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Shape-Selective Catalysts for Fischer-Tropsch Chemistry

Final Report: January 1, 2001 – December 31, 2008

Chemical Sciences and Engineering Division

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Abstract

Argonne National Laboratory carried out a research program to create, prepare, and evaluate catalysts to promote Fischer-Tropsch (FT) chemistry—specifically, the reaction of hydrogen with carbon monoxide to form long-chain hydrocarbons. In addition to needing high activity, it was desirable that the catalysts have high selectivity and stability with respect to both mechanical strength and aging properties. It was desired that selectivity be directed toward producing diesel fraction components and avoiding excess yields of both light hydrocarbons and heavy waxes. The original goal was to produce shape-selective catalysts that had the potential to limit the formation of long-chain products and yet retain the active metal sites in a protected "cage." This cage would also restrict their loss by attrition during use in slurry-bed reactors. The first stage of this program was to prepare and evaluate iron-containing particulate catalysts. Such catalysts were prepared with silica-containing fractal cages. The activity and strength was essentially the same as that of catalysts without the cages. Since there was no improvement, the program plan was modified as discussed below.

A second experimental stage was undertaken to prepare and evaluate active FT catalysts formed by atomic-layer deposition [ALD] of active components on supported membranes and particulate supports. The concept was that of depositing active metals (i.e. ruthenium, iron or cobalt) upon membranes with well defined flow channels of small diameter and length such that the catalytic activity and product molecular weight distribution could be controlled. In order to rapidly evaluate the catalytic membranes, the ALD coating processes were performed in an 'exploratory mode' in which ALD procedures from the literature appropriate for coating flat surfaces were applied to the high surface area membranes. Consequently, the Fe and Ru loadings in the membranes were likely to be smaller than those expected for complete monolayer coverage. In addition, there was likely to be significant variation in the Fe and Ru loading among the membranes due to difficulties in nucleating these materials on the aluminum oxide surfaces. The first series of experiments using coated membranes demonstrated that the technology needed further improvement. Specifically, observed catalytic FT activity was low. This low activity appeared to be due to: 1. low available surface area, 2. atomic deposition techniques that needed improvements, and 3. insufficient preconditioning of the catalyst surface prior to FT testing. Therefore, experimentation was expanded to the use of particulate silica supports having defined channels and reasonably high surface area.

An effective FT catalyst consisting of ALD-deposited Co and Pt on a silica support has been prepared and demonstrated. This catalyst was more effective than a similar catalyst deposited upon a support of ALD-deposited Al_2O_3 on silica. This result implies that the deposition of Al_2O_3 to form a support is not as effective as desired. The addition of Pt as a Co-containing catalyst promoter has been demonstrated; it appears to primarily affect the catalyst pre-conditioning step. Co on Al_2O_3 catalyst prepared by the Center for Applied Energy Research (CAER) is more effective than Argonne-prepared ALD-deposited Co on ALD-deposited Al_2O_3 catalyst. The FT activity of ALD-coated Co catalyst on Al_2O_3 is about linear with Co level from about 9 to 25%. A cooperative research effort was undertaken to test the deposition of platinum on Co FT catalysts; this Pt influences the effectiveness of catalyst conditioning and its continuing activity. In summary, the ALD Pt at a low concentration (0.1 wt %) was as effective as that of the wet chemical deposition technique of CAER (specifically incipient deposition on a Co catalyst that had been prepared and calcined before the Pt deposition.) The ALD technique appeared to be nominally better than the incipient wetness technique that involved co-deposition of Pt and Co prior to calcination. The activation energy of the rate of CO conversion was tightly grouped about an average of 29.2 Kcal/mol when all of the Co-containing catalysts other than those with high Pt promoter levels were

taken into account; this implies a uniform reaction mechanism. Catalysts containing Pt and Ru that were ALD-deposited on an ALD-Al_2O_3 coated catalyst support were found to be relatively inactive. Additional tests were made with a low concentration (0.1 wt %) of Ru or Ir deposited on the reference Co catalyst. The Ir coated catalysts were particularly effective.

In support of the above, there was an opportunity to undertake a study of cobalt/promoter/support interaction using the Advanced Photon Source (APS) of Argonne. A number of catalysts (including reference cobalt oxide and iron oxides) were tested using temperature programmed EXAFS/XANES experiments. This was a combined effort of Argonne and CAER of the University of Kentucky. It resulted in an extensive understanding of the preconditioning step of reducing the various Fe- and Co-containing FT catalysts. A number of manuscripts have been published, and additional papers have been submitted or are currently being drafted. The results of this work are summarized herein.

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Introduction

Fischer-Tropsch (FT) chemistry involves the reaction of hydrogen with carbon monoxide to form long-chain hydrocarbons. Even though this process was invented in Germany in 1923, there has been a continuing development of catalysts, the most common of which are based upon iron, cobalt, and ruthenium. Due to the water gas shift catalytic activity of iron, its use in FT catalysis is often directed toward a gas stream generated from the gasification of coal (namely, lower H/CO ratios.) In the case of gas to liquid (GTL) production with high H_2/CO ratios, emphasis is typically directed toward supported cobalt catalysts. Syngas having a relatively high H_2/CO ratio (~2:1) is converted over a supported cobalt catalysts – usually Co/Al_2O_3 – under pressure (e.g., ~20 bar) and mild temperatures (e.g., ~220°C) to produce a distribution of hydrocarbons - mainly straight chain paraffins – that can be upgraded to transportation fuels (e.g., diesel, jet fuel). Cobalt catalysts are relatively inactive intrinsically for the water-gas shift reaction. One drawback to cobalt is that it is more expensive than iron. Thus, catalyst activity must be maintained over long periods of time. (During the initial stages of this project, DOE directed that research in this project center upon iron-containing catalysts with an emphasis on physical strength and catalyst activity.)

The available literature on these catalysts is very extensive, and it is beyond the scope of this project to prepare another literature survey. Only recent literature dealing with specific problem areas is cited when appropriate. For reference, a very comprehensive recent series of articles on the FT process has been edited by Hans Schulz and Michael Claeys[1]; the kinetics literature was reviewed by Van der Laan and Beenackers[2] ; see also C.N. Satterfield[3]. B. H. Davis has carried out an extensive study of FT catalysis under DOE contracts; reference is made to the Final Technical Report[4] of Contract No. PC90056; also note interim reports of PC94055. An effective review of past work was also cited in the patent application of C.L. Kibby.[5]

Iron-containing Catalysts:

Iron is the least expensive FT catalyst. It is typically promoted with alkali (i.e., 0.5 wt% K_2O) for activity and stability. It has been proposed[3] that potassium donates electrons to the iron, weakens the CO bond, strengthens the Fe-C bond, and weakens the Fe-H bond, so the quantity of CO adsorbed increases and that of H_2 decreases. It was also cited[3] that the fixed-bed reactors at SASOL (South African Synthetic Oil Limited) operate at about 220°C and 2.7 MPa using a precipitated iron catalyst heavily promoted with potassium. Their entrained-bed reactors operate at about 320°C and 2.2 MPa with a reduced fused magnetite catalyst of considerably lower potassium content.

CuO is added to the Fe catalyst to lower the reduction temperature of Fe_2O_3. This addition reduces sintering and apparently does not affect catalyst selectivity. SiO_2 and Al_2O_3 may be added for structural strength; however, excessive levels reduce catalyst activity.

Numerous articles have indicated that iron catalysts are active for FT synthesis only when in the carbide state. Van der Laan and Beenackers[2] provides a good summary of pertinent references; see also Bukur et al.[6] Numerous articles have demonstrated the importance of catalyst pre-conditioning treatment of fresh catalyst with CO to establish the active carbide surfaces; for example, see Shroff et al.[7] The procedure used by Davis[4] is as follows:

"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/g Fe/hr for 22 hours."

The strength of iron-based catalysts is of concern, particularly when used in slurry-bed catalytic reactors. Espinoza et al.[8] of SASOL states, "The main difficulty with the commercial application of the SPR

(Slurry Phase Reactor) is the separation of the wax product from the catalyst. This is especially true for the relatively friable precipitated iron catalysts." D. S. Kalakkad et al.[9] studied the attrition and phase transformation of precipitated iron FT catalysts. They found that spray-dried particles (agglomerates) about 30 μm diameter easily fragmented to particles of about 1 μm size. In addition, phase transformation resulted in size reductions to about 20 μm. The recent presentation of Gormley, Deffenbaugh and Zarochark[10] also points out the difficulty of catalyst attrition with the subsequent problems of cleaning up the resulting FT wax product stream.

Interest in the first stage of this project was directed toward the formation of fractal surface structures that would provide structural strength and yet be porous for the flow of reactants and products to and from the iron-containing catalyst. Again, there is an extensive literature on the formation of fractal structures. The Symposia Proceedings of Brinker et al.,[11] the book of Brinker and Scherer,[12] the collection of manuscripts edited by Klein,[13] and the text of Zallen[14] present a good background of the subject.

The goal of the first stage of this project was to create, prepare, and evaluate catalysts to promote Fischer-Tropsch (FT) chemistry. Emphasis was placed upon iron-containing catalysts that are preferred for syngases having low ratios of H_2/CO. Emphasis was also placed upon shape-selective catalysts that had the potential to limit long-chain products and retain active metal sites in a protected "cage" to restrict their loss during use in slurry-bed reactors. The progress report covering this research stage has been issued.[15]

The goal of the second stage of this project was directed toward preparing active FT catalysts supported on porous membranes. Specifically, these catalytic films were controlled down to the number of atoms of thickness and the membrane pore size. Novel catalysts were synthesized by techniques that created composite membranes of nanopores constructed from molecular building blocks; specifically, electrochemically prepared anodic aluminum oxide materials. In addition, commercially available ceramic membranes were coated layer by layer with alumina and active catalytic metals including ruthenium, cobalt and/or iron using an atomic layer deposition (ALD) technique. The resulting membranes have been demonstrated to have high mechanical strength but limited FT catalytic activity. Because these membranes had low effective surface areas, it was decided to expand to experimentation with preformed silica gels of high surface area to test and improve the ALD techniques. It was also determined that the preconditioning step needed improvement. The progress report covering this membrane research stage has been issued.[16]

Cobalt and Other Deposited Metal Catalysts:

The goal of the third stage of this project was directed toward preparing active FT catalysts placed on porous supports. As a continuation of the above membrane research, in selected cases electrochemically prepared anodic aluminum oxide materials were deposited on silica supports. These supports were coated layer by layer with active catalytic metals including ruthenium, cobalt and/or iron using the atomic layer deposition (ALD) technique.

Two of the significant factors to be considered in the use of Co-containing catalysts are particle size and reducibility. Iglesia[17] reported a linear trend between FT activity and cobalt surface area on a per gram of catalyst basis as measured by hydrogen chemisorption, indicating that the active sites for the catalysis are the surface cobalt metal particles. Due to the strong interaction of alumina with cobalt oxides, alumina stabilizes very small cobalt oxide particles. The small particle size is important for producing a significant surface area of metallic cobalt following activation in H_2. However, the highly interacting small particles are difficult to reduce and thus, reduction promoters (e.g., Pt, Ru, and Re) are often employed – and often in combination - to facilitate reduction of the cobalt oxide crystallites to the metallic state.

Reduction of Co_3O_4 clusters takes place in two steps: $Co_3O_4 + H_2 \rightarrow 3CoO + H_2O$ and then $3CoO + 3H_2 \rightarrow 3Co^0 + 3H_2O$; this has been recently demonstrated by a TPR-EXAFS/XANES investigation[18] in part supported by the current program. When the reduction promoter reduces below the reduction temperature of Co_3O_4 to CoO (i.e., which typically occurs in the temperature range of 300 – 350°C), as in the case of Pt or Ru both steps are typically shifted to lower temperatures (Note references 19 through 22). However, in the case of Re[23-25] which reduces at a comparable temperature to the first step of reduction of Co_3O_4, only the second step of reduction (CoO to Co^0) has been observed to be impacted. Using a standard 10 hour H_2 reduction treatment of 350°C, Jacobs et al.[26] showed by hydrogen chemisorption/pulse reoxidation measurements that in all cases (Pt, Ru, Re), gains in active site densities (i.e., number of cobalt atoms exposed at the surface) were directly due to the higher extents of reduction gained by promoter addition. Two promoters, Pt and Re, have been observed to exhibit direct contact with Co at the atomic level by EXAFS spectroscopy.[27-29]

Also, not every metal reduction promoter of cobalt oxide displays good activity in the reaction testing. Jacobs et al.[30] examined Group 11 elements as potential promoters. While Cu, Ag, and Au were found to significantly promote the reduction of cobalt oxides, Cu acted as a poison on the surface of Co. Ag and Au, on the other hand, were able to promote reduction and boost CO conversion levels during FT. Nevertheless, during an EXAFS/XANES investigation comparing freshly reduced catalysts with those obtained by reducing a reduced/passivated catalyst, the Ag and Au catalysts significantly lost their ability to promote reduction after exposure to oxygen. In the initial calcined catalyst, the Ag and Au oxides were initially in good contact with cobalt oxides and during reduction, the tiny Group 11 metal particles formed were able to promote reduction of cobalt. However, after exposure to the 350°C condition, the promoter agglomerated, disrupting surface contact with cobalt. Thus, once the catalyst was cooled and passivated, it no longer was able to promote reduction a second time.

Experimental

Reactor System:

A continuous-flow catalytic-bed unit was modified and used for this FT study. A flow schematic for operation with a fixed bed of particulate catalyst is shown in Figure 1.

In the experiments made with a packed bed, the gaseous feed consisted of either a 1:1 or 2:1 molar blend of H_2:CO. The feed passed through a preheater/reactor that consisted of a 1/2-in.-O.D. (3/8-in.-I.D.) tube of 36 in. length. Gaseous flow was downward through the following zones:

1. An empty (quartz wool) zone to serve as a preheater,
2. Inert packing consisting of low-surface α-Al_2O_3 to ensure radial flow dispersion,
3. Supported catalyst that was mixed with inert filler,
4. Additional α-Al_2O_3 packing, and
5. A bottom zone made up of a low-internal-diameter tube so that the catalyst was retained in the temperature-controlled region of the tube.

The preheater/reactor had a total of six internal and two external thermocouples. The reactor temperature was controlled using the thermocouple at the center of the active catalyst bed.

The FT experiments made with particulate catalyst were carried out at temperatures ranging from about 260°C to 300°C, pressures averaging 13.1 MPa (190 psia), H_2/CO feed molar ratios of either 1.0 or 2.0, a gas feed rate of about 15 to 40 mL/min, and a catalyst charge of 0.1 to 0.7 g . At a gas feed rate of 40 mL/min and a catalyst charge of 0.7 g, the equivalent space velocity is about 3.4 normal liters per hour gram (NL/hr-g).

The reactor effluent was cooled in air; in limited cases the exit gas was passed through a wet-ice-cooled trap. There was a provision for a dry-ice trap that was not used due to plugging problems. The traps were set up for parallel operation so that periodic condensate samples could be recovered for weighing and sampling. The pressure of the off-gas was controlled, and it was subsequently metered and sampled.

The gas composition was determined using an HP 6890 Series gas chromatograph (GC) that had been modified by LINC Quantum Analytics of Foster City, CA. It had three columns: (1) a molecular sieve column (7 ft x 1/16 in. 13X 45/60) for light gas retention and separation, (2) a capillary column (50 m x 0.53 mm KCl modified Al_2O_3 PLOT) for hydrocarbon analysis by a flame ionization detector (FID), and (3) a packed column (7 ft x 1/16 in. Hayesep A 60/80) for CO_2 separation and analysis using a thermal conductivity detector (TCD).

Particulate Catalyst Preparation:

A list of the tested particulate catalysts is presented in Table 1. The methods of sample preparation are discussed below.

The preparation of the iron-containing particulate catalysts including those coated with fractal SiO_2 coatings have been described in the previous report.[15] Therefore, they are described herein only when changes were introduced.

Two samples of FT iron-based catalyst were obtained from B. H. Davis of CAER. The first consisted of the bulk spray-dried catalyst designated "RLS 4.4 Si/150 Cyclone Iron Catalyst" (RLS) and the second was freshly prepared catalyst designated "RJO 290 100Fe/4.6Si/1.44K."

Selected Fischer-Tropsch (FT) particulate catalysts were prepared by applying thin films of aluminum oxide and cobalt oxide onto a silica gel powder supports using atomic layer deposition (ALD). ALD is a thin film growth technique that uses alternating exposures to reactive precursor gases.[31] Self-limiting chemical reactions between the precursors and a solid surface ensure that each exposure produces one monolayer of adsorbed species, even for surfaces with complex topographies such as the mesoporous silica gel. However, there are some cases when this theory may be questionable.

Two types of silica gel were used in this study. The first, which was used only in exploratory runs, was Silicycle S10040T with a specific surface area of 50 m^2/g, a pore size of 100 nm and a particle size of 75-200 microns. The second, which was used in essentially all of the remaining experiments, was Silicycle S10040M with a specific surface area of 100 m^2/g, a pore size of 30 nm and a particle size of 75-200 microns.

The FT catalysts were prepared using a viscous flow ALD reactor[32] at 1 Torr pressure using ultrahigh purity nitrogen carrier gas at a mass flow rate of 360 sccm and a temperature of 465°C. Approximately 1 g of the silica gel support material was contained in a fixed-bed powder fixture. After allowing the powder to thermally equilibrate and outgas, the silica gel was cleaned using a 1 Torr, 400 sccm mixture of 10% ozone in oxygen for 10 minutes. In selected cases, an Al_2O_3 ALD technique was used to deposit an additional catalytic support layer. The Al_2O_3 ALD used 3 ALD cycles comprised of alternating exposures to trimethyl aluminum and water vapors to deposit ~0.4 nm of Al_2O_3.[33-35] Finally, the Co_3O_4 ALD coating was performed using 5-20 ALD cycles comprised of alternating exposures to bis(cyclopentadienyl)cobalt (II) and ozone. In addition to the silica gel powder, small portions of Si(100) wafers were coated concurrently with the ALD Co_3O_4 and subsequently analyzed using spectroscopic ellipsometry. These measurements determined that each ALD Co_3O_4 cycle deposits 0.23 nm of material. X-ray fluorescence measurements were performed on the silica gel powders to determine the cobalt loading. These measurements revealed that the Co_3O_4 ALD deposits ~1.7 wt% Co per ALD cycle on the S10040M powder. The weight gain on the S10040T powder was lower as a consequence of the lower specific surface area for this support material.

Preparation of SiO_2 Coated Catalysts:

As described in the previous Activities Report,[15] selected iron-containing FT catalysts were prepared with the goal of coating the catalyst particles with SiO_2 in order to increase catalyst particle attrition strength. A procedure using organo-silicates with nitric acid precipitation was found to deposit silica as a fractal surface on a CAER-prepared iron FT catalyst. As reported, "... the use of HNO_3 to form SiO2 surface coating on CAER FT catalyst was superior to that of using HCl and H_2SO_4 acids and also the NH_4OH base for SiO_2 precipitation. In all of these cases, there was a decrease of FT catalytic activity that increased as the amount of SiO_2 increased. The best SiO_2 level was about 2.0–2.5 wt%."

The same SiO_2 precipitation procedure as previously reported[15] for Sample 30AA was used to prepare approximately 24 g of fractal-coated CAER catalyst. The nominal SiO_2 concentration was 2.2 wt%.

Catalyst Preconditioning:

As determined in the APS studies of preconditioning of cobalt-containing F-T catalysts, a consistent temperature and time procedure must be used when comparing the activities of catalyst samples, because the extent of preconditioning strongly affects catalyst activity.

Specifically, a two-step reduction process was observed for Co_3O_4 to CoO and CoO to Co^0 transformations over catalysts exhibiting both weak metal/support interactions (i.e. Co/SiO_2) and strong interactions (i.e. Co/Al_2O_3). Increased reduction temperatures were needed to effectively reduce Co-containing catalysts deposited on strongly interacting surfaces when compared with those of unsupported Co_3O_4 or weakly supported Co catalyst. The addition of a noble metal promoter (i.e. Pt) strongly affected reducibility and resulting cobalt crystallite size.

In this program, cobalt-containing catalysts first were preconditioned in flowing 100% hydrogen at atmospheric pressure. The temperature was increased from room temperature to 350°C in 1 hour; the catalyst was then maintained at this temperature with 100% hydrogen flow for about 6 hours. A feed gas containing 3.8% hydrogen in helium was then used overnight for the next 17 hours. Similar conditions were used for fresh catalyst conditioning at 400°C. In several cases, a used catalyst that had been preconditioned at 350°C and used in FT experiments was further conditioned in flowing hydrogen at 400°C at atmospheric pressure prior to subsequent FT experiments (note Tables 2 and 3).

Attrition Testing of Coated Catalysts:

Selected iron-containing FT catalysts were prepared with the goal of coating the catalyst particles with SiO_2 in order to increase catalyst particle attrition strength. The same SiO_2 precipitation procedure as previously reported[15] for Sample 30AA was used to prepare approximately 24 g of fractal-coated CAER catalyst with a nominal SiO_2 concentration of 2.2 wt%.

The attrition strength of this later catalyst was then compared with that of a sample of uncoated comparable catalyst. An effective attrition test was reported by Srinivasan et al.[36] Due to a limited availability of catalyst, the procedure was modified. Specifically, about 3.8 g of catalyst was charged with 15 g of dodecane to a 30 mL wide-mouth bottle of 3.3 cm O.D. The bottle was placed on a rolling mill turning at about 27 rpm for 533 hours. The resulting slurry was recovered, filtered, flushed with hexane and dried. Field emission scanning electron microscopy (FE-SEM) was used to observe and analyze the rolled FT catalysts. The instrument was a Hitachi S-4700 configured for SEM and energy-dispersive x-ray (EDX) spectroscopic analysis. Photo-micrographs were taken at various levels of magnification. The observe particle size distributions, selected microphotograph images were loaded into Gatan DigitalMicrograph(TM) version 3.10.0. The images were altered only to increase the contrast between the background and the particles, and in a few cases, small areas of the images were cropped out due to the density of the particles being too high (i.e. no black background was visible between particles). The particles were then digitally separated from the background using a threshold routine in the software. The particle size analysis routine in the software then measured the particles and generated an equivalent circular diameter for each one.

Results and Discussion

Note: a list of the FT experiments is given in Table 1; the results of the FT experiments using 0.4 or 0.1 g particulate catalyst experiments are summarized in Tables 2 and 3.

Reference FT Experiments Using Reactors with and without Particulate Catalysts:

Reference FT experiments were made with an empty reactor, an empty reactor onto which a thin inert film of alumina was deposited using ALD techniques, a reactor filled with α-alumina particulates, iron FT catalyst supplied by CAER, and a cobalt FT catalyst supplied by CAER. The iron- and cobalt-containing catalysts were tested using the procedure described in the preceding section.

a. Empty Reactor with and without ALD Al_2O_3 Inert Coating:

Reference FT experiments were carried out using an empty reactor. There was a nominal level of CO conversion presumably due to the presence of a catalytic surface on the thermocouples and stainless steel tubes. To reduce the active catalytic surface effect of the reactor, the stainless tube and associated fittings were coated with alumina using the ALD system. The results of both approaches are summarized in Figure 2 and Table 2. In summary, the level of CO conversion was reduced by about one-half when the stainless steel surfaces were coated with a several Angstrom layer of alumina. Also shown in Figure 2 is the CO conversion for the reference 0.4 g charge of JE740 catalyst consisting of a 50 Angstrom coating of Al_2O_3 on the SiO_2 with no active metals. The level of CO conversion of this later Al_2O_3 coated catalyst was essentially zero. A similar lack of reactivity of α-Al_2O_3 was observed in previous reference runs (see Runs 85A, 85C, 87C and 85F as shown in the previous report[15]). Subsequent experimental runs were made with the ALD coated reactor and associated fittings.

b. Iron-based CAER FT Catalyst Including the SiO_2 Coated Samples:

Two samples of FT catalyst were obtained from B.H. Davis of the Center of Applied Energy Research (CAER). The first consisted of a bulk spray-dried catalyst designated "RLS 4.4 Si/150 Cyclone Iron Catalyst" (RLS) and the second was freshly prepared catalyst designated "RJO 290 100Fe/4.6Si/1.44K."

Selected CAER catalyst samples were separated by differential settling to isolate fractions of differing particle diameter. As previously described,[15] as-received iron-containing CAER FT catalyst (RLS, above) was used in Runs 100 and 101, made at 268° and 284°C, respectively. With catalyst charges of about 0.70 g, 35 and 57% CO conversion levels were observed at mid-bed temperatures of 268° and 284°C, respectively. Based upon an overall carbon material balance, the selectivity of converted CO to hydrocarbons averaged 56%, with the remainder forming CO_2. Experiments with the "coarse" CAER catalyst, designated 72 CAER, were carried out at reaction temperatures between 267° and 290°C. The activity of the coarse CAER catalyst was equivalent to that of as-received CAER catalyst with the exception that nominally more CO_2 was generated (see the previous report[15]).

As an extension of the above research, selected iron-containing FT catalysts were coated with SiO_2 with the goal of increasing catalyst particle attrition strength. Approximately 24 g of fractal-coated CAER catalyst was prepared with a nominal SiO_2 concentration of 2.2 wt%.

The CO conversion activities of 0.40 g charges of the CAER iron-containing FT catalysts and the above SiO_2 coated catalysts were observed in Runs 78, 121, and 124. The results are presented in Table 5 and Figure 3. In summary, all of the iron-containing catalysts had equivalent CO conversion activity at similar operating conditions. With a gas feed of 1:1 H_2:CO, CO conversions rose exponentially from about 24% at 270°C to 46% at 290°C.

Experimentation Using Membranes:

Because the results of the membrane experiments have been reported [16] only a summary is included below.

a. Reference Runs with Al_2O_3 Coating:

The results of runs made with only an ALD Al_2O_3 coating on a SiO_2 membrane (i.e. no active metal coating) were essentially equal to those of runs made with an empty reactor and with a reactor in which the membrane center was removed. The average CO conversions were 0.44 % and 3.07 % at temperatures of about 250° and 285°C, respectively.

b. Ruthenium-Coated Membranes:

Three runs were carried out using Ru deposited using the ALD technique on the Al_2O_3 coated silica membranes. The observed levels of CO conversion were essentially at or below those of the Al_2O_3 support, alone. The estimated thickness of the Ru coating of catalyst JE289 (Run 59) was 4 Angstroms. This thickness is based upon a visual observation of a concurrently coated glass plate using a J.A. Woollam M2000 Spectroscopic Ellipsometer operating in the transmission mode. The goal was to use a minimum amount of Ru, but still to have a somewhat uniform Ru catalyst coating. This latter observation indicated that the coating was not uniform. Subsequent experimentation has resulted in improved ALD procedures using alternative Ru-containing precursors. In addition, it was observed that additional work is necessary to establish effective preconditioning conditions with Ru.

Four subsequent experiments were carried out using combinations of Ru and Fe ALD coatings on Al_2O_3 coated silica membranes. In summary, the conversions were low and the ALD techniques need to be improved.

Considering both the low levels of observed FT catalytic activity along with the anticipated catalytic activity of Ru stated in the literature, three problems may have existed as follows:

1. The amount of deposited Ru is too low,
2. The Ru deposition technique needs improvement, and/or
3. The preconditioning conditions are inadequate.

