6.3 Etherification Runs

The above-mentioned light naphtha samples and methanol were the feedstock for a series of etherification runs at the same process conditions that were used for the earlier 2-methyl-2-butene/methanol tests. The reaction temperature was 150°F, except for a few runs at 125°F with feed "A." Tables XXIII-XXV show the major product analyses of these light naphtha/methanol runs with feedstocks "A," "B," and "C," respectively. The mixed ether product consisted of TAME and the three C_6 ethers, THME, (tertiary hexyl methyl ethers), which are 2-methyl-2-methoxypentane, 2,3-dimethyl-2-methoxybutane and 3-methyl-3-methoxypentane. Each run represents a weight balance period of at least 6 hours. There was good agreement in the product analyses for each test condition, except for the variability in the methanol analyses. In addition, the methanol and isobutylene components were not completely separated on the capillary GC column, a problem that did not allow for the quantification of the production of MTBE from the reaction of methanol and the minor amount of isobutylene in the naphtha sample. Table XXIII shows that higher conversions were obtained at 150°F than at 125°F reaction temperature, in agreement with the pure component 2-methyl-2-butene tests.

Different olefins have different reactivities and give different conversions during the etherification process. The conversion of each isomer can be calculated from the concentrations of feed and product that are given for each of the runs in Tables XXIII-XXV. Using data from Table XXIII, the effect of isomer and temperature on olefin reactivity is illustrated below in Table XXIIIa.

TABLE XXIIIa

REACTIVE ISO-OLEFINS CONVERSION TO ETHERS

Iso-olefin Component	125°F	150°F
C_5	Wt%	Wt%
2-Methyl-1-butene	85.4	89.9
2-Methyl-2-butene	29.9	65.5
C_6		
2,3 Dimethyl-1-butene	56.5	83.4
2-Methyl-1-pentene	65.9	87.5
2-Methyl-2-pentene	20.7	48.6
3-Methyl-cis-2-pentene	21.7	38.6
3-methyl-trans-2-pentene	20.8	29.8

The reaction products from the runs with feedstock "A" had a significant yellow color, especially at the higher reaction temperature of 150°F. The products from the pure component 2-methyl-1-butene tests were colorless. It is likely that polymerization of olefins to C_{10}+ hydrocarbon "color bodies" was responsible for the undesirable colored product. The color of the ether product could be a significant product quality issue. A possible solution would be to distill the ether product to remove the high molecular weight color bodies. However, the THME ethers boil at the high end of the product gasoline fraction, so such a separation might not be feasible. Another possible way to reduce color formation would be to use a catalyst that contained a hydrogenation metal component and hydrogen gas in the reactor.

To reduce color formation, runs were made with feedstocks "B" and "C" using Bayer's commercial etherification catalyst, K2634, in addition to Amberlyst 15. The Bayer catalyst contains a noble metal in addition to

TABLE XXIV

ETHERIFICATION RUNS WITH NAPHTHA "B"
(200 PSIG, METHANOL 1.37 G/HR, 200°F- NAPHTHA 5.5 G/HR)

Run No.	**Feed+MeOH**	**031-2**	**032-1**	**033-1**	**033-2**	**033-3**	**033-4**
Temp		**150°F**	**150°F**	**150°F**	**150°F**	**150°F**	**150°F**
Catalyst		**Amber15**	**Amber15**	**K2634**	**K2634**	**K2634**	**K2634**
Product, Wt% C4-5 Olefins:							H2 added
Isobutylene iC4=	1.036047	0.405	0.585	0.441	0.567	0.374	0.468
3M1BUTENE	0.225081	0.192	0.267	0.203	0.261	0.149	0.143
2M1BUTENE	1.81245	0.141	0.199	0.153	0.215	0.335	0.414
2M2BUTENE	4.778967	1.464	2.016	1.358	1.906	1.581	2.731
C6 OLEFINS							
3M1PENTENE	0.689574	0.66	0.767	0.6	0.748	0.423	0.429
23DMBUTENE	0.612861	0.512	0	0.038	0.048	0.03	0.083
4Mt2PENTENE	0.30348	0.293	0.368	0.289	0.363	0.221	0.262
4Mc2PENTENE	1.041105	0.995	1.159	0.912	1.136	0.69	0.929
2M1PENTENE	2.099913	0.276	0.329	0.239	0.335	0.424	0.583
HEXENE1	0.649953	0.622	0.696	0.544	0.68	0.368	0.387
tHEXENE3	1.620246	1.551	1.718	1.358	1.695	1.011	1.298
cHEXENE3	2.695914	2.569	2.633	2.086	2.601	1.594	2.207
2M2PENTENE	4.440081	1.81	2.08	1.497	2.008	1.46	2.478
tHEXENE2	0.06744	0.114	0	0.067	0.067	0.07	0.071
3Mt2PENTENE	2.640276	1.542	1.893	1.398	1.851	1.208	1.957
cHEXENE2	1.422141	1.359	1.482	1.169	1.468	0.863	1.04
3Mc2PENTENE	4.621326	2.969	3.378	2.436	3.289	2.127	3.521
OXYGENATES:							
MEOH	15.7	15.3	17.148	39.317	17.586	49.195	22.108
MTBE	0	1.558	2.031	1.459	1.991	0.927	1.835
TAME	0	6.17	6.328	4.452	6.338	2.853	4.644
THME1	0	1.172	0.67	0.466	0.677	0.386	0.52
THME2	0	5.535	4.369	2.866	4.397	2.45	3.542
THME3	0	4.142	3.003	2.148	3.113	1.782	2.376
NON-REACTIVE COMPOUNDS:							
nHEXANE	3.796872	3.25	3.598	2.883	3.484	2.48	4.653
TOLUENE	0.865761	0.851	0.746	0.499	0.739	0.461	0.714
2MPENTANE	3.153663	3.271	3.796	2.867	3.538	2.228	3.7
3MPENTANE	1.608444	1.746	1.972	1.455	1.794	1.121	1.878

TABLE XXV

ETHERIFICATION RUNS WITH NAPHTHA "c"
(200 PSIG, METHANOL 1.37 G/HR, 200°F- NAPHTHA 5.5 G/HR)

Run No.	**Feed+MeOH**	**034-1**	**034-2**	**034-3**	**034-4**
Temp		**150°F**	**150°F**	**150°F**	**150°F**
MEOHRATE		**K2634**	**K2634**	**K2634**	**K2634**
GASORATE		H2 added	H2 added	no H2	no H2
Product: C4-5 OL:					
Isobutylene iC4=	0.427401	0.3	0.206	0.435	0.3
3M1BUTENE	0.15174	0.019	0.008	0.111	0.159
2M1BUTENE	1.485366	0.348	0.302	0.213	0.151
2M2BUTENE	4.752834	3.095	2.778	2.094	1.595
C6 OLEFINS:					
3M1PENTENE	1.012443	0.073	0.052	0.709	1.012
23DMBUTENE	0.820239	0.115	0.115	0.115	0.115
4Mt2PENTENE	0.418971	0.145	0.123	0.458	0.46
4Mc2PENTENE	1.353858	0.751	0.651	1.481	1.404
2M1PENTENE	2.54586	0.54	0.548	0.351	0.318
HEXENE1	0.96945	0.067	0.048	0.407	0.957
tHEXENE3	2.128575	0.891	0.786	2.009	2.167
cHEXENE3	3.339966	1.884	1.692	3.589	3.43
2M2PENTENE	4.606152	3.087	3.219	2.281	2.187
tHEXENE2	0.06744	0.067	0	0.067	0.067
3Mt2PENTENE	2.774313	2.185	2.215	1.868	1.834
cHEXENE2	1.797276	0.588	0.518	1.609	1.817
3Mc2PENTENE	4.509207	4.125	4.237	3.399	3.29
OXYGENATES:					
MEOH	15.7	15.88	11.402	13.721	10.7
MTBE	0	1.318	1.117	1.082	1.049
TAME	0	4.555	4.854	5.838	6.819
THME1	0	0.494	0.597	0.679	0.893
THME2	0	3.876	4.932	5.012	6.114
THME3	0	2.087	2.589	3.366	4.166
NON-REACTIVE COMPOUNDS:					
nHEXANE	1.978521	7.371	7.847	2.943	2.151
TOLUENE	0.292521	0.375	0.335	0.269	0.325
2MPETANE	4.517637	5.961	6.157	5.253	4.731
3MPETANE	3.250608	3.691	3.973	3.571	3.316

