IV.10. PILOT PLANT FOR PREPARATION OF 100 LB/WEEK OF IRON CATALYST AND THE PREPARATION OF 100 POUNDS OF CATALYST FOR PETC

(Robert L. Spicer, Robert J. O'Brien, Sivaraj Chokkaram, Rongguang Lin, Fred L. Tungate and Burtron H. Davis)

A 160 lb. batch of precipitated "hydrous iron oxide" catalyst precursor was prepared at the CAER utilizing a continuous precipitation method (Figure IV.10.1). The catalyst was precipitated from an iron (III) nitrate solution that contained tetraethyl orthosilicate (TEOS). The TEOS was added to the iron solution such that the atomic ratio {Si/(Si + Fe)} in the final product would be at 0.044 (i.e., 4.4 atomic % for Si/(Si + Fe). Concentrated ammonium hydroxide was used to effect precipitation. Filtration of the precipitated slurry was performed utilizing two sectionalized rotary vacuum drum filters (6" dia. x 3" width) (Figure IV.10.2). The filter cake was then reslurried with deionized water, which constitutes the first wash, at a volume equal to the volume of the filtrate obtained from the filtration of the precipitated slurry. This reslurried material was then filtered using three rotary vacuum filters operating in parallel. The filter cake that was recovered from this filtration was again reslurried using the same amount of deionized water, as for the first wash.

The filter cake recovered from this final filtration was transported to UCI in Louisville, Kentucky, where it was diluted with deionized water to make a slurry that contains approximately 10-15% solids. Potassium nitrate (KNO_3) was added to this slurry to achieve a nominal 0.5 wt.% of K in the finished catalyst. After the slurry was blended (about 20 hours), UCI utilized their Bowen, Semi-works model #2 spray dryer

to produce a material with a particle size of about 30 micron diameter. The dried product was calcined at 371°C (700°F) in a gas fired, rotary drum apparatus. The dried product was calcined at 350°C for four hours.

The following is a listing of the reactants and the reactor conditions utilized for the precipitation of the catalyst precursor:

Reactants

- 360 kg $Fe(NO_3)_3 \bullet 9H_2O$, Shepherd Chemical Co. Tech. Grade
- 8.53 kg $Si(C_2H_5O)_4$, Fisher Scientific Reagent Grade
- 342L conc. Ammonium Hydroxide, Mallinckrodt ACS Grade
- 922.5 g KNO_3, Fisher Scientific Certified Primary Standard Grade
- 2000L deionized water furnished by UCI

Precipitation Reactor Conditions

- 4L-PFA coated stainless steel reactor
- U-shaped paddle stirring at 700 rpm
- Iron solution: 760L @ 1.17M $Fe(NO_3)_3 \bullet 9H_2O$/0.054M TEOS at a feed rate of 276mL/min.
- Ammonium Hydroxide: 342L @ 15.6M at a rate of 124mL/min.
- $R_{nominal} = [Fe^{+3}]/[OH^-] = 1/6$
- Control Volume: $CV_{nominal} = 2L$
- Residence Time: $t_{nominal} = 5$ min.
- Reactor and pH: $pH_{measured} = 9.48$; $T_{measured} = 38.9°C$

Upon completion of the final wash a sample of the filter cake was removed at the CAER and potassium nitrate was added so that the weight percent of potassium relative to $K+Fe_2O_3$ would be at a nominal value of 0.5% (i.e., 0.005 = $(K/K+Fe_2O_3)$. This sample was then split into two portions. The first portion was dried in a furnace at 135°C and then ground in a centrifugal mill (Retsch model ZM-1 mill with a 0.2mm screen) and the remaining portion was left as wet filter cake. Both portions were then divided into four samples. These samples were then calcined at 200°C, 300°C, 350°C and 400°C for four hours and then submitted for surface area/pore volume and XRD analysis. The surface areas and pore volumes are graphically presented in Figures IV.10.3 and IV.10.4 while an XRD plot that is typical of the four samples, both wet and dried, is given in Figure IV.10.5.

Spray Drying

The balance of the filter cake (~1000 lb. at ~ 16 wt.% solids) was transported to UCI in Louisville for spray drying and calcining. The wet filter cake was placed in a 300 gallon mixing tank and deionized water was added to effect good mixing action. At this point a solution containing 907.7 g of KNO_3 was added to the mixing tank to bring the weight percent of K to a level of 0.5 wt.%. The addition of the KNO_3 was based on a theoretical weight of 69851.9 g of Fe_2O_3 product in the wet filter cake. This slurry was allowed to mix overnight. A sample of the slurry was placed in a drying oven to determine the solids wt.%, which was found to be ~13.9 wt.% solids.

Spray drying of the slurry began on January 11, 1994, and was completed January 14, 1994. The spray drying unit is a Bowen Semi-Works model and a

schematic of the unit is shown in Figure IV.10.6. Under ideal operating conditions the particles produced in the spray drying unit would be spherical in shape with a nominal diameter of 70 microns. Likewise, under ideal conditions, the majority of the dried product would be collected in the main spray drying chamber with a minimum of the product (Fines and undersized material) being captured by the cyclone.

Prior to the beginning spray drying on the first day of operation, additional deionized water was added to dilute the solids concentration to ~13 wt.%. There were numerous instances of filter plugging, which was located between the pump discharge and the spray dryer nozzle. There was also a feed pump failure (i.e., the stator on a moyno type pump failed) which was rectified by switching to a centrifugal pump. Product from the spray chamber was periodically inspected using a microscope, and it was found to be undersized and agglomerated. The corrective action was to reduce the furnace set point temperature from 600°F to 500°F, which eliminated the agglomeration and produced particles that were more spherical in shape as well as being closer in size to the desired 70 micron diameter.

