SELECTIVE CATALYTIC CRACKING OF FISCHER-TROPSCH LIQUIDS TO HIGH VALUE TRANSPORTATION FUELS. REPORT NUMBER 13: QUARTERLY TECHNICAL PROGRESS REPORT FOR SECOND QUARTER FISCAL YEAR 1992 (JANUARY 1--MARCH 31, 1992)

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RESEARCH AND DEVELOPMENT DEPT

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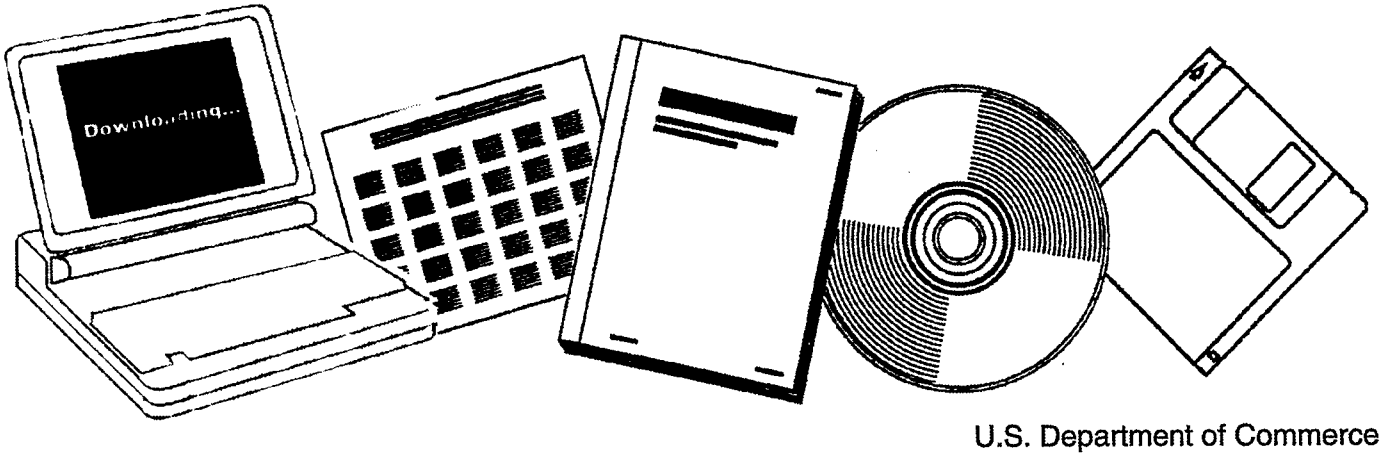

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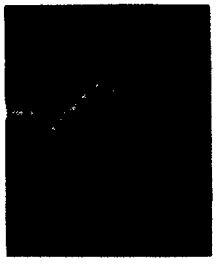

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THE SELECTIVE CATALYTIC CRACKING OF FISCHER-TROPSCH LIQUIDS TO HIGH VALUE TRANSPORTATION FUELS.

REPORT NO. 13

QUARTERLY TECHNICAL PROGRESS REPORT

FOR

SECOND QUARTER FISCAL YEAR, 1992

(January 1, 1992 - March 31, 1992)

PROJECT MANAGER: D. M. WASHECHECK

PRINCIPAL INVESTIGATOR: W. J. REAGAN

WORK PERFORMED UNDER CONTRACT NO. DE-AC22-91PC90057

FOR

U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER
PITTSBURGH, PENNSYLVANIA

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DISCLAIMER

EXECUTIVE SUMMARY

Amoco Oil Company, under a contract with the United States Department of Energy, is investigating a selective catalytic cracking process to convert the Fischer-Tropsch gasoline and wax fractions to high value transportation fuels. This report describes the work in the second quarter, fiscal year 1992, the third quarter of the two-year project.

Task 1, Project Management Plan. The plan has been accepted by the Project Manager DOE/PETC. This report contains the most current and accurate information and projections of the scope of work, schedules, milestones, staffing/manpower plan, and costs.

Task 2, Preparation of Feedstocks and Equipment Calibration. The work in this area is complete. The wax feedstock for this program, a commercial sample of Fischer-Tropsch product from Sasol, is a high melting point (>220°F), high boiling range (50% boiling above 1000°F), largely paraffinic material. The limited solubility of the wax in hydrocarbon solvents will require some equipment modifications and testing program changes. The new test equipment has been installed for the small scale test equipment and is now operational.

Task 3, Catalytic Cracking Catalyst Screening Program. The wax feedstock readily converts over conventional fluid catalytic cracking (FCC) catalysts (85%+ conversion) to high yields of C_4- gas (high in propylene and C_4 olefins) and gasoline (C_5-430°F). The work in this area focuses on the effects of process variables and catalyst types. The reaction temperature has only a small effect upon wax conversion in the range of 880-970°F. Larger variations in conversion occur with changes in the catalyst to oil weight ratio. Three different types of zeolite catalysts and one amorphous cracking catalyst show wide variations of product yields as a function of wax feedstock conversion. The beta and HZSM-5 zeolite catalysts have higher target light olefin (isobutylene and isoamylenes) yields than the Y zeolite sample. The HZSM-5 sample also produces the highest yields of propylene. The light olefin yields increase at the expense of C5-430°F gasoline production. Although the amorphous catalyst is less active than the zeolite samples, its light olefin yields are similar to the beta zeolite sample.

Task 4, Pilot Plant Tests. Some initial wax cracking tests on the pilot plant unit continue. This represents a small change in the original experimental plan. These test results also show high conversion (85%+) of the wax feedstock to light gases and gasoline. The ranking of the three zeolite catalyst types for C_4-C_5 iso-olefin production is similar to the findings of the small scale screening test program. It is not possible to obtain test results at a variety of conversion levels on the pilot plant due to operating constraints.

The catalytic cracking test results from both the small scale test unit and the pilot plant indicate that the wax feedstock readily converts to C_4- gas and gasoline. These tests suggest that very mild process conditions and low activity catalysts are needed to lower the overall wax conversion. The target light olefin yields vary with catalyst type and the process conditions.

BACKGROUND

Fischer-Tropsch (F-T) synthesis technology produces liquid hydrocarbons from synthesis gas (hydrogen and carbon monoxide) derived from the gasification of coal. Domestic supplies of both high- and low-rank coals are extensive and represent a strategic resource to supplement dwindling petroleum reserves. The Fischer-Tropsch technology has been practiced commercially at Sasol in South Africa since the mid-1950's. The F-T liquid product consists of a broad range of normal paraffins (C_5-C_{50}) and a small quantity of oxygenates and olefins. The gasoline range C_5-C_{12} product fraction consists of linear paraffins and olefins of low octane number. The distillate fraction, C_{12}-C_{18}, is an excellent quality fuel. The largest product fraction, C_{18}+, is primarily wax and is useless as a transportation fuel. There are many studies on the upgrading of these F-T liquids. These products are further treated by conventional petroleum processes, such as hydrotreating, reforming, and catalytic cracking, to produce conventional gasoline and distillate fuels. There are no reported studies of the catalytic cracking processing of F-T liquids to produce C_3-C_8 olefins as feedstocks for the synthesis of gasoline range ethers and alcohols. This is the primary focus of this project.

Fuel oxygenates, particularly alcohols and ethers, represent a potential solution to environmental concerns due to conventional automotive fuels. Governmental regulations, most recently in the Clean Air Act Amendments of November 1990, have resulted in the phase-out of lead additives, lowering of the Reid vapor pressure of gasoline, and, in some geographical areas, the mandated use of oxygenates. Recent studies of methyl tertiary butyl ether (MTBE) and tertiary amyl methyl ether (TAME) suggest that these compounds may reduce automotive carbon monoxide emissions, have high blending gasoline octane ratings, R+M/2 (MTBE-108, TAME-102), and have low Reid vapor pressure. These ethers are produced commercially by the etherification of the appropriate olefin by methanol (MTBE, isobutylene; TAME, isoamylenes). These olefins are derived from conventional petroleum processes such as catalytic cracking or steam/thermal reforming.

There is a growing need for alternative sources of olefins for ethers and alcohols syntheses as demand for these materials escalates beyond the capacity of conventional petroleum processes. This project addresses this requirement for an alternative olefin feedstock for oxygenate synthesis.

PROGRAM OBJECTIVES

The objective of this program is to prepare high-value transportation fuels, including gasoline, distillate, and gasoline range ethers and alcohols from non-petroleum resources. A selective catalytic cracking process of Fischer-Tropsch liquids is proposed. The C_4-C_8 product olefins would then be etherified with methanol to prepare the target ethers. Alcohols will be produced by direct hydration of C_3-C_8 product olefins. The gasoline and distillate products are also expected to be superior to conventional fuels because of the unique combination catalysts to be used in this process.

PROJECT DESCRIPTION

A two year, multi-task program will be used to accomplish the objective to develop a selective catalytic cracking process to produce premium transportation fuels, including ethers and alcohols from Fischer-Tropsch gasoline and wax products.

Task 1.--Project Management Plan. A plan will be prepared which describes the work to be done, milestones, and manpower and cost requirements.

Task 2.--Preparation of Feedstocks and Equipment Calibration. Suitable mixtures of Fischer-Tropsch waxes (C_{18}+) and light olefin components (C_5-C_{12}) will be prepared to simulate full range F-T liquids without the premium distillate products. The necessary analytical equipment will be calibrated for the detailed identification of C_4-C_8 olefins and ethers and other paraffin, aromatic, and naphthene gasoline range components.

Task 3.--Catalytic Cracking Catalyst Screening Program. Various zeolite catalysts and process variables will be studied with small scale test equipment.

Task 4.--Pilot Plant Tests of the Optimized Catalyst and Process. The optimized process will be tested on a pilot plant scale. The target light olefin, gasoline, and distillate products will be produced in sufficient quantities for complete characterization.

Task 5.--Preparation of C_5-C_8 Ethers and C_3-C_8 Alcohols. These products will be prepared from the pilot plant C_3-C_8 olefin products.

Task 6.--Evaluation of Gasoline Blending Properties of Ethers and Alcohol Products. The gasoline blending properties of the product ethers and alcohols will be measured. The properties of the distillate products will also be evaluated.

Task 7.--Scoping Economic Evaluation of the Proposed Processes. An economic analysis of the proposed process will be compared with conventional petroleum processes and ether and alcohol synthesis routes.

The DOE reporting requirements for this contract will be followed in all cases. This includes all project status, milestone schedule, and cost management reports. A final detailed project report will be submitted upon completion of the contract.