TABLE XXVI

SUMMARY OF ETHERIFICATION RUN DATA

	Run No.	Reaction Temp	Catalyst	Research Octane Number*	Paraffins	Iso-paraffins	Aromatics	Naphthenes	Olefins	Oxygenates	Unknowns
Feed A	92-0490-01A			80.92	6.689	42.712	1.736	3.956	44.507	0.071	0.33
	15586-024-2	125°F	Amberlyst 15	82.09	7.804	40.230	1.985	4.474	33.762	11.406	0.34
	15586-024-6	150°F	Amberlyst 15	83.76	6.463	40.429	2.247	4.576	29.671	16.294	0.32
	15586-024-8	150°F	Amberlyst 15	83.88	6.337	40.466	2.263	4.586	29.58	16.436	0.33
Feed B	93-0024-01A			83.12	8.437	17.637	2.623	5.549	64.472	0.17	1.11
	15586-031-2	150°F	Amberlyst 15	87.43	7.417	17.989	3.687	6.424	41.847	21.815	0.821
	15586-033-1	150°F	Bayer K2634	87.48	7.381	17.340	3.691	6.583	41.716	22.445	0.844
	15586-033-3	150°F	Bayer K2634	85.78	8.205	17.668	3.62	6.512	45.889	17.277	0.83
Feed C	93-0024-01C			84.56	4.315	22.881	0.353	3.161	68.651	0.15	0.49
	15586-034-1	150°F	Bayer H2 K2634	79.47	14.535	24.733	2.405	5.436	35.369	17.332	0.19
	15586-034-3	150°F	Bayer no H2 K2634	85.78	5.921	22.489	1.977	4.497	43.51	21.192	0.415

*Calculated

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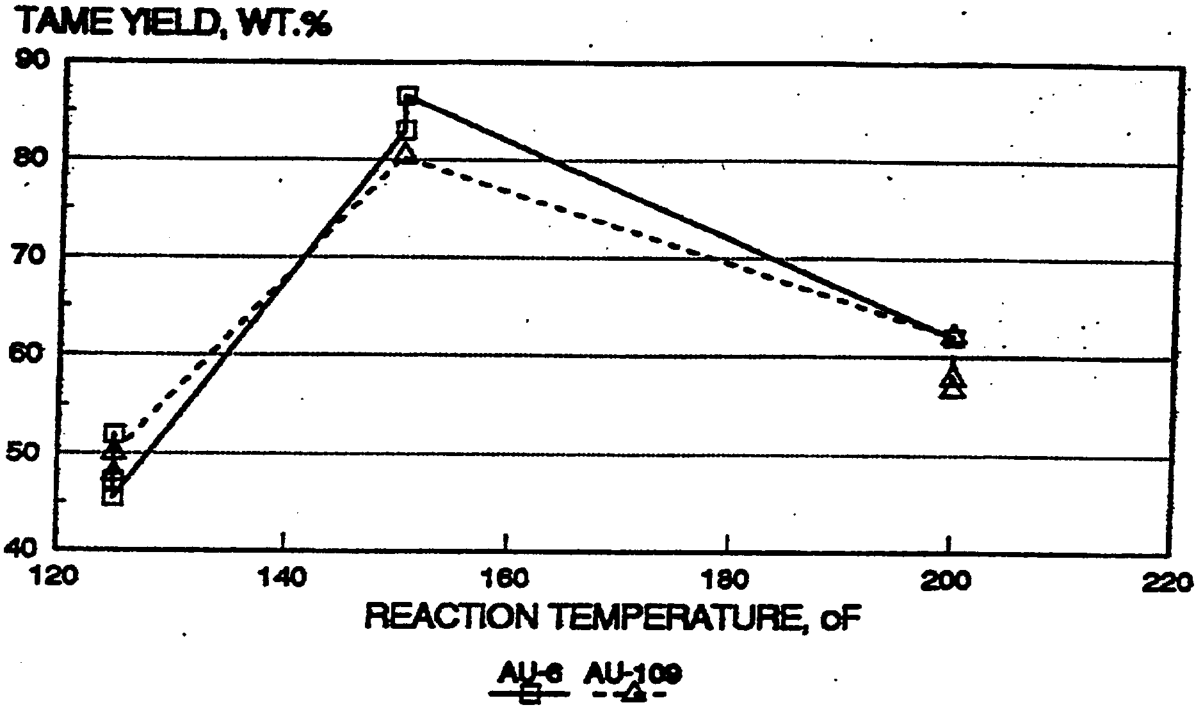
FIGURE 72

EFFECT OF REACTION TEMPERATURE ON ETHERIFICATION OF 2-METHYL-2-BUTENE WITH METHANOL



the strong acid functionality. The noble metal is available for olefin isomerization and diolefin saturation, in the presence of hydrogen.

When hydrogen gas was present with the Bayer catalyst (run No. 034-1, Table XXV), the color of the product improved, but there was a major loss of iso-olefin conversion because of concurrent hydrogenation of both reactive iso-olefins and linear olefins. This was an undesirable result since both the production of ethers and the octane number of the product decreased significantly. As Table XXVI shows, this run with added hydrogen gas had a lower research octane number (79.5) than the feedstock (84.6) or run No. 034-3 which was made without added hydrogen (85.8). This octane loss was due to the conversion of high octane olefins to low octane paraffins.

Table XXVI, which summarizes the etherification data at 150°F where the reaction was under equilibrium control, shows that iso-olefin conversions were similar for the three feedstocks and two catalysts, and *in the absence of hydrogen gas*, the light naphtha fractions from the catalytic cracking of Fischer-Tropsch wax were excellent feedstocks for the synthesis of TAME and THME. Table XXVI shows that the calculated research octane values for the products of these etherification runs were 2-4 numbers higher than the starting light naphtha feedstocks. As expected, this octane increase depended to some extent upon the concentrations of the ethers in the product.

7.0 EVALUATION OF GASOLINE BLENDING PROPERTIES OF ETHERS (TASK 6)

The previous section described RON data that were *calculated* from gas chromatography analyses of the mixed ether product from methanol etherification of the 200-°F fraction from the pilot plant catalytic cracking runs of Fischer-Tropsch wax feedstock. *Measured* RON and Motor Octane Numbers (MON) were obtained on those mixed ethers products in engine tests using 10% blends of the mixed ether product with unleaded regular gasoline (ULR). The octane number from the engine test of the blend is the *observed* octane number. The *blend octane number* is the octane number of the ether component. The blend octane number of the ethers was calculated from the observed octane number of the blend by using Equation 1, which assumes that the volumes of ethers and unleaded regular gasoline blend linearly. These RON and MON data are given in Table XXVII, which also gives the RON data shown in Table XXVI that were calculated from gas chromatography analyses.

Equation 1:

$$\text{Observed Octane} = (\text{Vol. Fr. Additive})(\text{Blend Value Additive}) + (\text{Vol. Fr. ULR})(\text{Obs. Octane ULR})$$

where Vol. Fr. ULR = 0.90, RON ULR = 91.9, and MON ULR = 82.3

The calculated RON values for the products of the etherification runs were 2-4 numbers higher than the starting light naphtha feedstocks. As expected, this octane increase depended to some extent upon the concentrations of the ethers in the product. However, as Figure 73 shows, there was only fair agreement between the measured blending RON and the RON calculated by gas chromatography, even after editing the data to exclude outliers from the engine tests. Figure 73 excluded the data for additive 92-0490-1A because the MON was higher than the RON, which is impossible. We believe these results reflect engine test measurement errors because of very small amounts of samples available for analysis. Although the measurement of octane numbers in engine tests is usually very accurate, the data we obtained on the mixed ether blends is extremely sensitive to small errors because only enough etherified product was available for a single evaluation as a 10% solution, and the octane numbers of the unleaded regular blend stock were very similar to those of the ether blends.