Therefore, it was decided to further develop the catalyst preparation procedure using uniform silica particulate supports of high surface area.

Experimental Results Using Particulate Catalysts:

a. Ruthenium and Platinum Coated Catalysts:

The goal of the third stage of this project was directed toward preparing active FT catalysts placed on porous particulate supports. As a continuation of the above membrane research, in selected cases electrochemically prepared anodic aluminum oxide materials were deposited on silica supports. On these supports were coated layer by layer active catalytic metals including ruthenium and palladium using the atomic layer deposition (ALD) technique.

The results of these FT experiments using a 0.4 g catalyst charge are summarized in Tables 2, 6, 7, and 8 and in Figure 4. The initial experiments were made with a minimal ALD coating of Ru on an ALD

coating of Al_2O_3 on a silica support (Runs 80 and 83 with JE751 and JE752, respectively) with the presumption that a thin uniform layer of Ru would demonstrate a high level of activity. This was not the case in that CO conversion levels fell in the range of 2% to 8% at temperatures between 275° and 295°C (see Figure 4). A run using a catalyst ALD coated with 1.1% Ru (JE989, Run 103) also resulted in a low level of CO conversion, namely, 3 to 6% at temperatures of 275° to 295°C. Characterization of these Ru catalysts indicated that the Ru coating was not uniform, and the overall ALD technique with the Ru precursor was not as effective as expected.

Two experiments made with Alfa Aesar Ru commercial catalyst with levels of 0.5 and 2.0 wt% Ru (Runs 93 and 96, respectively) resulted in higher levels of CO conversion; specifically, 2% to 4% and 3% to 12% at reactor temperatures of 260°C through 290°C, respectively. As will be shown these catalysts were not as effective as Co-containing catalysts. In addition, the commercial Ru-containing catalysts had essentially all of the active metal deposited on the surface. So it would be difficult to generalize how an increase in metal loading would affect activity.

A single experiment was made with a 9% level of ALD coated Pd (Run 107 with JE1033 catalyst). As noted in Tables 2 and 8 and Figure 4, this catalyst was relatively ineffective, specifically 3% to 7% CO conversion at reactor temperatures of 260°C through 290°C, respectively.

As indicated from the above membrane experiments with Ru metal, more research must be undertaken to both improve the deposition technique and perhaps the pre-conditioning stage. An improved ALD Ru deposition precursor has been found, but FT experiments were delayed and then not undertaken.

b. Cobalt Coated Catalysts (Including the Use of Pt as Promoter):

Due to the availability of Co-containing catalyst reference samples from CAER, experimentation was undertaken to evaluate these catalysts to provide a basis for comparison. In addition, we prepared ALD deposited Co with and without a Pt promoter on silica, alone, and on silica on which Al_2O_3 had been deposited. All of these catalysts exhibited high activities; therefore, the FT experiments were made with a reduced catalyst charge of 0.10 g to obtain a better comparison of catalyst activity between samples (see Table 3 for a summary of the results).

In our study of cobalt-containing catalysts, the following variables have been considered:

1. The effect of cobalt concentration (9 through 25% with an emphasis upon 16% and 25%).
2. ALD prepared vs. CAER reference catalysts.
3. Preconditioning (H_2 reduction) temperature, considering the APS study.
4. The effect of the addition of Pt as a promoter.
5. Support media (alumina, silica alone, and ALD alumina coated on silica).

There was a sizeable interaction between the effects of these variables. In some cases, it was not possible to separate these interactions due to the limitation of experimental time and funding.

<u>Effect of Co Concentration on the FT Catalyst:</u>

A series of ALD-prepared cobalt-containing catalysts was made using silica support on which a 50 nm ALD coating of Al_2O_3 had been deposited. The results of FT experiments are summarized in Tables 3, 10, 11, 12, and 17 and in Figure 5.

As shown in Figure 5, the level of CO conversion increased about linearly with the amount of ALD deposited Co in the range of 9% to 25% Co. With a reactor temperature of 280°C, a catalyst charge of 0.10 g, catalyst pre-conditioned at 400°C, and a feed of 2:1 H_2:CO ratio, the level of CO conversion was

estimated to be 4%, 6%, 12% and 16% for Co loadings of 9%, 11%, 17%, and 25%, respectively. The selectivity of CO conversion to hydrocarbons vs. conversion to CO_2 varied somewhat; specifically, the runs made with 11%, 17%, and 25% Co at the above conditions had selectivities of 85% to 97% while that made with 9% Co was low at about 40%. This later result may have been an anomaly, but the selectivity results of all of the runs made at various conditions with this specific catalyst charge were low.

Comparison of the ALD-prepared vs. CAER-prepared Co Catalysts:

One sample of CAER-prepared 15% Co on Al_2O_3 was also tested (Run 185). The CO conversion results are summarized in Tables 3 and 14, and Figure 5. In summary, the CAER catalyst was more active than that prepared using the ALD technique of depositing Co on Al_2O_3 that had also been deposited by the ALD technique on the silica support. The selectivity of CO conversion to hydrocarbons vs. conversion to CO_2 was high at 96% for the CAER catalyst at the reaction conditions cited above. Additional CAER samples of Co-containing catalysts were evaluated, but with a 350°C pre-conditioning temperature and/or Pt promoter. The results will be discussed later.

The above data indicates that depositing amorphous ALD Al_2O_3 layers onto a silica gel (SiO_2) support lowers the CO conversion efficiency of cobalt-containing FT catalysts. This is consistent with recent observations that ALD Al_2O_3 also yields lower conversion for oxidative dehydrogenation (ODH) catalysts. However, TiO_2 and Nb_2O_5 layers increased the conversion for these ODH catalysts. It would be interesting to examine these and other metal oxide materials as possible support layers for the FT catalysts. The combination of a silica support for particle strength plus a thin coating of an additional support capable of active metal/support interaction for increased overall FT activity should be effective. This aspect is beyond the funds and timing available under this program.

Effect of Preconditioning (H_2 Reduction) Temperature upon Catalyst Activity:

FT cobalt containing catalysts are preconditioned in H_2 to convert the surface oxide as follows:
$Co_3O_4 \rightarrow CoO \rightarrow Co^0$. The Co^0 is believed to be the active phase for the FT reaction, as discussed in the Introduction.

In a cooperative study between CAER and Argonne, selected CAER catalysts had been used in a catalyst preconditioning (H_2 reduction) study carried out in the Advanced Photon Source (APS) at ANL. A manuscript entitled "Fischer-Tropsch synthesis: Temperature programmed EXAFS/XANES investigation of the influence of support type, cobalt loading, and noble metal promoter addition to the reductive behavior of cobalt oxide particles" has been published.[37] The conclusions are presented below:

> "The use of the multiple-sample holder to carry out TPRXANES/EXAFS provided key information for verifying the nature of the chemical transformations occurring during catalyst activation in hydrogen, as well as providing insight into the resulting cobalt crystallite size. The first peak was assigned to the Co_3O_4 to CoO transformation and occurred over a comparable temperature range for the unpromoted catalysts, while the second peak was due to the CoO to Co^0 step, and depended strongly on the nature of the support, with the reduction of CoO in strongly interacting Co/Al_2O_3 extending beyond 700°C. For the catalysts studied in this work, direct Co formation during step one of the reduction process, could be ruled out. Direct reduction of larger Co_3O_4 to CoO crystallites during the first TPR peak was previously proposed by others. Another previously held view was that the first peak was assigned to reduction to CoO of a cobalt oxide surface phase not stabilized by the interaction with the support and was therefore more easily reduced. We detected no CoO formation during the first step, but only transformation from Co_3O_4 to CoO. Likewise, many authors have suggested that upon calcination, a mixed oxide of $(CoO)_x(Al_2O_3)_y$ is formed as a separate entity in addition to Co_3O_4 crystallite formation and responsible for the broad peak. In this contribution, we

did find that CoO is reduced in the broad peak, but it was first derived from the reduction of Co_3O_4 to CoO during the first peak. That is, the CoO phase was not already present as CoO in the catalyst directly after calcination (i.e., only Co_3O_4 was formed after calcination).

The results underscore the complex inter-relationships among the support interaction, the reducibility of the cobalt oxide species, and the resulting average cobalt metal cluster size formed. Support type, and not surface area, was found to be the key factor in determining the strength of the interaction and the rate at which the cobalt oxides underwent reduction. In addition, H_2 chemisorption/pulse reoxidation measurements and EXAFS indicated that the more weakly interacting support (in this case, SiO_2) yielded a much larger cobalt crystallite size which is detrimental to the resulting cobalt active metallic surface area. In contrast, after a standard reduction treatment, despite a much lower extent of reduction, the strongly interacting support (Al_2O_3) yielded much smaller cobalt crystallites. In fact, despite its relatively lower reducibility in comparison with 20%Co/SiO_2, unpromoted 15%Co/Al_2O_3 provided a higher cobalt metallic surface area after the 10 h reduction treatment, as measured by H_2 chemisorption. Gains in the extent of reduction of the strongly interacting 15%Co/Al_2O_3 catalyst were achieved by either (a) increasing the loading to provide a larger particle size that weakened the interaction with the support or (b) utilizing a noble metal promoter (i.e., Pt) to facilitate reduction, most likely by a hydrogen dissociation and spillover mechanism. Increasing the extent of reduction by Pt addition to 15%Co/Al_2O_3 led to the reduction of the tiny CoO species interacting with the support and, as measured by H_2 chemisorption, virtually doubled the number of active cobalt metal surface sites. Ideally, further development of the TPR-EXAFS technique would be beneficial. For example, findings ways to decouple the Debye–Waller factor from the coordination number as a function of temperature might allow for a determination of crystallite size during the TPR experiment."

Figure 6, drawn from the APS study, shows the progress of the Co reduction reaction as the temperature was increased in the Temperature Programmed Reduction (TPR) study. For both 15% and 25% Co on Al_2O_3 the Co_3O_4 to CoO reduction reaction started at about 150°C and appears to have been complete at about 400°C. The reduction of CoO to Co^0 appears to have started at about 400^0C and continued to temperatures above 700°C. The temperature cut-points were likely influenced by the rate of temperature rise and physical conditions within the TPR unit. The reduction reaction rates of the Co catalyst in the FT experimental unit are presumably similar.

The temperature used for the Co catalyst preconditioning in the FT series was originally set at 350°C, but as a result of the above APS study and initial FT experiments, it was increased to 400°C, which was near the design limit of the unit. Experiments were undertaken to confirm the effect of the preconditioning temperature upon catalyst activity. To insure reproducibility the operating procedures were set and used in all subsequent runs. See the Experimental Section for details.

The effect of preconditioning (H_2 reduction) on FT cobalt catalyst activity is shown in Tables 3, 11, 12, and 14, and in Figure 7. As noted in this later figure, the FT activity of 9.4% Co ALD coated catalyst when preconditioned at only 350°C was only marginally better than that of an empty reactor. However, there was a 3 to 5% increase of CO conversion when the catalyst was preconditioned at 400°C. With a Co level of 17%, there was about a 5% increase of CO conversion when the catalyst preconditioning was increased from 350° to 400°C. In the case of 15% Co catalyst obtained from CAER, the increase of CO conversion level ranged from about 5% to 15% (270° to 290° FT temperature, respectively) when the preconditioning temperature increased from 350°C to 400°C. Therefore, there is an obvious advantage in an increase of preconditioning temperature when testing Co-coated catalysts (without any promoters). If the active surface of the FT catalyst is Co^0, further increases of preconditioning would be of advantage; however, operating temperature limits of the unit would control the system.

Effect of the Addition of Pt as a Promoter:

As observed in the above APS study of Co catalyst preconditioning with H_2 reduction, the addition of Pt as a promoter greatly enhanced the Co reduction process (see Figure 6). Therefore, a series of FT experiments was undertaken to observe the interaction of Pt addition and preconditioning temperature upon FT catalyst activity.

The results of experiments made with CAER-supplied catalysts are given in Tables 3 and 14 and in Figure 8. The overall conversions of CO of these catalysts can be compared at a reactor temperature of 280°C. The use of 15% Co CAER catalysts preconditioned at 350° and 400°C resulted in CO conversions of 13% and 24%, respectively. With the addition of 0.5% Pt and a preconditioning temperature of 400°C, the level of CO conversion increased to about 56%. This confirms the conclusion of the above APS study and the associated publication[37] that the addition of a promoter such as Pt greatly increases catalytic activity after preconditioning.

The results of FT experiments made with ALD-prepared catalysts with a support of Al_2O_3 deposited on SiO_2 are shown in Figure 9. Consistent with the above, the overall conversions of CO of these catalysts can be compared at a reactor temperature of 280°C. The use of 17% Co ALD catalysts preconditioned at 350° and 400°C resulted in CO conversions of about 7% and 12%, respectively. These levels of CO conversion were about one-half of those of the equivalent CAER catalysts; note the previous discussion concerning the effect of ALD Al_2O_3 deposition.

With the deposition of 2% Pt on the 17% ALD Co catalysts, there was a major change of catalyst activity. Namely, about 50% CO conversion was observed at a FT reaction temperature of 280°C for both the 350° and 400°C preconditioned catalysts. This catalyst was one of the early Pt deposition trials, and the resulting 2% Pt level was excessive. As will be discussed later, the reaction mechanism was probably altered and the catalyst probably functioned as a Pt catalyst as opposed to a Co catalyst with a Pt promoter.

As also noted in Figure 9, the ALD deposition of Pt at a level of 0.5% on a 25% Co on ALD Al_2O_3 generated an active catalyst. Specifically, CO conversions were about 15% and 38% for the 25% Co catalysts without and with Pt, respectively.

Effect of the Use of Silica as Support Along with the Interaction of Co and Pt:

Figure 10 provides a comparison between the ALD-Al_2O_3 and SiO_2 supported catalysts when the level of Co was 25% and the preconditioning temperature was limited to 400°C. The activities of the Al_2O_3 and SiO_2 supported catalysts with no promoter were equal. With the deposition of about 0.6% Pt, the activity of the SiO_2 supported catalyst was about double that of the Al_2O_3 supported catalyst. Therefore, there is a strong interaction of Co metal, Pt promoter and silica support.

See also Figure 11 which includes the effect of preconditioning temperature on the ALD prepared catalysts. The primary observation is that catalyst activity was greatly enhanced by the deposition of Pt on the Co/SiO_2 catalyst in combination with the increased preconditioning temperature. Considering the reference FT reactor temperature of 280°C, the most active catalyst was that containing 25% Co and 0.67% Pt with a preconditioning temperature of 400°C; the observed CO conversion level was about 85%. This conversion level was about twice that observed with the equivalent Co/Pt (25/0.5) catalyst deposited on ALD Al_2O_3. The 16% Co/2% Pt ALD deposited catalyst was very active (namely, 55% and 67% CO conversion at preconditioning temperatures of 350°C and 400°C, respectively). Of course, the high level of Pt (2%) is again noted as being excessive.

Figure 12 is included to show a direct comparison between Al_2O_3 and SiO_2 supported catalysts along with appropriate CAER-prepared catalysts. In summary, the CAER catalyst is preferred in the case of unpromoted catalysts. While the activities of the promoted catalysts are equivalent, the levels of Pt are greater in the ALD-prepared samples, so further runs with lower levels of Pt were needed before effective comparisons could be made.

Comparison of Catalyst Supports and Promoters Using 25% Co as the Active Metal:

Based upon the above results, experimentation was directed toward the use of various supports and promoters with 25% Co as the level of active metal. In addition, the catalyst pre-reduction step was limited to a temperature of 400°C. The experiments were also limited to the use of 0.1grams of active catalyst charge so that direct comparisons could be made.

As noted in Figure 13, CO conversion followed a power law correlation with reaction temperature in the range of about 230° to 280°C. Catalysts consisting of 25% Co deposited using the ALD technique on either silica or alumina ALD-deposited on silica had essentially the same CO conversion activity (note Runs 8 and 12). Two experiments (Runs 53 and 75) made with a 25% Co on alumina catalyst prepared by CAER using incipient wetness exhibited reasonable reproducibility. In addition, these later two runs demonstrated that this catalyst was about three times as active for CO conversion as the ALD prepared catalyst.

A comparison of experimental results of catalysts promoted with a low level of Pt, namely 0.1%, is presented in Figure 14 (note also Tables 20 and 21). In all cases, the use of 0.1% Pt as a promoter increased CO conversion activity. The use of the ALD technique to deposit Pt increased the activity by about 15%. The use of the incipient wetness technique to deposit this low level of Pt was shown to be more effective. The most active catalyst was prepared at CAER using incipient wetness in which the Co-containing catalyst was first calcined and then exposed to the Pt solution followed by a second calcination (note Runs 59 and 70). An intermediate activity catalyst was also prepared at CAER, but the Pt solution was introduced prior to the Co calcination step. As noted in Figure 14, there remains some question of the difference of activities with order of calcination due to the results observed at about 265°C. In any event, the incipient wetness technique is more effective than the ALD technique for Pt deposition. This may be due to an observation that ALD deposits a smooth film of metals while incipient wetness approach may result in islands of active metals. Therefore, "edge effects" and the likes may influence adsorption of CO, H_2 and various hydrocarbons on the surface and therefore increase its activity.

The effectiveness of depositing low levels of Ir and Ru on the 25% Co catalyst is shown in Figure 15. Ir deposited by both incipient wetness and ALD was shown to be a more effective promoter than Pt or Ru. Again the incipient wetness technique was best. Ru was shown to be only about 60% as effective as Ir.

TPR-EXAFS/XANES Evaluation of Ir Promoted 25% Co Catalyst:

TPR-EXAFS/XANES experiments were carried out over 0.1% iridium-doped 25%Co/Al_2O_3 catalysts in order to (1) assess the effectiveness of Ir as a promoter of cobalt oxide reduction and (2) evaluate the effectiveness of the incipient wetness impregnation (IWI) technique for adding the Ir precursor by comparing a catalyst prepared by IWI to one prepared by atomic layer deposition (ALD).

The reduction of Co_3O_4 clusters takes place in two steps: $Co_3O_4 + H_2 \rightarrow 3CoO + H_2O$ and then $3CoO + 3H_2 \rightarrow 3Co0 + 3H_2O$; this has been demonstrated by a TPR-EXAFS/XANES investigation of Pt deposited on the 25% Co/Al_2O_3 catalyst ; note reference 37 and the summary presented above. One aim of the work was to determine if Ir promotes the reduction of Co_3O_4 to CoO and/or CoO to the Co metal

and to evaluate differences in cobalt crystallite size following TPR. The experimental procedure has been reported; again see reference 37.

TPR-XANES profiles (Figures 16 - 18) in all cases reflect a two-step reduction process for the reduction of Co_3O_4, whereby the first step, which is completed between 300° and 350°C is $Co_3O_4 + H_2 \rightarrow 3CoO + H_2O$, followed by a second step whereby $CoO + 3H_2 \rightarrow 3Co0 + 3\ H_2O$. It is clear that even at 750°C, this step did not achieve complete transformation to CoO. Examining first the unpromoted 25% Co/Al_2O_3 catalyst, reduction of Co_3O_4 to CoO is rapid - the catalyst achieves close to 50% conversion of Co_3O_4 to CoO at 322°C and 100% CoO at ~342°C. Reduction of CoO to Co, the step which generates the active phase for FT, is relatively slower. 50% of the CoO is converted to the metal at ~506°C.

With incorporation of 0.1% Ir promoter by IWI, the first step of reduction is hardly impacted, with 50% of the Co_3O_4 converting to CoO at 318.3°C and 100% CoO at ~343°C. However, the second reduction step is clearly more rapid, and 50% of the CoO is converted to the metal at 406°C, a reduction in temperature of 100°C relative to the unpromoted catalyst. This result suggests that Ir oxide itself reduces in the same range of temperature as the first step of cobalt reduction, such that the Ir metal can only facilitate the second step of reduction – one likely possibility being a H_2 dissociation and spillover mechanism, whereby Ir reduces to the metal and facilitates the nucleation of CoO within the CoO domains. However, while spillover is an attractive explanation, one cannot rule out the possibility of a direct chemical effect (e.g., from alloying formation) that is responsible for facile reduction.

Not surprisingly, the addition of 0.1% Ir by atomically dispersing iridium by ALD resulted in slight, but measurable decreases in the temperatures required to achieve 50% conversion of Co_3O_4 (~274°C), 100% CoO (322°C), and 50% transformation of CoO to the metallic Co (374°C).

The TPR-EXAFS results of Figures 19 and 20 confirm the interpretation of the TPR-XANES data. In all of the TPR-EXAFS spectra, it is evident that cobalt-oxide and cobalt-cobalt coordination reflect Co_3O_4, and that the oxide converts to a second oxide, CoO, due to the changes in cobalt-oxide and cobalt-cobalt coordination (i.e., between 300 and 350°C). Finally, only Co-Co coordination of the first coordination shell of metallic cobalt appears at higher temperatures. The more facile reduction of CoO to Co^0 in the 0.1% Ir-promoted 25%Co/Al_2O_3 catalyst compared to the unpromoted catalyst is evidenced by the presence and slow loss of the Co-O peak at low atomic distance in the EXAFS spectra plotted of the unpromoted catalyst as a function of time at 500°C. This peak is absent in the 0.1% Ir –promoted catalysts during the temperature hold at 500°C.

The reduced catalysts were analyzed following cooling to ambient conditions. According to the Fourier transform magnitude plots and the results of EXAFS fittings, there is no measurable difference within experimental error in the coordination number for Co-Co metal that would suggest a significant difference in Co particle size. This result suggests that increases in Co conversion due to gains in Co site densities are the result of a higher extent of reduction of CoO to Co^0, the direct result of the role that Ir plays in promoting cobalt oxide reduction.

<u>Arrhenius Plots of Selected Catalytic Runs:</u>

As shown in Figures 21 through 24, the FT runs exhibited similar linear Arrhenius correlations with equal slopes with the exception of the runs in which high levels of Pt promoter were present. First, the activation energy of the empty reactor that had been ALD-coated with Al_2O_3 was about 28.3 Kcal/mol. The average of the FT runs of the two CAER-prepared catalysts with 15%Co without Pt was 32.0 Kcal/mol, and that of the 0.5 % Pt promoted catalyst was about 29.5 Kcal/mol. The average activation energy of the various ALD-prepared Co catalysts was 28.6 Kcal/mol. The average of all of the FT runs

with particulate Co-containing FT catalysts, including those with low levels of Pt promoter, was about 29.2 Kcal/mol. Therefore, it appears that there was a common reaction mechanism. On the other hand, the activation energies of the FT runs with catalysts containing 2% Pt promoter were significantly lower at 14.4 Kcal/mol and 21.7 Kcal/mol for the ALD catalysts having about 16% Co on Al_2O_3 and SiO_2, respectively (see Figures 23 and 24.) It is apparent that the reactions taking place on these later catalysts were different (perhaps a combination of water-gas-shift and FT with an influence of gaseous diffusion).

Results of Attrition Tests of the SiO_2 Coated CAER Iron FT Catalysts:

As described above, selected iron-containing FT catalysts were coated with SiO_2 with the goal of increasing catalyst particle attrition strength. Approximately 24 g of fractal SiO_2-coated CAER catalyst was prepared with a nominal SiO_2 concentration of 2.2 wt%.

The attrition strength of this later catalyst was then compared with that of a sample of uncoated comparable catalyst. The attrition testing procedure is described in the above Experimental Procedure. Field emission scanning electron microscopy (FE-SEM) was used to observe and analyze the recovered samples of solids after they had been rolled for an extended time. Photo-micrographs were taken at various levels of magnification, and the particles were digitally measured using an equivalent circular diameter for each.

Typical photomicrograph images of the coated and non-coated catalysts are shown in Figures 25 and 26. The resulting images are similar. The recorded particle size distributions are shown in Figures 27 and 28 (distributions of individual counts and cumulative counts, respectively). In summary, there appears to be no difference between the coated and non-coated samples and even with those of the unrolled samples.

Selected particles of coated and non-coated catalysts were scanned with higher magnification using the SEM along with energy-dispersive x-ray (EDX) spectroscopic analysis. Typical results of the coated catalyst are shown in Figures 29a, 29b, and 29c (500X, 2500X, and 6,000X, respectively). The EDX surface quantification scans of the coated and non-coated particles were taken at 2,500X. The surface Si:Fe ratios (observed without standards) were 0.031 and 0.020 for the coated and non-coated samples. These ratios confirm that the surface was coated with additional SiO_2. However, as observed in Figures 29b and 29c, this coating did not appear to be uniform, and it would probably not protect the particles from abrasion.

This aspect of attempting to coat iron-containing FT catalysts with fractal SiO_2 was then discontinued. The following reasons are noted:

1. There was a lack of uniform fractal SiO_2 coating,
2. The results of attrition testing were not definitive, and
3. The length of process time to prepare coated catalysts was excessive (particularly for a commercial-scale process).

To provide a better comparison of attrition strengths, it would be necessary to both prepare additional coated samples and increase the scale of the procedure to match that of the above reference attrition test procedure.[36] Due to a lack of available time and funding, emphasis was placed upon the other aspects of this program.

Observations and Conclusions

Considering that the research program was divided into three areas, the overall program conclusions are also reported in a similar manner; namely, A. Iron-containing catalyst attrition improvement, B. Membrane catalyst preparation and evaluation, and C. Preparation of active particulate catalysts using atomic-layer-deposition (ALD) of active metals and/or promoters. In addition, the conclusions drawn from the APS study of Co- and Fe-containing catalyst conditioning are included for completeness as Section D.

A. The following observations/conclusions were drawn from the study of preparing shape-selective catalysts that would retain the active metal sites in a protected "cage:"

1. Iron-based catalysts can be prepared at ANL using the techniques outlined in the CAER reports, but a high degree of mixing must be introduced to generate more uniform particle sizes. (The use of spray-drying catalyst particles should generate a more uniform particle size distribution as demonstrated at CAER.)

2. The spray-dried bulk catalyst sample of CAER contains a high level of dispersed fine particles. A portion of these fines can be removed by differential settling techniques.

3. A flow unit with a fixed bed of diluted catalyst has been demonstrated for use in FT experimentation with these later CAER iron-containing catalysts.

4. Reaction conditions have been established such that reasonable levels of CO conversion can be achieved with an active catalyst. These conditions can be used as a basis to compare catalyst samples.

5. SiO_2-coated iron-containing catalyst samples have been prepared using caustic precipitation techniques. A wide range of catalytic activities have been observed. The greatest activity was achieved with those catalysts coated with the least SiO_2 (i.e. 2.2 wt %). Specifically, the activities of catalyst samples designated 135A/550 and 135A/475 were about equal to that of the CAER coarse FT catalyst from which they were prepared.

6. In the case of the 135A series, calcination at 550°C and 475°C resulted in more active catalysts than that calcined at 400°C.

7. SiO_2-coated catalysts were prepared using acidic precipitation techniques; HNO_3 and HCl were effective while those with H_2SO_4 were not.

8. Bulk samples of SiO_2-coated and non-coated Fe-containing catalysts were prepared using the preferred HNO_3 technique. The catalysts had comparable activity. The attrition test, as set up at Argonne, was not able to differentiate between the strengths of the two catalysts. SEM observations were also unable to differentiate between the two samples. Considering the time necessary for the coating technique and potential commercialization costs, this study was discontinued with the concurrence of DOE.