RESULTS AND DISCUSSION

During this quarter, project activities center on Tasks 3 and 4 of the contract.

TASK 1. Project Management Plan.

The draft Project Management Plan has been accepted by the Program Manager at DOE/PETC. This completes Task 1 of the contract. This document contains the most current and accurate information and projections of the

scope of work, schedules, milestones, staffing/manpower plan, and costs. This plan contains the following sections:

-- Management Plan
-- Technical Plan
-- Milestone Schedule/Manpower Plan
-- Cost Plan
-- Notice of Energy RD&D Project

The technical approach builds from small scale tests of the selective cracking concept to pilot plant scale verification of product yields. The screening test results will serve as a preliminary milestone of this process scheme. An assessment of project directions, scope of work, and objectives after this milestone will be appropriate.

TASK 2. Feedstock Characterization.

The wax feedstock has been analyzed by various analytical methods. The boiling point and the carbon number distributions of the largely paraffinic material are consistent with literature reports of similar Fischer-Tropsch samples. No further work in this area is planned.

TASK 3. Screening Catalytic Cracking Tests.

Activities under Task 3 of the contract continue on the small scale test unit, the MYU (micro yields unit). The primary feedstock for this program is a commercial Fischer-Tropsch wax product from Sasol, Limited. The initial choice of fluid catalytic cracking (FCC) catalyst and process conditions focuses on comparisons with conventional gas oil, the usual feedstock to commercial FCC units. At these conditions (970°F reaction temperature, 3 catalyst to oil weight ratio), the wax feedstock readily converts (85%+ conversion) to high yields of C_4- gas (high in propylene and C_4 olefins) and gasoline (C_5-430°F). In order to optimize the desirable olefin product (isobutylene and isoamylenes) yields, a lower overall conversion of the wax is desirable. The reaction severity is a function of catalyst activity, a measure of the active sites or zeolite concentration and process conditions, such as temperature, catalyst to oil weight ratio, and space velocity. The simplest variable to change in the MYU test is the reaction temperature. Two FCC catalysts with similar gas oil cracking activities, a Y faujasite zeolite sample and a beta zeolite sample, were evaluated in a series of variable temperature MYU runs. Both catalysts show conversions of the wax feedstock (to C_4-gas, gasoline, and coke) greater than 85%, even at the lowest reaction temperature of 880°F. The zeolite beta sample has a higher wax conversion level (~92%) than the zeolite Y sample (~88%). Figure 1 shows that the wax conversions of these two catalysts vary little with temperature. The beta zeolite catalyst produces more propylene, isobutylene, and slightly less isoamylenes than the Y zeolite catalyst, Figures 2 and 3. The higher production of light olefins for the beta sample occurs at the expense of gasoline yield, Figure 4. The gasoline yield of the beta catalyst is between 5 and 10% lower than the Y zeolite sample. The yields of the desired products, isobutylene and isoamylenes, are in the range of 6-8 wt%. The catalytic cracking of normal gas oil feedstocks generally yield about 2-4 wt% of these desirable olefins. It is likely that heavy aromatic molecules and catalyst poisons, such as aromatic nitrogen compounds, in the normal gas

oil feedstocks limit the amount of conversion by normal FCC catalysts. The wax feedstock does not contain these types of molecules, and the overall conversion and olefin yields for the wax are significantly higher than for gas oil feedstocks.

The comparison of product yields between catalyst is usually done at the same conversion level. These test results are for qualitative comparisons only since there are differences in the wax conversion levels of the two catalysts.

The next major process variable under study is the catalyst to oil weight ratio. This variable is conveniently changed by diluting the starting catalyst with an inert material. The total catalyst bed volume and weight in the reactor remains constant so that heat and mass transfer effects can be minimized between different catalyst blends. The initial choice of an "inert" diluent focuses on a low surface area, clay-based microsphere obtained from a catalyst manufacturer. This diluent was tested for wax cracking at two reaction temperatures, 880 and 970°F. Table I shows that this material has a low wax conversion level of less than 20%. However, conversion is usually defined as the sum of products of C_4- gas, gasoline (C_5-430°F), and coke. A somewhat different picture emerges when the boiling point distributions of the total liquid product of the two catalytic cracking runs with the diluent material are compared with the feed, Figures 5 and 6. A large fraction of the heavier feed components, boiling greater than 1000°F, is converted to 1000°F- products, including a significant amount of distillate (430-650°F). The 970°F reaction temperature liquid product has a higher portion of the lower boiling products than the 880°F product. The term "inert" diluent must be used cautiously.

Three FCC catalysts, containing zeolite Y, zeolite beta, and zeolite HZSM-5, were tested for wax conversion and selectivity as a series of blends (50%, 25%, 12.5%, 6.25%) with this diluent. The wax conversion levels for the three catalysts do decrease with amount of diluent, Table II and Figure 7. Most of these tests are at a single reaction temperature of 880°F. The HZSM-5 zeolite catalyst is the most active catalyst for wax conversion tested to date. At the dilution level of 1:15 (6.25% zeolite catalyst), the HZSM-5 sample has wax conversion levels of over 80%, while the Y and beta samples have wax conversions between 60 and 70%. At a dilution level of 1:31 (3.1% zeolite), the HZSM-5 zeolite has a wax conversion of 65%. The beta sample has a higher wax conversion level than the Y zeolite catalyst. There is some scatter in the conversion levels of replicate runs, especially at the high dilution (6.25% catalyst) of the Y and beta samples. This effect is not understood at this time. There may be feed bypass with the low catalyst levels or some other physical test problem.

These tests present a wide range of wax conversion values for the three catalysts. The product selectivity features among the tested catalysts are compared in Figures 8-13. The HZSM-5 zeolite has the highest yields of the desirable isoamylenes (Figure 8) and isobutylene (Figure 9). However, the HZSM-5 catalyst also produces high yields of propylene and total C_3+C_4 gas (Figure 10 and 11) and lower C5-430°F (Figure 12) gasoline than the other two catalysts. The beta zeolite is superior to the Y zeolite sample for olefin production in agreement with the temperature

survey test results presented above. The yields of the light olefin products appear to maximize for the Y and beta catalysts at a conversion level in the 80-85% range. This does not occur for the HZSM-5 sample where high C_4- gas levels and low gasoline production occurs at the low conversion levels of 65% (Figure 12). This information is important for the economic evaluation of the proposed wax catalytic cracking process. The coke yields for these three catalysts are a function of conversion (Figure 13) and the dilution level (Figure 14). At the higher conversion levels, the HZSM-5 catalyst produces the lowest coke yields. However, at low conversion levels, the coke differences between the catalysts are small.

Table III presents the detailed product distributions for the three catalysts at a similar conversion level of about 83%. The trade-offs of light olefin and gasoline yields are apparent. The detailed C_4 and C_5 isomer distributions in the liquid products from these three tests are compared in Figures 15 and 16. The yields of the isobutylene and isoamylenes olefins for the HZSM-5 and beta zeolite catalysts are close to equilibrium values. In addition, the HZSM-5 sample has low yields of isobutane and isopentane compared with the other zeolite samples. This may reflect the smaller pore structure of the HZSM-5 zeolite. The detailed carbon number distributions of the paraffin, isoparaffin, aromatics, naphthene, and olefin gasoline fractions of the three catalysts tests are shown in Figure 17. The concentrations of these components contribute to the octane qualities of the gasolines (Table III). The overall higher olefin content of the gasolines from the beta and HZSM-5 samples compared with the Y zeolite gasoline are similar to the rankings for the C_4 and C_5 olefin products. Small differences exist in the calculated octane numbers of the gasoline products from the three catalysts, Figures 18 and 19, across the wax conversion range studied in these tests.

These product yields differences will form the basis for a future economic evaluation of these catalyst options. The addition of low levels of the HZSM-5 catalyst with another zeolite catalyst is a strong candidate to maximize the yields of light olefins but maintain a reasonable gasoline yield. This is one of the current commercial uses for the HZSM-5 catalyst in FCC units.

Amorphous, non-zeolitic acidic catalysts are another catalyst option for wax cracking. These materials are no longer used in commercial units due to their lower activity than zeolite-based FCC catalysts. However, our tests show that the Fischer-Tropsch wax cracking occurs readily and low activity catalysts may not be a disadvantage. One example of this type of material is the matrix-only fraction of a commercial FCC catalyst, Davison Chemical Company's AD type. This material consists of an active alumina phase and inert clay components. The wax cracking of a steamed sample of this catalyst was tested at 970°F and 3 catalyst to oil ratio. These results are compared with tests of diluted zeolite Y and zeolite beta in Table IV. Although the conversion levels of the three catalysts are not equivalent, some qualitative observations are possible. The amorphous matrix sample has excellent light olefin selectivities, comparable to the beta zeolite and superior to the Y zeolite sample. This catalyst option will be explored further with additional matrix types.

The Fischer-Tropsch synthesis process also produces a light gasoline fraction in addition to the heavy wax materials that have been utilized thus far in this project. A small sample (50 cc) of this type of gasoline was obtained from Universal Oil Products. This company is conducting F-T catalyst studies under a DOE contract. The detailed characterization of this liquid is under way. In addition, some preliminary catalytic cracking experiments with this feedstock have been completed. This gasoline is a complex mixture of C_5-C_{12} linear paraffins, olefins, and oxygenates. The oxygen compounds include the normal alcohols, methanol, ethanol, propanol, and aldehydes such as propanal and butanal. The quantitative analysis of this mixture will require further effort. The initial survey of the catalytic cracking behavior of this gasoline is presented in Table V. The gasoline feedstock was allowed to react over four catalyst samples: the clay diluent only and a 6.3% blend of the Y, beta and HZSM-5 zeolite catalysts, and diluent. The liquid product consists of two phases, water (and soluble, unconverted oxygenates) and hydrocarbons. The water originates from the dehydration of the alcohols and aldehydes. The low water quantities in these MYU tests (~0.2 g) makes quantitative analyses difficult. Under these test conditions, the HZSM-5 catalyst is the most active (highest C_5- yields), followed by the beta and Y zeolite samples. The detailed catalytic cracking behavior of this F-T gasoline is complex. Several of the important reactions are:

1. Dehydration of oxygenates to olefins and water.
2. Isomerization of 1-olefins to 2 or 3-olefins.
3. Cracking of olefins.
4. Cracking of normal paraffins.

This listing probably represents the relative rates of these reactions as well, but no detailed kinetic studies are available.

The catalytic cracking results from both the small scale test unit (MYU) and the pilot plant indicate that the wax feedstock readily converts to product gas (C_4-) and gasoline. There are clear differences in the target light olefin yields (isobutylene and isoamylenes) among the catalysts tested to date. Further catalyst screening studies will continue.