The second day of spray drying started with a slurry at 11.6 wt.% solids. Water was added to bring the solids concentration to 10.9 wt.%. This yielded a main chamber product that was slightly damp and this was rectified by increasing the furnace temperature set point from 500°F to 550°F. Plugging of the pre-nozzle filter was again a persistent problem and was ultimately corrected by pre-filtering the slurry through a 30 mesh nylon screen before adding it to the spray dryer's feed tank. Once the above mentioned problems were corrected, it appeared that the spray dryer

was operating at or near its optimum level. This was shown not to be the case upon inspection of the main chamber, as partially dry material had been deposited on practically the entire surface of the main chamber at a thickness of approximately 1/4" and had the appearance of cauliflower. A sample of this coating was collected and calcined for four hours at 350°C. Inspection with a microscope of this calcined sample the next day showed agglomerated particles, shaped like raspberries, but with diameters of approximately 70 microns.

The third day of operation of the spray dryer involved removing and collecting the material that had coated the inside walls of the main chamber of the dryer. This material was then loaded onto trays for calcining at 350°C (662°F) for four hours. Once the spray drying resumed, it was observed that the fraction of product collected in the cyclone had substantially increased as compared to the previous two days operation. Attempts were made to rectify this problem by adjusting the atomizing air pressure, the total feed back pressure, the nozzle back pressure, the furnace temperature and combinations of these. These changes met with little or no success as, on average, approximately 75% of the product was collected in the cyclone.

The final day of operation started by switching to a new nozzle in anticipation of increasing the weight fraction of the processed material collected in the primary chamber, but this resulted in little, if any, improvement. The atomizing air pressure was decreased to increasing droplet size and thereby increasing the dried particle size. This increased the weight fraction of processed material collected in the primary chamber, but the improvement was not enough to return to the levels of operation

(weight fraction collected in chamber) obtained during the first two days of spray drying.

The weight fractions of the chamber and cyclone catches for the sample collection periods for the four days of operation of the spray dryer show that on average, 36 wt.% of the processed material was collected in the primary chamber of the spray dryer (Figure IV.10.7). In fact, this may be an artificially high value as some of the material collected in the primary chamber was damp to wet and the data used for the construction of this graph was based on product that had not been calcined.

Three distinct categories of product resulted from the spray drying operation: the first was the material collected in the cyclone of the spray dryer; the second and third categories are both products that were collected in the primary chamber of the unit. The difference between the later two samples is that one was wet/damp while the other was the dryer product.

All of the spray material was calcined at 700°F (371°C).

The particle size distribution of the samples from spray drying are collected in Figures IV.10.8-IV.10.11. The cumulative frequency distributions are summarized in Figure IV.10.12. The weights of the calcined materials were distributed as follows:

Dry Chamber	43.9 lb.
Wet Cake I	1.0 lb.
Wet Cake II	16.4 lb.
Cyclone	88.1 lb.
Total	149.4 lb.

It is clear that the problems encountered in spray drying the material caused the dominant fraction of the material to be collected as the cyclone sample and, as expected, this sample has a dominant fraction of the material present in the 0-20 micron size fraction. .

The activity of each fraction was measured using $H_2/CO = 0.7$, T = 270°C, and P = 175 psig. The catalyst was pretreated in CO; the sample was heated from 110 to 270°C during a period of about 2 (2°C/min.) hours and then held at 270°C in a CO flow of 2 NL/gFe/hr for 22 hours. The CO conversion attained a level of about 85% and then gradually declined during 1992 hours of use to about 70% (Figure IV.10.13). The initial conversion of a small portion of the material that was dried at 110°C in the lab was more active and produced a CO conversion of 90%. Thus, the spray drying and calcination procedures caused a slight decrease in the initial activity of the material. The CO conversion declined gradually during the period at a rate of 1.27%/week, slightly in excess of the targeted rate of 1%/week. The alpha value at 288 hours of operation was 0.73 (Figure IV.10.14) and is representative of the values obtained throughout the run.

A material balance and process flow sheet for a plant to produce 100 lb/week (58 hour shifts) of a precipitated catalyst is shown in Figure IV.10.15. The equipment list and cost as of January, 1994, are shown in Figure IV.10.16; the total cost is estimated to be $226,246.75. The spray dryer makes up 70.7% of the total equipment cost.

An estimate of the cost for the preparation of a 100 pound batch of precipitated catalyst is given in Figure IV.10.17. It is emphasized that this cost does not take into account many factors that could impact the cost of the catalyst as it compares to the price that may be quoted by a vendor. The cost to prepare the 100 lb. of catalyst is only for the chemicals and the labor. The cost does not take into account any additional cost such as supervision of labor, building space, overhead, sales, etc.

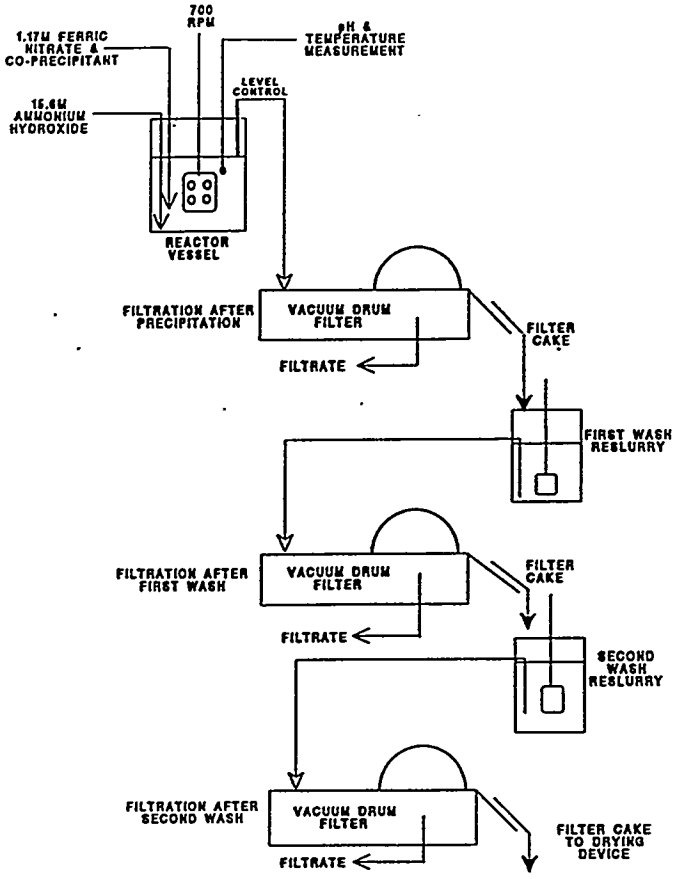

Figure IV.10.1. Schematic of reactor and filtration system for continuous preparation of precipitated iron Fischer-Tropsch catalysts.