8.0 ECONOMIC EVALUATIONS (TASK 7)

8.1 Product Value of FCC Pilot Plant Runs

8.1.1 Propylene Valued as Fuel Gas

Product values were calculated for eight pilot plant runs (939-1, -2, -4, -5, 940-1, -2, 941-1, and 941-2) using the product yields given in Table XVIII plus the product yields of reactive (for the production of methyl ethers) C_5 and C_6 olefin isomers that are shown in Table XXVIII. Tables XXIX-XXXVI show the results of the calculations for the eight runs, respectively. The rate basis for all the analyses was 283,687 lb/hr, which is consistent with the F-T wax rate used in the "Baseline Design/Economics for Advanced Fischer-Tropsch Technology."(9) Net product values (which accounts for the external energy required to maintain heat balance) were calculated for both simple (no ether unit) and complex (contains ether unit) refinery configurations. The price structure was the 1989 average spot price, PAD III obtained from the National Petroleum Council. All the iso-olefins were valued 100% as etherification feedstocks although they are only partially converted to ethers. Table XXXVII summarizes the net product values for simple and complex refineries, and the difference between the two, for the data in Tables XXIX-XXXVI.

Table XXXVII shows that irrespective of catalyst or reaction conditions, the net product values ($/d) for a simple refinery, which ranged from about $555,500 to $584,500, were always lower than the net product values for a complex refinery, which ranged from about $605,600 to $653,300. The net product values from the complex refinery configuration were higher because isobutylene was valued at 85.4 cpg as MTBE unit vs 63.8 cpg as alkylation product and the isoamylenes and isohexenes were valued at ~ 69 cpg as ethers vs 59.2 cpg as gasoline. Additional experimental data would be required to select the best catalyst if the products were valued for a simple refinery configuration. The HZSM-5 and beta zeolite catalysts would be better catalysts than USY zeolite catalyst in a complex refinery configuration because of their higher yields of iso-olefins. The complex refinery values of the beta and HZSM-5 catalyst runs were about $630,000-653,000/d vs $606,000-626,000/d for the USY catalyst runs.

8.1.2 Propylene Valued as Feedstock to Di-isopropyl Ether Unit

The product values in Tables XXVIII-XXXVI were recalculated with propylene valued at 42.7 cpg as feedstock to a diisopropyl ether unit(10) (DIPE) rather than 17.1 cpg as fuel gas. Table XXXVIII compares the product values *for a complex refinery* that were calculated with the propylene valued as feedstock to a DIPE unit rather than as fuel gas. The propylene value was computed using the properties(10) shown in Table XXXIX. Gasoline product values were calculated based on octane, RVP, and unit operating costs. The complete economic evaluation is shown in Appendix B.

Valuing propylene as DIPE feedstock raised the value of the FCU products by between 4% and 10.2%, depending on yield. The net product values from the HZSM-5 and beta zeolite catalysts increased by 8.4-10.2% (to $694,000-708,000/d) vs 4-6.1% (to $635,000-653,000/d) for the USY catalysts. The net product values from the HZSM-5 and beta zeolite catalysts were additionally increased over the Y zeolite catalyst because high yields of propylene accompanied the high yields of iso-olefins.