TASK 4. Pilot Plant Tests.

The initial screening tests on the pilot plant unit (AU-2L) continue this quarter. This represents a small change in the experimental plan. The unit is available, and short-term screening runs on this equipment will provide additional guidance in the choice of process conditions and catalyst activity. Table VI presents a summary of the current pilot plant catalytic cracking runs with the wax feedstock. The first run, No. 939-05, is a repeat of last quarter's test of wax cracking at the lowest severity conditions possible and the low activity equilibrium Y zeolite FCC catalyst, CCC1397. This run produces enough liquid product for a complete characterization of both gasoline and distillate product fractions. Some of these analytical results are presented in Table VII. These octane test results will be used to verify and adjust the octane number estimates by the gas chromatograph method. This catalyst is an ultrastable Y faujasite zeolite catalyst taken from one of Amoco's commercial FCC units. The high conversions of the wax feedstock in the pilot plant agree with the small-scale test results (Table II).

The next two runs, No. 940-1 and 940-2, are tests of the same beta zeolite catalyst discussed in the last section. These pilot plant results also confirm the conclusions of the MYU tests: the beta zeolite converts a greater fraction of the wax feedstock to light olefins, including propylene, isobutylene, and isoamylenes, than the Y zeolite catalyst. The higher olefin yields are offset by a significantly lower gasoline yield for the beta zeolite catalyst compared with the standard Y zeolite catalyst. The next run in Table VI, No. 941-1, represents another option to generate light olefins, the addition of the shape-selective zeolite, HZSM-5. The test results for the HZSM-5 catalyst mixture are similar to the beta zeolite. High yields of the target light olefins are produced, but gasoline yield is much lower than the Y zeolite catalyst. This trade-off of light olefin and gasoline yield can be adjusted by the amount of the HZSM-5 additive. One run (Table VI, No. 942-2) with a 50% dilution of the equilibrium Y zeolite catalyst with the inert clay microspheres also shows very high wax conversion levels. Further dilution of this catalyst or lower activity (less zeolite) samples will be needed to obtain pilot plant tests at lower wax conversions. However, there were circulation problems in the pilot plant test of this catalyst mixture. The diluent has a higher particle density than normal FCC catalysts. Further pilot plant tests will require another diluent.

CONCLUSIONS

Task 1 of the contract, the Project Management Plan, and Task 2, Feedstock Characterization, are complete.

The catalytic cracking screening tests of the wax feedstock under Task 3 (small scale) and Task 4 (pilot plant scale) of the contract are under way. The catalytic cracking results of both the small-scale test unit (MYU) and the pilot plant indicate that the wax feedstock readily converts (>85%) to product gas (C_4-) and gasoline (C5-430°F). Under similar test conditions, a normal gas oil feedstock would have much lower conversion levels. (~65%) The yields of the target product olefins, isobutylene and isoamylenes, from wax cracking are more than twice the levels found with gas oil cracking. The HZSM-5 zeolite catalyst produces the highest yields of the target isobutylene and isoamylenes. The beta zeolite and the amorphous catalyst have lower light olefin yields than the HZSM-5 sample but greater olefin yields than the Y zeolite. These high olefin yields come at the expense of gasoline product. The Y zeolite has the highest gasoline yields among the catalysts tested. These variations in product yields will form the basis for economic evaluations of the various process and catalyst options that will follow in later stages of this project.

ACKNOWLEDGEMENT

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TABLE I

MYU TESTS OF INERT DILUENT FOR FISCHER-TROPSCH WAX CATALYTIC CRACKING

Run No.	12	13
Reaction Temp, °F	880	970
Conversion, Wt%	11.8	17.3
Products, Wt%:		
C_4-	2.6	5.9
C_5-430°F	9.1	11.4
430-650°F	22.7	24.6
650°F+	65.5	58.1
Coke	0.08	0.07

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TABLE II

MYU TEST RESULTS--DILUTION STUDIES

Equilibrium Zeolite Y, CCC1397					Steamed Zeolite Beta, CCC1875					Steamed HZSM-5 CCC1891				
Run No.	% Catalyst	Cat/ Oil	Temp, °F	Conversion, Wt%	Run No.	% Catalyst	Cat/ Oil	Temp, °F	Conversion, Wt%	Run No.	% Catalyst	Cat/ Oil	Temp, °F	Conversion, Wt%
14	50	1.5	970	86.0	4	100	3	970	90.9	32	100	3	880	93.6
15	50	1.5	970	85.1	5	100	3	970	91.8	33	100	3	880	90.4
16	50	1.5	970	86.2	7	100	3	940	91.4	50	25	0.75	880	84.1
17	50	1.5	970	86.1	9	100	3	910	91.4	51	25	0.75	880	87.7
18	25	0.75	970	84.3	11	100	3	880	92.4	52	12.5	0.375	880	88.3
19	25	0.75	970	84.4	26	25	0.75	880	91.2	53	12.5	0.375	880	85.6
20	25	0.75	970	84.3	27	25	0.75	880	89.6	54	6.25	0.1875	880	84.1
21	25	0.75	970	84.5	28	12.5	0.375	880	88.9	55	6.25	0.1875	880	83.8
22	25	0.75	880	70.1	29	12.5	0.375	880	84.2	64	3.12	0.09	880	65.5
23	25	0.75	880	82.6	36	6.25	0.187	880	64.7	65	3.12	0.09	880	66.7
24	25	0.75	880	81.8	37	6.25	0.187	880	80.3					
25	25	0.75	880	74.7	42	6.25	0.187	880	83.3					
30	12.5	0.375	880	77.6	43	6.25	0.187	880	58.0					
31	12.5	0.375	880	83.0										
34	6.25	0.187	880	55.1										
35	6.25	0.187	880	64.0										
38	6.25	0.187	880	71.5										
39	6.25	0.187	880	62.2										
40	6.25	0.187	880	69.1										
41	6.25	0.187	880	71.4										

WJR/ml/92431
5/7/92

TABLE III

MYU TEST RESULTS--CATALYST COMPARISONS AT 880°F

Catalyst Type	Zeolite Y	Zeolite Beta	Zeolite HZSM-5
Run No.	031	042	055
Conversion, Wt%	83.0	83.3	83.8
Product Yields, Wt%:			
C_2^-	0.6	0.6	1.5
$C_3^=$	7.4	8.9	17.5
C_3°	0.8	0.9	2.7
$C_4^=$	13.2	17.7	27.4
C_4°	3.7	3.6	3.6
$C_5^=$	11.7	13.5	13.9
C_5°	3.6	2.2	2.0
C_6-430°F	41.7	35.8	15.3
430°F$^+$	17.0	16.8	16.2
Coke	0.3	0.2	0.1
Isobutylene	5.8	9.4	12.3
Isoamylenes	7.7	9.2	9.8
C_5-430°F	57.0	51.4	31.1
RON	85.2	84.4	84.4
MON	76.2	74.6	76.0

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TABLE IV

MYU TEST RESULTS—CATALYST COMPARISONS AT 970°F

Catalyst Type	AD Matrix	Zeolite Y	Zeolite Beta
Run No.		046	044
C/O	3.0	0.2	0.2
Conversion, Wt%	72.6	70.9	77.8
Product Yields, Wt%:			
C_2^-	1.4	1.1	1.1
$C_3^=$	9.6	5.7	8.4
C_3°	1.0	0.7	0.8
$C_4^=$	16.4	9.7	14.9
C_4°	2.3	1.8	2.5
$C_5^=$	12.1	9.8	13.4
C_5°	1.7	1.8	1.5
C_6–430°F	27.4	40.2	35.1
430°F$^+$	27.4	29.1	22.3
Coke	0.6	0.1	0.1
Isobutylene	7.2	4.2	7.6
Isoamylenes	8.1	5.9	8.0
C_5–430°F	41.2	51.9	50.0

WJR/ml/92431
5/7/92

TABLE V

CATALYTIC CRACKING RESULTS OF UOP F-T GASOLINE
MYU TEST RESULTS AT 880°F

Catalyst Type	Diluent Only	Zeolite Y	Zeolite Beta	Zeolite HZSM-5
Run No.	063	057	059	061
C/O	3.0	0.2	0.2	0.2
Product Yields, Wt%:				
Hydrocarbon	86	82	84	80
H_2O	14	18	16	20
Product Yields, HC Only, Wt%:				
H_2	0.01	0.01	0.01	0.01
C_1	0.07	0.04	0.04	0.03
$C_2^=$	0.7	2.8	2.7	4.3
C_2°	0.31	0.2	0.2	0.1
$C_3^=$	1.1	2.8	3.8	8.1
C_3°	0.13	0.1	0.1	0.1
$C_4^=$	1.7	3.0	5.4	8.9
C_4°	0.3	0.1	0.3	0.2
$C_5^=$	3.5	4.9	7.9	8.4
C_5°	0.4	0.4	0.5	0.4
C_6+	91.7	85.5	79.0	69.4
Coke	0.2	0.2	0.1	0.1
Isobutylene	0.58	0.50	1.6	3.0
Isoamylenes	0.24	1.23	2.9	4.5

WJR/ml/92431
5/8/92

TABLE VI

JANUARY, FEBRUARY 1992 PILOT PLANT (AU-2L) RUNS

Preliminary Results[1]	Wax Feedstock					
Run No.	939-05	940-1	940-2	941-1		942-2
Run Conditions:						
Reaction Temp, °F	879	934	910	965		937
C/O Ratio	2.25	5.08	3.35	2.84		1.57
WHSV (hr^{-1})	42.2	43.8	61.5	54.61		33.51
Catalyst	Steamed CCC1397	Steamed Beta	Steamed Beta	Steamed CCC1397 (75%)	Steamed HZSM-5 (25%)	50% CCC1397, 50% Diluent
Conversion, Wt%	85.0	96.6	96.5	89.0		90.0
Product Yields, Wt%:						
H_2	0.02	0.02	0.01	0.02		0.02
C_1	0.14	0.10	0.07	0.09		0.16
$C_2^=$	0.21	0.66	0.50	1.01		0.34
C_2	0.14	0.11	0.08	0.10		0.15
$C_3^=$	6.23	13.89	13.64	15.98		8.93
C_3	0.89	2.10	1.81	2.46		1.25
iC_4	3.31	8.91	7.55	3.36		4.96
nC_4	0.94	2.51	2.04	1.88		1.26
$iC_4^=$	6.51	12.29	12.72	12.76		7.59
$tC_4^=$	3.03	5.51	5.29	5.23		3.63
$CC_4^=$	2.18	4.04	3.86	3.68		2.60
iC_5	2.90	4.68	3.41	2.04		3.51
nC_5	0.81	1.53	1.35	1.33		0.73
Total $C_5^=$	8.02	8.31	8.44	11.49		5.61
C_6-430°F	48.14	30.55	34.54	26.49		47.97
430°F+	15.83	3.59	3.67	11.60		10.42
Coke	0.68	1.20	1.00	0.47		0.88

(1) The liquid products contain small amounts of C_4 and C_5 components that have not been redistributed to the individual gas fractions.