9. SEM study indicated that the as-received CAER catalyst recovered after differential sedimentation (132E) consisted of large (~50-70 μm) and small (~15-30 μm) spherical agglomerates along with small chips. The catalyst particles recovered from FT runs had similar appearances. SEM, even at 150K magnification, did not appear to be an effective tool to differentiate various surface treatment procedures.

10. Large spherical particles of Fe-containing FT catalysts were made up of agglomerates of particles that were, in turn, also agglomerates.

11. Chips of broken catalyst particles had clean, smooth surfaces that had higher Fe/Si atomic ratios than those of the rough external surfaces, even in the case of the CAER as-received sample. The chips were the result of particle crushing, and they should represent the inside catalyst material. Therefore, the Si precursor was transported to the surface during the spray drying catalyst preparation process.

12. The EDX Fe/Si ratio analyses of the surface of catalyst particles recovered after the FT reaction were the same as those of the fresh catalyst.

13. The C/Fe atomic ratio of the surface of a recovered FT catalyst particle was high at about 6.6, while that of a smooth particle chip was only 1.0. That of fresh catalyst averaged 0.4. Therefore, there was only a limited penetration of carbon (i.e., CO) into the FT catalyst during the pre-conditioning step with CO.

-- In summary, experimentation has demonstrated that fractal SiO_2 can be coated upon FT catalysts with a minimum loss of activity. It doesn't appear that the attrition strength of these catalysts can be effectively increased by this route.

B. Membrane preparation and evaluation:

1. The flow unit that was modified for the testing of coated membranes has been used successfully at FT reaction conditions. The membranes were held in place during the runs, and all of the gas flow was directed through the membranes.

2. The atomic layer deposition (ALD) of Ru and Fe has been carried out on Al_2O_3 coated silica membranes, but improvements need to be made to increase catalyst activity and increase active surface area.

C. The following conclusions are drawn from experimentation using particulate FT catalysts:

1. The most effective prepared FT catalyst was one containing cobalt deposited on a silica support that was subsequently ALD coated with about 0.6% Pt promoter. This catalyst had about the same FT activity as a similar Co and Pt on Al_2O_3 catalyst prepared by CAER. The goal for proposed future experimentation was to determine if lower levels of Pt will be as effective and could they be deposited on selective active sites.

2. The addition of Pt greatly promotes the preconditioning of Co-containing catalysts. This is valid for both ALD and CAER prepared catalysts.

3. The use of Pt at high levels of coverage (i.e. 2.0% vs. 0.5%) changes the overall reaction and is not recommended.

4. Both FT and TPR-EXAFS/XANES experiments were carried out over 0.1% iridium-doped 25%Co/Al_2O_3. These demonstrated that Ir was an effective promoter for facilitating the second step of cobalt oxide reduction, CoO to Co^0, and the incipient wetness method was found to be nominally superior to that of the ALD technique.

5. The preconditioning of Co-containing catalysts is best done at a temperature of 400°C (or higher). This is confirmed from both the above FT reaction experiments and the APS series that was published and is summarized below.

6. The catalyst activity of Co deposited on ALD-deposited Al_2O_3 on silica was less than that of an ALD-deposited Co active surface on silica alone. (Other supports have been found to be superior to Al_2O_3 in other reactions, so further studies are needed.)

7. The CAER-prepared Co catalyst deposited on Al_2O_3 was more active than ALD-prepared Co catalyst deposited on ALD-coated Al_2O_3 catalyst.

8. The FT activity of ALD-coated Co catalysts on Al_2O_3 is about linear with Co level from about 9 to 25%. Therefore, there is a question about the uniformity of the ALD deposition process and atomic level interactions with the Al_2O_3 deposited surface.

9. Catalysts containing Pt and Ru that were ALD-deposited on an ALD-Al_2O_3 coated catalyst support were found to be relatively inactive. Commercial catalysts of Ru on Al_2O_3 were also rather ineffective.

10. The average activation energy of the rate of CO conversion was about 29.2 Kcal/mol when all of the Co-containing catalysts including those with low levels of Pt were taken into account. The activation energies of the catalysts with high levels of Pt were greatly different.

D. The following conclusions were drawn from the experimentation undertaken using the Advanced Photon Source (APS) of Argonne National Laboratory for the preconditioning (reduction) of Co-containing FT catalysts:

1. TPR-XANES/EXAFS provided key information for verifying the nature of the chemical transformations occurring during FT cobalt-containing catalyst activation in hydrogen.

2. A two-step reduction process involving Co_3O_4 to CoO and CoO to Co^0 transformations over standard calcined catalysts was quantified over catalysts exhibiting both weak interactions (e.g., Co/SiO_2) and strong interactions (e.g., Co/Al_2O_3) with the support.

3. Cobalt loading and noble metal promoter addition (e.g., Pt) strongly affected reducibility and resulting cobalt crystallite size.

4. Increased reduction temperatures were needed to effectively reduce Co-containing catalysts deposited on strongly interacting surfaces when compared with those of unsupported Co_3O_4 or weakly supported Co catalyst.

5. The addition of the noble metal promoter greatly reduced the temperature needed to reduce the Co oxides to active metal Co surfaces.

Cited References

1. H. Schulz and M. Claeys, "Special Issue: Recent Advances in Fischer-Tropsch Synthesis," in *Applied Catalysis A: General*, 186, 1-433 (1999).

2. G.P. van der Laan and A.A.C.M. Beenackers, *Catal. Rev.-Sci. Eng.*, 41(3&4), 255–318 (1999).

3. C. N. Satterfield, *Heterogeneous Catalysis in Industrial Practice*, 2nd Ed., Krieger Publ. Co., Malabar, FL, 1996.

4. B. H. Davis, *Technology Development for Iron Fischer-Tropsch Catalysts, Final Technical Report*, December 18, 1990—December 17, 1993, DE96005561, DOE/PC/90056--T17, 12/31/96.

5. C. L. Kibby, *Patent Application Publication No. US 2002/0188031 A1,* Dec. 12, 2002.

6. D. B. Bukur, et al., *Journal of Catalysis* 155, 353–365 (1995).

7. M. D. Shroff, et al., *Journal of Catalysis* 156, 185–207 (1995).

8. R. L. Espinoza, A. P. Steynberg, B. Jager, and A.C. Vosloo, *Applied Catalysis A: General* 186, 13-26 (1999).

9. D. S. Kalakkad, M. D. Shroff, S. Kohler, N. Jackson, and A. K.Datye, *Applied Catalysis A: General* 133, 335-350 (1995).

10. R. J. Gormley, P.W. Deffenbaugh, and M.F. Zarochark, "In-situ Filtration of Fischer-Tropsch Product Wax from Iron-based Catalysts," National Laboratory Catalysis Conference 2000, Argonne, IL, Oct. 12–13, 2000.

11. C. J. Brinker, D. E. Clark, and D. R. Ulrich, eds., *Materials Research Soc. Sym. Proceedings* 32, Elsevier Science Pub. Co., Inc., 1984; Note the following chapters: *1*. D. W. Schaefer and K. D. Keefer, Structure of Soluble Silicates," p. 1-14, *2*. K. D. Keefer, "The Effect of Hydrolysis Conditions on the Structure and Growth of Silicate Polymers," p. 15–24, *3*. C. J. Brinker, et al., "A Comparison between the Densification Kinetics of Colloidal and Polymeric Silica Gels," p. 25–32, and *4*. L. C. Klein and G. J. Garvey, "Effect of Water on Acid- and Base-Catalyzed Hydrolysis of Tetraethylorthosilicate," p. 33–39.

12. C. J. Brinker and G. W. Scherer, *Sol-gel Science: The Physics and Chemistry of Sol-gel Processing,* Boston, Academic Press, 1990.

13. L. C. Klein, ed., *Sol-Gel Technology for Thin Films, Fibers, Preforms, Electronics, and Specialty Shapes*, Noyes Publications, 1988.

14. R. Zallen, *The Physics of Amorphous Solids*, John Wiley & Sons, Inc., 1983.

15. D.C. Cronauer, "Shape Selective Catalysts for Fischer-Tropsch Chemistry: Iron-Containing Particulate Catalysts; Activity Report: January 1, 2001-December 31, 2004" August 2005.

16. D.C. Cronauer, "Shape Selective Catalysts for Fischer-Tropsch Chemistry: Membrane Catalysts; Activity Report: January 1, 2005-September 30, 2005" 2006.

17. E. Iglesia, Appl. Catal. A: General 161 (1997) 59.

18. G. Jacobs, Y. Ji, B.H. Davis, D.C. Cronauer, A.J. Kropf, C.L. Marshall, Appl. Catal. A: General 333 (2007) 177.

19. G. Jacobs, T.K. Das, Y. Zhang, J. Li, G. Racoillet, B.H. Davis, Appl. Catal. A 233 (2002) 263.

20. L. Guczi, D. Bazin, I. Kovacs, L. Borko, Z. Schay, J. Lynch, P. Parent, C. Lafon, G. Stefler, Z. Koppany, I. Sajo, Top. Catal. 20 (1–4) (2002) 129.

21. A. Kogelbauer, J.G. Goodwin Jr., R. Oukaci, J. Catal. 160 (1996) 125; D. Schanke, S. Vada, E.A. Blekkan, A.M. Hilmen, A. Hoff, A. Holmen, J. Catal. 156 (1995) 85.

22. D. Schanke, S. Vada, E.A. Blekkan, A.M. Hilmen, A. Hoff, A. Holmen, J. Catal. 156 (1995) 85.

23. G. Jacobs, T.K. Das, Y.-Q. Zhang, J. Li, G. Racoillet, B.H. Davis, Appl. Catal. A: General 233 (2002) 263.

24. A.M. Hilman, D. Schanke, A. Holmen, Catal. Lett. 38 (1996) 143.

25. A.M. Hilmen, D. Schanke, K.F. Hanssen, A. Holmen, Appl. Catal. A 186 (1999) 169.

26. G. Jacobs, T.K. Das, Y.-Q. Zhang, J. Li, G. Racoillet, B.H. Davis, Appl. Catal. A: General 233 (2002) 263.

27. Guczi, L., Bazin, D., Kovacs, I., Borko, L., Schay, Z., Lynch, J., Parent, P., Lafon, C., Stefler, G., Koppany, Z. & Sajo, I. (2002). Top. Catal. 20, 129-139.

28. Jacobs, G.; Chaney, J.A.; Patterson, P.M.; Das, T.K.; Maillot, J.C.; and Davis, B.H., Journal of Synchrotron Radiation 11 (2004) 414-422.

29. Jacobs, G.; Chaney, J.A.; Patterson, P.M.; Das, T.K.; and Davis, B.H., Applied Catalysis A: General 264 (2004) 203-212.

30. Jacobs, G.; Ribeiro, M.C.; Ma, W.; Ji, Y.; Khalid, S.; Sumodjo, P.T.A.; Davis, B.H., Applied Catalysis A: General 361 (2009) 137-151.

31. P.C. Stair, C. Marshall, G. Xiong, H. Feng, M.J. Pellin, J.W. Elam, L. Curtiss, L. Iton, H. Kung, M. Kung, H.H. Wang, *Topics In Catalysis* 39 (2006) 181.

32. J.W. Elam, M.D. Groner, S.M. George, *Reviews of Scientific Instruments* 73 (2002) 2981.

33. A.W. Ott, J.W. Klaus, J.M. Johnson, S.M. George, *Thin Solid Films* 292 (1997) 135.

34. O. Nilsen, M. Lie, S. Foss, H. Fjellvag, A. Kjekshus, *Appl. Surf. Sci.* 227 (2004) 40.

35. T. Aaltonen, P. Alen, M. Ritala, M. Leskela, *Chemical Vapor Deposition* 9 (2003) 45.

36. R. Srinivasan, L. Xu, R.L. Spicer, F.L. Tungate, and B.H. Davis, *Fuel Science & Tech. Int'L*, 14(10), (1996) 1337-1359.

37. G. Jacobs, Y. Ji, B.H. Davis, D.C. Cronauer, A.J. Kropf, C.L. Marshall, *Applied Catalysis A, General* 333 (2007) 177-191.

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Figure 1
Bench Scale Catalytic Unit

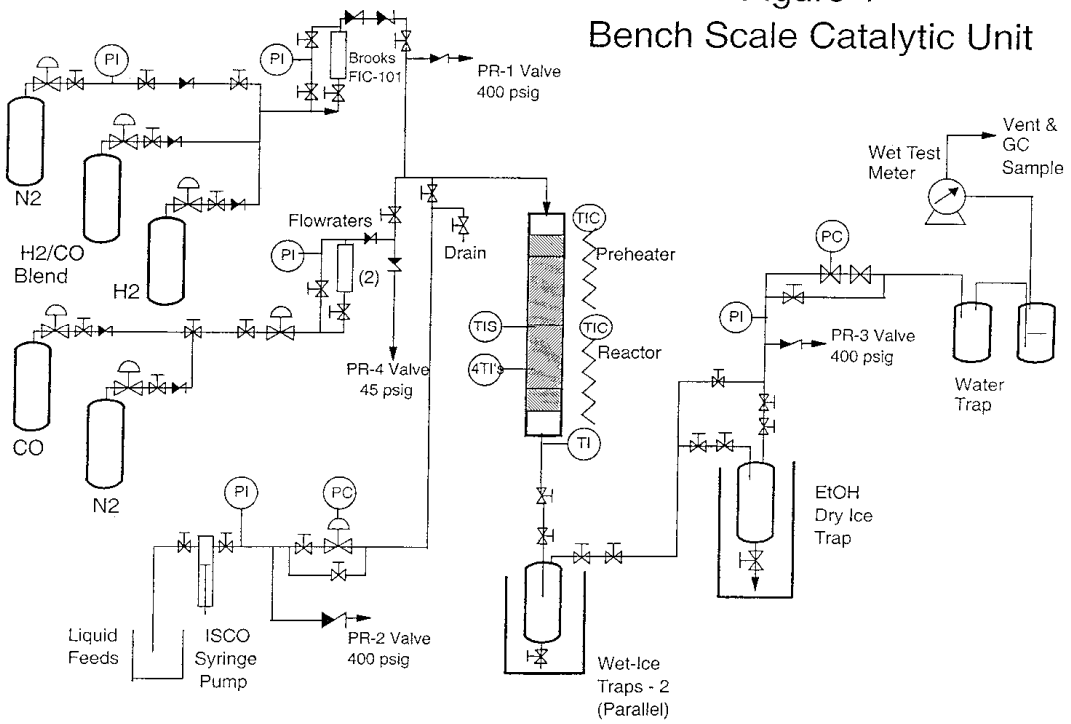

Figure 2: CO Conversion Reactor Reference Series
(2:1 H2:CO Feed Gas)

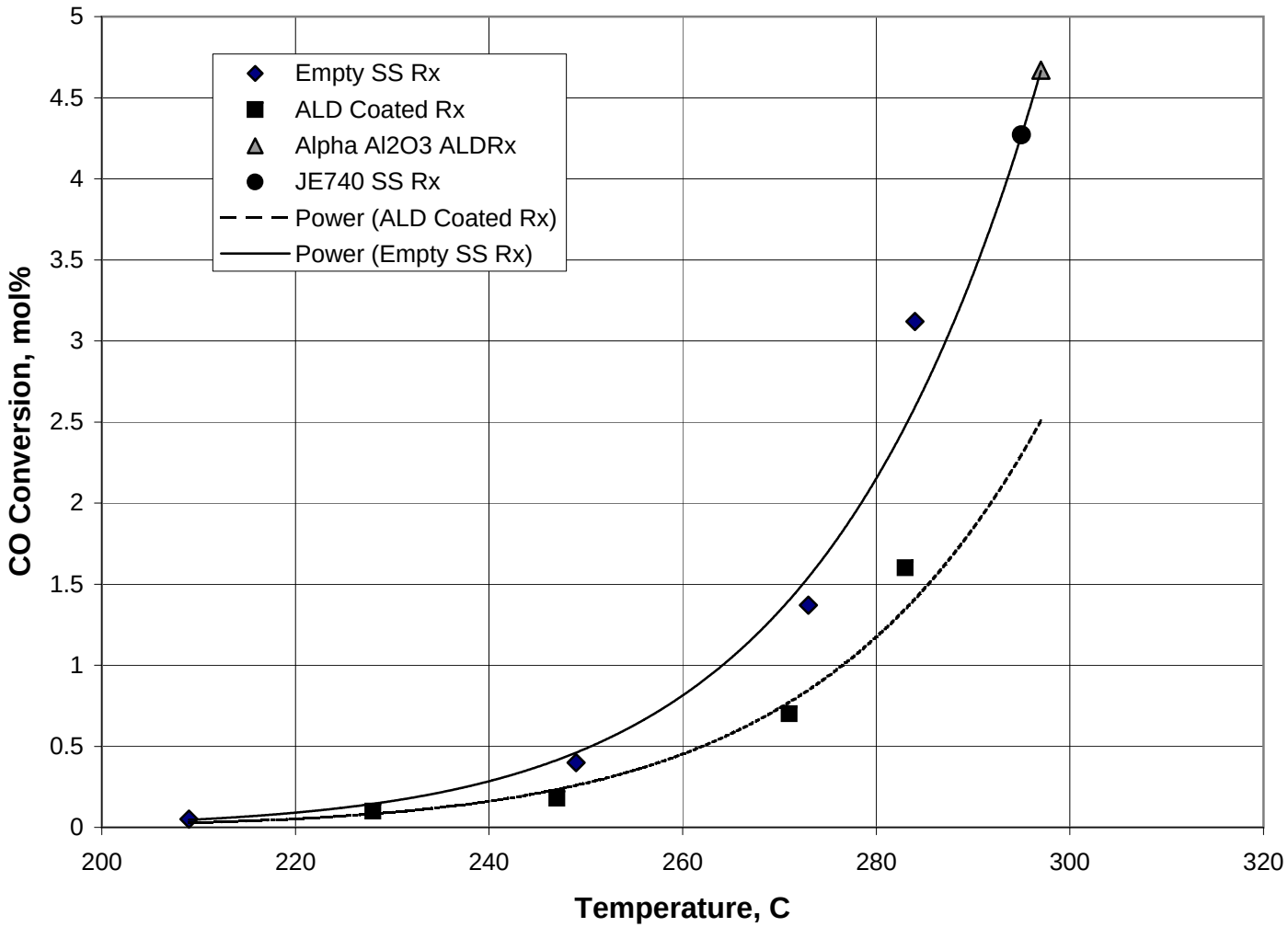

Figure 3: Iron-containing Catalyst Reaction Series
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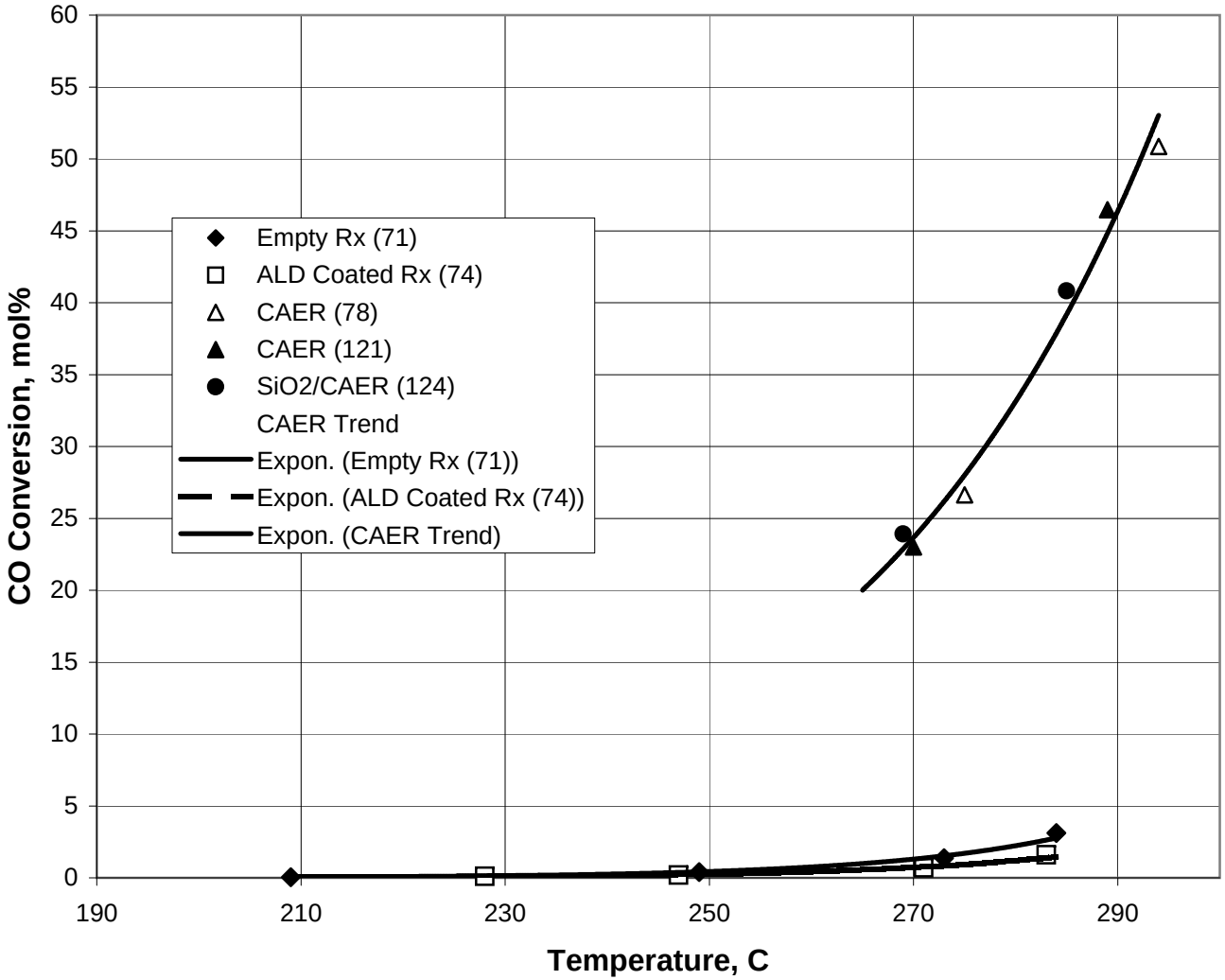


Figure 4: Ru- and Pd-containing Catalyst Reaction Series
(1:1 H2:CO Feed Gas; 0.4 g Catalyst Charge)