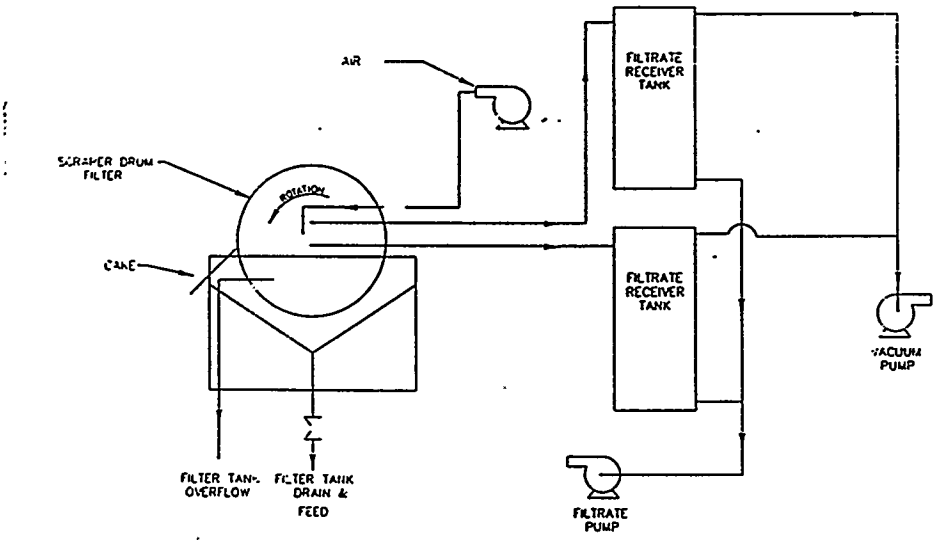

Figure IV.10.2. Schematic of a drum filter used for catalyst preparation.

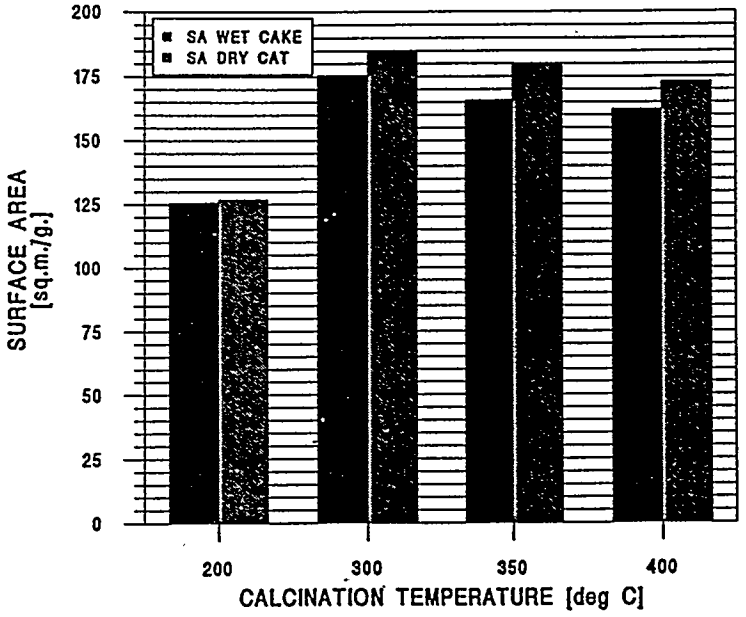

Figure IV.10.3. Dependence of the surface area of an iron catalyst containing 4.4 mole% Si on the calcination temperature.

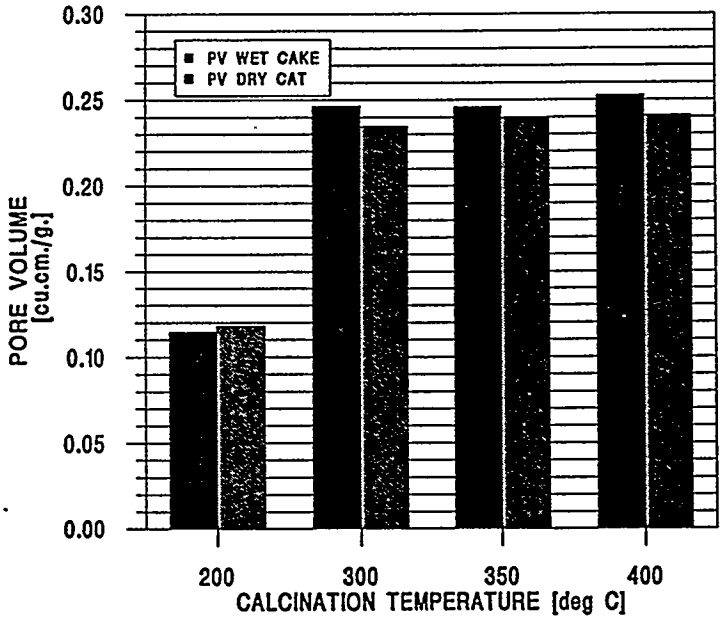

Figure IV.10.4. Dependence of the total pore volume of the catalysts shown in Figure 3 on the calcination temperature.