WJR/ml/92431
5/8/91

TABLE VII

PRODUCT ANALYSES--PILOT PLANT (AU-2L) RUN

Run No. 939-05	
D-2892 ASTM Atmospheric Distillation:	
Weight Percent Yields	
430°F-	77.8
430°F+	22.2
D-2699 Research Octane No. of 430°F- Fraction:	86.7
D-2700 Motor Octane No. of 430°F+ Fraction:	78.1

WJR/ml/92431
5/7/92

FIGURE 1

FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS

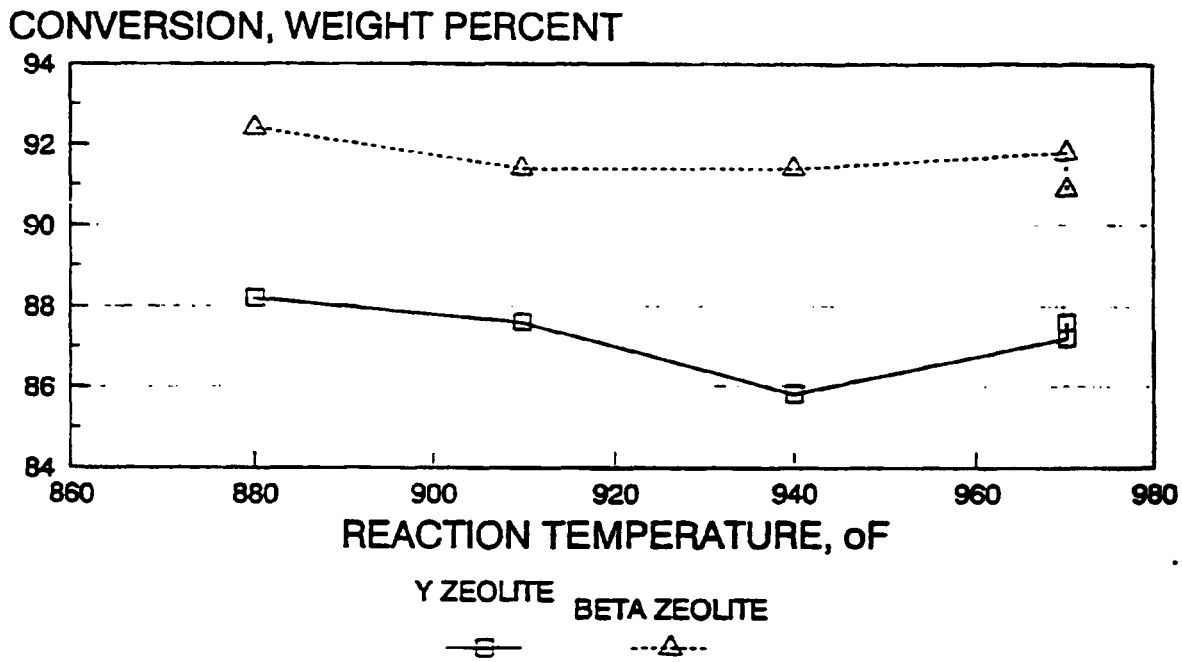


FIGURE 2

FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS

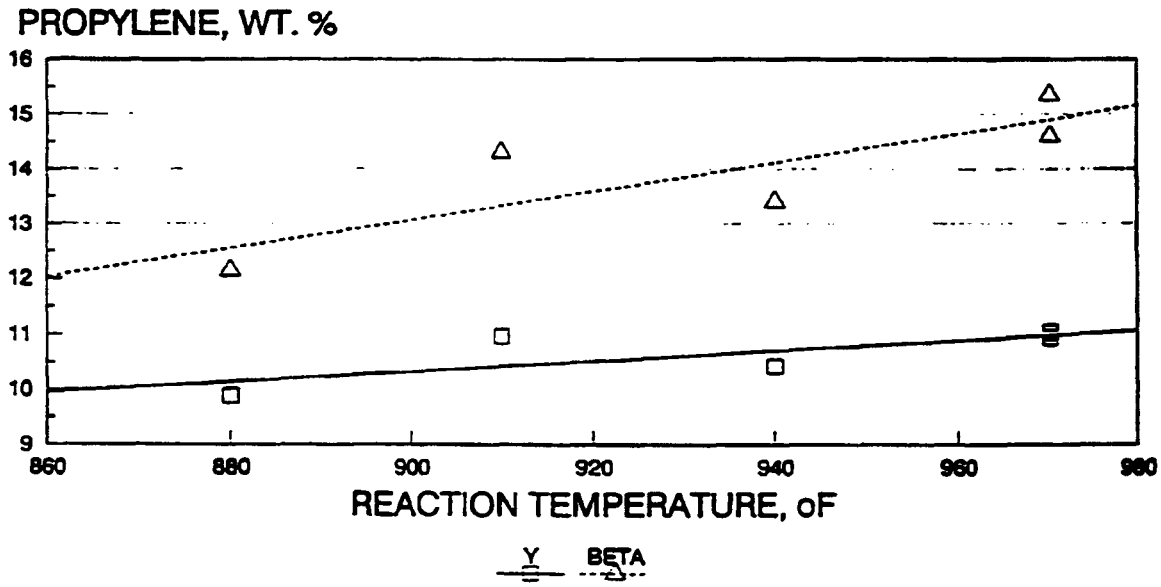


FIGURE 3

FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS

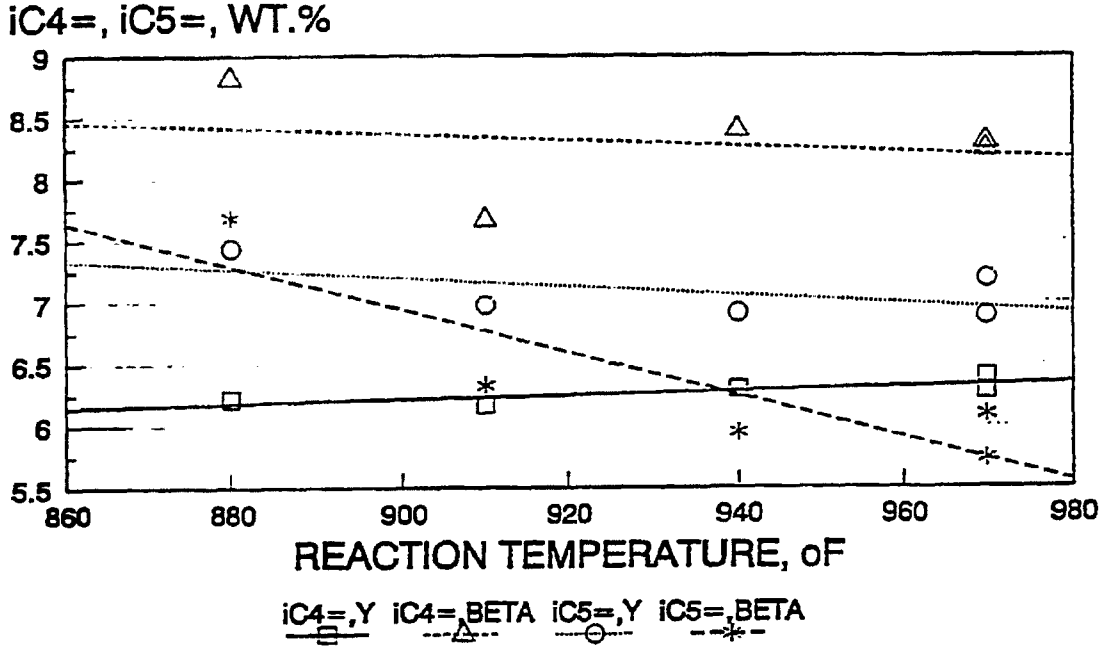


FIGURE 4

FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS

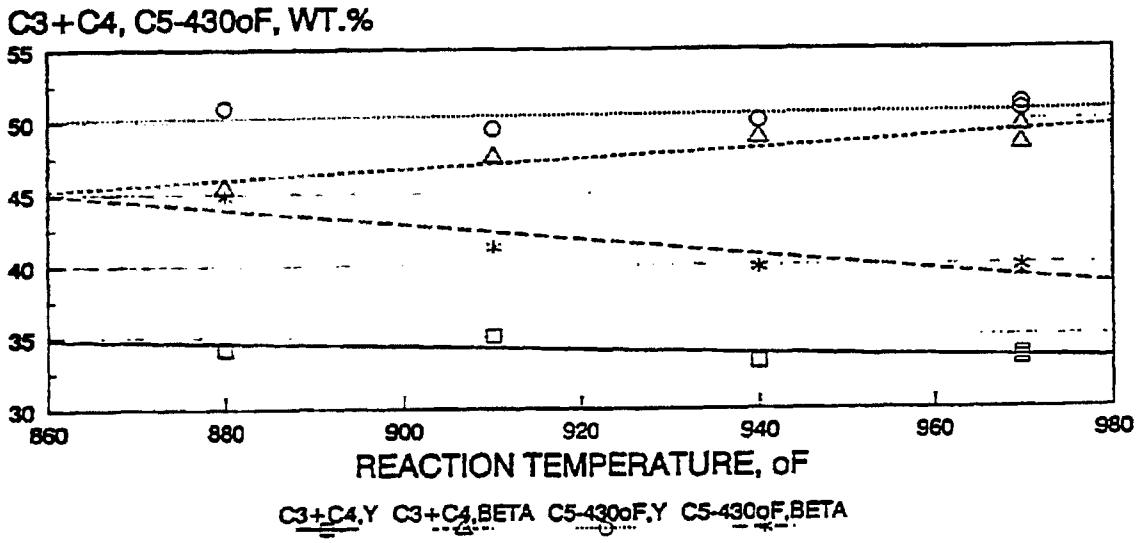


FIGURE 5
FISCHER-TROPSCH WAX CRACKING MYU TEST
DILUENT ONLY FEED AND PRODUCTS SIM DIST

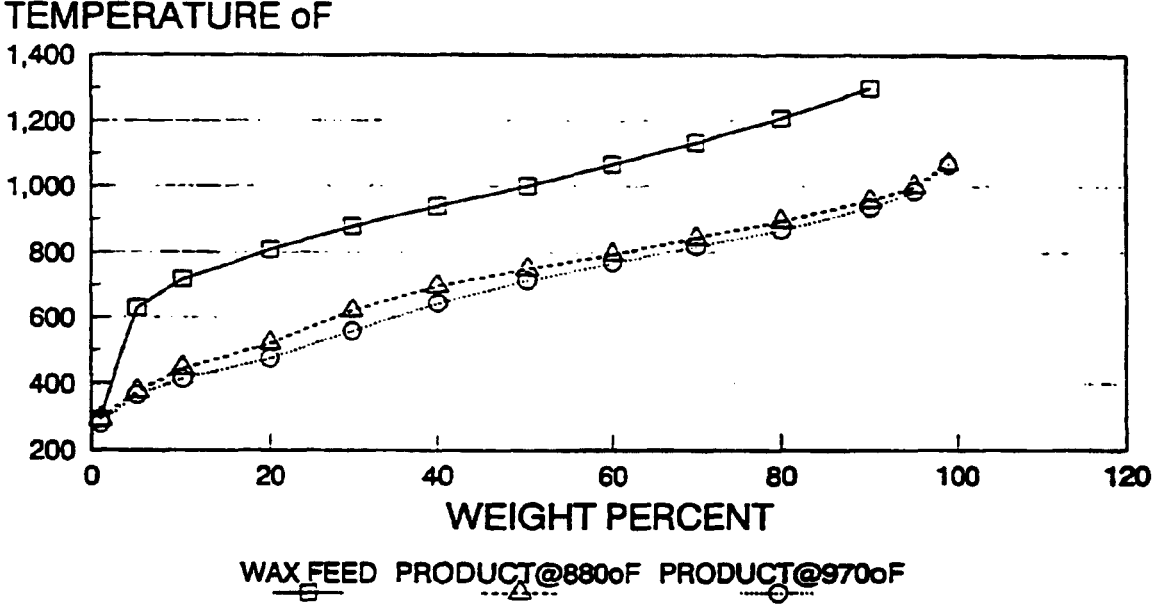


FIGURE 6
FISCHER-TROPSCH WAX CRACKING MYU TEST
DILUENT ONLY FEED AND PRODUCTS SIM DIST

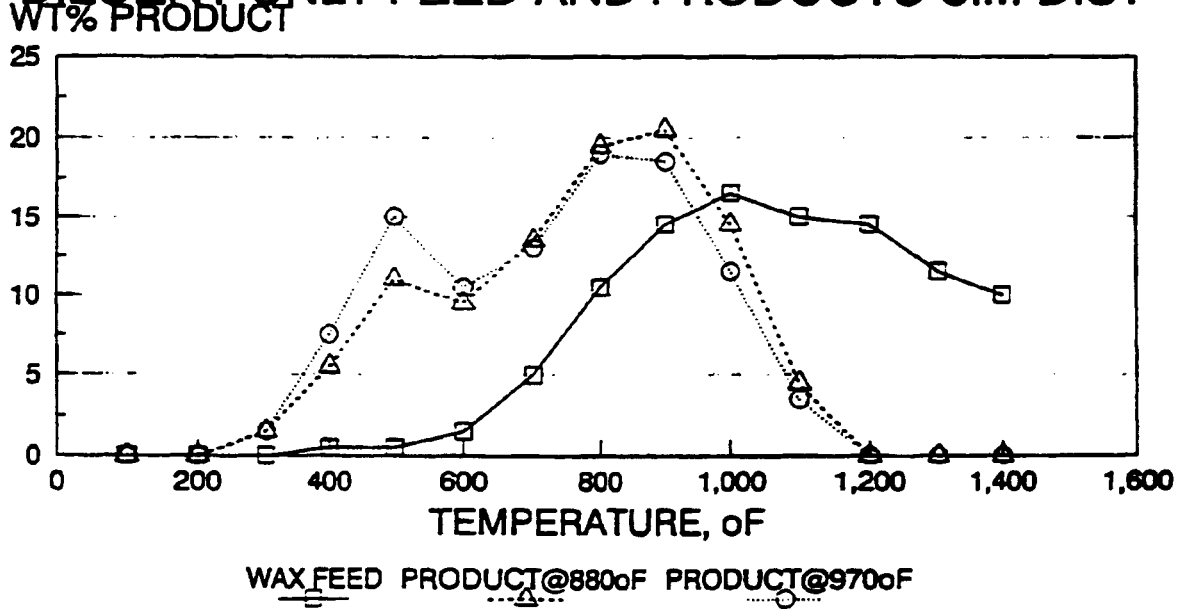


FIGURE 7
FISCHER-TROPSCH WAX CATALYTIC CRACKING MYU TEST RESULTS DILUTION STUDIES

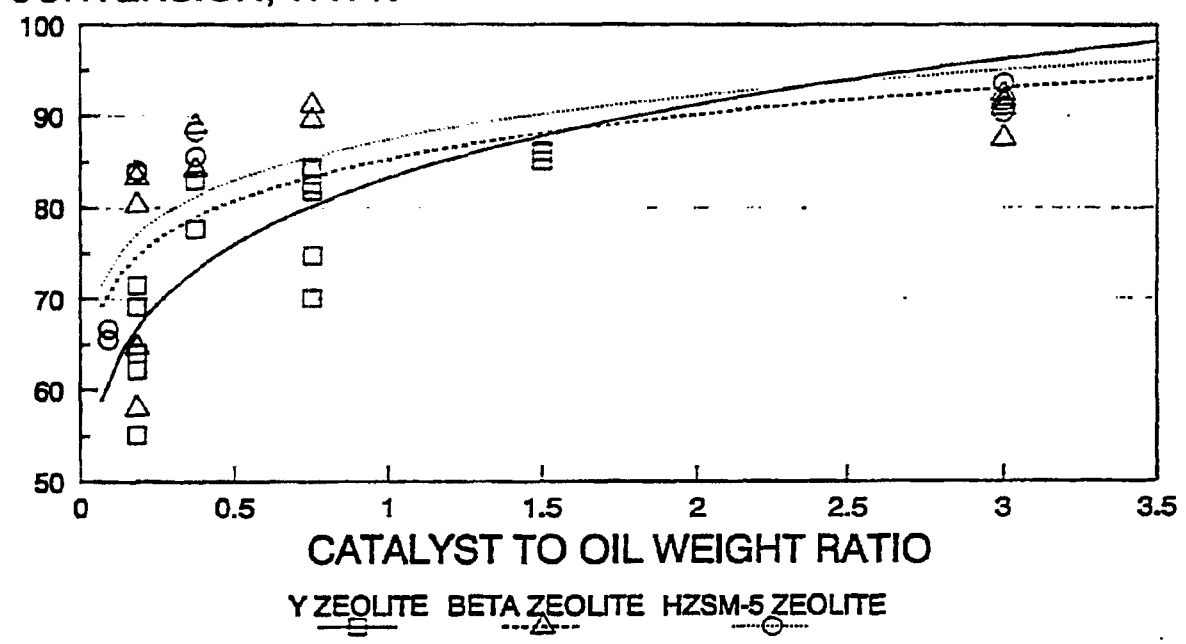


FIGURE 8
FISCHER-TROPSCH WAX CATALYTIC CRACKING MYU TEST RESULTS DILUTION STUDIES

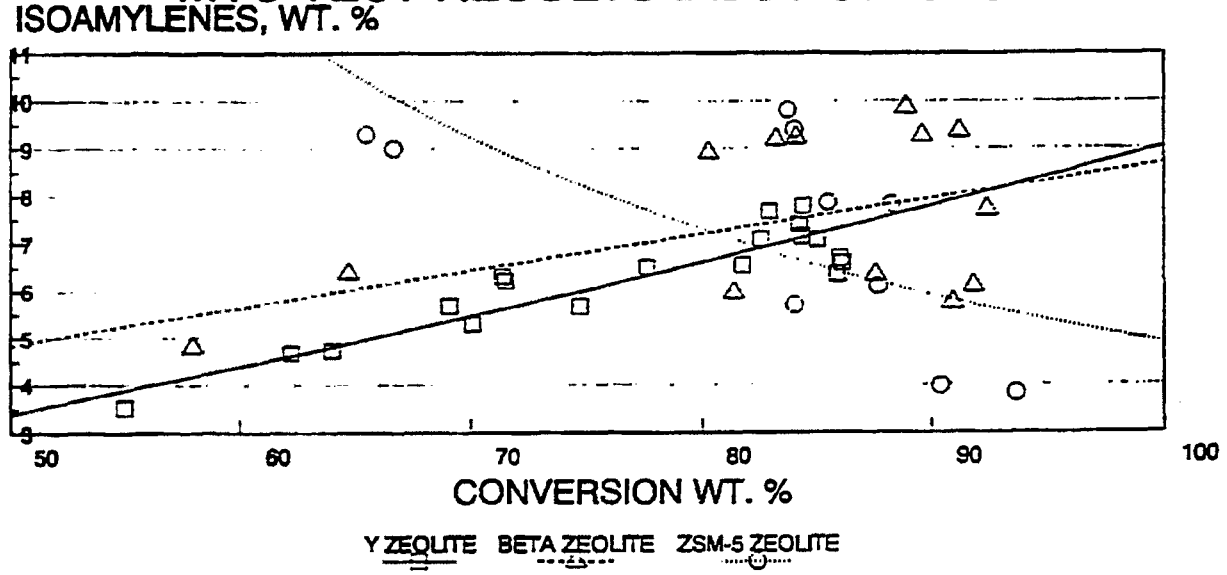


FIGURE 9
FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS DILUTION STUDIES