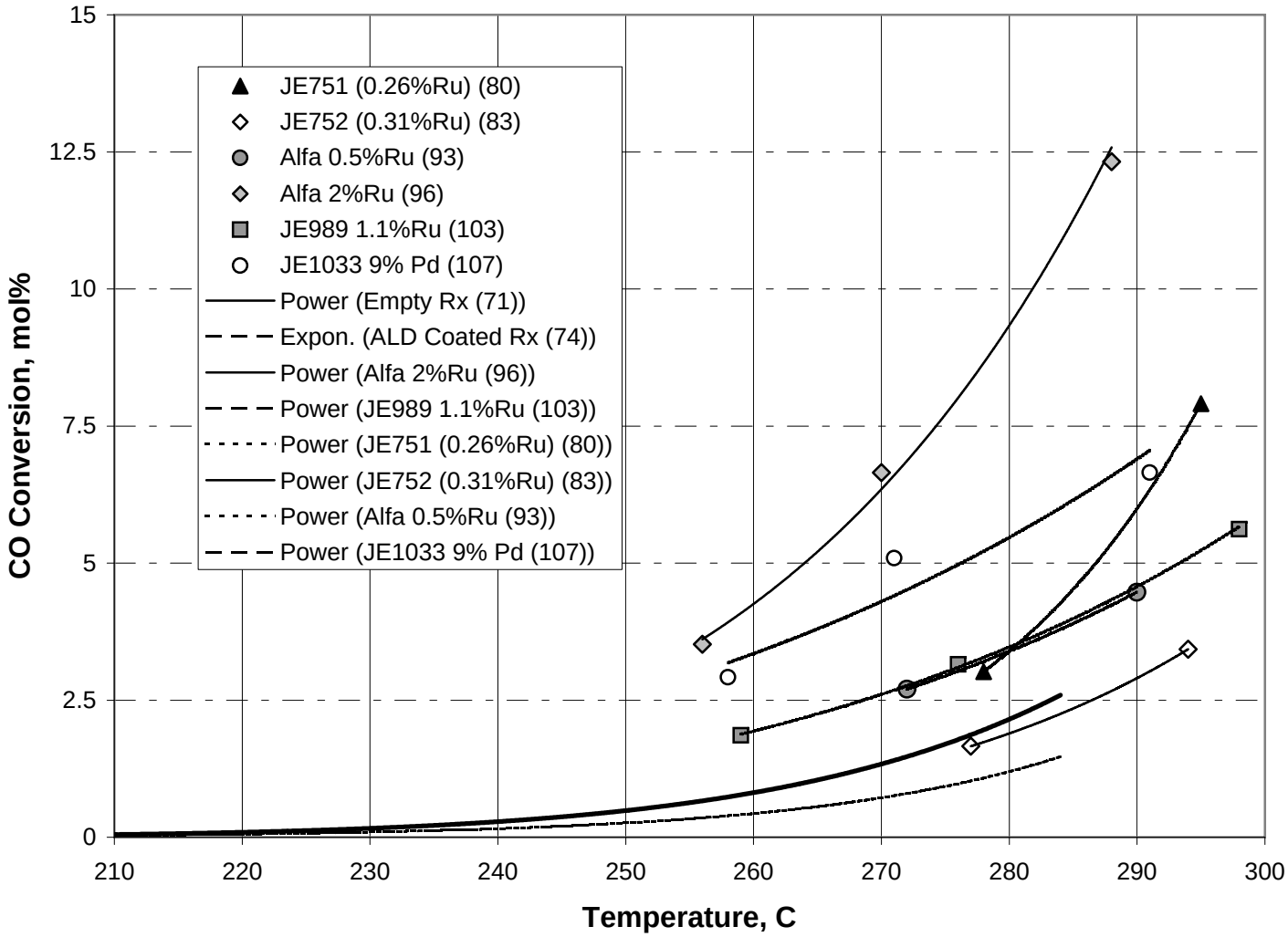
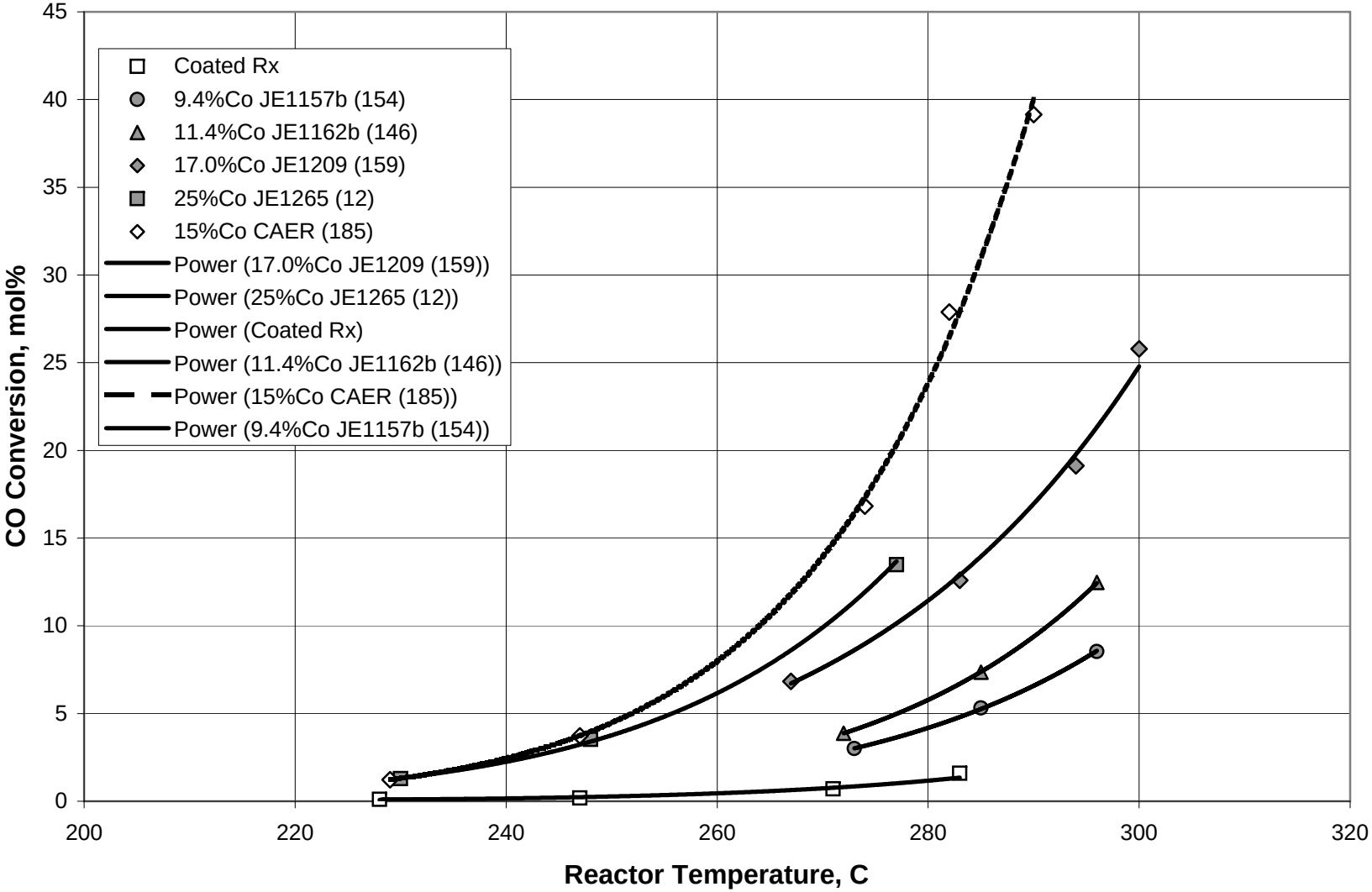
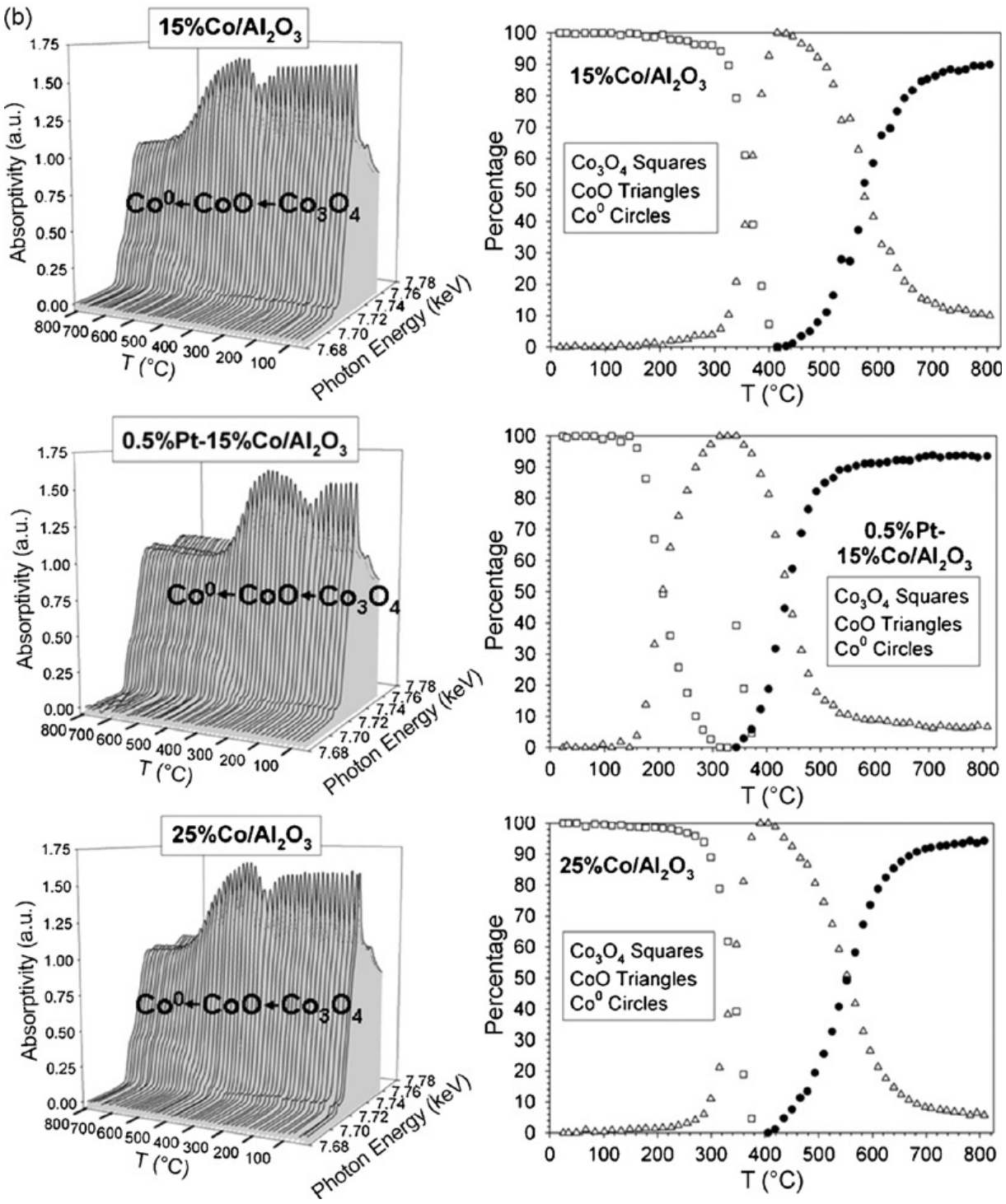


Figure 5: ALD Co & CAER Co on Al2O3 Catalyst Reaction Series
(0.1 g Catalyst Charge; 400C Reduction)





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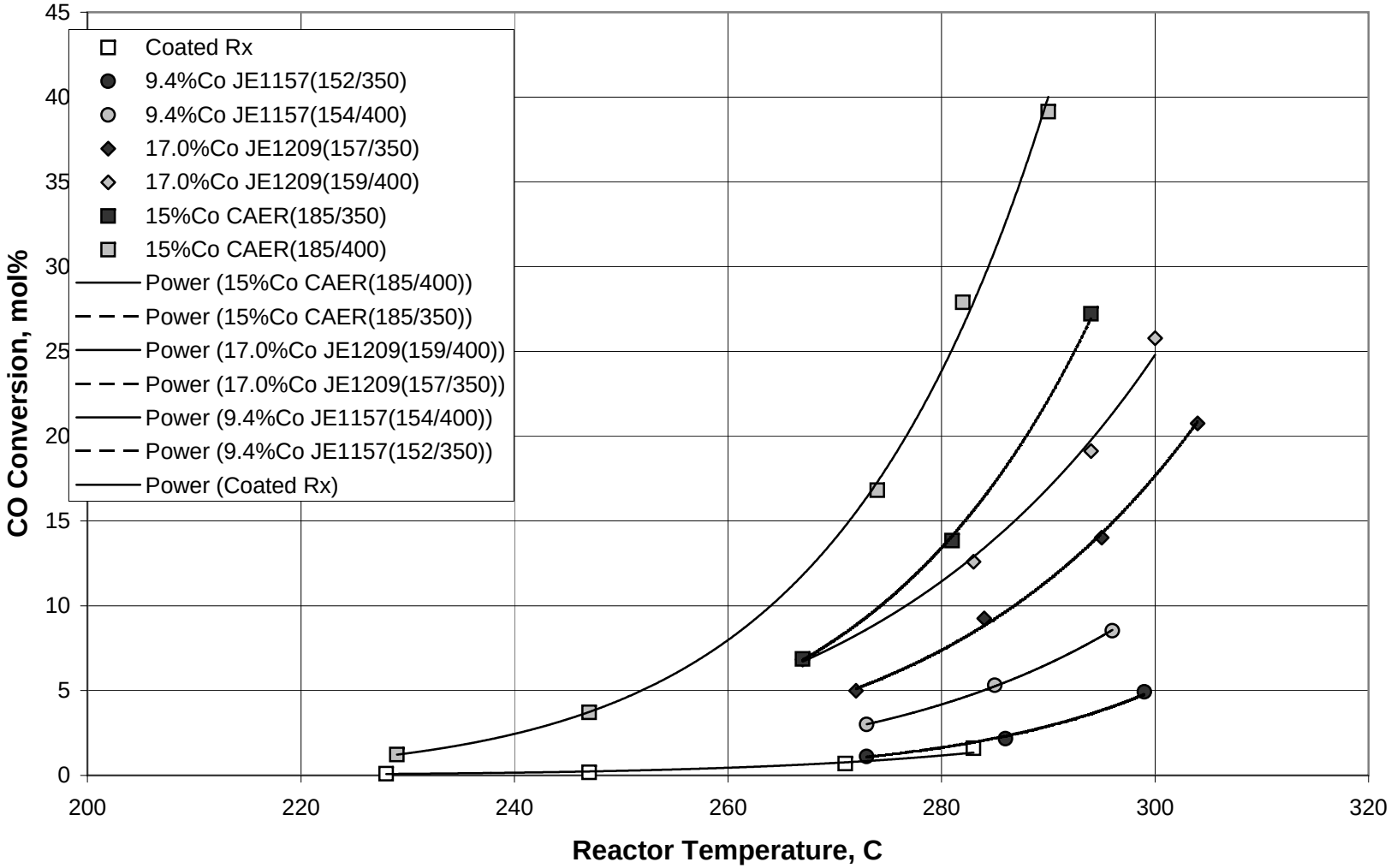


Figure 8: Effect of Pt Addition upon CAER Co Activity with 350C and 400C Reduction (0.1 g Catalyst Charge)

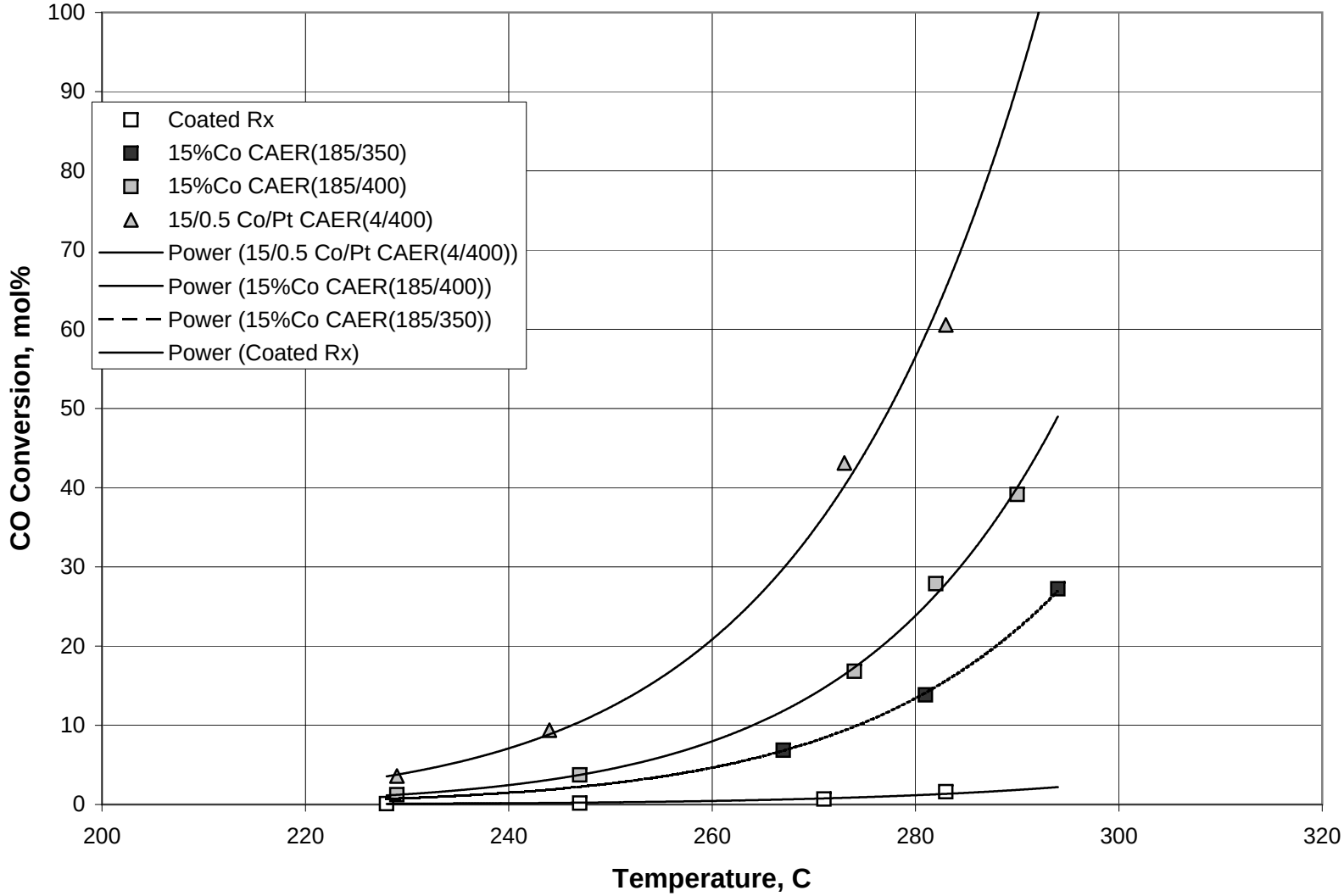


Figure 9: Effect of Pt Addition upon ALD Co Activity with 350C and 400C Reduction (0.1 g Catalyst Charge)

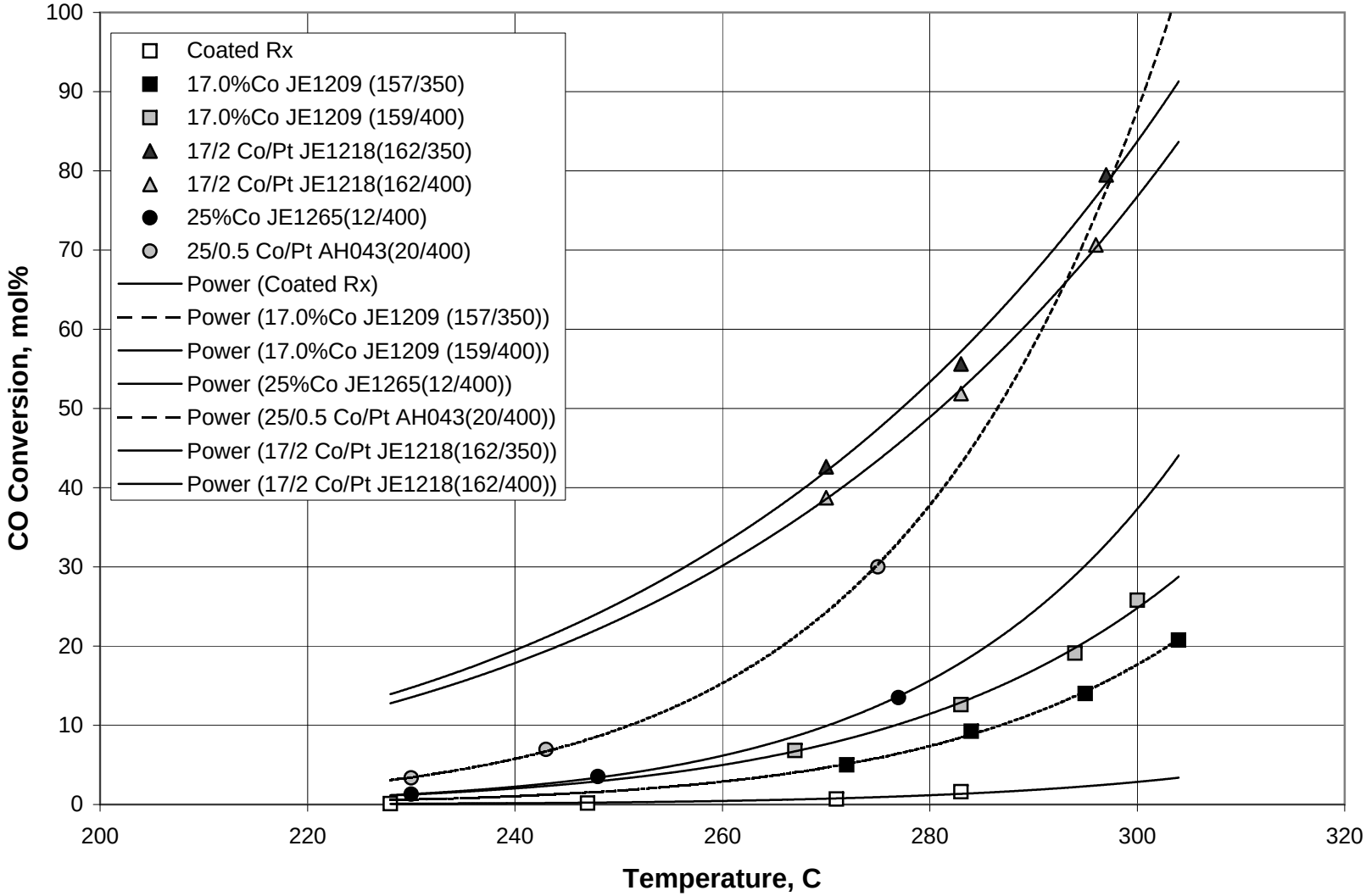


Figure 10: Comparison of Support and Pt Addition with 25% Co ALD Catalysts (400C Reduction; 0.1 g Catalyst Charge)

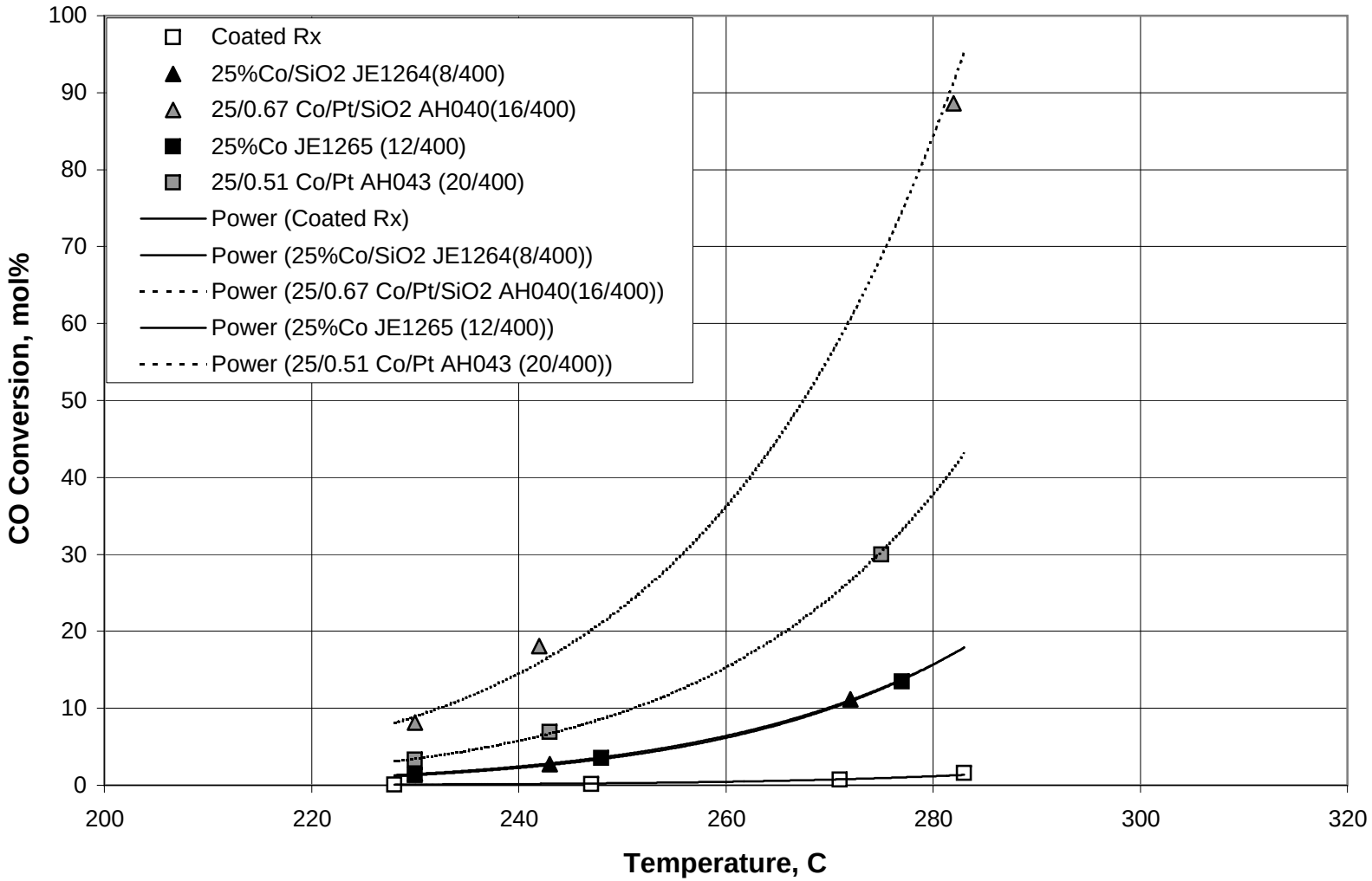


Figure 11: ALD Silica Support; Effect of the Interaction of Co Level and Pt Addition (0.1 g Catalyst Charge)

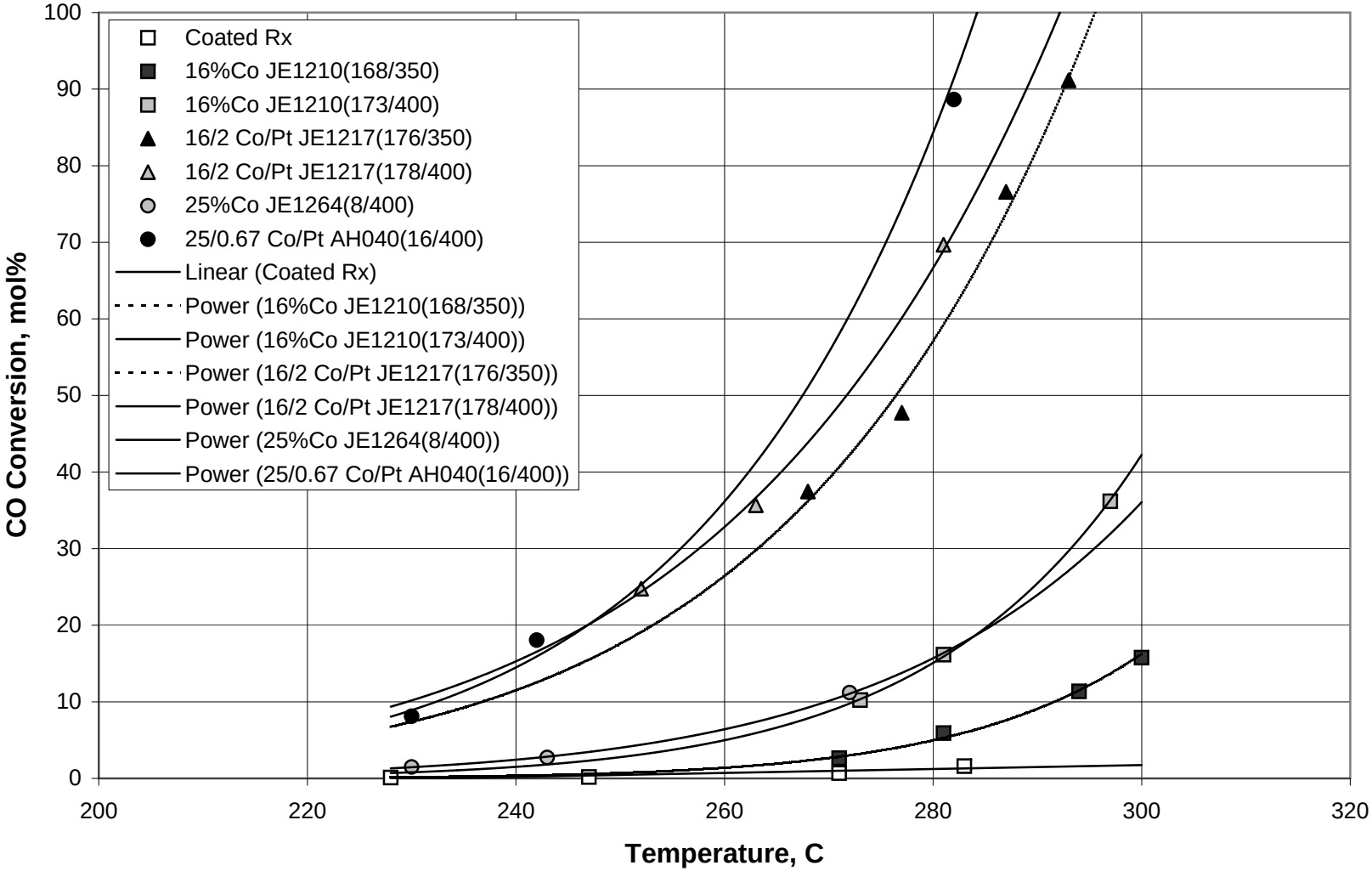
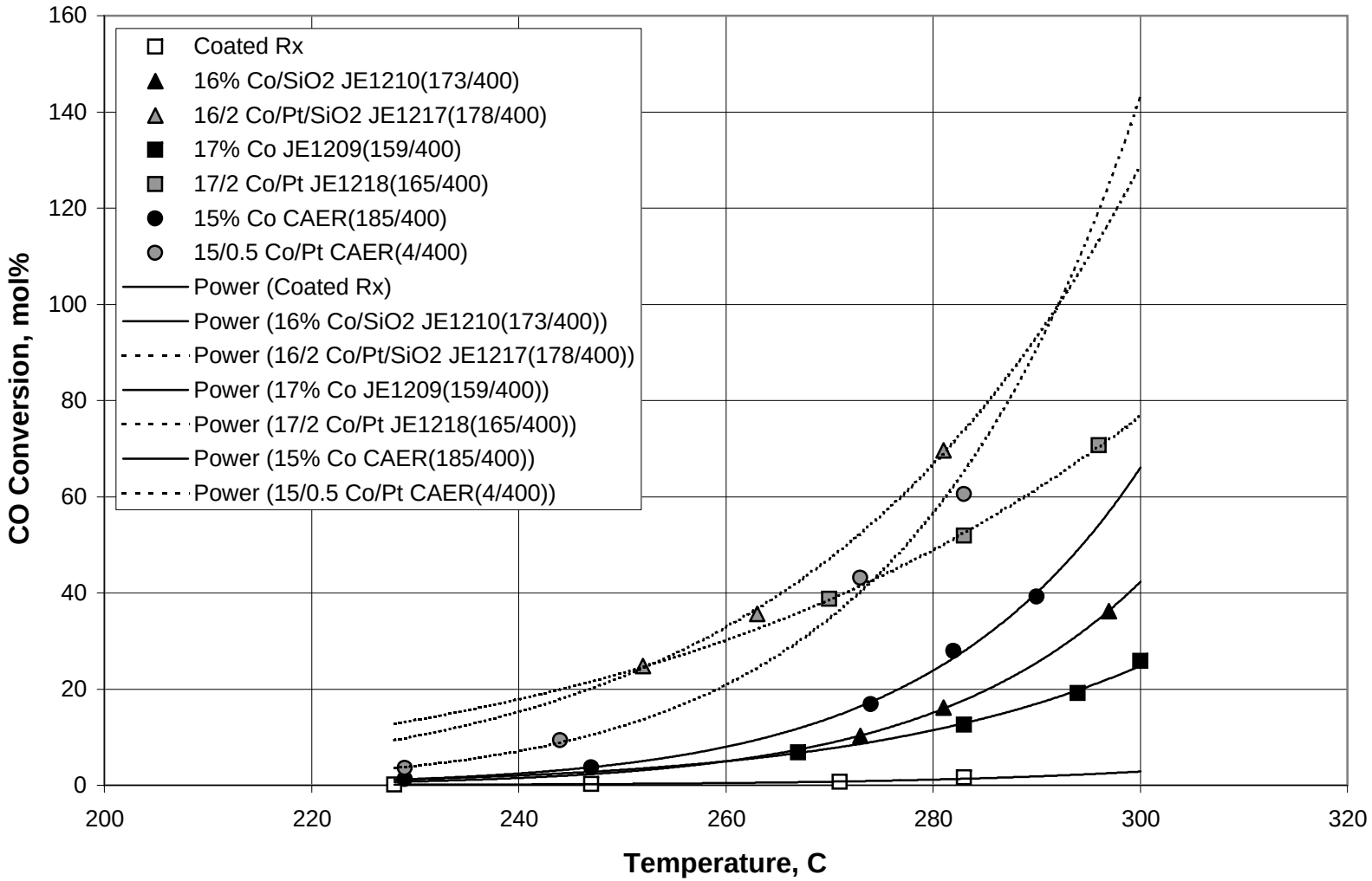


