_2$.CH_3CHO (20-40-40-0.01)	ZrO_2

Source	Temperature	Pressure	C_4 Yield mmol/min	i-C_4 Selectivity	% i-C_4H_8 of i-C_4	Feed ml/min	Catalyst
7	643 K	69 kPa	4.4	98%	99%	N_2-CO-H_2-$CH_3CH(OCH_3)_2$ (20-40-40-0.02)	ZrO_2
7	643 K	69 kPa	0.4	42%	57%	N_2-CO-H_2-CH_3CH_2CHO (20-40-40-0.003)	ZrO_2
7	643 K	69 kPa	0.4	—	—	N_2-CO-H_2-CH_3COCH_3 (20-40-40-0.03)	ZrO_2
			C4 Yield µmol/min			Feed Ratios 35 ml/min	
8	523 K	69 kPa	0.23	29%	98%	H_2-CO (3:1)	ZrO_2
8	573 K	69 kPa	5.3	91%	100%	H_2-CO (3:1)	ZrO_2
8	623 K	69 kPa	129	98%	99%	H_2-CO (3:1)	ZrO_2
8	673 K	69 kPa	220	92%	95%	H_2-CO (3:1)	ZrO_2
8	723 K	69 kPa	151	68%	84%	H_2-CO (3:1)	ZrO_2
8	673 K	71 kPa	0.6	—	—	H_2-CO (3:1)	Zr
8	673 K	71 kPa	1.4	—	—	H_2-CO (3:1)	ZrH
8	673 K	84 kPa	280	—	—	H_2-CO (3:1)	ZrO_2
8	673 K	71 kPa	79	—	—	H_2-CO (3:1)	ZrO_2 + 13% NaOH
8	673 K	84 kPa	152	—	—	H_2-CO (3:1)	ZrO_2 + 10% CaO
8	623 K	67 kPa	8.7	—	—	H_2-CO (3:1)	ZrO_2 + 10% Al_2O_3
8	623 K	67 kPa	2	—	—	H_2-CO (3:1)	ZrO_2 + 10% SiO_2
8	623 K	84 kPa	150	—	—	H_2-CO (3:1)	ZrO_2 + 1% Sc_2O_3
8	623 K	84 kPa	274	—	—	H_2-Co (3:1)	ZrO_2 + 1% Y_2O_3
8	623 K	84 kPa	278	—	—	H_2-CO (3:1)	ZrO_2 + 10% CeO_2
8	623 K	84 kPa	282	—	—	H_2-CO (3:1)	ZrO_2 + 1% Nd_2O_3
8	623 K	84 kPa	189	—	—	H_2-CO (3:1)	ZrO_2+5% Nd_2O_3
8	623 K	84 kPa	263	—	—	H_2-CO (3:1)	ZrO_2+1% Sm_2O_3
8	623 K	84 kPa	37	—	—	H_2-CO (3:1)	ZrO_2+10%Nb_2O_5