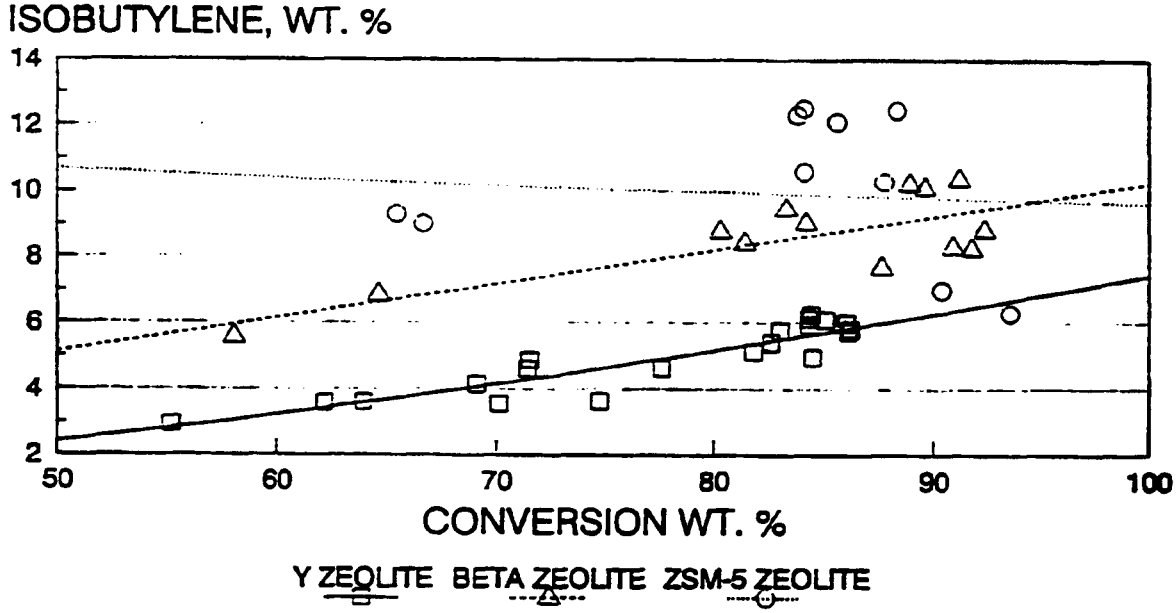


FIGURE 10
FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS DILUTION STUDIES

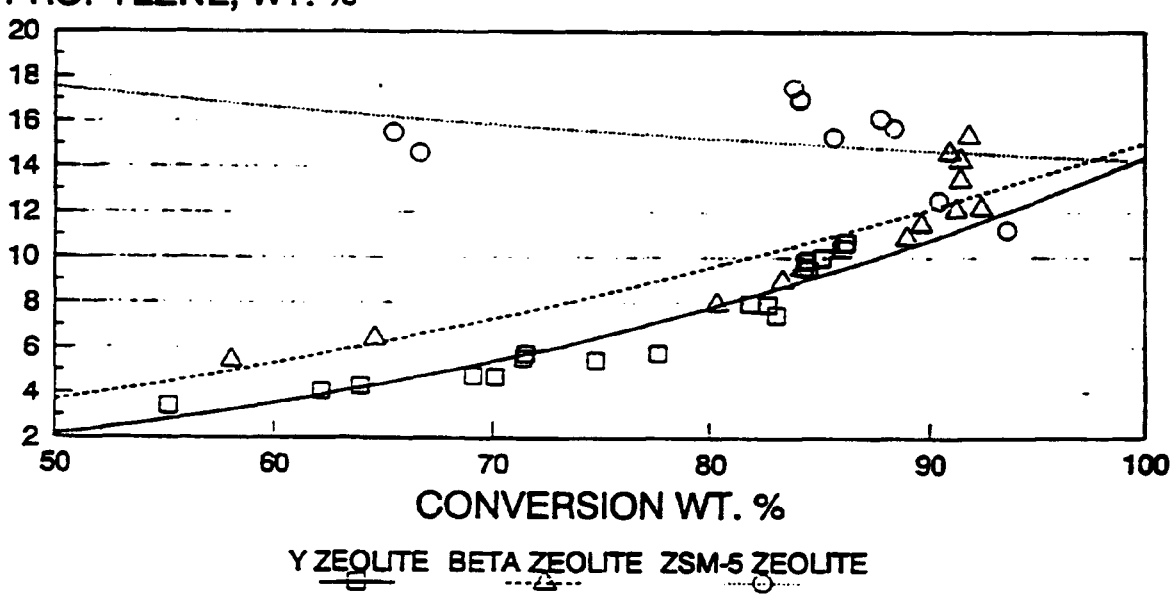


FIGURE 11
FISCHER-TROPSCH WAX CATALYTIC CRACKING MYU TEST RESULTS DILUTION STUDIES

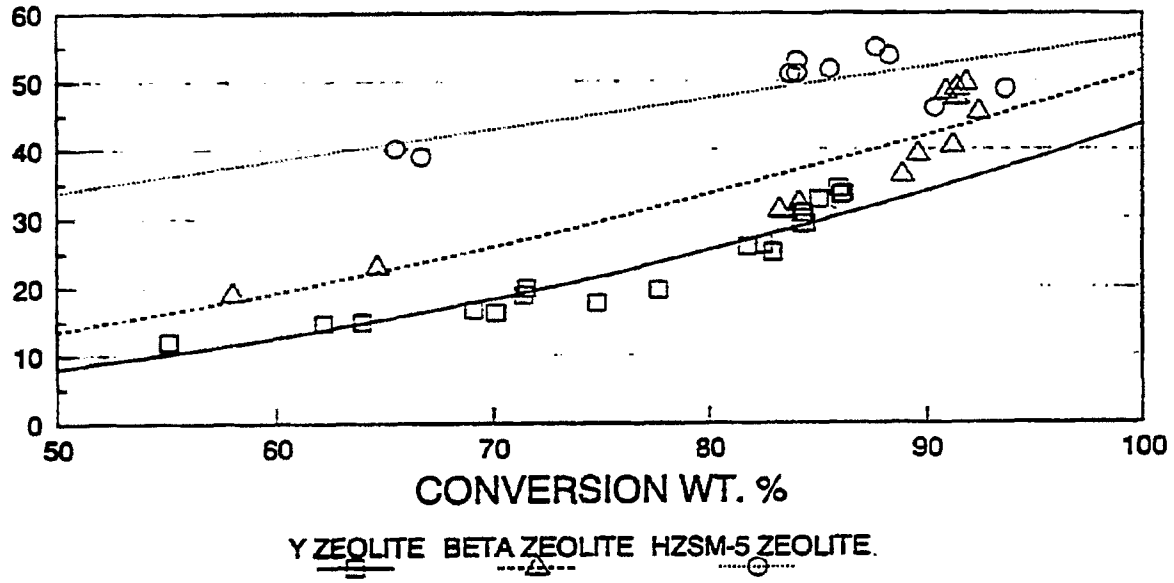


FIGURE 12
FISCHER-TROPSCH WAX CATALYTIC CRACKING MYU TEST RESULTS DILUTION STUDIES

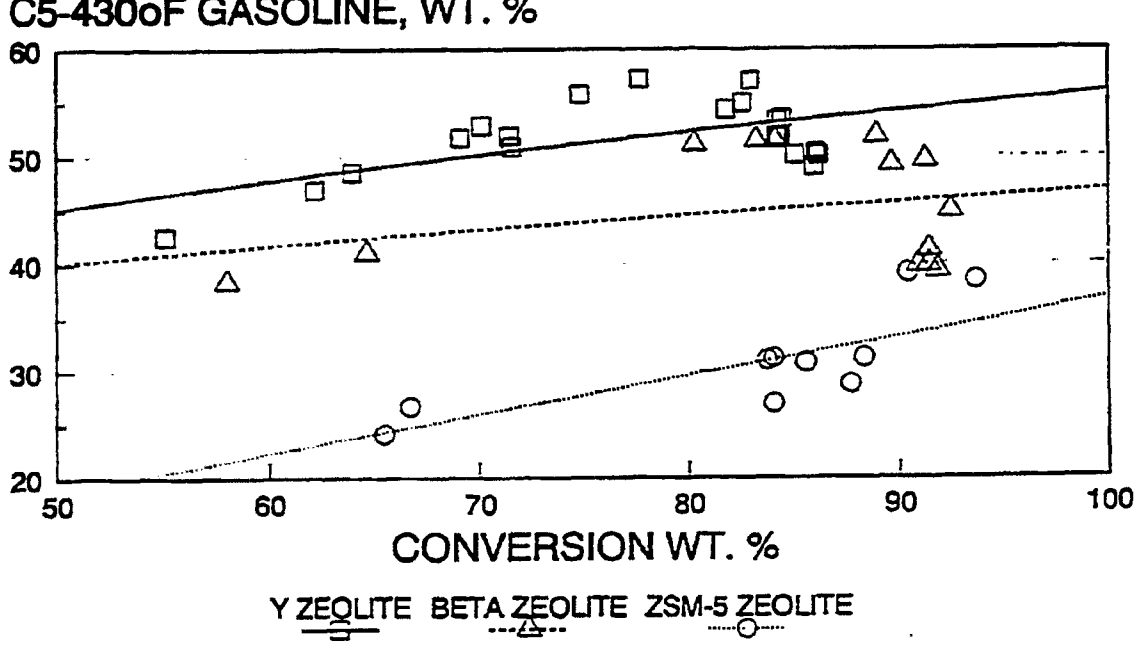


FIGURE 13
FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS DILUTION STUDIES