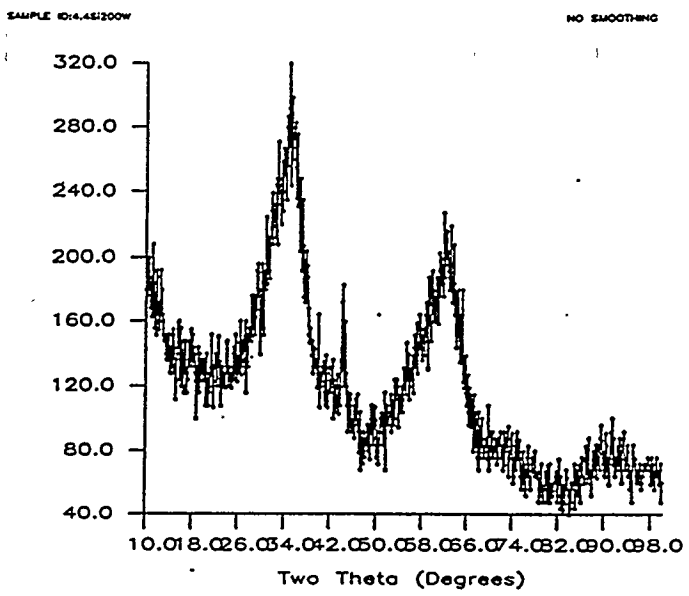

Figure IV.10.5. XRD pattern that is representative of the four wet and dried samples.

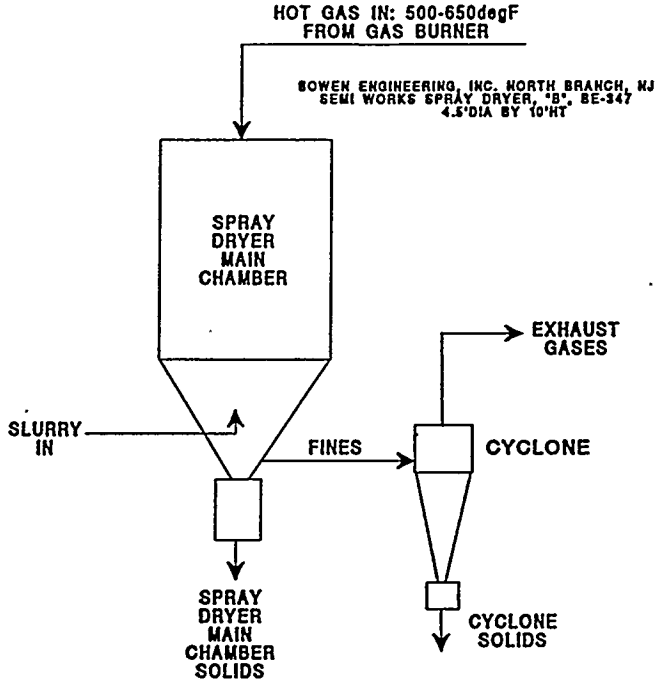

Figure IV.10.6. Schematic of United Catalysts, Inc. spray dryer.

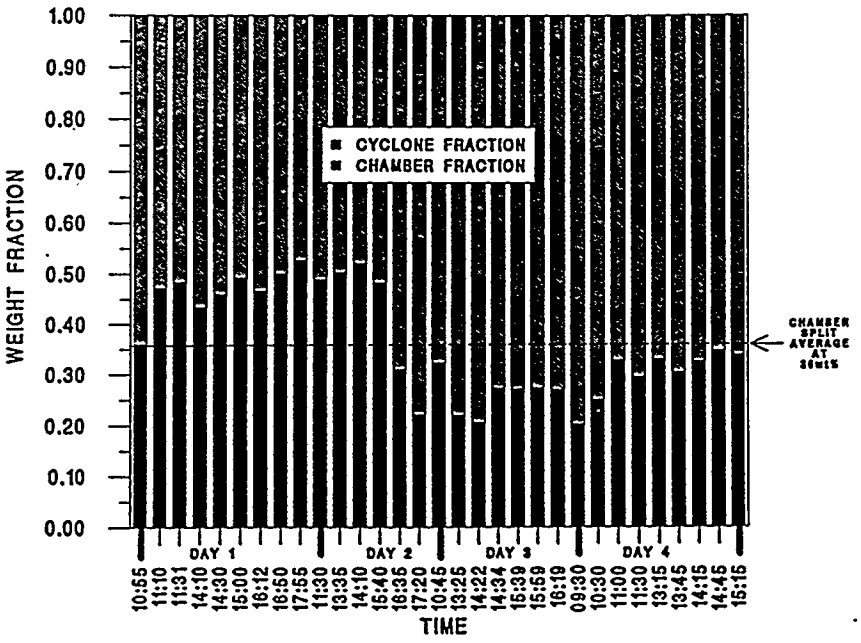

Figure IV.10.7. Weight fractions of the chamber and cyclone samples versus spray dryer operating time, hours.

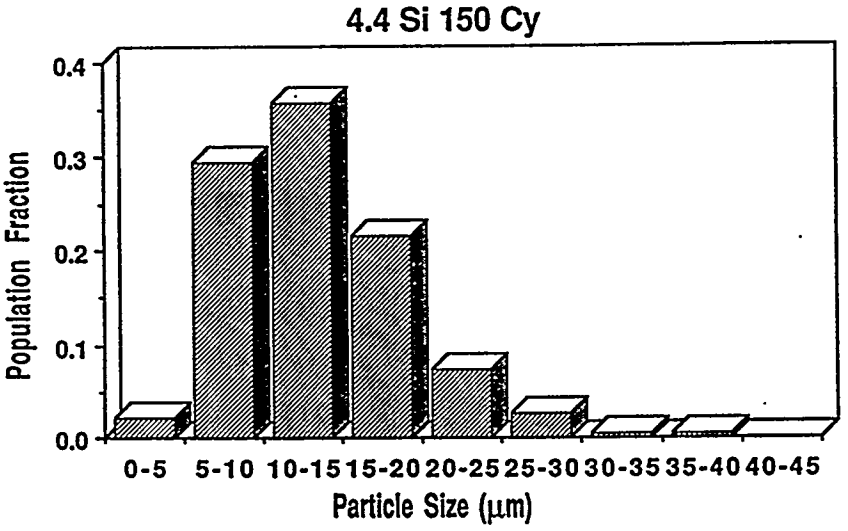

Figure IV.10.8. Particle size distribution for the cyclone sample following calcination at 300°C.