FIGURE 73

ENGINE TEST RON VS CALCULATED RON FOR MIXED ETHER REACTION PRODUCTS

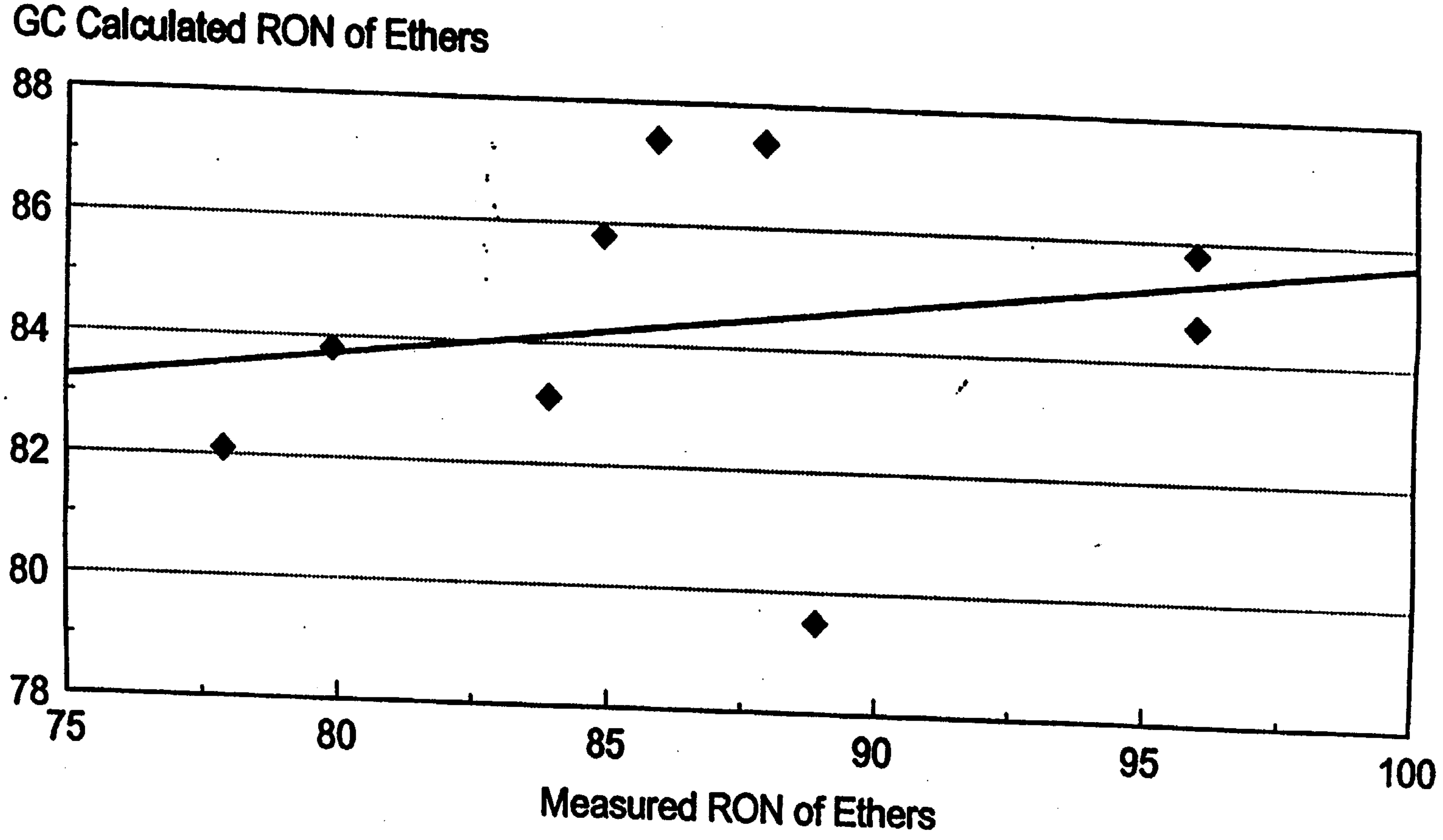


TABLE XXVII

RON AND MON OF PRODUCTS OBTAINED FROM LIGHT NAPHTHA ETHERIFICATION RUNS

	Run No.	Reaction Temp.	Catalyst	Olefins	Oxygenates	GC Calc. Research Octane Number +	Engine Test Measurements of RON and MON for Products Obtained from Light Naphtha Etherification Runs			
							Blend Value RON	Blend Value MON	Observed RON*	Observed MON*
Feed A	92-0490-01A			44.507	0.071	80.92	66.9	67.3	89.4	80.8
	15586-024-2	125°F	Amberlyst 15	33.762	11.406	82.09	77.9	74.3	90.5	81.5
	15586-024-6	150°F	Amberlyst 15	29.671	16.294	83.76	79.9	75.3	90.7	81.6
	15586-024-8	150°F	Amberlyst 15	29.58	16.436	83.88	--	--	--	--
Feed B	93-0024-01A			64.472	0.17	83.12	83.9	--	91.1	--
	15586-031-2	150°F	Amberlyst 15	41.847	21.815	87.43	87.9	78.3	91.5	81.9
	15586-033-1	150°F	Bayer K2634	41.716	22.445	87.48	85.9	79.3	91.3	82.0
	15586-033-3	150°F	Bayer K2634	45.889	17.277	85.78	84.9	74.3	91.2	81.5
Feed C	93-0024-01C			68.651	0.15	84.56	95.9	80.3	92.3	82.1
	15586-034-1	150°F	Bayer H2 K2634	35.369	17.332	79.47	88.9	81.3	91.6	82.2
	15586-034-3	150°F	Bayer no H2 K2634	43.51	21.192	85.78	95.9	85.3	92.3	82.6

*Observed Octane = (Volume Fraction Additive) (Blend Value Additive) + (Volume Fraction Unleaded Regular Gasoline) (Observed Octane Unleaded Regular Gasoline)

Volume fraction unleaded regular gasoline = 0.90
RON unleaded regular gasoline = 91.9
MON unleaded regular gasoline = 82.3

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TABLE XXVIII

C4-C6 ISOMER DISTRIBUTION OF FCC PILOT PLANT PRODUCTS

RUN NO.	939-1	939-2	939-4	939-5	940-1	940-2	941-1	942-2
CATALYST	eq Y	eq Y	eq Y	eq Y	BETA	BETA	Y+ZSM	Y BLD
CONVERSION, WT%	93.5	93.7	83	85	96.6	96.5	89	90.5
COMPONENT, WT.%								
HYDROGEN	0.04	0.04	0.03	0.02	0.02	0.01	0.02	0.02
METHANE	0.36	0.33	0.18	0.14	0.1	0.07	0.09	0.16
ETHYLENE	0.48	0.42	0.26	0.21	0.66	0.5	1.01	0.34
ETHANE	0.26	0.23	0.16	0.14	0.11	0.08	0.1	0.15
PROPYLENE	9.26	8.2	7.28	6.28	13.93	13.68	16.03	8.94
PROPANE	1.86	1.67	1.07	0.9	2.11	1.81	2.47	1.25
i-BUTANE	7.93	7.23	4.15	3.4	9.04	7.66	3.4	5.02
n-BUTANE	2.08	1.84	1.21	0.99	2.58	2.09	1.92	1.3
1-BUTENE	1.47	1.32	1.4	1.22	2.22	2.24	2.2	1.41
i-BUTYLENE	5.91	5.38	6.28	5.53	10.24	10.75	10.75	6.26
t-2-BUTENE	4.19	3.74	3.69	3.19	5.65	5.44	5.33	3.72
c-2-BUTENE	3.12	2.77	2.67	2.31	4.16	3.98	3.76	2.68
i-PENTANE	8.49	8.65	3.38	3.35	5.11	3.73	2.16	3.97
n-PENTANE	1.25	1.42	0.77	0.96	1.73	1.51	1.4	0.85
3M-1-BUTENE	0.086	0.166	0.092	0.168	0.187	0.214	0.279	0.126
2M-1-BUTENE	0.993	1.47	0.936	1.516	1.68	1.77	2.3	1.13
2M-2-BUTENE	3.78	4.57	2.99	5.077	5.03	4.896	5.94	3.36
1-PENTENE	0.297	0.47	0.312	0.505	0.476	0.505	0.62	0.378
t-2-PENTENE	1.4	1.8	1.248	2.069	1.768	1.826	2.145	1.45
c-2-PENTENE	0.806	1.01	0.7166	1.203	1	1.029	1.18	0.819
2,3-DM-1-BUTENE	0.187	0.173	0.33	0.369	0.193	0.147	0.085	0.22
2M-1-PENTENE	0.48	0.525	0.7177	0.803	0.579	0.507	0.266	0.57
2M-2-PENTENE	0.812	0.919	1.287	1.419	1.065	1.078	0.682	1.136
c-3M-2-PENTENE	0.812	0.923	1.306	1.419	1.078	1.169	0.84	1.21
t-3M-2-PENTENE	0.52	0.588	0.822	0.907	0.689	0.693	0.448	0.733
C6-430oF *	34.29	35.85	39.43	41.16	23.74	27.94	22.49	41.49
430-650oF	4.97	5.12	10.08	8.95	2.72	2.96	7.47	7.47
650oF+	1.5	1.15	6.61	5.1	0.87	0.71	4.13	2.95
SUBTOTAL	97.642	97.976	99.4046	99.308	98.731	98.99	99.514	99.113
COKE	2.34	2.01	0.61	0.68	1.2	1	0.47	0.88
GRAND TOTAL	99.982	99.986	100.0146	99.988	99.931	99.99	99.984	99.993

*C_6 fraction contains paraffins and non-ether-forming olefins.

TABLE XXIX

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 939-1: USY CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 939-1

Component	normalized wt % Yield	lb/hr	BBL/Day	<----Simple Configuration---->				<---Complex Configuration--->			
				cpg	$/Day	Valued as		cpg	$/Day	Valued as	
Hydrogen	0.040	113	111	6.0	279	Fuel Gas	2	6.0	279	Fuel Gas	2
Methane	0.360	1,021	233	10.8	1,059	Fuel Gas	2	10.8	1,059	Fuel Gas	2
Ethylene	0.480	1,362	252	12.8	1,356	Fuel Gas	2	12.8	1,356	Fuel Gas	2
Ethane	0.260	738	142	12.1	721	Fuel Gas	2	12.1	721	Fuel Gas	2
Propylene	9.263	26,274	3,450	17.1	24,777	Fuel Gas	2	17.1	24,777	Fuel Gas	2
Propane	1.861	5,277	713	16.8	5,028	Fuel Gas	2	16.8	5,028	Fuel Gas	2
i-Butane	7.932	22,500	2,739	37.2	42,792	Alkylation	3	37.2	42,792	Alkylation	3
n-Butane	2.081	5,902	692	29.8	8,662	Gasoline	5	29.8	8,662	Gasoline	5
1-Butene	1.470	4,171	475	63.9	12,756	Alkylation	3	63.9	12,756	Alkylation	3
i-Butylene	5.912	16,769	1,914	63.8	51,289	Alkylation	3	85.4	68,654	Ether Unit	4
t-2-Butene	4.191	11,888	1,336	64.8	36,349	Alkylation	3	64.8	36,349	Alkylation	3
c-2-Butene	3.121	8,852	968	66.6	27,065	Alkylation	3	66.6	27,065	Alkylation	3
i-Pentane	8.492	24,089	2,652	49.4	55,017	Gasoline	5	49.4	55,017	Gasoline	5
n-Pentane	1.250	3,547	385	33.8	5,469	Gasoline	5	33.8	5,469	Gasoline	5
3M-1-Butene	0.086	244	27	50.3	560	Gasoline	5	53.6	597	Alkylation	3
2M-1-Butene	0.993	2,817	294	50.3	6,216	Gasoline	5	86.5	10,689	Ether Unit	4
2M-2-Butene	3.781	10,725	1,101	50.3	23,268	Gasoline	5	88.0	40,707	Ether Unit	4
1-Pentene	0.297	843	89	50.3	1,889	Gasoline	5	54.9	2,062	Alkylation	3
t-2-Pentene	1.400	3,972	417	50.3	8,803	Gasoline	5	55.5	9,713	Alkylation	3
c-2-Pentene	0.806	2,287	240	50.3	5,068	Gasoline	5	55.5	5,592	Alkylation	3
2,3-diM-1-Butene	0.187	531	53	59.2	1,326	Gasoline	5	68.6	1,537	Ether Unit	4
2-M-1-Pentene	0.480	1,362	137	59.2	3,395	Gasoline	5	68.7	3,940	Ether Unit	4
2-M-2-Pentene	0.812	2,304	229	59.2	5,689	Gasoline	5	69.4	6,669	Ether Unit	4
c-3-M-2-Pentene	0.812	2,304	227	59.2	5,634	Gasoline	5	70.1	6,671	Ether Unit	4
t-3-M-2-Pentene	0.520	1,475	144	59.2	3,586	Gasoline	5	70.5	4,270	Ether Unit	4
C6-430	34.299	97,292	8,416	59.7	211,018	Gasoline	5	59.7	211,018	Gasoline	5
430-650	4.971	14,102	1,019	52.1	22,296	Diesel	6	52.1	22,296	Diesel	6
650+	1.500	4,256	275	31.8	3,666	No 6 FO	7	31.8	3,666	No 6 FO	7
Sub-total	97.659	277,018	28,728		575,033				619,411		
Coke	2.341	6,639									
Grand Total	100.000	283,657									
Coke Amount for Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		8,290									
MMBTU/Day		3,382									
$/Day		6,765			(6,765)				(6,765)		
Net $/Day					568,269				612,646		