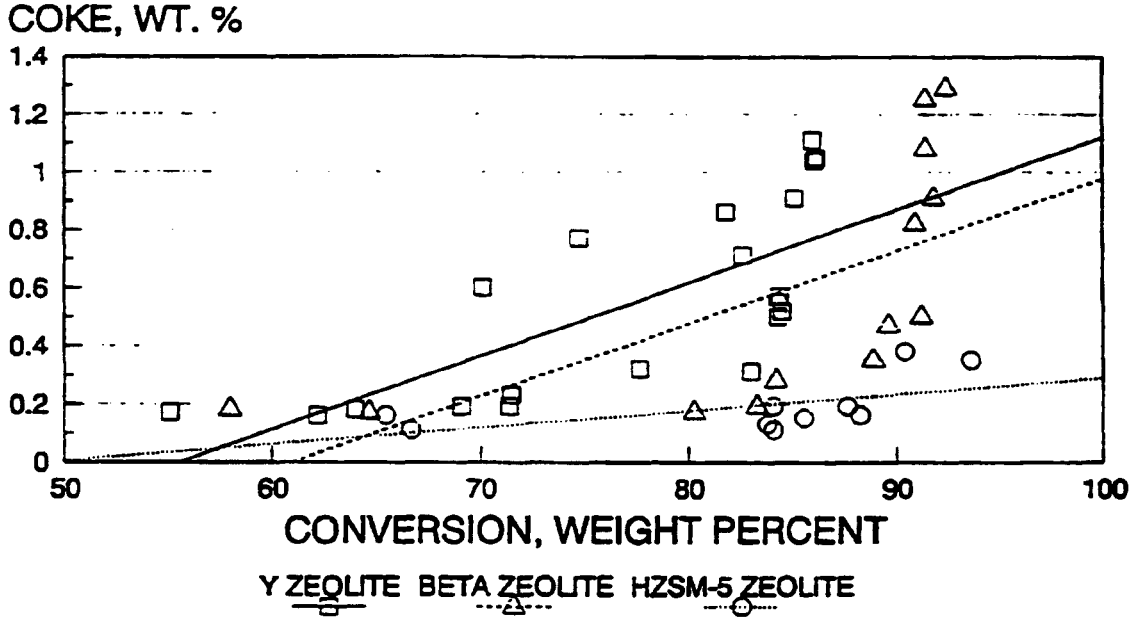


FIGURE 14
FISCHER-TROPSCH WAX CATALYTIC CRACKING
MYU TEST RESULTS DILUTION STUDIES

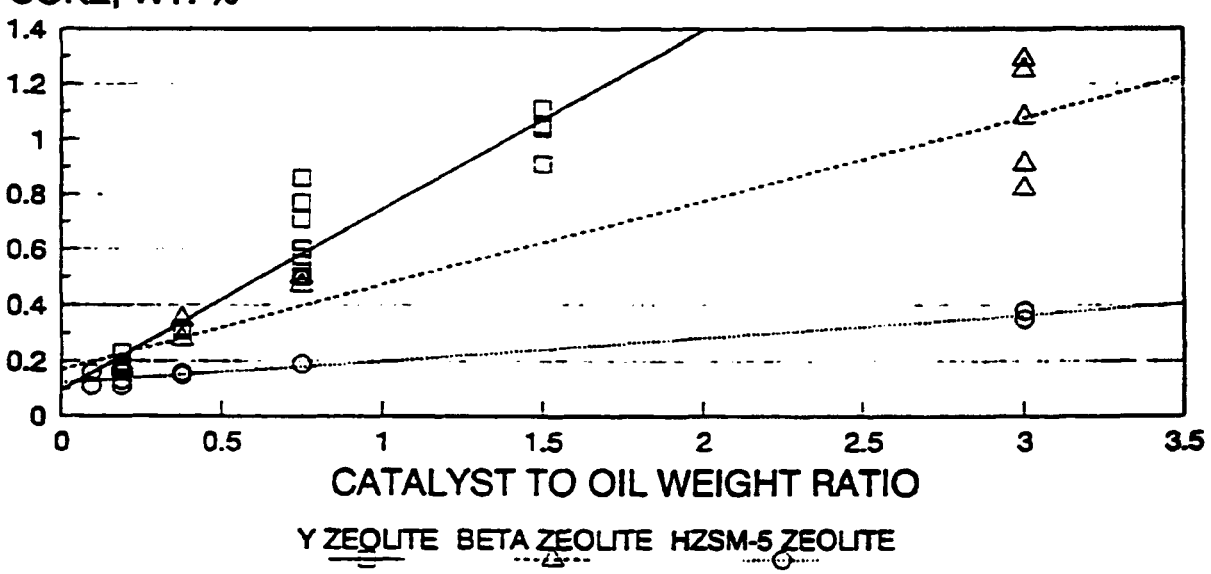


FIGURE 15

FISCHER-TROPSCH WAX CATALYTIC CRACKING
C4 ISOMER DISTRIBUTION AT 83% CONVERSION

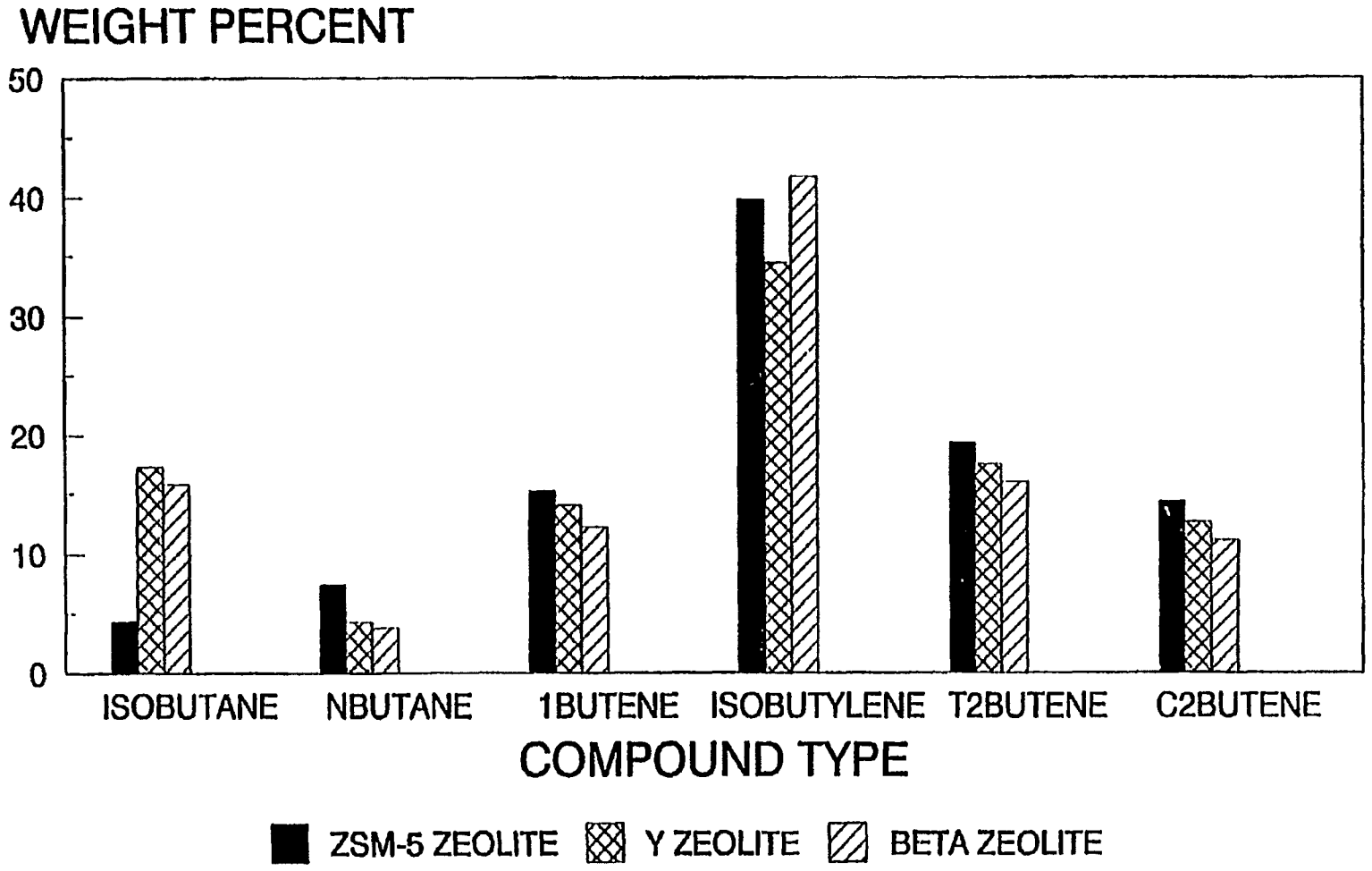


FIGURE 16

FISCHER-TROPSCH WAX CATALYTIC CRACKING
C5 ISOMER DISTRIBUTION AT 83% CONVERSION

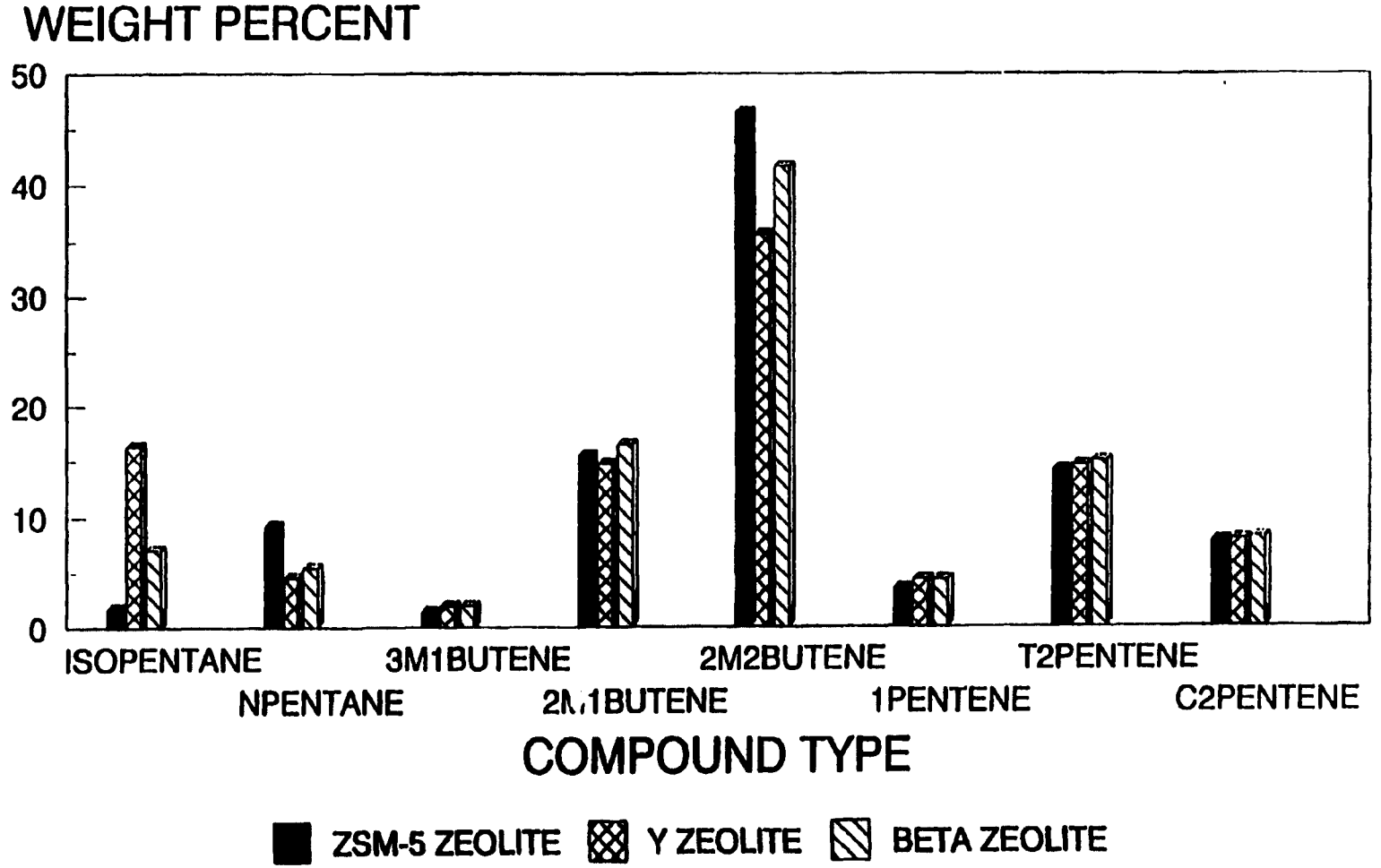


FIGURE 17

FISCHER-TROPSCH WAX CATALYTIC CRACKING
GASOLINE COMPOSITION AT 83% CONVERSION

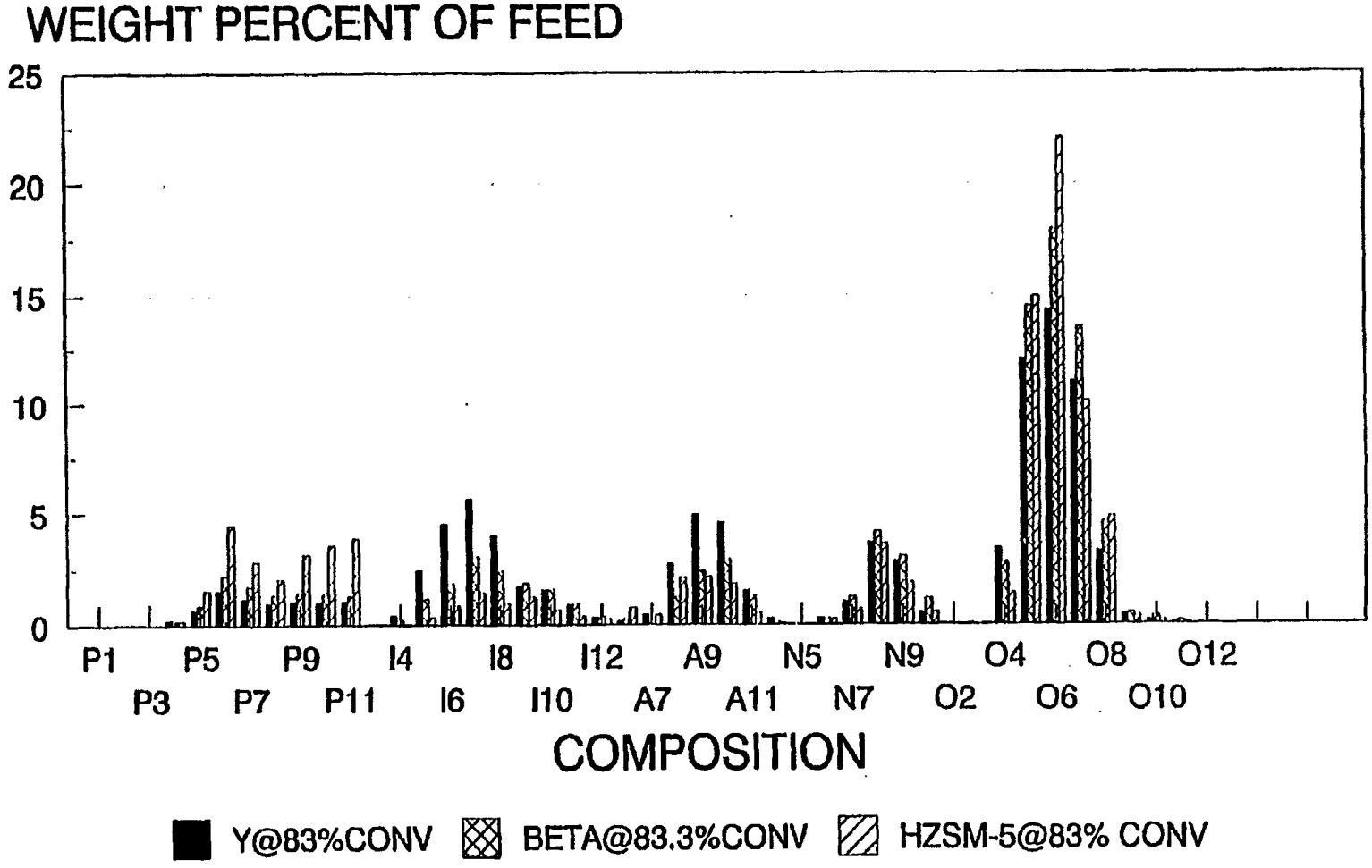


FIGURE 18
FISCHER-TROPSCH WAX CATALYTIC CRACKING MYU TEST RESULTS DILUTION STUDIES

RESEARCH OCTANE, C5-430oF

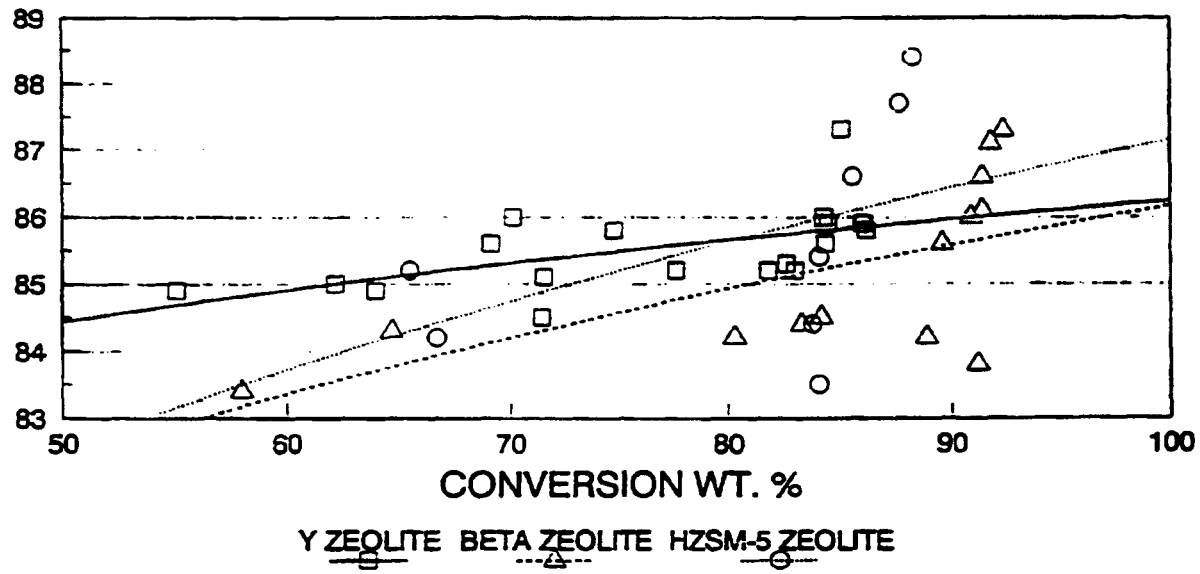
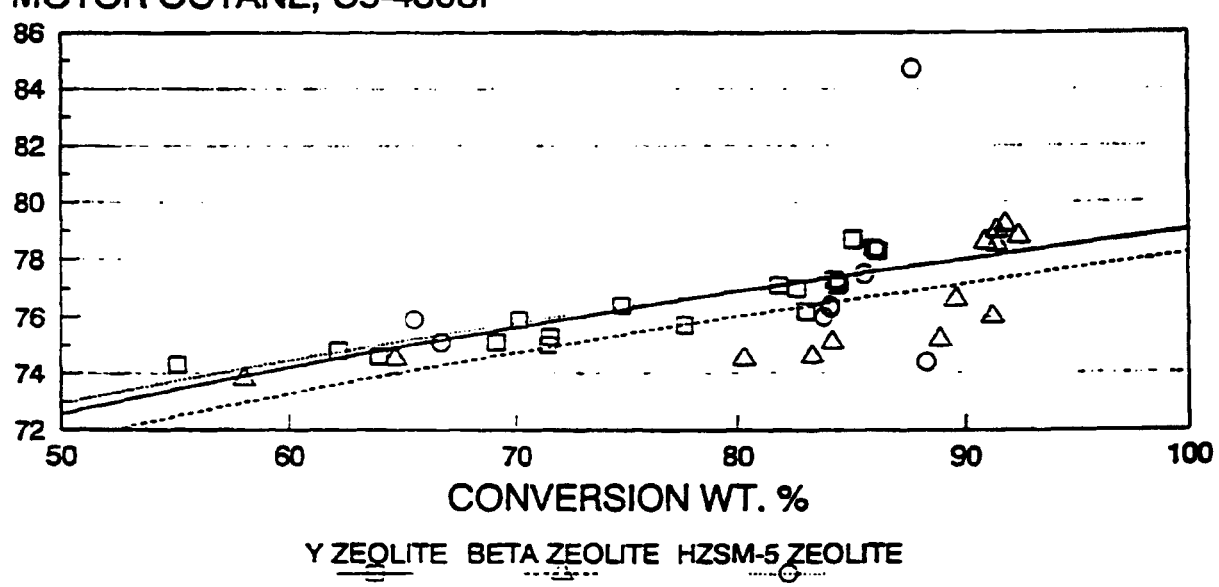


FIGURE 19
FISCHER-TROPSCH WAX CATALYTIC CRACKING MYU TEST RESULTS DILUTION STUDIES