Figure 12: Comparison of Support and Pt Addition with 15 - 17% Co Catalysts (400C Reduction; 0.1 g Catalyst Charge)



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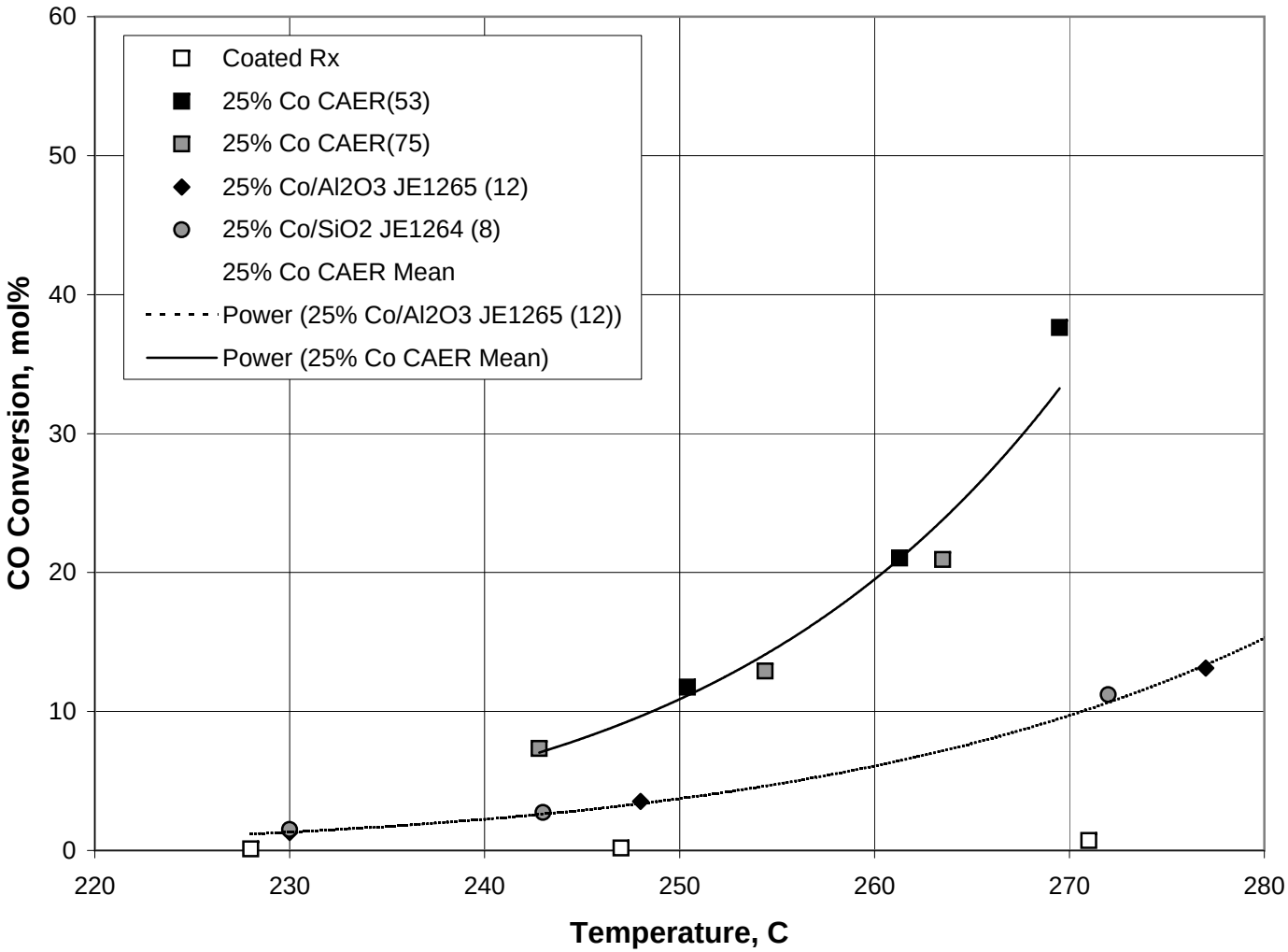


Figure 14: Comparison of Pt Addition Techniques with 25% Co Catalysts (400C Reduction; 0.1 g Catalyst Charge)

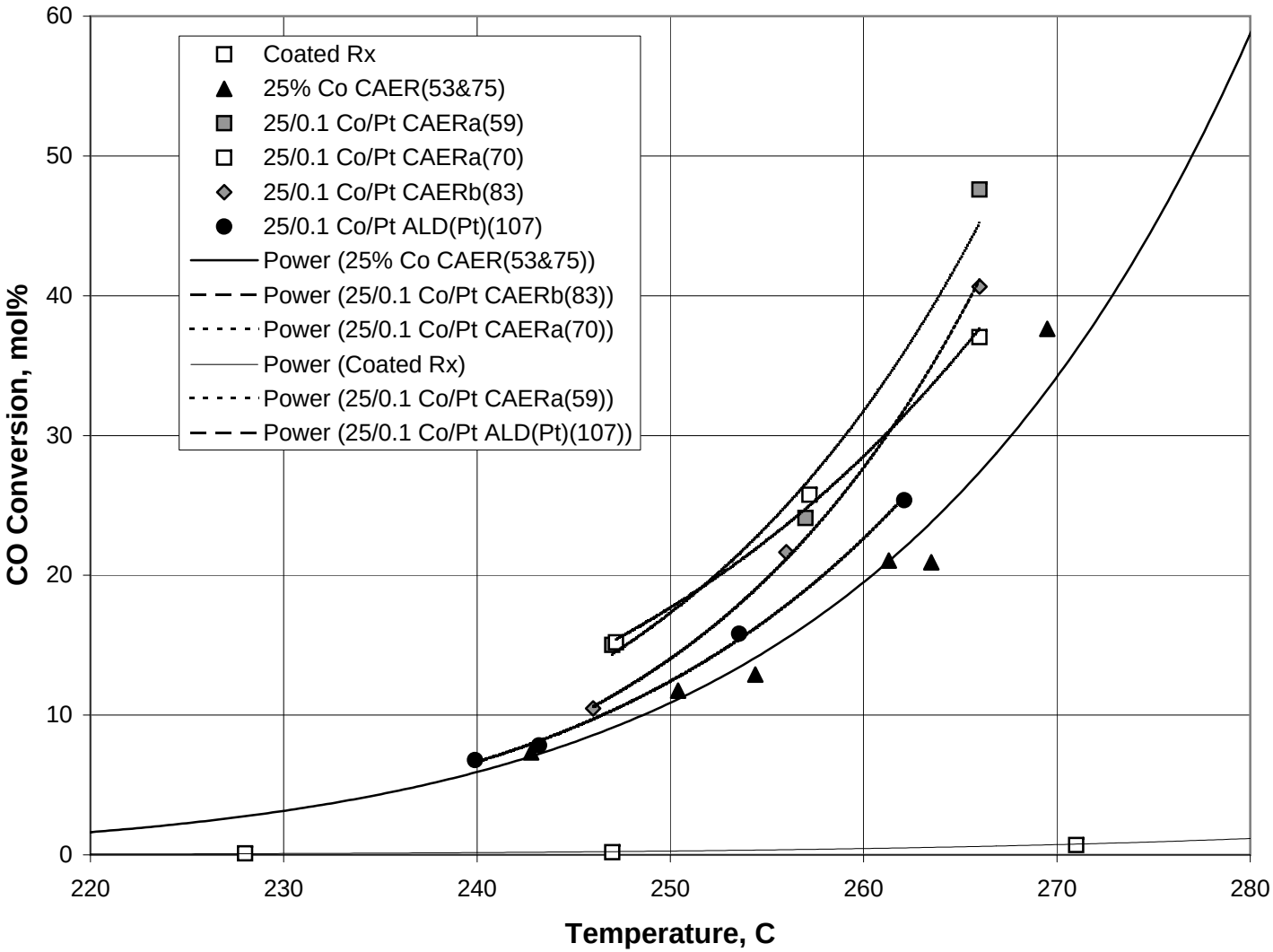
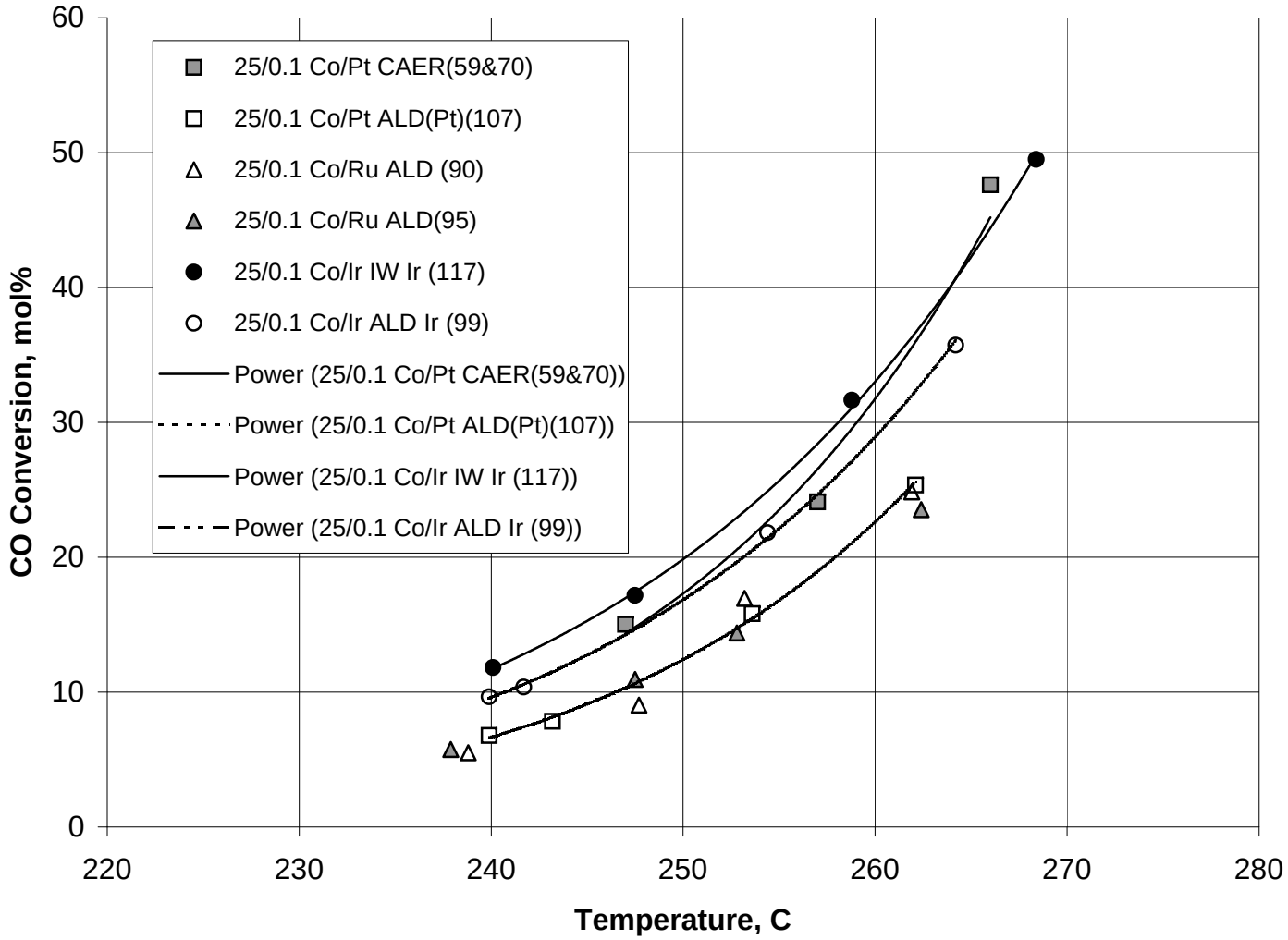


Figure 15: Comparison of Various Promoters with 0.1% Deposited on CAER 25% Co Catalysts (400C Reduction; 0.1 g Catalyst Charge



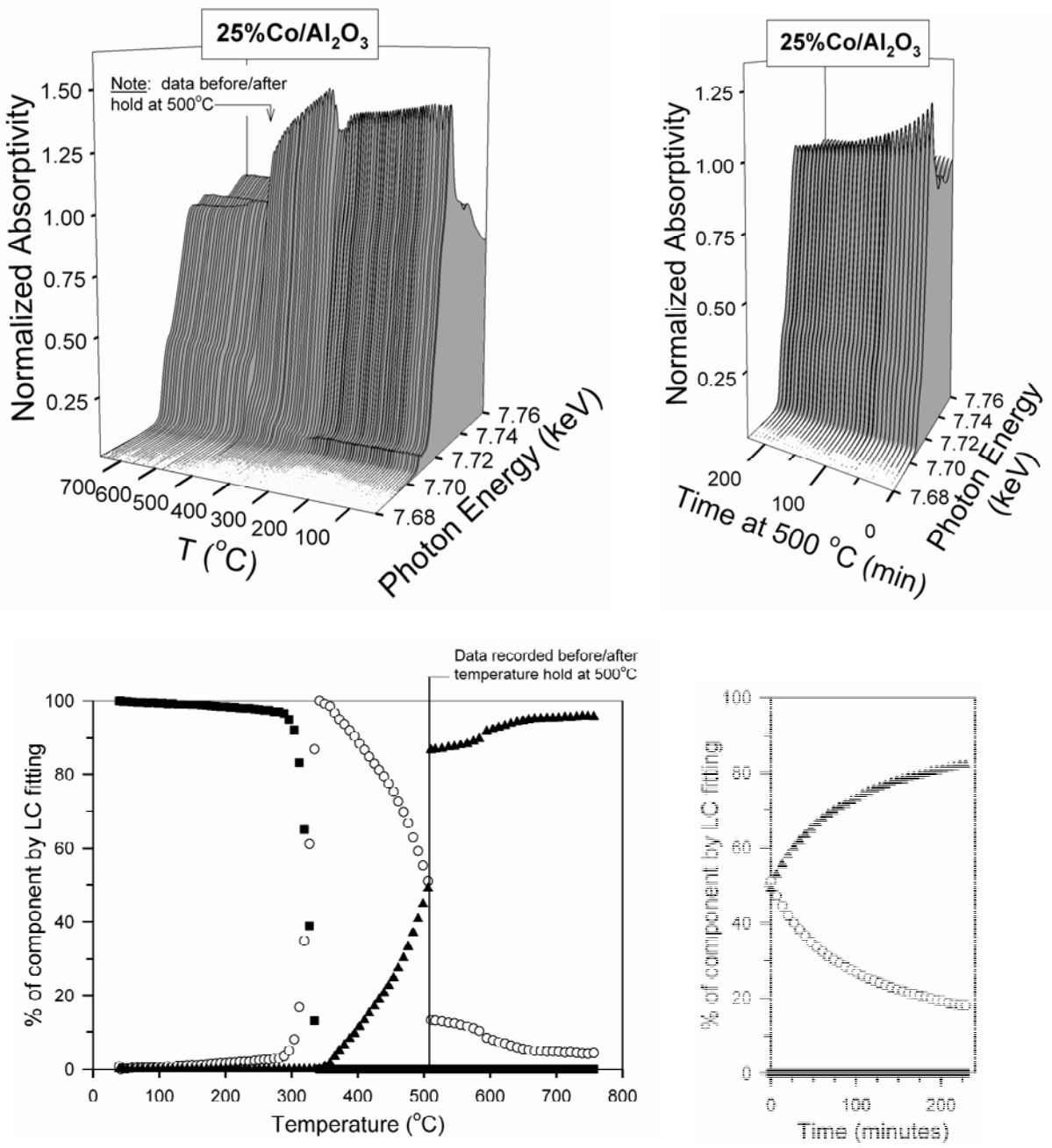


Figure 16: Hydrogen TPR-XANES profile for the unpromoted 25%Co/Al_2O_3 catalyst as a function of (top left) temperature and (top right) time at 500°C. Linear combination fittings as a function of (bottom left) temperature and (bottom right) time are provided.

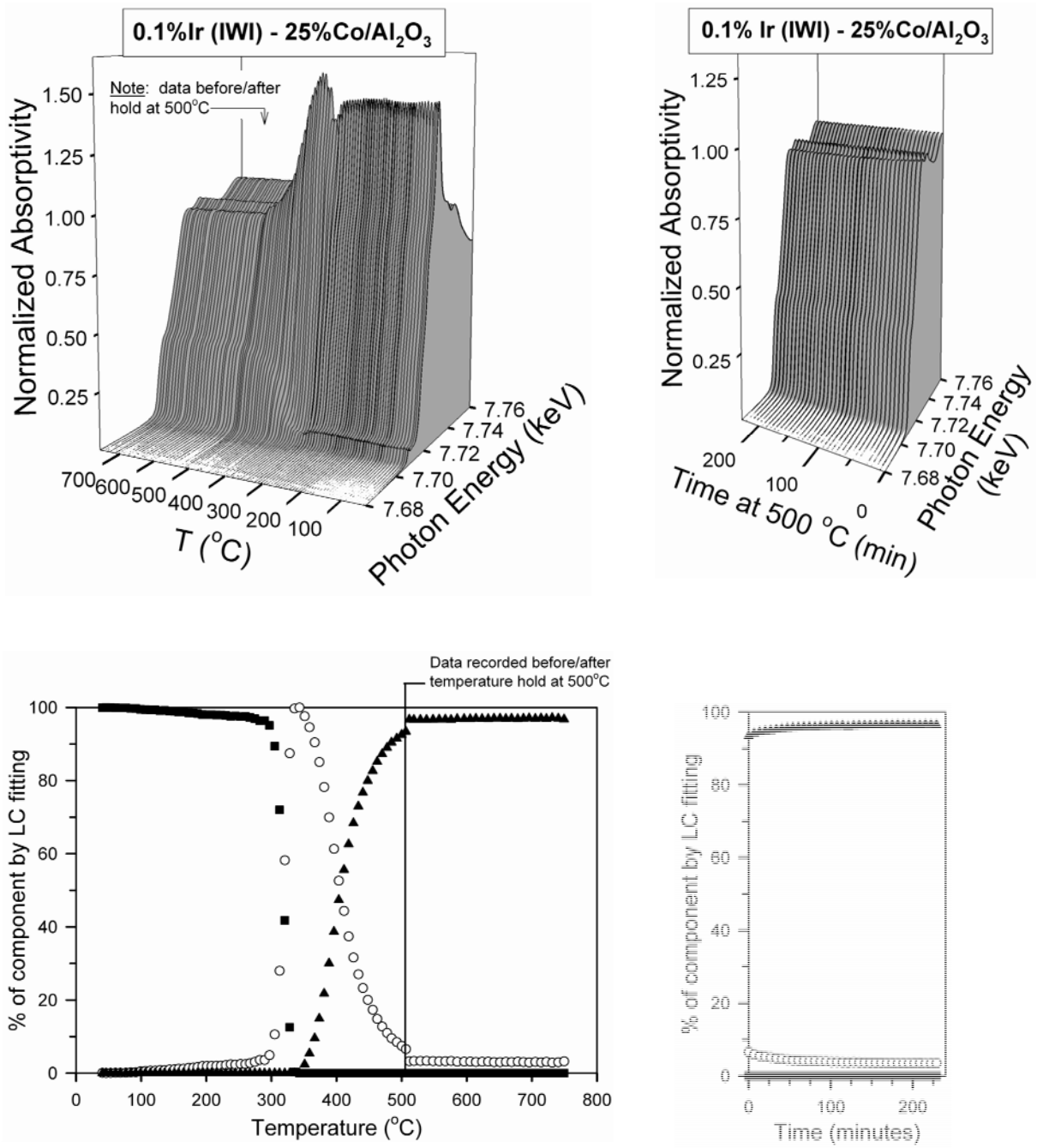


Figure 17: Hydrogen TPR-XANES profile for the 0.1% Ir promoted 25%Co/Al_2O_3 catalyst prepared by IWI of Ir as a function of (top left) temperature and (top right) time at 500°C. Linear combination fittings as a function of (bottom left) temperature and (bottom right) time are provided.

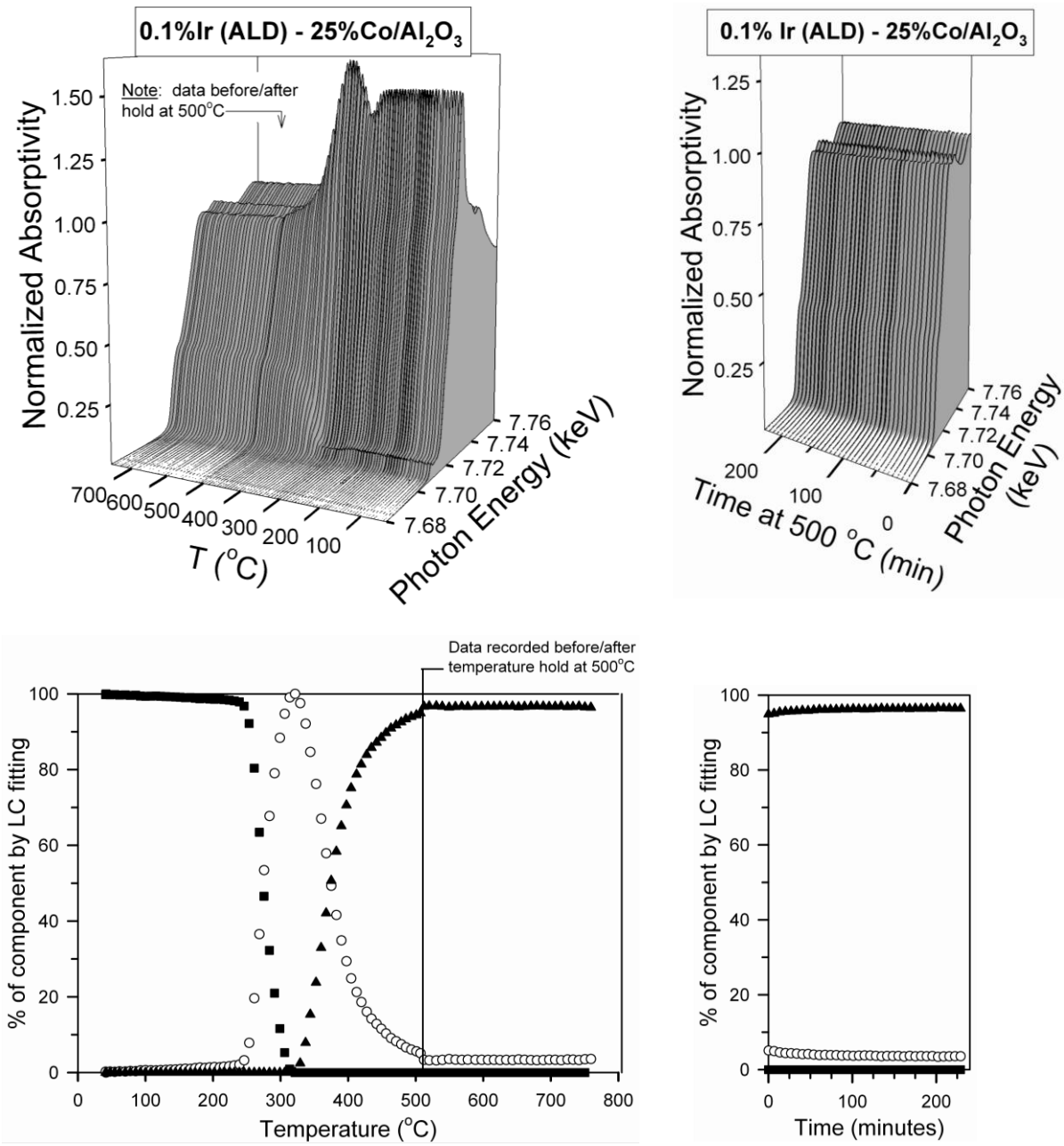
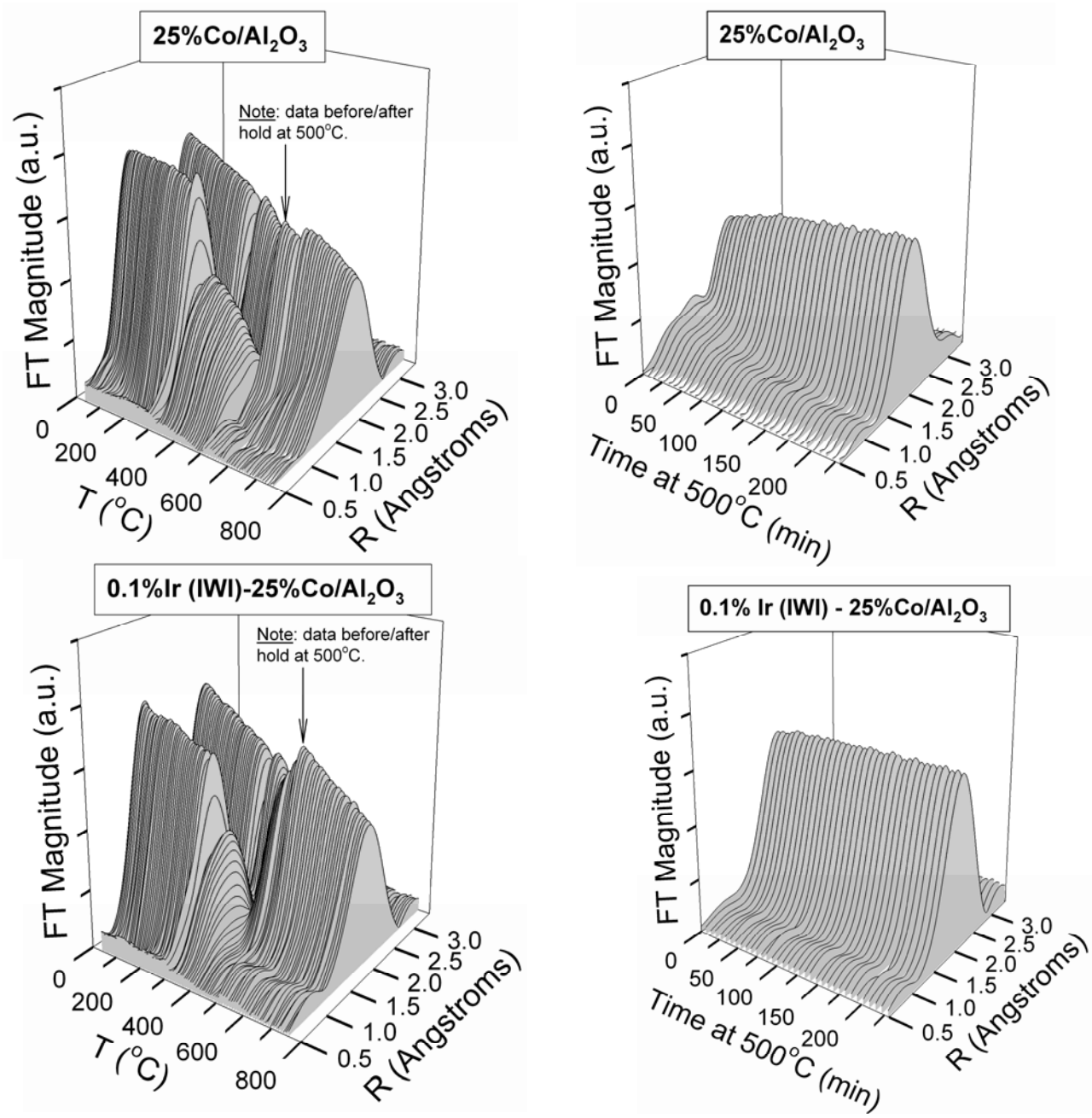


Figure 18: Hydrogen TPR-XANES profile for the 0.1% Ir promoted 25%Co/Al_2O_3 catalyst prepared by ALD of Ir as a function of (top left) temperature and (top right) time at 500°C. Linear combination fittings as a function of (bottom left) temperature and (bottom right) time are provided.