TABLE XXX

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 939-2: USY CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 939-2

Component	normalized wt % Yield	lb/hr	BBL/Day	<----Simple Configuration---->				<----Complex Configuration--->			
				cpg	$/Day	Valued as		cpg	$/Day	Valued as	
Hydrogen	0.040	113	111	6.0	279	Fuel Gas	2	6.0	279	Fuel Gas	2
Methane	0.330	936	214	10.8	970	Fuel Gas	2	10.8	970	Fuel Gas	2
Ethylene	0.420	1,192	221	12.8	1,187	Fuel Gas	2	12.8	1,187	Fuel Gas	2
Ethane	0.230	653	125	12.1	638	Fuel Gas	2	12.1	638	Fuel Gas	2
Propylene	8.201	23,264	3,055	17.1	21,939	Fuel Gas	2	17.1	21,939	Fuel Gas	2
Propane	1.670	4,738	640	16.8	4,514	Fuel Gas	2	16.8	4,514	Fuel Gas	2
I-Butane	7.231	20,512	2,497	37.2	39,010	Alkylation	3	37.2	39,010	Alkylation	3
n-Butane	1.840	5,220	612	29.8	7,661	Gasoline	5	29.8	7,661	Gasoline	5
1-Butene	1.320	3,745	427	63.9	11,454	Alkylation	3	63.9	11,454	Alkylation	3
I-Butylene	5.381	15,263	1,742	63.8	46,685	Alkylation	3	85.4	62,490	Ether Unit	4
t-2-Butene	3.741	10,610	1,192	64.8	32,442	Alkylation	3	64.8	32,442	Alkylation	3
c-2-Butene	2.770	7,859	859	66.6	24,026	Alkylation	3	66.6	24,026	Alkylation	3
I-Pentane	8.651	24,540	2,701	49.4	56,048	Gasoline	5	49.4	56,048	Gasoline	5
n-Pentane	1.420	4,029	438	33.8	6,212	Gasoline	5	33.8	6,212	Gasoline	5
3M-1-Butene	0.166	471	51	50.3	1,081	Gasoline	5	53.6	1,151	Alkylation	3
2M-1-Butene	1.470	4,170	435	50.3	9,200	Gasoline	5	86.5	15,822	Ether Unit	4
2M-2-Butene	4.571	12,965	1,331	50.3	28,127	Gasoline	5	88.0	49,209	Ether Unit	4
1-Pentene	0.470	1,333	141	50.3	2,989	Gasoline	5	54.9	3,262	Alkylation	3
t-2-Pentene	1.800	5,107	536	50.3	11,317	Gasoline	5	55.5	12,487	Alkylation	3
c-2-Pentene	1.010	2,865	301	50.3	6,350	Gasoline	5	55.5	7,007	Alkylation	3
2,3-diM-1-Butene	0.173	491	49	59.2	1,227	Gasoline	5	68.6	1,421	Ether Unit	4
2-M-1-Pentene	0.525	1,489	149	59.2	3,713	Gasoline	5	68.7	4,308	Ether Unit	4
2-M-2-Pentene	0.919	2,607	259	59.2	6,438	Gasoline	5	69.4	7,547	Ether Unit	4
c-3-M-2-Pentene	0.923	2,619	258	59.2	6,404	Gasoline	5	70.1	7,583	Ether Unit	4
t-3-M-2-Pentene	0.588	1,668	163	59.2	4,054	Gasoline	5	70.5	4,828	Ether Unit	4
C6-430	35.856	101,707	8,798	59.7	220,594	Gasoline	5	59.7	220,594	Gasoline	5
430-650	5.121	14,526	1,050	52.1	22,967	Diesel	6	52.1	22,967	Diesel	6
650+	1.150	3,263	210	31.8	2,811	No 6 FO	7	31.8	2,811	No 6 FO	7
Sub-total	97.990	277,955	28,565		580,334				629,866		
Coke	2.010	5,702									
Grand Total	100.000	283,657									
Coke Amount for											
Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		9,227									
MMBTU/Day		3,765									
$/Day		7,529			(7,529)				(7,529)		
Net $/Day					572,805				622,337		

TABLE XXXI

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 939-4: USY CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 939–4

Component	normalized wt % Yield	lb/hr	BBL/Day	<----Simple Configuration-----> cpg	$/Day	Valued as		<----Complex Configuration----> cpg	$/Day	Valued as	
Hydrogen	0.030	85	83	6.0	209	Fuel Gas	2	6.0	209	Fuel Gas	2
Methane	0.180	510	117	10.8	529	Fuel Gas	2	10.8	529	Fuel Gas	2
Ethylene	0.260	737	137	12.8	734	Fuel Gas	2	12.8	734	Fuel Gas	2
Ethane	0.160	454	87	12.1	443	Fuel Gas	2	12.1	443	Fuel Gas	2
Propylene	7.279	20,647	2,711	17.1	19,471	Fuel Gas	2	17.1	19,471	Fuel Gas	2
Propane	1.070	3,035	410	16.8	2,891	Fuel Gas	2	16.8	2,891	Fuel Gas	2
I–Butane	4.149	11,770	1,433	37.2	22,384	Alkylation	3	37.2	22,384	Alkylation	3
n–Butane	1.210	3,432	402	29.8	5,036	Gasoline	5	29.8	5,036	Gasoline	5
1–Butene	1.400	3,971	452	63.9	12,144	Alkylation	3	63.9	12,144	Alkylation	3
I–Butylene	6.279	17,811	2,033	63.8	54,476	Alkylation	3	85.4	72,920	Ether Unit	4
t–2–Butene	3.689	10,465	1,176	64.8	31,997	Alkylation	3	64.8	31,997	Alkylation	3
c–2–Butene	2.670	7,572	828	66.6	23,151	Alkylation	3	66.6	23,151	Alkylation	3
I–Pentane	3.379	9,586	1,055	49.4	21,893	Gasoline	5	49.4	21,893	Gasoline	5
n–Pentane	0.770	2,184	237	33.8	3,367	Gasoline	5	33.8	3,367	Gasoline	5
3M–1–Butene	0.092	261	28	50.3	599	Gasoline	5	53.6	638	Alkylation	3
2M–1–Butene	0.936	2,655	277	50.3	5,856	Gasoline	5	86.5	10,071	Ether Unit	4
2M–2–Butene	2.989	8,480	871	50.3	18,397	Gasoline	5	88.0	32,185	Ether Unit	4
1–Pentene	0.312	885	94	50.3	1,983	Gasoline	5	54.9	2,165	Alkylation	3
t–2–Pentene	1.248	3,539	371	50.3	7,844	Gasoline	5	55.5	8,655	Alkylation	3
c–2–Pentene	0.716	2,032	213	50.3	4,504	Gasoline	5	55.5	4,970	Alkylation	3
2,3–diM–1–Butene	0.330	936	94	59.2	2,339	Gasoline	5	68.6	2,710	Ether Unit	4
2–M–1–Pentene	0.718	2,035	204	59.2	5,074	Gasoline	5	68.7	5,888	Ether Unit	4
2–M–2–Pentene	1.287	3,650	362	59.2	9,013	Gasoline	5	69.4	10,566	Ether Unit	4
c–3–M–2–Pentene	1.306	3,704	364	59.2	9,058	Gasoline	5	70.1	10,725	Ether Unit	4
t–3–M–2–Pentene	0.822	2,331	228	59.2	5,666	Gasoline	5	70.5	6,747	Ether Unit	4
C6–430	39.423	111,827	9,673	59.7	242,542	Gasoline	5	59.7	242,542	Gasoline	5
430–650	10.078	28,588	2,066	52.1	45,201	Diesel	6	52.1	45,201	Diesel	6
650+	6.609	18,746	1,209	31.8	16,149	No 6 FO	7	31.8	16,149	No 6 FO	7
Sub–total	99.390	281,927	27,216		572,952				616,383		
Coke	0.610	1,730									
Grand Total	100.000	283,657									
Coke Amount for											
Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		13,199									
MMBTU/Day		5,385									
$/Day		10,771			(10,771)				(10,771)		
Net $/Day					562,181				605,612		