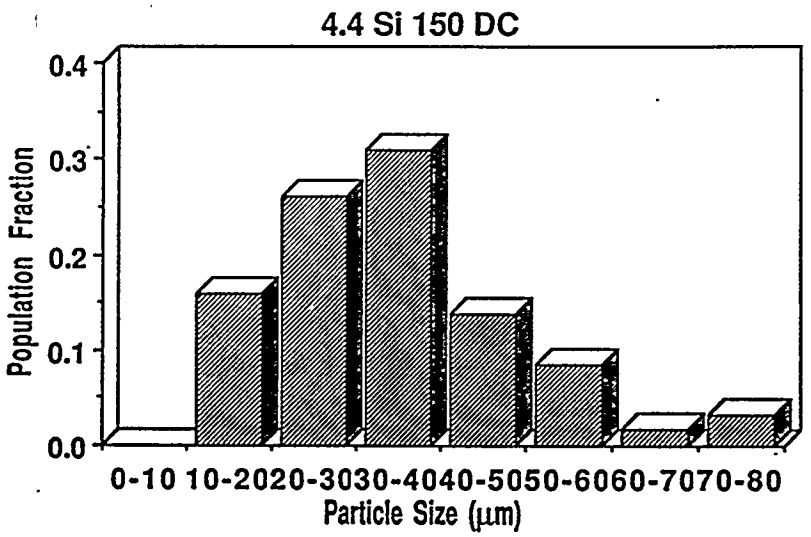

Figure IV.10.9. Particle size distribution for the dry chamber sample following calcination at 300°C.

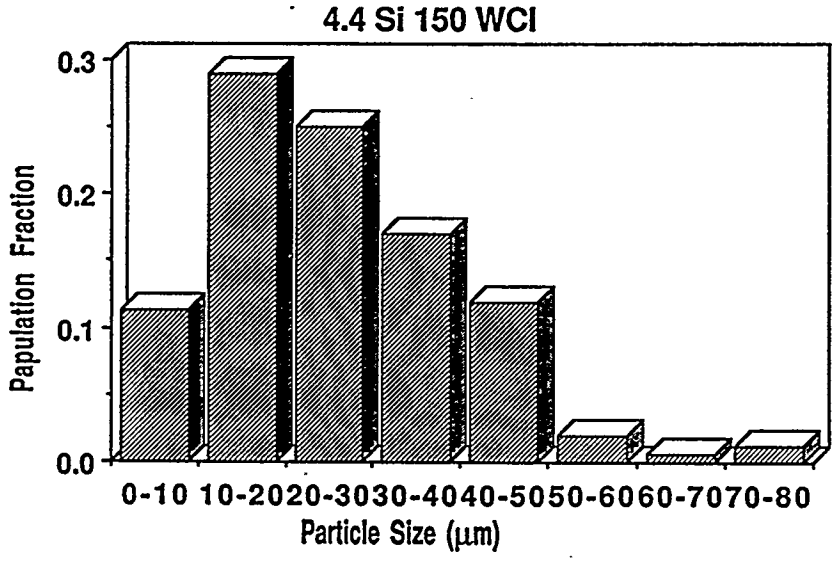

Figure IV.10.10. Particle size distribution for the Wet Cake I sample following calcination at 300°C.

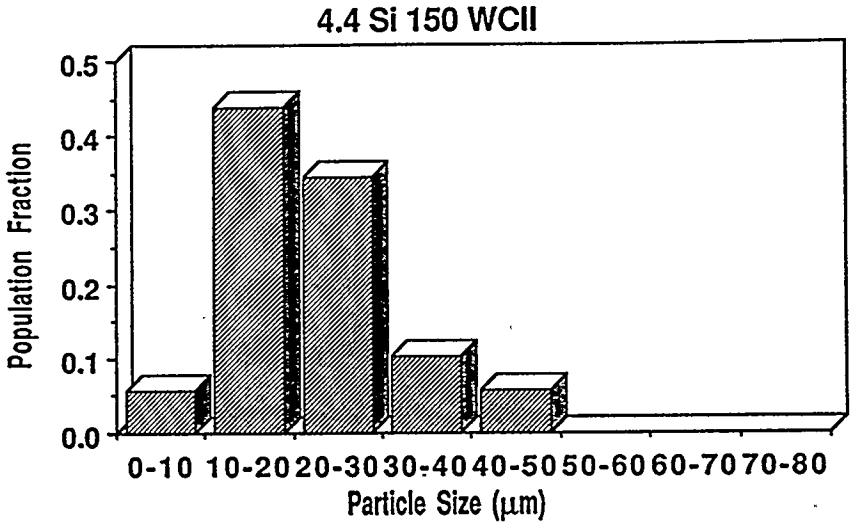

Figure IV.10.11. Particle size distribution for the Wet Cake II sample following calcination at 300°C.

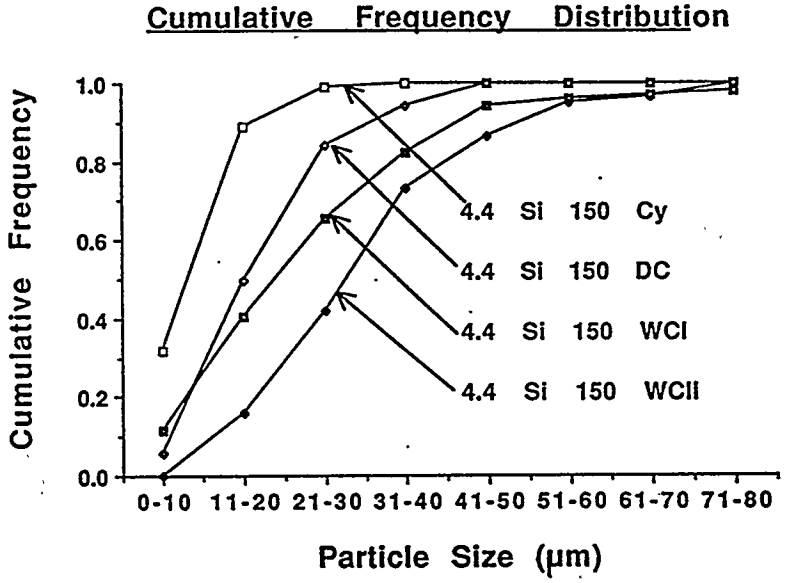

Figure IV.10.12. Cumulative particle size distribution for the four samples indicated in Figures 8-11.