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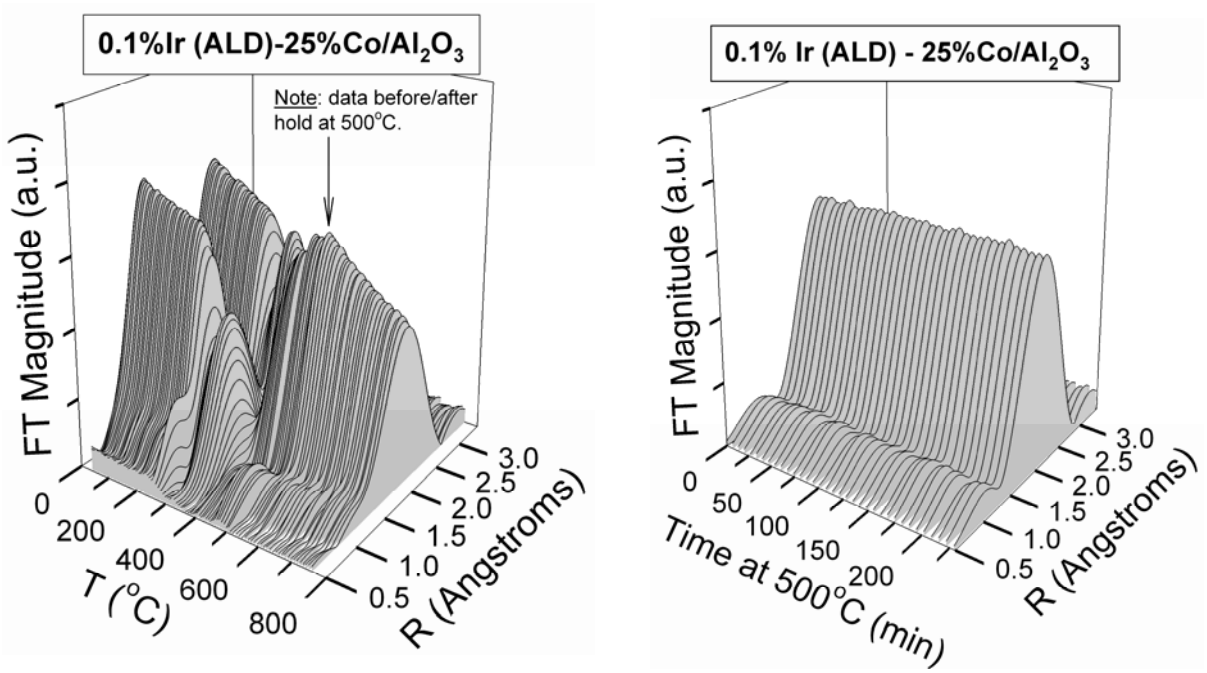

Figure 20: Hydrogen TPR-EXAFS profile for the 0.1% Ir promoted 25%Co/Al_2O_3 catalyst prepared by ALD of Ir as a function of (left) temperature and (right) time at 500°C.

Figure 21: Arrhenius Plot of CAER 15% Cobalt Catalytic Runs
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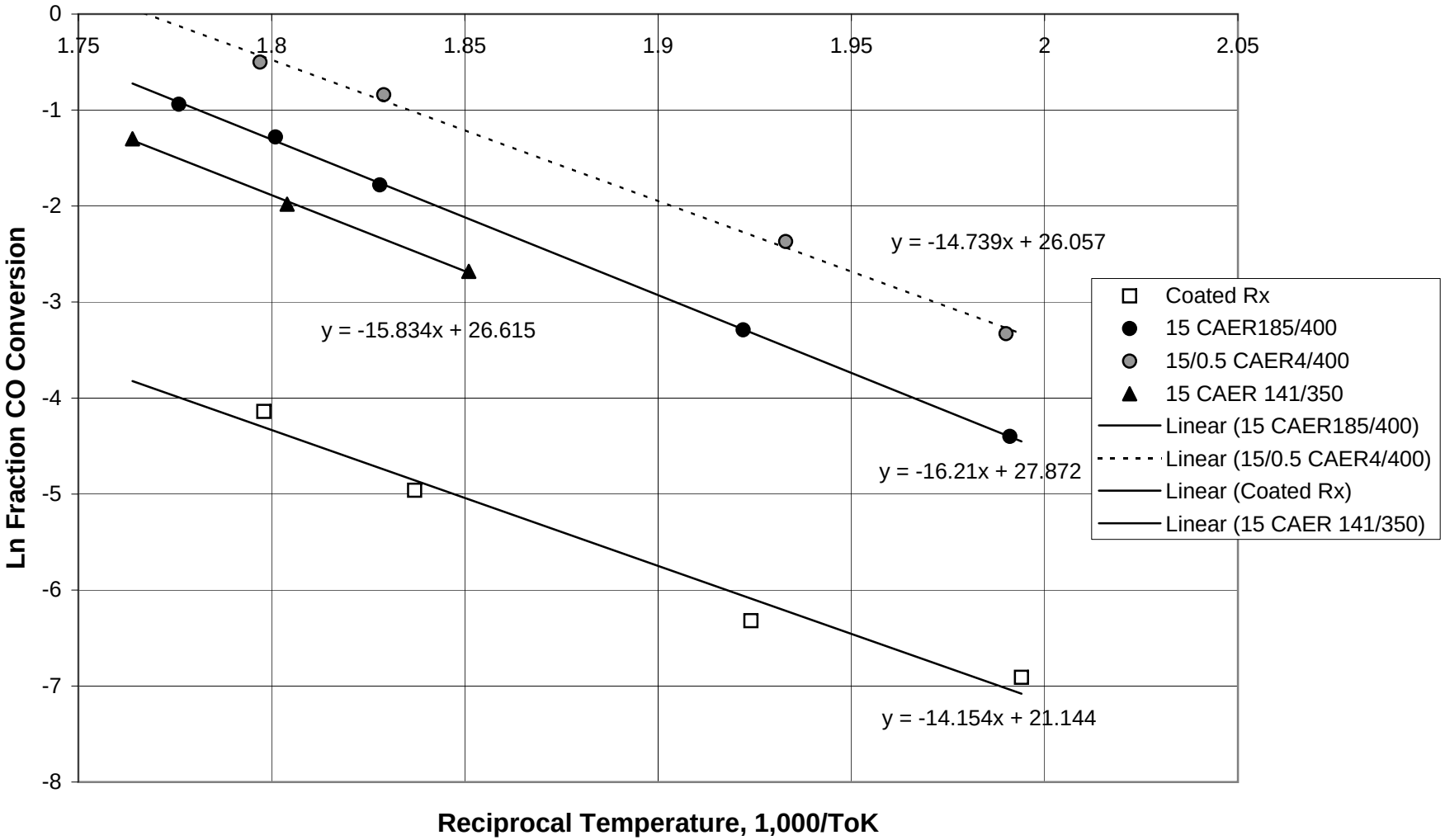


Figure 22: Arrhenius Plot of ALD 17% Co on Al2O3 Catalytic Series (0.1 g Catalyst Charge)

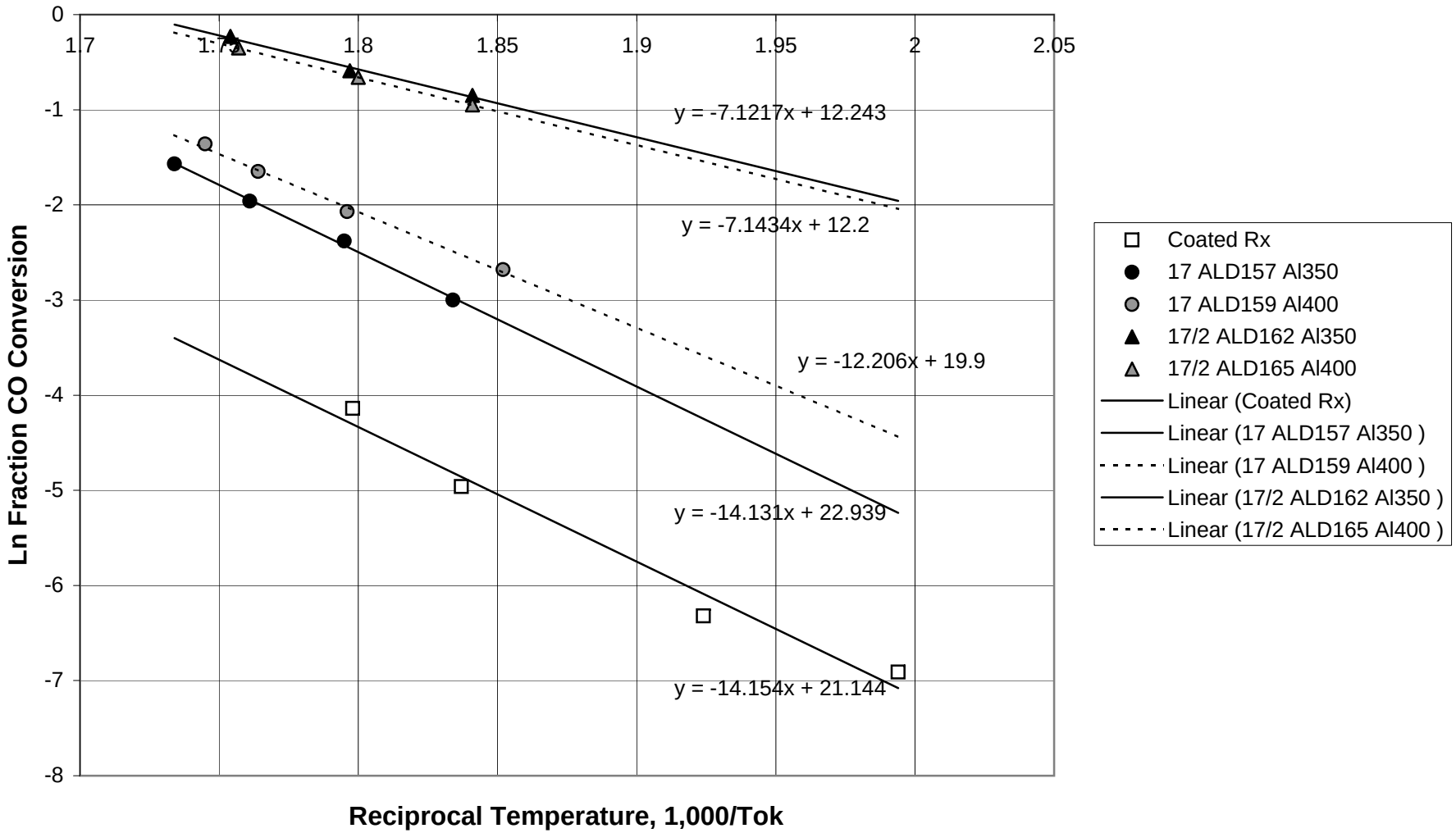


Figure 23: Arrhenius Plot of 16% ADL Cobalt on SiO2 Catalyst Series (0.1 g Catalyst Charge)

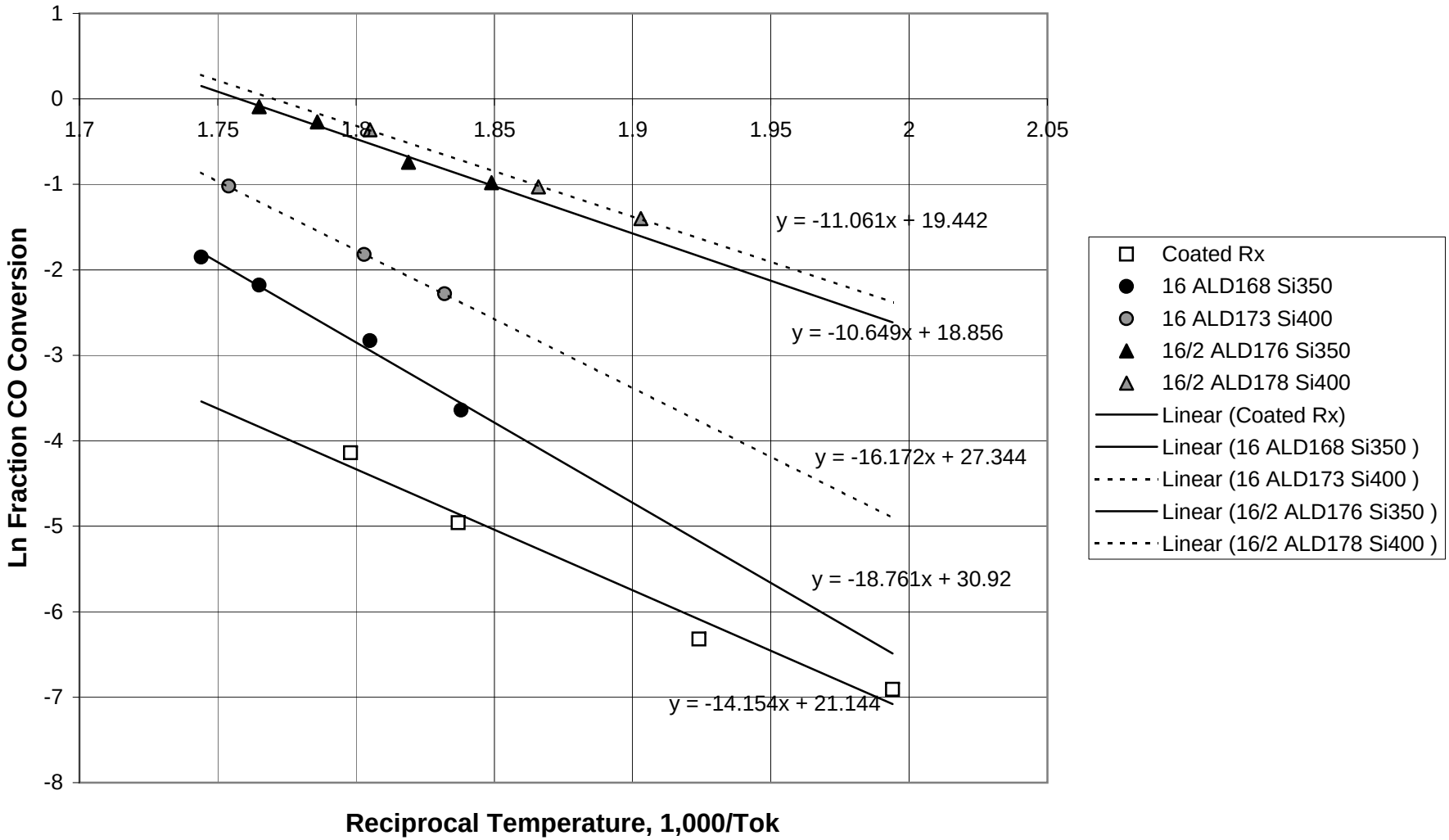
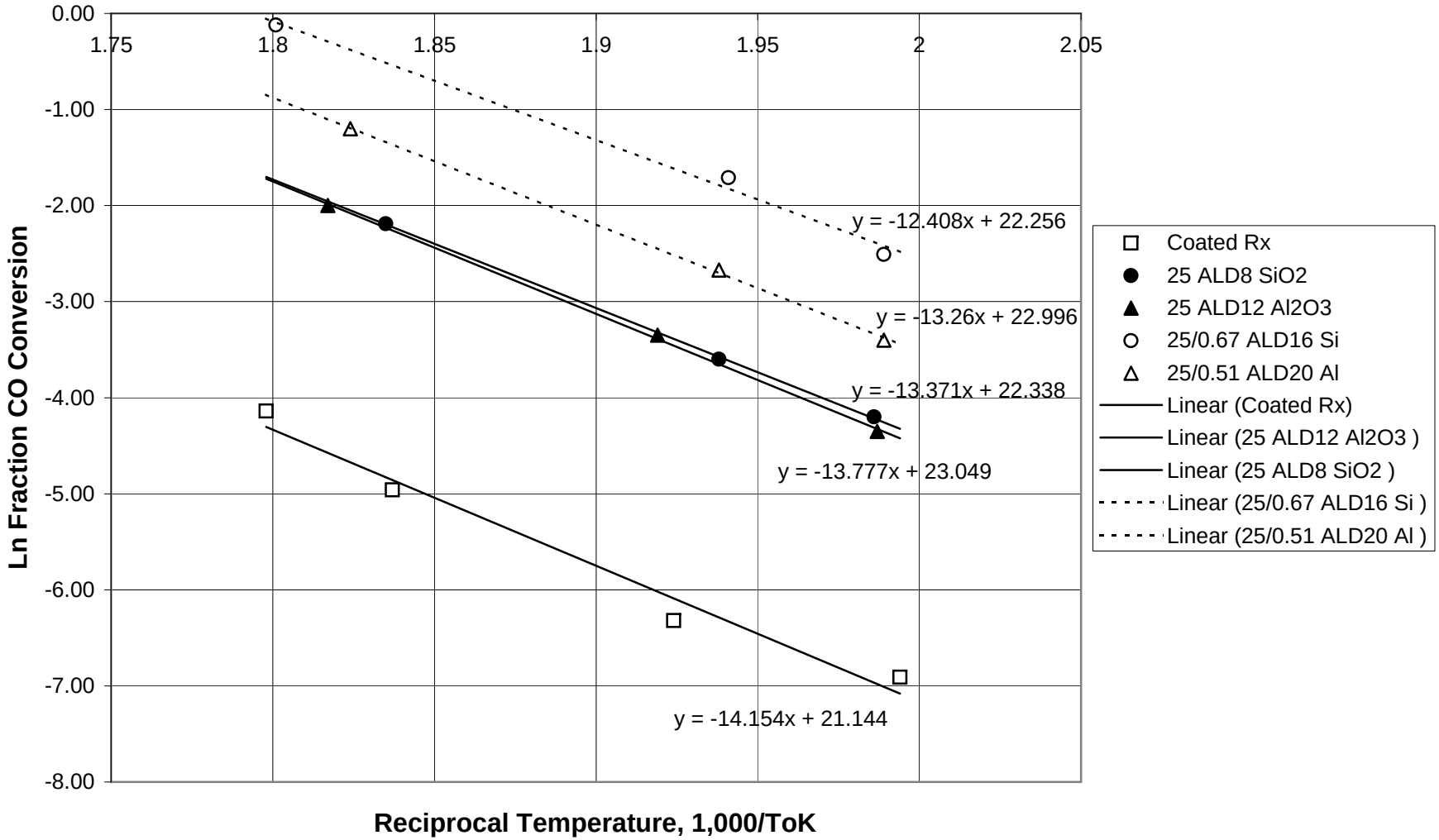


Figure 24: Arrhenius Plot of 25% ALD Cobalt Catalyst Series (400C Reduction, 0.1 g Catalyst Charge)



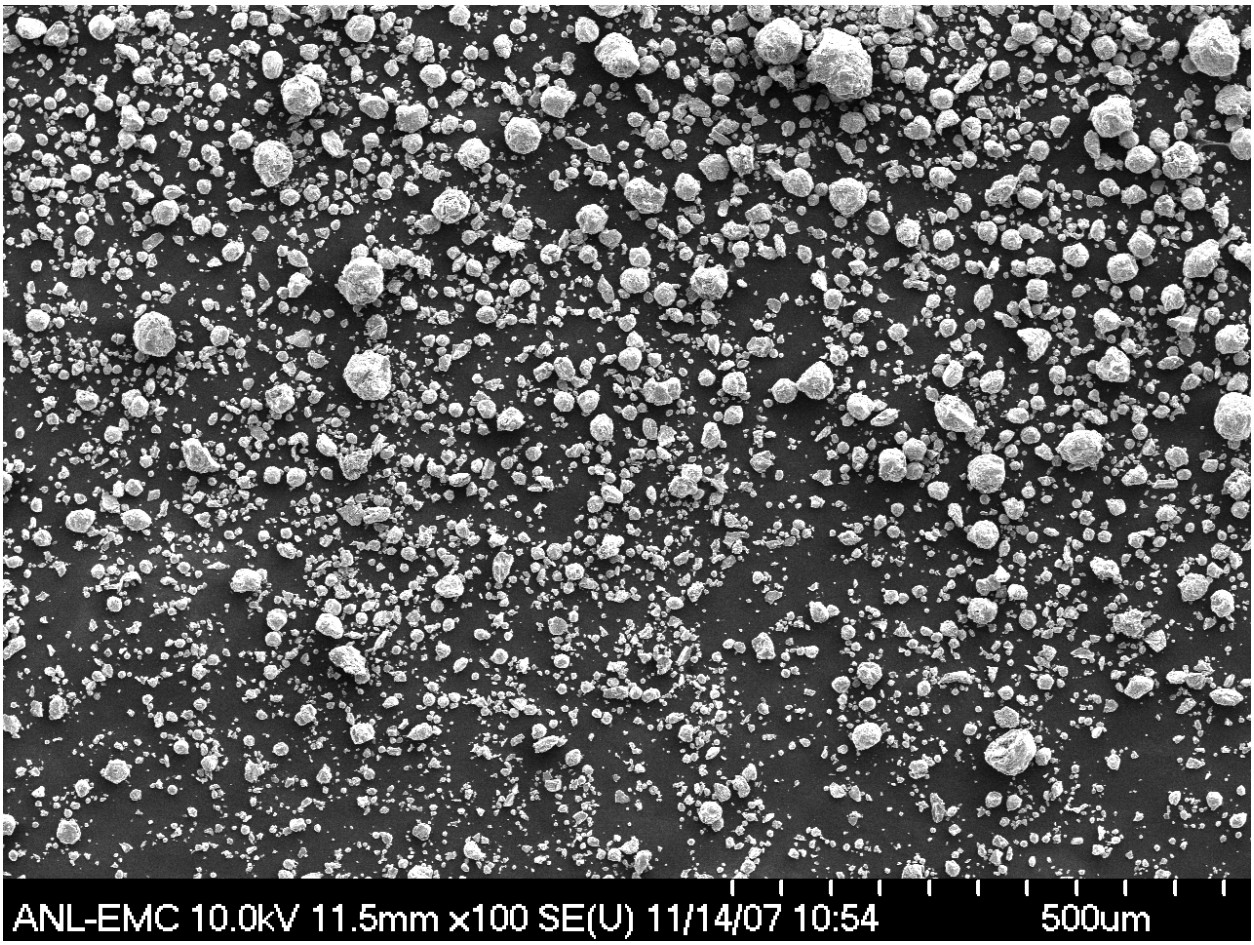


Figure 25: Photomicrograph SEM Scan of Coated Catalyst Sample after Rolling Test
(Sample DC4_100B: Treated 104A: Jar No. 4)