TABLE XXXII

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 939-5: USY CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 939-5

				<---Simple Configuration---->				<---Complex Configuration--->			
Component	normalized wt % Yield	lb/hr	BBL/Day	cpg	$/Day	Valued as		cpg	$/Day	Valued as	
Hydrogen	0.020	57	55	6.0	140	Fuel Gas	2	6.0	140	Fuel Gas	2
Methane	0.140	397	91	10.8	412	Fuel Gas	2	10.8	412	Fuel Gas	2
Ethylene	0.210	596	110	12.8	593	Fuel Gas	2	12.8	593	Fuel Gas	2
Ethane	0.140	397	76	12.1	388	Fuel Gas	2	12.1	388	Fuel Gas	2
Propylene	6.281	17,816	2,339	17.1	16,802	Fuel Gas	2	17.1	16,802	Fuel Gas	2
Propane	0.900	2,553	345	16.8	2,432	Fuel Gas	2	16.8	2,432	Fuel Gas	2
I-Butane	3.401	9,646	1,174	37.2	18,345	Alkylation	3	37.2	18,345	Alkylation	3
n-Butane	0.990	2,809	329	29.8	4,122	Gasoline	5	29.8	4,122	Gasoline	5
1-Butene	1.220	3,461	394	63.9	10,586	Alkylation	3	63.9	10,586	Alkylation	3
I-Butylene	5.531	15,689	1,791	63.8	47,986	Alkylation	3	85.4	64,232	Ether Unit	4
t-2-Butene	3.190	9,050	1,017	64.8	27,671	Alkylation	3	64.8	27,671	Alkylation	3
c-2-Butene	2.310	6,553	716	66.6	20,036	Alkylation	3	66.6	20,036	Alkylation	3
I-Pentane	3.351	9,504	1,046	49.4	21,706	Gasoline	5	49.4	21,706	Gasoline	5
n-Pentane	0.960	2,724	296	33.8	4,199	Gasoline	5	33.8	4,199	Gasoline	5
3M-1-Butene	0.168	477	52	50.3	1,094	Gasoline	5	53.6	1,165	Alkylation	3
2M-1-Butene	1.516	4,301	449	50.3	9,488	Gasoline	5	86.5	16,316	Ether Unit	4
2M-2-Butene	5.078	14,403	1,479	50.3	31,247	Gasoline	5	88.0	54,667	Ether Unit	4
1-Pentene	0.505	1,433	152	50.3	3,211	Gasoline	5	54.9	3,505	Alkylation	3
t-2-Pentene	2.069	5,870	616	50.3	13,008	Gasoline	5	55.5	14,353	Alkylation	3
c-2-Pentene	1.203	3,413	358	50.3	7,564	Gasoline	5	55.5	8,346	Alkylation	3
2,3-diM-1-Butene	0.369	1,047	105	59.2	2,616	Gasoline	5	68.6	3,032	Ether Unit	4
2-M-1-Pentene	0.803	2,278	228	59.2	5,678	Gasoline	5	68.7	6,590	Ether Unit	4
2-M-2-Pentene	1.419	4,026	400	59.2	9,940	Gasoline	5	69.4	11,653	Ether Unit	4
c-3-M-2-Pentene	1.419	4,026	396	59.2	9,845	Gasoline	5	70.1	11,657	Ether Unit	4
t-3-M-2-Pentene	0.907	2,573	252	59.2	6,254	Gasoline	5	70.5	7,447	Ether Unit	4
C6-430	41.166	116,771	10,101	59.7	253,266	Gasoline	5	59.7	253,266	Gasoline	5
430-650	8.951	25,391	1,835	52.1	40,147	Diesel	6	52.1	40,147	Diesel	6
650+	5.101	14,469	933	31.8	12,464	No 6 FO	7	31.8	12,464	No 6 FO	7
Sub-total	99.320	281,728	27,136		581,240				636,272		
Coke	0.680	1,929									
Grand Total	100.000	283,657									
Coke Amount for											
Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		13,000									
MMBTU/Day		5,304									
$/Day		10,608			(10,608)				(10,608)		
Net $/Day					570,631				625,664		

TABLE XXXIII

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 940-1: STEAMED BETA CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 940-1

Component	normalized wt % Yield	lb/hr	BBL/Day	<----Simple Configuration----->				<----Complex Configuration--->			
				cpg	$/Day	Valued as		cpg	$/Day	Valued as	
Hydrogen	0.020	57	55	6.0	140	Fuel Gas	2	6.0	140	Fuel Gas	2
Methane	0.100	284	65	10.8	294	Fuel Gas	2	10.8	294	Fuel Gas	2
Ethylene	0.660	1,873	347	12.8	1,866	Fuel Gas	2	12.8	1,866	Fuel Gas	2
Ethane	0.110	312	60	12.1	305	Fuel Gas	2	12.1	305	Fuel Gas	2
Propylene	13.939	39,539	5,192	17.1	37,287	Fuel Gas	2	17.1	37,287	Fuel Gas	2
Propane	2.111	5,989	809	16.8	5,706	Fuel Gas	2	16.8	5,706	Fuel Gas	2
i-Butane	9.046	25,659	3,123	37.2	48,800	Alkylation	3	37.2	48,800	Alkylation	3
n-Butane	2.582	7,323	859	29.8	10,748	Gasoline	5	29.8	10,748	Gasoline	5
1-Butene	2.221	6,301	718	63.9	19,272	Alkylation	3	63.9	19,272	Alkylation	3
i-Butylene	10.247	29,065	3,318	63.8	88,901	Alkylation	3	85.4	118,999	Ether Unit	4
t-2-Butene	5.654	16,037	1,802	64.8	49,034	Alkylation	3	64.8	49,034	Alkylation	3
c-2-Butene	4.163	11,808	1,291	66.6	36,100	Alkylation	3	66.6	36,100	Alkylation	3
i-Pentane	5.113	14,504	1,597	49.4	33,127	Gasoline	5	49.4	33,127	Gasoline	5
n-Pentane	1.731	4,910	533	33.8	7,571	Gasoline	5	33.8	7,571	Gasoline	5
3M-1-Butene	0.187	531	58	50.3	1,218	Gasoline	5	53.6	1,298	Alkylation	3
2M-1-Butene	1.681	4,769	498	50.3	10,520	Gasoline	5	86.5	18,091	Ether Unit	4
2M-2-Butene	5.033	14,277	1,466	50.3	30,974	Gasoline	5	88.0	54,188	Ether Unit	4
1-Pentene	0.476	1,351	143	50.3	3,028	Gasoline	5	54.9	3,305	Alkylation	3
t-2-Pentene	1.769	5,018	526	50.3	11,122	Gasoline	5	55.5	12,271	Alkylation	3
c-2-Pentene	1.001	2,838	298	50.3	6,290	Gasoline	5	55.5	6,941	Alkylation	3
2,3-diM-1-Butene	0.193	548	55	59.2	1,369	Gasoline	5	68.6	1,586	Ether Unit	4
2-M-1-Pentene	0.579	1,643	165	59.2	4,096	Gasoline	5	68.7	4,754	Ether Unit	4
2-M-2-Pentene	1.066	3,023	300	59.2	7,464	Gasoline	5	69.4	8,750	Ether Unit	4
c-3-M-2-Pentene	1.079	3,060	301	59.2	7,483	Gasoline	5	70.1	8,860	Ether Unit	4
t-3-M-2-Pentene	0.689	1,956	191	59.2	4,753	Gasoline	5	70.5	5,660	Ether Unit	4
C6-430	23.755	67,384	5,829	59.7	146,150	Gasoline	5	59.7	146,150	Gasoline	5
430-650	2.722	7,720	558	52.1	12,207	Diesel	6	52.1	12,207	Diesel	6
650+	0.871	2,469	159	31.8	2,127	No 6 FO	7	31.8	2,127	No 6 FO	7
Sub-total	98.799	280,251	30,315		587,951				655,438		
Coke	1.201	3,406									
Grand Total	100.000	283,657									
Coke Amount for Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		11,523									
MMBTU/Day		4,701									
$/Day		9,403			(9,403)				(9,403)		
Net $/Day					578,548				646,035		