MOTOR OCTANE, C5-430oF



NOTICE

Prepared by
Amoco Oil Company (Amoco Corporation)
Naperville, Illinois

QUARTERLY MANPOWER REPORT

For SECOND QUARTER FISCAL YEAR, 1992

(January 1, 1992 - March 31, 1992)

TITLE: THE SELECTIVE CATALYTIC CRACKING OF FISCHER-TROPSCH LIQUIDS TO HIGH VALUE TRANSPORTATION FUELS

IDENTIFICATION NUMBER: DE-AC22-91PC90057

START DATE: June 1, 1991
COMPLETION DATE: May 31, 1993

PARTICIPANT NAME AND ADDRESS:

AMOCO OIL COMPANY
P. O. BOX 3011
NAPERVILLE, ILLINOIS 60566

	Manpower in Hours by Task							
Name	1	2	3	4	5	6	7	Total
W. J. Reagan	0	0	277	10	0	0	0	287
D. M. Washecheck	0	0	70	0	0	0	0	70
G. G. Glasrud	0	0	0	57	0	0	0	57
Other Professionals	0	0	0	0	0	0	0	0
Technical Support	0	0	459	137	0	0	0	596
Secretarial	0	0	28	0	0	0	0	28
Total Hours	0	0	790	204	0	0	0	1038

FOR : S. LEVINESS

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