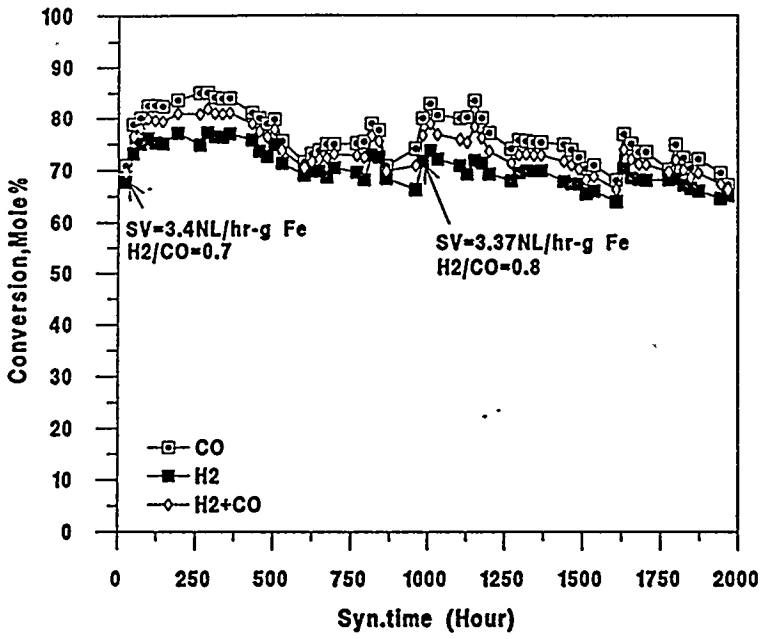

Figure IV.10.13. Conversions of synthesis gas with the cyclone sample of the spray dried material (CO pretreated; T = 270°C, H_2/CO = 0.7; P = 175 psig).

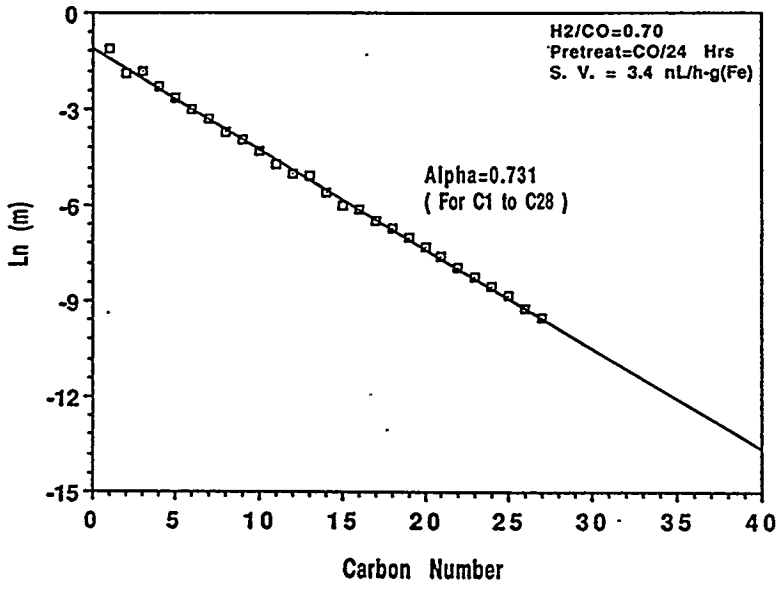

Figure IV.10.14. Anderson-Schulz-Flory plot for the products obtained at 288 hours on-stream using the cyclone sample (See Figure 13 for conversion).

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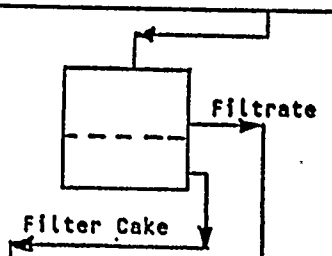
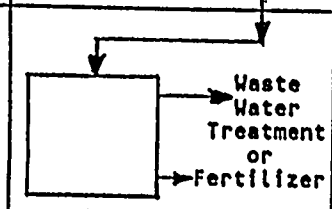
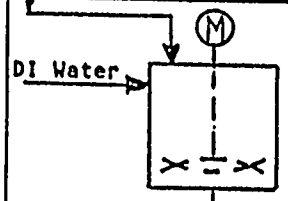
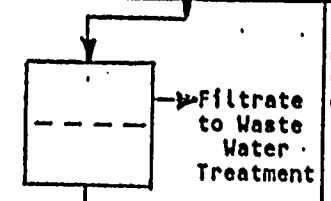
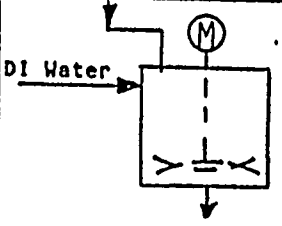
MATERIAL BALANCE AND PROCESS FLOW

PROMOTED IRON FISCHER-TROPSCH SLURRY PHASE CATALYST

Date: 2/10/94
Approved: F. Tungat

Process Stage	Raw Materials: Identification	Weight, lbs.	Density g/cc	Temp °F	Equipment	Products: Identification	Weight, lbs.	Density g/cc	Temp °F	Operation: Time, mins	Operation: Identification	Remarks
Dissolution	Iron (III) Nitrate Monohydrate 1) 2) 3)	664.9 656.55 648.46		amb	$Fe(NO_3)_3$ $9H_2O$ → M ← H_2O; Steam; Condensate	Iron solution	1702	1.21	108	60	Dissolve & heat $Fe(NO_3)_3$ $9H_2O$ to a 1.17M solution	
	Deionized Water 1) 2) 3)	1037.1 1045.5 1053.5	1.0	amb								
Mixing	1) $Al(NO_3)_3$ $9H_2O$ aluminum nitrate monohydrate	25.71	---	amb	M	Promoted iron solution premix	1728	1.21	108	15	Add co-precipitant (promoter)	1) 60 wt. % solution
	2) $Si(C_2H_5O)_4$ tetra ethyl orthosilicate	17.82	---	amb			1720	1.23	108			
	3) $ZrO(NO_3)_2$ zirconium oxynitrate	9.26	---	amb			1711	1.24	108			3) In nitric acid solution
	Aqueous ammonia 29.5% NH_3	570.0	0.894	amb	Aq. NH_3; Steam; Condensate	Aqueous ammonia premix	570.0	0.894	108	15		
Precipitation	1) Promoted iron solution premix	1728	1.21	108	Ph, M, T; 700 rpm; Level Control	Promoted hydrous iron oxide precipitate slurry	2298	1.112	108	Continuous 2312 (38.5 hrs)	134.9 lbs. solids precipitated hydrous iron oxide and promoters	Promoted iron solution pumped at 16.56 liter/hour Aqueous ammoni premix pumped at 7.50 liter/hour pH = 9.1 ± 1.0
	2) Aqueous ammonia premix	570.0	0.894	108								