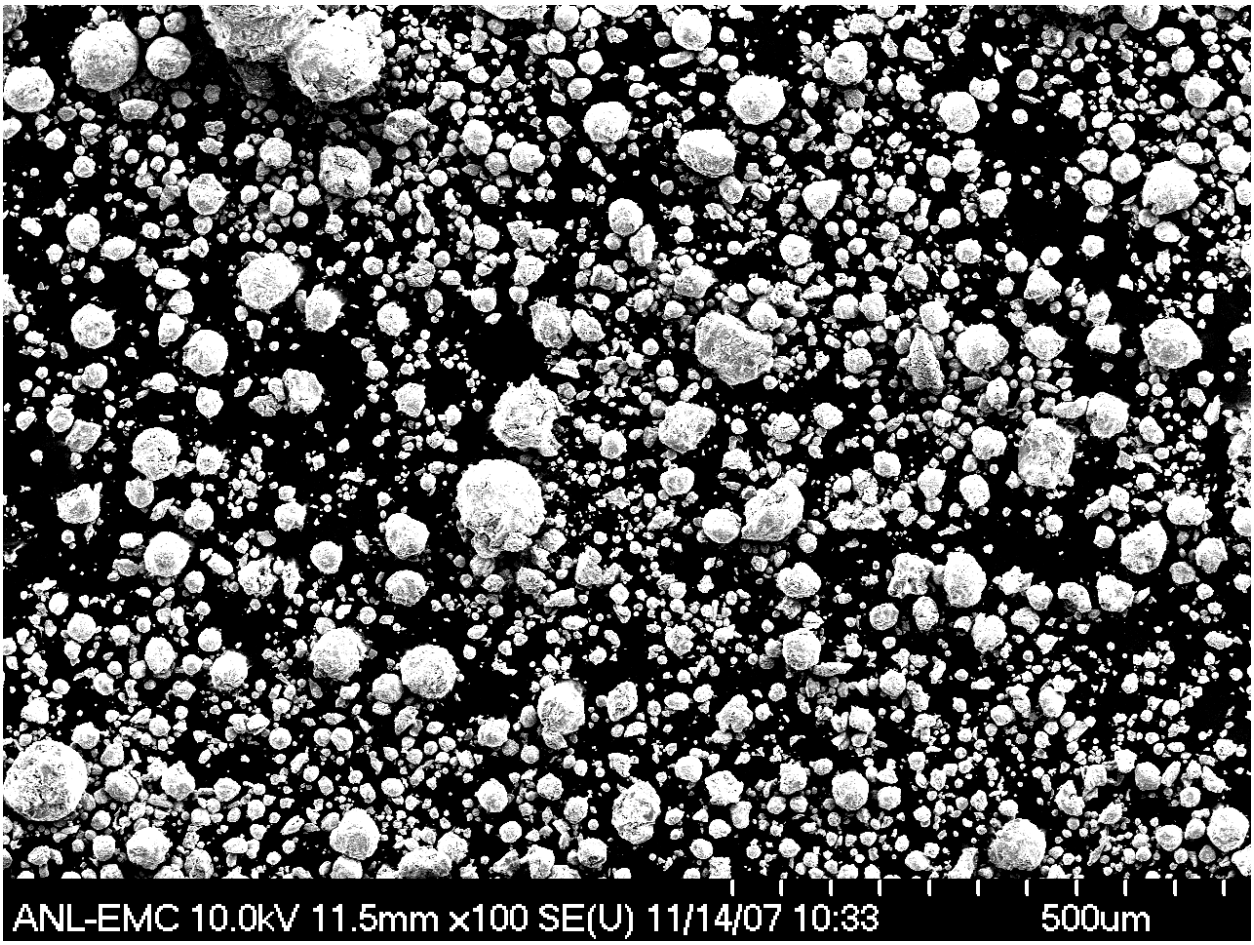
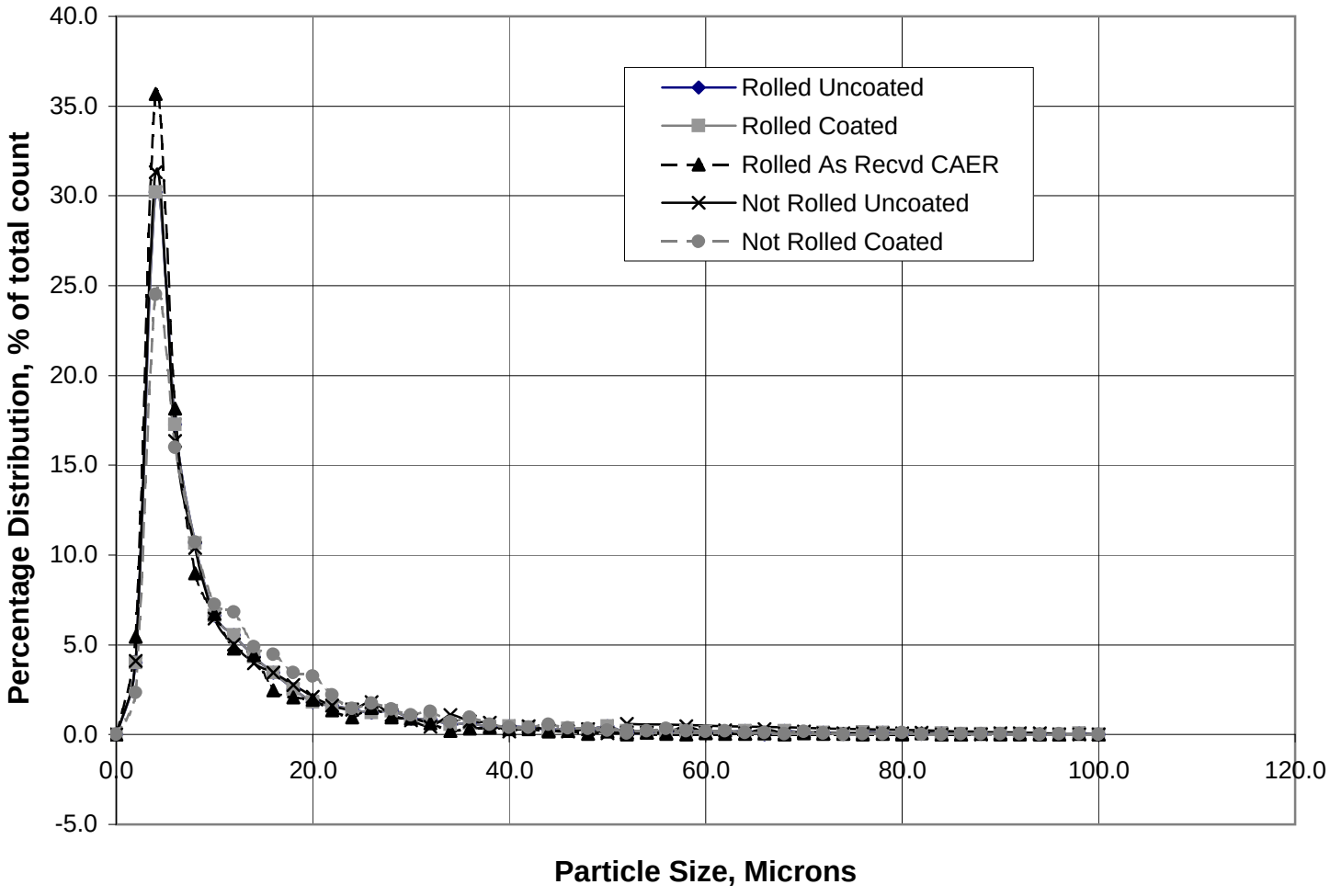


Figure 26: Photomicrograph SEM Scan of Non-coated Catalyst Sample after Rolling Test
(Sample DC1_100A; Untreated 98C: Jar No. 1)

Figure 27: Effect of SiO2 Coating Upon Particle Size Distribution Before and After Rolling



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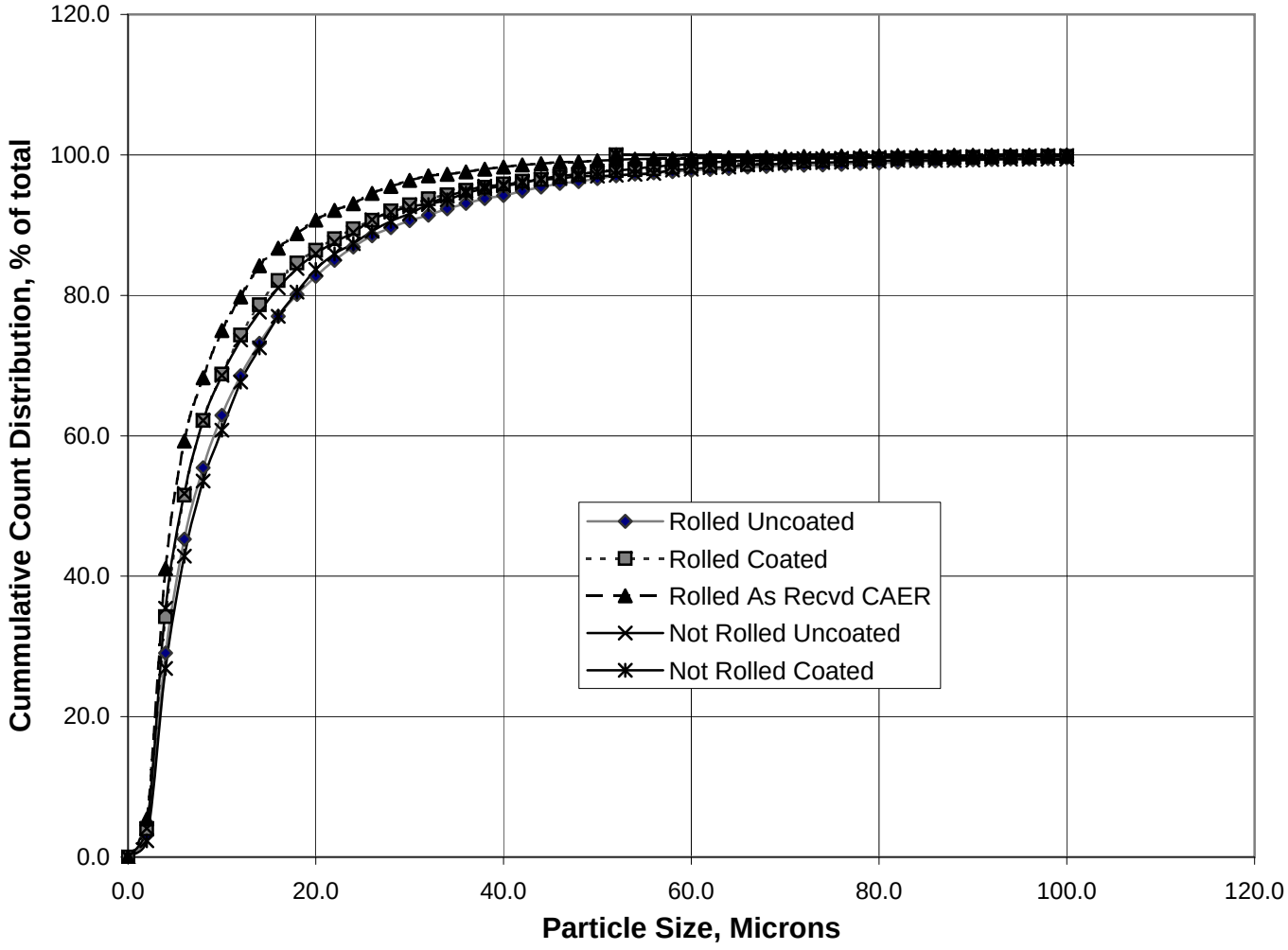


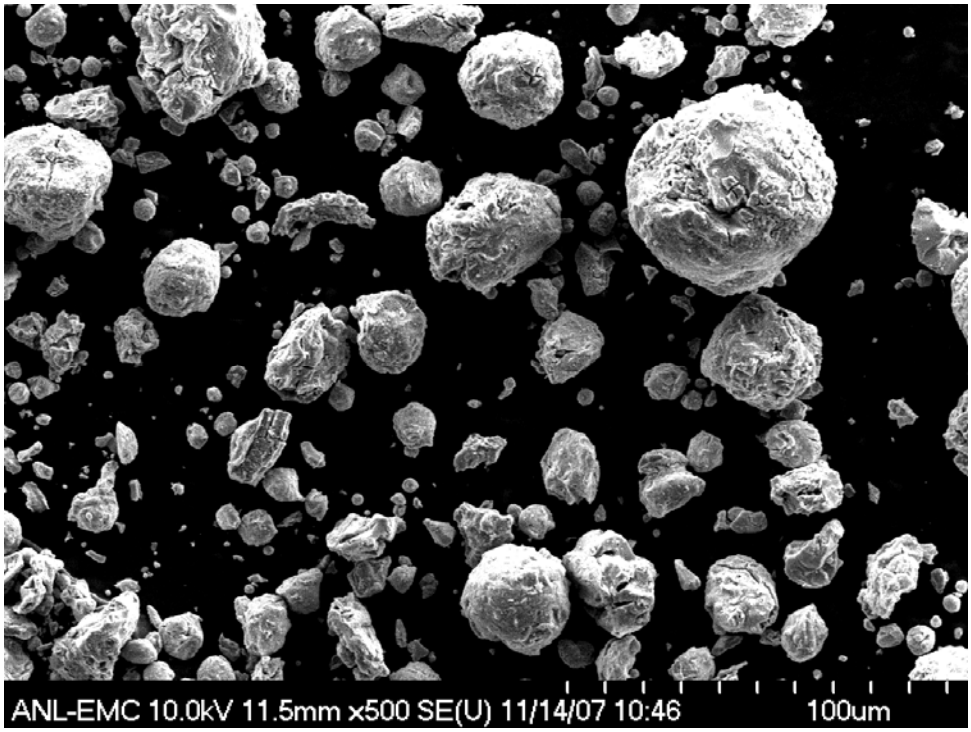
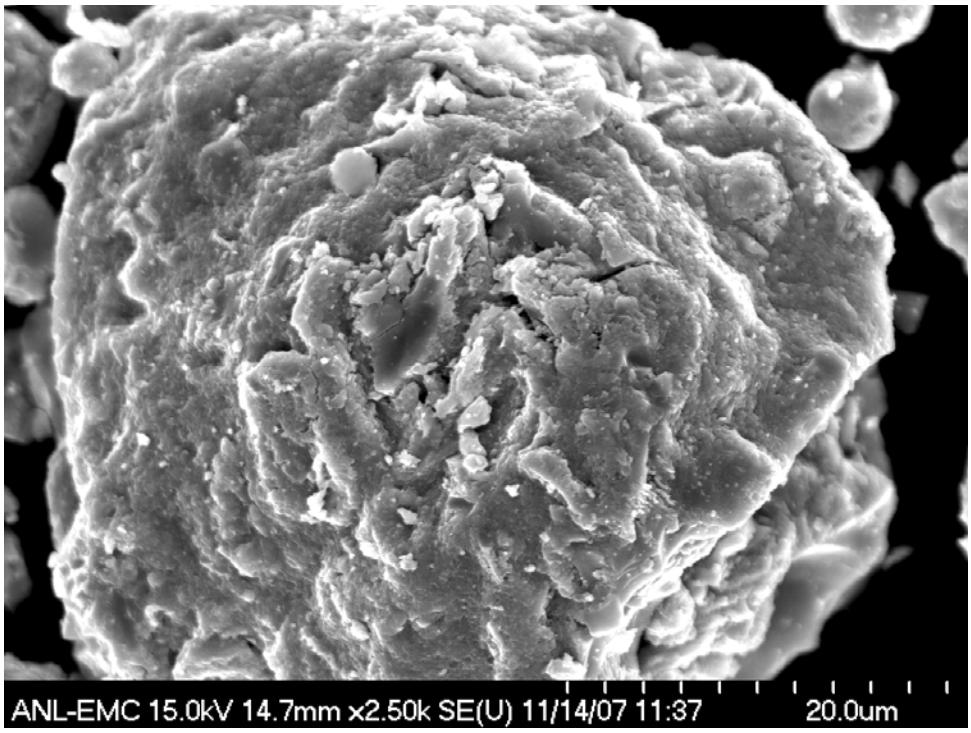


Figure 29a: SEM Scan 500X of Sample DC3_500A



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(Treated and Rolled 104a Catalyst)

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Table 1
Summary of Particulate Catalysts and FT Runs

Catalyst Designation	Catalyst Description/Preparation	Catalyst, g	FT Run No. (NB # 2121)	Date of Run
JE740 (Al2O3 only)	50 Angstrum Al2O3 coating by ALD, only (no active metals) on SiO2	0.4	88 A-C	2/16/2006
CAER Fe Catalyst (RLS)	A-R RLS 4.4 Si/150 Cyclone Iron Catalyst of CAER	0.4	78, 121	1/12/06 & 8/4/2006
CAER Fe with SiO2 coating	Fractal SiO2 coated RLS catalyst of CAER	0.4	124 A-C	8/15/2006
JE751 (Ru)	Ru/ALD on ALD/Al2O3 coated Silicycle (SiO2) (0.26 wt% Ru)	0.4	80 A-C	1/18/2006
JE752 (Ru)	Ru/ALD on ALD/Al2O3 coated Silicycle (SiO2) (0.31 wt% Ru)	0.4	83 A-C	1/31/2006
AA 43048 0.5 wt% Ru	Commercial Alfa Aesar No. 43048 0.5 % Ru on Al2O3	0.4	93 A-D	4/6/2006
AA 44575 2 wt% Ru	Commercial Alfa Aesar No. 44575 2.0 % Ru on Al2O3	0.4	96 A-E	4/19/2006
JE989 (Ru)	Ru by ALD on ALD/Al2O3 coated Silicycle (SiO2) (1.1 wt% Ru)	0.4	103 A-E	5/11/2006
JE1033 (Pd)	Pd by ALD on ALD/Al2O3 coated Silicycle (SiO2) (9 wt% Pd)	0.4	107 A-E	5/18/2006
CAER Co (ZYQ000)	A-R CAER 15 wt% Co on Al2O3 (350oC Reduction)	0.4	130 A-C	9/7/2006
	A-R CAER 15 wt% Co on Al2O3 (350oC Reduction)	0.1	141 A-C	10/12/2006
	A-R CAER 15 wt% Co on Al2O3 (400oC Reduction)	0.1	185 A-E	6/29/2007
CAER CoPt (ZYQ036)	A-R CAER 15 wt% Co + 0.5 wt% Pt on Al2O3 (350oC)	0.4	134 A-C	9/13/2006
	A-R CAER 15 wt% Co + 0.5 wt% Pt on Al2O3 (400oC)	0.1	2264-4A-D	9/27/2007
CAER Co (GJ002)	A-R CAER 25 wt% Co on Al2O3 (350oC Reduction)	0.4	137 A-C	9/27/2006
JE1162b (Co)	11.4 wt% Co by ALD on Al2O3 by ALD on SiO2 (350oC Reduction)	0.1	144 A-C	11/15/2006
	11.4 wt% Co by ALD on Al2O3 by ALD on SiO2 (400oC Reduction)	0.1	146 A-C	11/17/2006
JE1157b (Co)	9.4 wt% Co by ALD on Al2O3 by ALD on SiO2 (350oC Reduction)	0.1	152 A-C	1/26/2007
	9.4 wt% Co by ALD on Al2O3 by ALD on SiO2 (400oC Reduction)	0.1	154 A-C	1/31/2007
JE1209 (Co)	17 wt% Co by ALD on Al2O3 by ALD on SiO2 (350oC Reduction)	0.1	157 A-C	2/21/2007
	17 wt% Co by ALD on Al2O3 by ALD on SiO2 (400oC Reduction)	0.1	159 A-D	3/7/2007
JE1218 (Co)	17 wt% Co + 2 wt% Pt/ALD on Al2O3 by ALD on SiO2 (350oC Reduction)	0.1	162 A-C	3/15/2007
	17 wt% Co + 2 wt% Pt/ALD on Al2O3 by ALD on SiO2 (400oC Reduction)	0.1	165 A-C	3/21/2007
JE1210 (Co on SiO2)	16 wt% Co by ALD on SiO2 alone (350oC Reduction)	0.1	168 A-D	3/30/2007
	16 wt% Co by ALD on SiO2 alone (400oC Reduction)	0.1	173 A-D	4/26/2007
JE1217 (Co & Pt on SiO2)	2 wt% Pt by ALD on 16 C by ALD on SiO2 alone (350oC Reduction)	0.1	176 A-D	5/2/2007
	2 wt% Pt by ALD on 16 C by ALD on SiO2 alone (400oC Reduction)	0.1	178 A-C	5/4/2007
CAER CoPt (ZYQ036)	0.5 wt% Pt by ALD on 15 wt% Co by CAER on Al2O3 (400oC Reduction)	0.1	2264-4A-D	9/27/2007
JE1264 (Co)	25 wt% Co by ALD on SiO2 alone (400oC Reduction)	0.1	2264-8A-C	10/4/2007
JE1265 (Co)	25 wt% Co by ALD on Al2O3 by ALD on SiO2 (400oC Reduction)	0.1	2264-12A-C	10/10/2007
AH040 (Co & Pt on SiO2)	0.67 wt% Pt/ALD on 25% Co/ALD on SiO2 (400oC Reduction)	0.1	2264-16A-C	10/18/2007
AH043	0.51 wt%Pt/ALD on 25% Co/ALD on Al2O3/ALD on SiO2 (400oC Reduction)	0.1	2264-20A-C	10/24/2007
JE-1352 (Note JE1265)	0.1 wt% Pt/ALD on 25 wt% Co/ALD + on Al2O3 on SiO2 (400oC)	0.1	2264-27A-C	5/21/2008
JE-1350 (Note JE1264)	0.1 wt% Pt/ALD on 25 wt% Co/ALD on SiO2 (400oC)	0.1	2264-29A-C	5/23/2008
JE-1351 (Note GJARG002)	0.1 wt% Pt/ALD on 25 wt% Co/CAER on Al2O3 (400oC)	0.1	2264-32A-C	5/28/2008
GJARG001	25 wt% Co on Al2O3 (CAER one step calcination)	0.1	2264-53A-C	11/21/2008
GJARG001(Repeat of 2264-53)	25 wt% Co on Al2O3 (CAER one step calcination)	0.1	2264-75A-C	4/22/2009
GJARG002	0.1 wt% Pt by CAER on 25 wt% Co on Al2O3 (CAER prep) Pt added after Co calcination followed by recalcination	0.1	2264-59A-C	12/10/2008
GJARG002 (Repeat of 2264-59)	0.1 wt% Pt by CAER on 25 wt% Co on Al2O3 (CAER prep) Pt added after Co calcination followed by recalcination	0.1	2264-70A-C	4/15/2009
GJARG003	0.1 wt% Pt by CAER on 25 wt% Co on Al2O3 (CAER prep) Pt added before Co calcination	0.1	2264-83A-C	5/14/2009
HF063-1/26/2009 on GJARG001	0.1 wt% ALD Pt on 25 wt% Co by CAER on Al2O3 (GJARG001)	0.1	2264-79A-C	4/29/2009
SC02015090	0.1 wt% ALD/Ru on CAER 25% Co on Al2O3 (200...200oC) (GJARG001)	0.1	2264-90A-D	9/9/2009
SC02015088	0.1 wt% ALD/Ru on CAER 25% Co on Al2O3 (300...100oC) (GJARG001)	0.1	2264-95A-D	9/15/2009
SC02015107	0.1 wt% ALD/Ir on CAER 25% Co on Al2O3 (GJARG001)	0.1	2264-99A-D	9/18/2009
CAER Sample IW Prep	0.018 wt% CAER IW/Pt on CAER 25% Co on Al2O3	0.1	2264-103A-D	9/23/2009
SC02037119	0.1 wt% ALD/Pt on CAER 25% Co on Al2O3 (GJARG001)	0.1	2264-107A-D	10/1/2009
DCC2264-114-2	0.1 wt% IW/Ir on CAER 25% Co on Al2O3 (GJARG001)	0.1	2264-117A-D	12/3/2009

Notes: 1. The SiO2 base support for the above was Silicycle S10040M (100 micron SiO2)
2. File -- N:/DCC_ANL/FT_FETC/Reports Ext.../FINAL DRAFT VERSION/Total overall Particulate Catalyst List 1.xls

Table 2

Summary of FT Catalytic Runs with 0.4g Particles

Catalyst Designation		FT Run Number (NB 2121-)	H2/CO Rate % Rate (FIC-101)	H2/CO Rate mL/min (25C-1atm)	Added H2 Rate % Rate (FIC-102)	Added H2 Rate mL/min (25C-1atm)	Feed Gas mol% CO	Run Temp., C	% CO Conversion CO (Total)	% CO Conversion C1-C6+
Empty Reactor (Membrane series)	SS Rx Tube	71A	3.00	17.70	6.88	10.06	33.4	209	0.05	0.05
		71B	3.00	17.70	6.88	10.06	33.4	249	0.40	0.37
		71C	3.00	17.70	6.88	10.06	33.4	273	1.37	1.13
		71D	3.00	17.70	6.88	10.06	33.4	284	3.12	2.29
Empty Reactor coated with ALD Al2O3	ALD Al2O3	74A	3.00	17.70	6.90	10.09	33.3	228	0.10	0.10
(Membrane series)	Coated	74B	3.00	17.70	6.90	10.09	33.3	247	0.18	0.18
	Tube	74C	3.00	17.70	6.90	10.09	33.3	271	0.70	0.70
		74D	3.00	17.70	6.90	10.09	33.3	283	1.60	1.60
Alpha Al2O3 Filled Reactor coated	ALD Al2O3	90A	6.90	40.05	0.00	0.00	52.3	274	0.96	0.68
with ALD Al2O3	Coated	90B	6.90	40.05	0.00	0.00	52.3	297	2.71	2.44
(Particulate Series)	Tube	90C	6.90	40.05	15.90	22.80	33.3	297	4.67	3.81
JE740 Al2O3 coated (only)	SS Rx Tube	88A	6.90	40.05	0.00	0.00	52.3	274	0.91	0.64
100 micron Silicycle support		88B	6.90	40.05	0.00	0.00	52.3	294	2.27	1.93
		88C	6.90	40.05	15.90	22.80	33.3	295	4.27	3.41
CAER Fe Catalyst (0.4 g)	ALD Al2O3	78A	6.90	40.05	0.00	0.00	52.3	275	26.63	15.74
	Coated	78B	6.90	40.05	0.00	0.00	52.3	294	50.87	24.63
	Tube	78C	6.90	40.05	15.90	22.80	33.3	294	64.92	40.23
CAER Fe Catalyst (0.4 g)	ALD Al2O3	121A	6.90	40.05	0.00	0.00	52.3	270	23.01	14.65
(Base catalyst for CAER strength testing)	Coated	121B	6.90	40.05	0.00	0.00	52.3	289	46.47	23.34
	Tube	121C	6.90	40.05	15.90	22.80	33.3	285	64.35	43.23
CAER Fe Catalyst (0.4 g)	ALD Al2O3	124A	6.90	40.05	0.00	0.00	52.3	269	23.91	15.94
(SiO2 coated catalyst for strength testing)	Coated	124B	6.90	40.05	0.00	0.00	52.3	285	40.82	21.77
	Tube	124C	6.90	40.05	15.90	22.80	33.3	284	58.20	38.82
JE751 Ru on Al2O3 coated	ALD Al2O3	80A	6.90	40.05	0.00	0.00	52.3	278	3.02	1.84
100 micron Silicycle support	Coated	80B	6.90	40.05	0.00	0.00	52.3	295	7.91	5.24
(Low level of Ru)	Tube	80C	6.90	40.05	15.90	22.80	33.3	295	11.01	7.88
JE752 Ru on Al2O3 coated	SS Rx Tube	83A	6.90	40.05	0.00	0.00	52.3	277	1.66	1.23
100 micron Silicycle support		83B	6.90	40.05	0.00	0.00	52.3	294	3.43	2.72
(Increased level of Ru)		83C	6.90	40.05	15.90	22.80	33.3	294	5.57	4.85
Alfa Aesar #43048 0.5 wt% Ru on Al2O3	ALD Al2O3	93A	6.90	40.05	0.00	0.00	52.3	272	2.70	1.83
	Coated	93B	6.90	40.05	0.00	0.00	52.3	290	4.47	3.83
	Tube	93C	6.90	40.05	15.90	22.80	33.3	292	6.52	5.57
		93D	6.90	40.05	15.90	22.80	33.3	297	7.03	6.06
Alfa Aesar #44575 2 wt% Ru on Al2O3	ALD Al2O3	96A	6.90	40.05	0.00	0.00	52.3	256	3.52	2.46
	Coated	96B	6.90	40.05	0.00	0.00	52.3	270	6.56	5.56
	Tube	96C	6.90	40.05	0.00	0.00	52.3	288	12.32	10.88
		96D	6.90	40.05	16.00	22.94	33.3	290	16.99	14.13
		96E	5.20	30.04	23.00	32.82	25.0	290	44.01	17.61
JE989 1.1 wt% Ru on Al2O3 coated SiO2 Gel	ALD Al2O3	103A	6.90	40.05	0.00	0.00	52.3	259	1.86	0.52
100 micron Silicycle support	Coated	103B	6.90	40.05	0.00	0.00	52.3	276	3.15	1.23
	Tube	103C	6.90	40.05	0.00	0.00	52.3	298	5.62	2.98
		103D	6.90	40.05	16.00	22.94	33.3	297	19.41	3.69
		103E	5.20	30.04	23.00	32.82	25.0	294	42.63	4.95
JE1033 9 wt% Pd on Al2O3 coated SiO2 Gel	ALD Al2O3	107A	6.90	40.05	0.00	0.00	52.3	258	2.92	0.54
100 micron Silicycle support	Coated	107B	6.90	40.05	0.00	0.00	52.3	271	5.09	1.53
	Tube	107C	6.90	40.05	0.00	0.00	52.3	291	6.65	4.31
		107D	6.90	40.05	16.00	22.94	33.3	292	44.01	17.61
		107E	5.20	30.04	23.00	32.82	25.0	291	37.82	21.43
CAER Co Catalyst (0.4 g)	ALD Al2O3	130A	6.90	40.05	0.00	0.00	52.3	268	2.25	1.88
(ZYQ000 - 15% Co on Al2O3)	Coated	130B	6.90	40.05	0.00	0.00	52.3	287	6.28	5.43
	Tube	130C	6.90	40.05	15.90	22.80	33.3	286	13.83	13.05
CAER Co Catalyst (0.4 g)	ALD Al2O3	134A	6.90	40.05	0.00	0.00	52.3	272	30.34	17.86
(ZYQ036 - 15% Co + 0.5% Pt on Al2O3)	Coated	134B	6.90	40.05	0.00	0.00	52.3	288	50.31	26.46
	Tube	134C	6.90	40.05	15.90	22.80	33.3	288	97.85	71.55
CAER Co Catalyst (0.4 g)	ALD Al2O3	137A	6.90	40.05	0.00	0.00	52.3	268	15.13	12.71
(GJ002 - 25% Co on Al2O3)	Coated	137B	6.90	40.05	0.00	0.00	52.3	285	27.45	19.06
	Tube	137C	6.90	40.05	15.90	22.80	33.3	287	82.21	52.81