TABLE XXXIV

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 940-2: STEAMED BETA CATALYST

Fischer Tropsch Wax Economics Rate Basis: 283,657 lb/hr
Pilot Plant Results of Wax Run Through an FCU Run No. 940-2
03/19/93

Component	normalized wt % Yield	lb/hr	BBL/Day	<---Simple Configuration----> cpg	$/Day	Valued as		<---Complex Configuration---> cpg	$/Day	Valued as	
Hydrogen	0.010	28	28	6.0	70	Fuel Gas	2	6.0	70	Fuel Gas	2
Methane	0.070	199	45	10.8	206	Fuel Gas	2	10.8	206	Fuel Gas	2
Ethylene	0.500	1,418	263	12.8	1,413	Fuel Gas	2	12.8	1,413	Fuel Gas	2
Ethane	0.080	227	44	12.1	222	Fuel Gas	2	12.1	222	Fuel Gas	2
Propylene	13.681	38,807	5,096	17.1	36,596	Fuel Gas	2	17.1	36,596	Fuel Gas	2
Propane	1.810	5,134	693	16.8	4,891	Fuel Gas	2	16.8	4,891	Fuel Gas	2
I-Butane	7.660	21,729	2,645	37.2	41,326	Alkylation	3	37.2	41,326	Alkylation	3
n-Butane	2.090	5,929	695	29.8	8,701	Gasoline	5	29.8	8,701	Gasoline	5
1-Butene	2.240	6,354	724	63.9	19,434	Alkylation	3	63.9	19,434	Alkylation	3
I-Butylene	10.751	30,495	3,481	63.8	93,273	Alkylation	3	85.4	124,852	Ether Unit	4
t-2-Butene	5.440	15,432	1,734	64.8	47,183	Alkylation	3	64.8	47,183	Alkylation	3
c-2-Butene	3.980	11,290	1,234	66.6	34,518	Alkylation	3	66.6	34,518	Alkylation	3
I-Pentane	3.730	10,581	1,165	49.4	24,166	Gasoline	5	49.4	24,166	Gasoline	5
n-Pentane	1.510	4,283	465	33.8	6,605	Gasoline	5	33.8	6,605	Gasoline	5
3M-1-Butene	0.214	607	66	50.3	1,393	Gasoline	5	53.6	1,484	Alkylation	3
2M-1-Butene	1.770	5,021	524	50.3	11,077	Gasoline	5	86.5	19,049	Ether Unit	4
2M-2-Butene	4.896	13,889	1,426	50.3	30,131	Gasoline	5	88.0	52,714	Ether Unit	4
1-Pentene	0.505	1,433	152	50.3	3,211	Gasoline	5	54.9	3,505	Alkylation	3
t-2-Pentene	1.826	5,180	543	50.3	11,480	Gasoline	5	55.5	12,666	Alkylation	3
c-2-Pentene	1.029	2,919	306	50.3	6,469	Gasoline	5	55.5	7,138	Alkylation	3
2,3-diM-1-Butene	0.147	417	42	59.2	1,042	Gasoline	5	68.6	1,208	Ether Unit	4
2-M-1-Pentene	0.507	1,438	144	59.2	3,585	Gasoline	5	68.7	4,160	Ether Unit	4
2-M-2-Pentene	1.078	3,058	304	59.2	7,551	Gasoline	5	69.4	8,852	Ether Unit	4
c-3-M-2-Pentene	1.169	3,316	326	59.2	8,109	Gasoline	5	70.1	9,603	Ether Unit	4
t-3-M-2-Pentene	0.693	1,966	192	59.2	4,778	Gasoline	5	70.5	5,690	Ether Unit	4
C6-430	27.942	79,259	6,856	59.7	171,905	Gasoline	5	59.7	171,905	Gasoline	5
430-650	2.960	8,397	607	52.1	13,276	Diesel	6	52.1	13,276	Diesel	6
650+	0.710	2,014	130	31.8	1,735	No 6 FO	7	31.8	1,735	No 6 FO	7
Sub-total	99.000	280,820	29,930		594,346				663,167		
Coke	1.000	2,837									
Grand Total	100.000	283,657									
Coke Amount for											
Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		12,093									
MMBTU/Day		4,934									
$/Day		9,868			(9,868)				(9,868)		
Net $/Day					584,479				653,299		

TABLE XXXV

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 941-1: BLEND 25% STEAMED HZSM-5 WITH USY CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 941-1