Figure IV.10.15. Material balance and process flow sheet for 100 lb/week pilot plant to prepare precipitated iron catalysts.

Process Stage	Raw Materials: Identification	Weight, lbs.	Density g/cc	Temp °F	Equipment	Products: Identification	Weight, lbs.	Density g/cc	Temp °F	Operation: Time, mins	Identification	Remarks
Filtration	Promoted hydrous iron oxide precipitate slurry	2298	1.112	108		Promoted hydrous iron oxide filter cake	809.4	---	108	Continuous 2312 (38.5 hrs)	Filtration 134.9 x 0.96 = 129.5 lbs.	Rotary drum vacuum filter 96% yield 16% solids
Disposal						Ammonium nitrate solution	1488.6	1.05	108		Filtrate collection and disposal.	
1st Reslurry	1) Promoted hydrous iron oxide filter cake 2) Deionized water	809.4 1488.6	1.0	108 108		Promoted hydrous iron oxide slurry	2298		108	30	Reslurry	
Filtration	Promoted hydrous iron oxide filter slurry	2298	1.112	108		Promoted hydrous iron oxide filter cake	777	---	108	Continuous 2312 (38.5 hrs)	Repeat filtration 129.5 x 0.96 = 124.3	Rotary drum vacuum filter 96% yield 16% solids
2nd Reslurry	1) Promoted hydrous iron oxide filter cake 2) Deionized water	777 1521	1.0	108 108		Promoted hydrous iron oxide slurry	2298	1.112	108	30	Reslurry	

Process Stage	Raw Materials: Identification	Weight, lbs.	Density g/cc	Temp °F	Equipment	Products: Identification	Weight, lbs.	Density g/cc	Temp °F	Operation: Time, mins	Identification	Remarks
Filtration	Promoted hydrous iron oxide slurry	2298	1.112	108	Filtrate to Waste Water Treatment	Promoted hydrous iron oxide filter cake	746	---	108	Continuous 2312 (38.5 hrs)	124.3 x 0.96 = 119.3	Rotary drum vacuum filter 96% yield 16% solids
Reslurry for Spray Drying	1. Promoted hydrous iron oxide filter cake 2. Deionized water	746 460	--- 1.0	108 amb	DI Water	Promoted hydrous iron oxide slurry	1206	---	amb	30		Reslurry to 9.9% solids to spray dry
Spray Drying	Promoted hydrous iron oxide slurry	1206	---	amb	550°F Hot Air; 350°F Hot Air	Chamber fluid bed powder	88.6	1.1	amb	Continuous 480 (8 hours)	119.3 x 0.95 x 0.75 = 85 85/0.96 = 88.6	Spray Dryer Chamber LOI = 4% 95% Yield
	Spray dryer exhaust gas	1206	---	amb	Hot Air Exhaust	Cyclone fluid bed powder	29.5	1.1	amb	Continuous 480 (8 hours)	119.3 x 0.95 x 0.25 = 29.5	Spray Dryer Cyclone LOI = 4% 95% Yield
Screening	Spray dried fluid bed powder	118.1	1.1	amb	Product; Overs; Fines	+150u +20-150u Fluid bed powder -20u	5.9 106.3 5.9	1.1 1.1 1.1	amb amb amb	120	Screening 90% Yield +20-150u	LOI = 4%

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PROMOTED IRON FISCHER-TROPSCH SLURRY PHASE CATALYST

Date: 2/10/94
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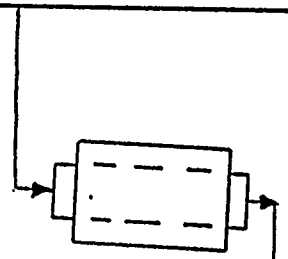
Process Stage	Raw Materials: Identification	Weight, lbs.	Density g/cc	Temp °F	Equipment	Products: Identification	Weight, lbs.	Density g/cc	Temp °F	Operation: Time, mins	Operation: Identification	Remarks
Calcination	Screened, spray dried promoted iron Fischer-Tropsch catalyst	106.3	1.1	amb		Calcined promoted iron Fischer-Trop. catalyst	100	1.1	700	Continuous 420	98% yield of 96% solids	Rotary Calciner 0% LOI
Packaging	Calcined promoted iron Fischer-Tropsch catalyst	100	1.1	amb		Calcined promoted iron Fischer-Trop. catalyst	100	1.1	amb	Continuous 420	Product packaging	Product