Component	normalized wt % Yield	lb/hr	BBL/Day	<----Simple Configuration----> cpg	$/Day	Valued as		<----Complex Configuration----> cpg	$/Day	Valued as	
Hydrogen	0.020	57	55	6.0	140	Fuel Gas	2	6.0	140	Fuel Gas	2
Methane	0.090	255	58	10.8	265	Fuel Gas	2	10.8	265	Fuel Gas	2
Ethylene	1.010	2,865	531	12.8	2,854	Fuel Gas	2	12.8	2,854	Fuel Gas	2
Ethane	0.100	284	55	12.1	277	Fuel Gas	2	12.1	277	Fuel Gas	2
Propylene	16.032	45,477	5,971	17.1	42,887	Fuel Gas	2	17.1	42,887	Fuel Gas	2
Propane	2.470	7,007	946	16.8	6,676	Fuel Gas	2	16.8	6,676	Fuel Gas	2
I-Butane	3.401	9,646	1,174	37.2	18,345	Alkylation	3	37.2	18,345	Alkylation	3
n-Butane	1.920	5,447	639	29.8	7,994	Gasoline	5	29.8	7,994	Gasoline	5
1-Butene	2.200	6,241	711	63.9	19,089	Alkylation	3	63.9	19,089	Alkylation	3
I-Butylene	10.752	30,498	3,481	63.8	93,282	Alkylation	3	85.4	124,863	Ether Unit	4
t-2-Butene	5.331	15,121	1,699	64.8	46,233	Alkylation	3	64.8	46,233	Alkylation	3
c-2-Butene	3.761	10,667	1,166	66.6	32,613	Alkylation	3	66.6	32,613	Alkylation	3
I-Pentane	2.160	6,128	675	49.4	13,996	Gasoline	5	49.4	13,996	Gasoline	5
n-Pentane	1.400	3,972	431	33.8	6,124	Gasoline	5	33.8	6,124	Gasoline	5
3M-1-Butene	0.279	792	86	50.3	1,816	Gasoline	5	53.6	1,935	Alkylation	3
2M-1-Butene	2.300	6,525	681	50.3	14,395	Gasoline	5	86.5	24,755	Ether Unit	4
2M-2-Butene	5.941	16,852	1,731	50.3	36,559	Gasoline	5	88.0	63,960	Ether Unit	4
1-Pentene	0.620	1,759	187	50.3	3,942	Gasoline	5	54.9	4,303	Alkylation	3
t-2-Pentene	2.145	6,085	638	50.3	13,486	Gasoline	5	55.5	14,880	Alkylation	3
c-2-Pentene	1.180	3,348	351	50.3	7,419	Gasoline	5	55.5	8,186	Alkylation	3
2,3-diM-1-Butene	0.085	241	24	59.2	603	Gasoline	5	68.6	698	Ether Unit	4
2-M-1-Pentene	0.266	755	76	59.2	1,881	Gasoline	5	68.7	2,183	Ether Unit	4
2-M-2-Pentene	0.682	1,935	192	59.2	4,778	Gasoline	5	69.4	5,601	Ether Unit	4
c-3-M-2-Pentene	0.840	2,383	234	59.2	5,828	Gasoline	5	70.1	6,901	Ether Unit	4
t-3-M-2-Pentene	0.448	1,271	124	59.2	3,089	Gasoline	5	70.5	3,679	Ether Unit	4
C6-430	22.493	63,804	5,519	59.7	138,385	Gasoline	5	59.7	138,385	Gasoline	5
430-650	7.471	21,192	1,531	52.1	33,508	Diesel	6	52.1	33,508	Diesel	6
650+	4.131	11,717	756	31.8	10,093	No 6 FO	7	31.8	10,093	No 6 FO	7
Sub-total	99.530	282,324	29,723		566,555				641,421		
Coke	0.470	1,333									
Grand Total	100.000	283,657									
Coke Amount for											
Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		13,596									
MMBTU/Day		5,547									
$/Day		11,094			(11,094)				(11,094)		
Net $/Day					555,461				630,327		

TABLE XXXVI

ECONOMIC ANALYSIS OF FCC PILOT PLANT RUN 942-2: BLEND 50% USY WITH DILUENT CATALYST

Fischer Tropsch Wax Economics
Pilot Plant Results of Wax Run Through an FCU
03/19/93

Rate Basis: 283,657 lb/hr
Run No. 942-2

				<----Simple Configuration----->				<----Complex Configuration---->			
Component	normalized wt % Yield	lb/hr	BBL/Day	cpg	$/Day	Valued as		cpg	$/Day	Valued as	
Hydrogen	0.020	57	55	6.0	140	Fuel Gas	2	6.0	140	Fuel Gas	2
Methane	0.160	454	104	10.8	471	Fuel Gas	2	10.8	471	Fuel Gas	2
Ethylene	0.340	965	179	12.8	961	Fuel Gas	2	12.8	961	Fuel Gas	2
Ethane	0.150	426	82	12.1	416	Fuel Gas	2	12.1	416	Fuel Gas	2
Propylene	8.941	25,361	3,330	17.1	23,916	Fuel Gas	2	17.1	23,916	Fuel Gas	2
Propane	1.250	3,546	479	16.8	3,378	Fuel Gas	2	16.8	3,378	Fuel Gas	2
I-Butane	5.020	14,241	1,733	37.2	27,084	Alkylation	3	37.2	27,084	Alkylation	3
n-Butane	1.300	3,688	432	29.8	5,412	Gasoline	5	29.8	5,412	Gasoline	5
1-Butene	1.410	4,000	456	63.9	12,233	Alkylation	3	63.9	12,233	Alkylation	3
I-Butylene	6.261	17,758	2,027	63.8	54,316	Alkylation	3	85.4	72,706	Ether Unit	4
t-2-Butene	3.720	10,553	1,186	64.8	32,266	Alkylation	3	64.8	32,266	Alkylation	3
c-2-Butene	2.680	7,603	831	66.6	23,244	Alkylation	3	66.6	23,244	Alkylation	3
I-Pentane	3.970	11,262	1,240	49.4	25,722	Gasoline	5	49.4	25,722	Gasoline	5
n-Pentane	0.850	2,411	262	33.8	3,718	Gasoline	5	33.8	3,718	Gasoline	5
3M-1-Butene	0.126	357	39	50.3	820	Gasoline	5	53.6	874	Alkylation	3
2M-1-Butene	1.130	3,206	335	50.3	7,072	Gasoline	5	86.5	12,161	Ether Unit	4
2M-2-Butene	3.360	9,532	979	50.3	20,678	Gasoline	5	88.0	36,177	Ether Unit	4
1-Pentene	0.378	1,072	114	50.3	2,403	Gasoline	5	54.9	2,623	Alkylation	3
t-2-Pentene	1.450	4,113	432	50.3	9,116	Gasoline	5	55.5	10,058	Alkylation	3
c-2-Pentene	0.819	2,323	244	50.3	5,149	Gasoline	5	55.5	5,681	Alkylation	3
2,3-diM-1-Butene	0.220	624	63	59.2	1,560	Gasoline	5	68.6	1,807	Ether Unit	4
2-M-1-Pentene	0.570	1,617	162	59.2	4,031	Gasoline	5	68.7	4,677	Ether Unit	4
2-M-2-Pentene	1.136	3,223	320	59.2	7,957	Gasoline	5	69.4	9,328	Ether Unit	4
c-3-M-2-Pentene	1.210	3,433	338	59.2	8,394	Gasoline	5	70.1	9,940	Ether Unit	4
t-3-M-2-Pentene	0.733	2,079	203	59.2	5,054	Gasoline	5	70.5	6,018	Ether Unit	4
C6-430	41.493	117,699	10,181	59.7	255,278	Gasoline	5	59.7	255,278	Gasoline	5
430-650	7.471	21,191	1,531	52.1	33,506	Diesel	6	52.1	33,506	Diesel	6
650+	2.950	8,369	540	31.8	7,209	No 6 FO	7	31.8	7,209	No 6 FO	7
Sub-total	99.120	281,161	27,874		581,503				627,004		
Coke	0.880	2,496									
Grand Total	100.000	283,657									
Coke Amount for											
Heat Balance, wt %		5%									
lb/hr		14,929									
Coke Deficit, lb/hr		12,433									
MMBTU/Day		5,073									
$/Day		10,145			(10,145)				(10,145)		
Net $/Day					571,358				616,859		

TABLE XXXVII

SUMMARY OF NET PRODUCT VALUES FOR FCC PILOT PLANT RUNS WITH PROPYLENE VALUED AS FEEDSTOCK TO A DIISOPROPYL ETHER UNIT

	<--------------Net $/Day------------->		
Run Number	Propylene valued as fuel	Propylene valued as DIPE feedstock	Percent Increase
939-1	612,646	649,740	6.1%
939-2	622,337	655,180	5.3%
939-4	605,612	634,761	4.8%
939-5	625,664	650,817	4.0%
940-1	646,035	701,856	8.6%
940-2	653,299	708,086	8.4%
941-1	630,327	694,532	10.2%
942-2	616,859	652,663	5.8%

TABLE XXXVIII

SUMMARY OF NET PRODUCT VALUES FOR FCC PILOT PLANT RUNS

Run Number	Catalyst	Net Product Value, $/D Simple Refinery	Complex Refinery	(Complex-Simple)
939-1	Eq. USY	568,269	612,646	44,377
939-2	Eq. USY	572,805	622,337	49,532
939-4	Eq. USY	562,181	605,612	43,431
939-5	Stmd Eq. USY	570,631	625,664	55,033
940-1	Stmd Beta	578,548	646,035	67,487
940-2	Stmd Beta	584,479	653,299	68,820
941-1	75% Stmd Eq USY; 25% Stmd HZSM-5	555,461	630,327	74,866
942-2	50% Eq USY; 50% Diluent	571,358	616,859	45,501

MSS/ml/94156
4/11/94