Fischer-Tropsch Equipment List

Description	Manufacturer/Model No.	Supplier/PN	Quantity	Unit Cost	Total Cost
30-gallon Polyethylene (LDPE) Drums	Kerro, Inc.	Cole-Parmer Instrument Co. 7425 North Oak Park Ave. Chicago, IL 60648-9930 P/N: G-06950-25	3	$73.00 each	$219.00
15-gallon Cylindrical Tank with cover (HDPE)	Nalge Co. Model: 54100-0015	Fisher Scientific Co. 9403 Kenwood Road, Suite C208 Cincinnati, OH 45242	4	34.35 each	137.40
Peristaltic Tubing Pump Drive (0-100 rpm)	Barnant Co. Z8W092 Commercial Ave. Barrington, IL 60010 Model: 7520-35	Cole-Parmer Instrument Co. P/N: L-07520-35	2	650.00 each	1300.00
Peristaltic Tubing Pump Drive (0-600 rpm)	Barnant Co. Barrington, IL 60010 Model: 7520-25	Cole-Parmer Instrument Co. P/N: L-07520-25	1	650.00 each	650.00
Peristaltic Pump Heads	Barnant Co. Barrington, IL 60010 Model: 7518-10 Model: 7518-12	Cole-Parmer Instrument Co. P/N: L-07518-10 P/N: L-07518-12	 3 3	 170.00 each 170.00 each	 510.00 510.00
Peristaltic Tubing (Norprene)	Barnant Co. Barrington, IL 60010 Model: 6404-14 Model: 6404-15 Model: 6404-16 Model: 6404-24	Cole-Parmer Instrument Co. P/N: G-06404-14 P/N: G-06404-15 P/N: G-06404-16 P/N: G-06404-24	 2 2 2 2	 27.00 each 60.00 each 40.00 each 80.00 each	 54.00 120.00 80.00 160.00
				Page Total:	$ 3740.40

Figure IV.10.16. Equipment list and cost for a pilot plant to prepare 100 lb/week of precipitated iron catalyst.

Fischer-Tropsch Equipment List
(continued)

Description	Manufacturer/Model No.	Supplier/PN	Quantity	Unit Cost	Total Cost
2-liter PTFE Griffin Beaker (Reactor #1)	Unknown	Cole-Parmer Instrument Co. Chicago, IL 60648-9930 P/N: G-06004-17	1	134.85 each	134.85
4-liter ss Griffin Style Beaker (Reactor #2, & #3)	Polar-Ware Co. Model: 4000B	Cole-Parmer Instrument Co. Chicago, IL 60648-9930 P/N: G-07205-90	2	66.20 each	132.40
PFA/FEP Coating for Reactors #2 & #3 (listed above)	Bergof/America 125 Mason Circle-Unit J Concord, CA 94524	Cole-Parmer Instrument Co. Chicago, IL 60648-9930 P/N: G-07205-90	1	175.00 each	175.00
U-Shaped Polypropylene Mixer Blade		Indco P. O. Box 589 New Albany, IN 47150 P/N: F37202	2	13.75 each	27.50
0-700 rpm Electric Stirrer	Haake Buchler Lab Assistants Model: RZR-2000	Unknown (Comparable stirrer from Indco, i.e. P/N: E5134-2)	1	600.00 each	600.00
pH/T Meter	Orion Model: 420A	Baxter Scientific 2340 McGaw Road Obetz, OH 43207 P/N: H4000-108	1	860.00 each	860.00
pH Electrode	Orion Model 510ZBN	Baxter Scientific Obetz, OH 43207 P/N: H4102-2B	2	126.00 each	252.00

Page Total: $ 2181.75

Fischer-Tropsch Equipment List
(continued)

Description	Manufacturer/Model No.	Supplier/PN	Quantity	Unit Cost	Total Cost
ATC Temperature Electrode	Orion Model: 917006	Baxter Scientific Obetz, OH 43207 P/N: H4100-31	2	136.00 each	272.00
Drum Filter 6" diameter x 3" width	Westech Engineering 3605 South West Temple Salt Lake City, UT 84115 Model: 6x3 Scraper	Westech Engineering, Inc.	3	5147.00 each	15,441.00

NOTE: A single vacuum filter comparable to the three we currently have has been quoted from Westech as follows:

18" x 12" ss construction @ $30,000-$35,000
18" x 12" pvc construction @ $45,000-$50,000

Reslurry Motor & Speed Controller Combination	Reliance Electric	Grainger 1357 Georgetown Road Lexington, KY 40511 P/N: 7Z195	1	590.00 each	590.00
7.5 CF Drying Oven	Despatch P. O. Box 1320 Minneapolis, MN 55440 Model: LEB 1-76-4	Same	1	1600.00 each	1600.00

Page Total: $ 17,903.00

Fischer-Tropsch Equipment List
(continued)

Description	Manufacturer/Model No.	Supplier/PN	Quantity	Unit Cost	Total Cost
Spray Dryer	Bowen Engineering, Inc. Model: BE #347	Niro Inc. 9165 Rumsey Rd. Columbia, MD 21045-1911	1	$160,000 each	$160,000.00
3.5 CF Air Circulating Furnace	Hot Pack Corp. 10942 Dutton Rd. Philadelphia, PA 19154 Model: 1443	Hot Pack Corp.	1	16,872 each	16,872.00
5.0 CF Air Circulating Furnace	Hot Pack Corp. Model: 1445	Hot Pack Corp.	1	20,550 each	20,550.00
18" Screener, s.s. Decks & Screens	Sweco, Inc. Los Angeles, CA Model: #LR-2262	Sweco, Inc. 8029 U.S. Highway 25 Florence, KY 41042	1	5,000 each	5,000.00

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FTT-284
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Page Total: $ 202,422.00

Product Description: Promoted Iron Fischer-Tropsch Catalyst

Costs per 100 Pounds

Yield Basis: 74.1%

	Quantity	Unit Cost	Cost
MATERIALS			
Iron (III) Nitrate Monohydrate, crystals, Tech	664.9 gals	1.000	664.900
Aluminum Nitrate Monohydrate 60% solution, tech	25.7 lbs	0.268	6.888
Aqueous Ammonia, 29.5 weight % NH_3	569.4 lbs.	0.034	19.360
Potassium Nitrate, crystals, tech	2.0 lbs.	0.750	1.500
UTILITIES			
Water	1800 gals	1.95/1000 gals	3.510
Natural Gas	4200 SCF	3.25/1000 SCF	13.650
Power	65 KWH	0.0386/KWH	2.509
Deionized Water	1200 gals	2.06/1000 gals	2.472
MISCELLANEOUS MANUFACTURING COSTS			2.500
LABOR			
Direct Standard	65 hrs	22.396/hr	1455.740
CONTAINER(S)	1 drum	9.75 ea	9.75
TOTAL COSTS PER 100 POUNDS AS SHIPPED:			2182.779

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2/14/94

Figure IV.10.17. Estimated cost for the production of 100 lb. batch of precipitated iron catalyst.