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Table 3a

Summary of FT Catalytic Runs with 0.1g Charge of Particulates

Catalyst Designation	FT Run Number (NB 2121-)	Feed Gas mol% CO	Run Temp., C	% CO Conversion CO (Total)	% CO Conversion C1-C6+	C1-C6 Select.	Rec. Temp 1,000/ToK	Ln(frn CO Conv)
CAER Co Catalyst (0.1 g)	141A	33.3	267	6.86	6.57	95.8	1.851	-2.68
(ZYQ000 - 15% Co on Al2O3)	141B	33.3	281	13.84	13.38	96.7	1.804	-1.98
(350 C reduction in H2)	141C	33.3	294	27.21	26.41	97.1	1.764	-1.30
CAER Co Catalyst (0.1 g)	185A	33.3	229	1.23	1.23	~100	1.991	-4.40
(ZYQ000 - 15% Co on Al2O3)	185B	33.3	247	3.72	3.72	~100	1.922	-3.29
(400 C reduction in H2)	185C	33.3	274	16.82	15.88	94.4	1.828	-1.78
	185D	33.3	282	27.89	26.76	96.0	1.801	-1.28
	185E	33.3	290	39.14	37.01	94.6	1.776	-0.94
JE-1162b Co Catalyst (0.1 g)	144A	33.9	266	GC Error (FID detector)			1.854	GC Error
(11.4% Co by ALD on Al2O3/SiO2)	144B	33.9	283				1.798	
(350 C reduction in H2)	144C	33.9	295				1.759	
Continued JE-1162b Co Catalyst (0.1 g)	146A	35.4	272	3.88	3.76	96.9	1.833	-3.25
(11.4% Co by ALD on Al2O3/SiO2)	146B	35.4	285	7.35	7.01	95.5	1.792	-2.61
(Further reduced in H2 at 400 C)	146C	35.4	296	12.47	11.94	95.7	1.756	-2.08
JE-1157b Co Catalyst (0.1 g)	152A	33.3	273	1.12	0.61	54.6	1.831	-4.49
(9.4% Co by ALD on Al2O3/SiO2)	152B	33.3	286	2.17	1.33	61.2	1.788	-3.83
(350 C reduction in H2)	152C	33.3	299	4.93	3.64	73.8	1.748	-3.01
Continued JE-1157b Co Catalyst (0.1 g)	154A	33.3	273	4.0 (Note 2)	1.83	35.8	1.830	-3.22
(9.4% Co by ALD on Al2O3/SiO2)	154B	33.3	285	5.31	3.08	58.1	1.791	-2.94
(Further reduced in H2 at 400 C)	154C	33.3	296	8.53	6.06	71.1	1.756	-2.46
JE-1209 Co Catalyst (0.1 g)	157A	33.3	272	4.99	4.04	80.9	1.834	-3.00
(17% Co by ALD on Al2O3/SiO2)	157B	33.3	284	9.25	7.64	82.7	1.795	-2.38
(350 C reduction in H2)	157C	33.3	295	14.02	12.96	92.4	1.761	-1.96
	157D	33.3	304	20.75	19.35	93.3	1.734	-1.57
JE-1209 Co Catalyst (0.1 g)	159A	33.3	267	6.83	5.14	75.3	1.852	-2.68
(17% Co by ALD on Al2O3/SiO2)	159B	33.3	283	12.60	10.66	84.6	1.798	-2.07
(Further reduced in H2 at 400 C)	159C	33.3	294	19.12	16.67	87.2	1.764	-1.65
	159D	33.3	300	25.78	22.62	87.8	1.745	-1.36
JE-1218 Co Catalyst (0.1 g)	162A	33.3	270	42.65	40.72	95.5	1.841	-0.85
(17% Co & 2% Pt by ALD on Al2O3/SiO2)	162B	33.3	283	55.61	50.59	91.0	1.797	-0.59
(350 C reduction in H2)	162C	33.3	297	79.48	65.85	82.9	1.754	-0.23
JE-1218 Co Catalyst (0.1 g)	165A	33.3	270	38.75	36.96	95.4	1.841	-0.95
(17% Co & 2% Pt by ALD on Al2O3/SiO2)	165B	33.3	283	51.90	48.02	92.5	1.800	-0.66
(Further reduced in H2 at 400 C)	165C	33.3	296	70.66	58.58	82.9	1.757	-0.35
JE-1210 Co Catalyst (0.1 g)	168A	33.3	271	2.62	1.56	59.5	1.838	-3.64
(16% Co by ALD on SiO2, alone)	168B	33.3	281	5.92	3.89	65.7	1.805	-2.83
(350 C reduction in H2)	168C	33.3	294	11.36	8.98	79.0	1.765	-2.18
	168D	33.3	300	15.76	12.67	80.4	1.744	-1.85
JE-1210 Co Catalyst (0.1 g)	173A	33.3	273	10.23	10.21	99.8	1.832	-2.28
(16% Co by ALD on SiO2, alone)	173B	33.3	281	16.15	16.08	99.6	1.803	-1.82
(Further reduced in H2 at 400 C)	173C	33.3	297	36.18	33.58	92.8	1.754	-1.02
JE-1217 Co Catalyst (0.1 g)	176A	33.3	268	37.45	36.47	97.4	1.849	-0.98
(16% Co with 2% Pt by ALD on SiO2, alone)	176B	33.3	277	47.74	44.13	92.5	1.819	-0.74
(350 C reduction in H2)	176C	33.3	287	76.58	60.62	79.2	1.786	-0.27
	176D	33.3	293	91.14	69.31	76.1	1.765	-0.09
JE-1217 Co Catalyst (0.1 g)	178A	33.3	252	24.76	24.66	99.6	1.903	-1.40
(16% Co with 2% Pt by ALD on SiO2, alone)	178B	33.3	263	35.67	33.91	95.1	1.866	-1.03
(Further reduced in H2 at 400 C)	178C	33.3	281	69.67	55.13	79.1	1.805	-0.36
CAER CoPt Catalyst (0.1 g)	2164-4A	33.3	229	3.58	3.58	100.0	1.990	-3.33
(ZYQ036 - 15% Co 0.5% Pt on Al2O3)	2164-4B	33.3	244	9.37	9.04	94.5	1.933	-2.37
(400 C reduction in H2)	2164-4C	33.3	273	43.11	39.45	91.5	1.829	-0.84
	2164-4D	33.3	283	60.54	52.67	87.0	1.797	-0.50
JE1264 (Co)	2164-8A	33.3	230	1.50	1.50	100.0	1.986	-4.20
25 wt% Co on SiO2 alone	2164-8B	33.3	243	2.73	2.53	92.4	1.938	-3.60
(Reduced in H2 at 400 C)	2164-8C	33.3	272	11.20	10.71	95.6	1.835	-2.19
JE1265 (Co)	2164-12A	33.3	230	1.29	1.19	92.4	1.987	-4.35
25 wt% Co on ALD Al2O3 on SiO2	2164-12B	33.3	248	3.52	3.28	93.0	1.919	-3.35
(Reduced in H2 at 400 C)	2164-12C	33.3	277	13.48	13.04	96.7	1.817	-2.00
AH040 (Co & Pt on SiO2)	2164-16A	33.3	230	8.11	7.90	97.4	1.989	-2.51
25 wt% Co + 0.67 wt% Pt on SiO2 alone	2164-16B	33.3	242	18.05	17.65	97.8	1.941	-1.71
(Reduced in H2 at 400 C)	2164-16C	33.3	282	88.63	65.57	74.0	1.801	-0.12
AH043	2164-20A	33.3	230	3.35	3.35	100.0	1.989	-3.40
25 wt% Co + 0.51 wt% Pt on Al2O3 on SiO2	2164-20B	33.3	243	6.95	6.74	96.9	1.938	-2.67
(Reduced in H2 at 400 C)	2164-20C	33.3	275	30.00	28.79	96.0	1.824	-1.20

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2. The CO2 yield was decreased to be consistent with other comparable runs.

Table 3b

Summary of FT Catalytic Runs with 0.1g Charge of Particulates

Catalyst Designation	FT Run Number (NB 2264)	Feed Gas mol% CO	Run Temp., C	% CO Conversion CO (Total)	% CO Conversion C1-C6+	C1-C6 Select.	Rec. Temp 1,000/ToK	Ln(frn CO Conv)
JE-1352 (Note JE1265)	27A	33.3	249	3.88	3.76	96.9	1.915	-3.25
0.1 wt% Pt/ALD on 25 wt% Co/ALD + on Al2O3 on SiO2	27B	33.3	257	7.35	7.01	95.5	1.887	-2.61
(400 C reduction in H2)	27C	33.3	266	12.47	11.94	95.7	1.855	-2.08
JE-1350 (Note JE1264)	29A	33.3	249	27.53	27.04	98.2	1.915	-1.29
0.1 wt% Pt/ALD on 25 wt% Co/ALD on SiO2	29B	33.3	260	30.57	28.68	93.8	1.875	-1.19
(400 C reduction in H2)	29C	33.3	265	54.72	51.98	95.0	1.859	-0.60
JE-1351 (Note GJARG002)	32A	33.3	247	20.03	19.49	97.3	1.923	-1.61
0.1 wt% Pt/ALD on 25 wt% Co/CAER on Al2O3	32B	33.3	253	33.19	32.37	97.5	1.900	-1.10
(400 C reduction in H2)	32C	33.3	266	58.31	50.90	87.3	1.854	-0.54
CAER GJARG001	53A	33.3	250	11.74	11.54	98.3	1.910	-2.14
25 wt% Co on Al2O3 (CAER one step calcination)	53B	33.3	261	21.05	20.34	96.6	1.871	-1.56
(Further reduced in H2 at 400 C)	53C	33.3	270	37.63	35.79	95.1	1.843	-0.98
CAER GJARG001 (Repeat of 2264-53)	75A	33.3	243	7.33	7.29	99.4	1.938	-2.61
25 wt% Co on Al2O3 (CAER one step calcination)	75B	33.3	254	12.90	12.52	97.1	1.896	-2.05
(Further reduced in H2 at 400 C)	75C	33.3	264	20.94	19.87	94.9	1.863	-1.56
CAER GJARG002	59A	33.3	247	15.02	14.60	97.2	1.922	-3.22
0.1 wt% Pt by CAER on 25 wt% Co on Al2O3 (CAER prep)	59B	33.3	257	24.09	23.01	95.5	1.886	-1.42
Pt added after Co calcination followed by recalcination	59C	33.3	266	47.60	44.74	94.0	1.855	-0.74
CAER GJARG002 (Repeat of 2264-59)	70A	33.3	247	15.20	14.88	97.9	1.922	-1.88
0.1 wt% Pt by CAER on 25 wt% Co on Al2O3 (CAER prep)	70B	33.3	257	25.76	24.69	95.8	1.886	-1.36
Pt added after Co calcination followed by recalcination	70C	33.3	266	37.03	33.65	90.9	1.855	-0.99
CAER GJARG003	83A	33.3	246	10.48	10.12	96.6	1.926	-2.26
0.1 wt% Pt by CAER on 25 wt% Co on Al2O3 (CAER prep)	83B	33.3	256	21.66	20.13	92.9	1.890	-1.53
Pt added before Co calcination	83C	33.3	266	40.66	35.15	86.5	1.855	-0.90
HF063-1/26/2009 on GJARG001	79A	33.3	246	15.09	14.84	96.3	1.927	-1.89
0.1 wt% ALD Pt on 25 wt% Co by CAER on Al2O3 (GJARG001)	79B	33.3	255	26.83	25.36	94.5	1.892	-1.32
	79C	33.3	266	40.79	36.39	89.2	1.855	-0.90
SC02015090	90A	33.3	239	5.51	5.17	94.0	1.953	-2.90
0.1% ALD/Ru on CAER 25% Co on Al2O3 (200...200oC)	90B	33.3	248	9.04	8.80	97.3	1.920	-2.40
	90C	33.3	253	16.95	16.61	98.0	1.900	-1.77
	90D	33.3	261.9	24.85	24.19	97.3	1.869	-1.39
SC02015088	95A	33.3	238	5.74	5.74	100.0	1.957	-2.86
0.1% ALD/Ru on CAER 25% Co on Al2O3 (300...100oC)	95B	33.3	248	10.95	10.75	98.2	1.921	-2.21
	95C	33.3	253	14.39	14.07	97.8	1.901	-1.94
	95D	33.3	262	23.53	22.64	96.2	1.867	-1.45
SC02015107	99A	33.3	240	9.64	9.46	98.1	1.949	-2.34
0.1% ALD/Ir on CAER 25% Co on Al2O3	99B	33.3	242	10.37	10.20	98.4	1.942	-2.27
	99C	33.3	254	21.82	20.89	95.7	1.896	-1.52
	99D	33.3	264	35.72	33.33	93.3	1.861	-1.03
CAER Sample IW Prep	103A	33.3	238	4.71	4.60	97.6	1.957	-3.06
0.018% CAER IW/Pt on CAER 25% Co on Al2O3	103B	33.3	243	7.38	7.25	98.3	1.939	-2.61
	103C	33.3	256	16.32	15.75	96.5	1.891	-1.81
	103D	33.3	266	26.36	24.40	92.6	1.855	-1.33
SC02037119	107A	33.3	240	6.78	6.60	97.3	1.949	-2.69
0.1% ALD/Pt on CAER 25% Co on Al2O3	107B	33.3	243	7.82	7.51	96.1	1.937	-2.55
	107C	33.3	254	15.81	15.36	97.2	1.898	-1.84
	107D	33.3	262	25.36	23.33	92.0		-1.37
DCC2264-114-2	117A	33.3	240	11.82	11.09	93.8	1.948	-2.14
0.1% IW/Ir on CAER 25% Co on Al2O3 (CAER GJARG001)	117B	33.3	248	17.17	16.57	96.5	1.921	-1.76
	117C	33.3	259	31.65	29.34	92.7	1.880	-1.15
	117D	33.3	268	49.45	41.40	83.7	1.847	-0.70

1. File -- N:/DCC_ANL/FT_FETC/Reports../Final Draft Version/Table 3b Particulate List 0.1g...xls
2. The CO2 yield was decreased to be consistent with other comparable runs.
3. All runs were made with an ALD Al2O3 coated tube.

Table 4

Result Summary: Fischer-Tropsch Experimental Series with Coated Silica Spherical Catalysts
Runs 2121-90 88

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
Non-catalytic Base Case	Gas Analyses, %	90A	274	44.00	55.65	0.159	0.099	0.011	0.024	0.004	0.027	0.002	0.015	0.008	0.003	0.191
Alpha Al2O3 filled ALD-coated tub	Conversion, %				0.96	0.28	0.18	0.04	0.09	0.02	0.14	0.01	0.11	0.07	0.03	0.68
	Selectivity, %					29.40	18.32	3.99	8.84	1.94	14.75	1.41	11.09	6.93	3.33	70.60
	Gas Analyses, %	90B	297	43.16	55.96	0.152	0.402	0.049	0.068	0.015	0.100	0.008	0.034	0.030	0.019	0.723
	Conversion, %				2.71	0.26	0.70	0.17	0.24	0.08	0.52	0.05	0.23	0.26	0.19	2.44
	Selectivity, %					9.77	25.83	6.23	8.72	2.87	19.24	2.03	8.61	9.57	7.13	90.23
	Gas Analyses, %	90C	297	63.04	35.81	0.324	0.522	0.067	0.049	0.021	0.084	0.010	0.033	0.015	0.020	0.820
	Conversion, %				4.67	0.86	1.39	0.36	0.26	0.17	0.67	0.10	0.35	0.20	0.31	3.81
	Selectivity, %					18.45	29.72	7.68	5.55	3.55	14.27	2.16	7.56	4.36	6.70	81.55
JE740 Al2O3 coated (Only)	Gas Analyses, %	88A	274	44.09	55.59	0.152	0.088	0.009	0.024	0.003	0.025	0.002	0.010	0.007	0.007	0.174
100 micron Silicycle support	Conversion, %				0.91	0.27	0.16	0.03	0.08	0.02	0.14	0.01	0.07	0.06	0.08	0.64
	Selectivity, %					29.66	17.11	3.67	9.21	1.70	14.87	1.17	7.57	6.73	8.31	70.34
	Gas Analyses, %	88B	294	43.32	55.93	0.196	0.293	0.033	0.058	0.010	0.080	0.006	0.023	0.023	0.021	0.548
	Conversion, %				2.27	0.34	0.51	0.12	0.20	0.05	0.42	0.04	0.16	0.20	0.22	1.93
	Selectivity, %					15.07	22.55	5.12	8.97	2.40	18.41	1.75	7.04	9.00	9.69	84.93
	Gas Analyses, %	88C	295	63.98	35.04	0.315	0.398	0.046	0.043	0.014	0.071	0.007	0.052	0.015	0.018	0.664
	Conversion, %				4.27	0.86	1.09	0.25	0.24	0.12	0.58	0.08	0.57	0.20	0.29	3.41
	Selectivity, %					20.17	25.47	5.88	5.56	2.77	13.54	1.82	13.37	4.67	6.76	79.83

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 5

Result Summary: Fischer-Tropsch Experimental Series with CAER Catalysts w&w/o Coating
Runs 2121-78, 121, 124

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
CAER Fe Catalyst (0.40 g)	Gas Analyses, %	78A	275	32.34	54.67	8.115	1.760	0.372	0.458	0.118	0.884	0.066	0.375	0.341	0.306	4.680
	Conversion, %				26.63	10.89	2.36	1.00	1.23	0.48	3.56	0.35	2.01	2.29	2.46	15.74
	Selectivity, %					40.89	8.87	3.75	4.61	1.79	13.37	1.33	7.55	8.59	9.25	59.11
	Gas Analyses, %	78B	294	28.68	40.91	21.846	3.467	0.770	0.690	0.203	1.572	0.113	0.748	0.618	0.376	8.557
	Conversion, %				50.87	26.24	4.16	1.85	1.66	0.73	5.66	0.54	3.60	3.71	2.71	24.63
	Selectivity, %					51.58	8.18	3.64	3.26	1.44	11.13	1.07	7.07	7.30	5.33	48.42
	Gas Analyses, %	78C	294	58.96	18.30	12.875	4.956	1.131	0.461	0.326	1.403	0.165	0.463	0.505	0.437	9.847
	Conversion, %				64.92	24.68	9.50	4.34	1.77	1.87	8.07	1.27	3.55	4.84	5.03	40.23
	Selectivity, %					38.02	14.63	6.68	2.72	2.88	12.43	1.95	5.47	7.45	7.75	61.98
CAER Fe Catalyst (0.40 g)	Gas Analyses, %	121A	270	35.49	54.60	5.925	1.487	0.306	0.425	0.106	0.568	0.069	0.410	0.407	0.246	4.023
Sample sent to CAER	Conversion, %				23.01	8.35	2.10	0.86	1.20	0.45	2.40	0.39	2.31	2.87	2.08	14.65
	Selectivity, %					36.31	9.11	3.75	5.21	1.95	10.44	1.68	10.06	12.46	9.03	63.69
	Gas Analyses, %	121B	289	30.26	43.34	18.731	2.885	0.619	0.756	0.181	1.541	0.111	0.522	0.707	0.338	7.661
	Conversion, %				46.47	23.13	3.56	1.53	1.87	0.67	5.71	0.55	2.58	4.36	2.51	23.34
	Selectivity, %					49.78	7.67	3.29	4.02	1.44	12.29	1.18	5.55	9.39	5.40	50.22
	Gas Analyses, %	121C	285	59.58	18.98	11.238	4.526	1.098	0.548	0.354	1.601	0.187	0.717	0.676	0.388	10.095
	Conversion, %				64.35	21.12	8.50	4.12	2.06	2.00	9.02	1.41	5.39	6.35	4.38	43.23
	Selectivity, %					32.82	13.22	6.41	3.20	3.10	14.02	2.19	8.37	9.87	6.80	67.18
SiO2 Coated Fe CAER Catalyst	Gas Analyses, %	124A	269	35.88	53.91	5.642	1.729	0.338	0.401	0.110	0.812	0.071	0.375	0.379	0.274	4.489
Sample sent to CAER	Conversion, %				23.91	7.96	2.44	0.95	1.13	0.47	3.44	0.40	2.12	2.68	2.32	15.94
	Selectivity, %					33.31	10.21	3.99	4.73	1.95	14.38	1.68	8.86	11.19	9.70	66.69
	Gas Analyses, %	124B	285	32.08	45.76	14.731	2.913	0.594	0.658	0.167	1.385	0.100	0.166	0.623	0.429	7.036
	Conversion, %				40.82	19.05	3.77	1.54	1.70	0.65	5.38	0.52	0.86	4.03	3.33	21.77
	Selectivity, %					46.68	9.23	3.77	4.17	1.59	13.17	1.27	2.10	9.87	8.15	53.32
	Gas Analyses, %	124C	284	59.48	21.05	9.756	4.733	1.046	0.495	0.330	1.474	0.173	0.064	0.554	0.434	9.303
	Conversion, %				58.20	19.37	9.40	4.15	1.97	1.97	8.78	1.38	0.51	5.50	5.17	38.82
	Selectivity, %					33.29	16.15	7.14	3.38	3.38	15.09	2.36	0.88	9.45	8.88	66.71

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 6

Result Summary: Fischer-Tropsch Experimental Series with Coated Silica Spherical Catalysts
Runs 2121-80 83

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE751 Ru on Al2O3 coated	Gas Analyses, %	80A	278	43.64	55.18	0.671	0.268	0.040	0.035	0.012	0.071	0.007	0.030	0.027	0.017	0.506
100 micron Silicycle support	Conversion, %				3.02	1.18	0.47	0.14	0.12	0.06	0.37	0.05	0.21	0.23	0.18	1.84
	Selectivity, %					39.07	15.60	4.66	4.10	2.04	12.37	1.63	6.99	7.74	5.80	60.93
	Gas Analyses, %	80B	295	41.66	55.40	1.605	0.676	0.092	0.068	0.027	0.163	0.016	0.111	0.056	0.133	0.020
	Conversion, %				7.91	2.67	1.12	0.30	0.22	0.14	0.81	0.11	0.74	0.46	1.33	5.24
	Selectivity, %					33.73	14.22	3.85	2.84	1.73	10.29	1.36	9.35	5.83	16.80	66.27
	Gas Analyses, %	80C	295	65.53	33.65	1.185	0.992	0.136	0.045	0.042	0.161	0.023	0.077	0.048	0.063	1.587
	Conversion, %				11.01	3.13	2.62	0.72	0.24	0.34	1.28	0.25	0.81	0.63	0.99	7.88
	Selectivity, %					28.45	23.82	6.52	2.14	3.05	11.61	2.25	7.36	5.76	9.03	71.55
JE752 Ru on Al2O3 coated	Gas Analyses, %	83A	277	44.26	55.20	0.242	0.126	0.016	0.027	0.005	0.039	0.014	0.029	0.014	0.017	0.287
100 micron Silicycle support	Conversion, %				1.66	0.43	0.22	0.06	0.09	0.03	0.21	0.10	0.21	0.13	0.18	1.23
	Selectivity, %					26.00	13.50	3.48	5.69	1.74	12.47	6.06	12.55	7.74	10.77	74.00
	Gas Analyses, %	83B	294	43.08	55.81	0.400	0.375	0.048	0.059	0.015	0.105	0.009	0.033	0.035	0.048	0.727
	Conversion, %				3.43	0.69	0.65	0.17	0.20	0.08	0.55	0.06	0.23	0.30	0.50	2.74
	Selectivity, %					20.18	18.92	4.85	5.97	2.27	15.91	1.82	6.64	8.78	14.65	79.82
	Gas Analyses, %	83C	294	63.52	35.26	0.269	0.567	0.079	0.043	0.023	0.107	0.013	0.048	0.029	0.038	0.945
	Conversion, %				5.57	0.72	1.52	0.42	0.23	0.19	0.86	0.14	0.51	0.38	0.60	4.85
	Selectivity, %					12.94	27.28	7.62	4.09	3.38	15.38	2.48	9.16	6.85	10.82	87.06

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 7

Result Summary: Fischer-Tropsch Experimental Series with Commercial Ru Catalysts
Runs 2121-93, 96

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
Alfa Aesar #43048 0.5 wt% Ru on Al2O3	Gas Analyses, %	93A	**272**	43.09	55.90	0.50	0.29	0.05	0.00	0.02	0.05	0.01	0.02	0.04	0.02	0.509
	Conversion, %				2.70	0.87	0.51	0.17	0.01	0.10	0.28	0.07	0.16	0.31	0.22	1.83
	Selectivity, %					32.22	18.97	6.11	0.55	3.58	10.52	2.65	6.01	11.31	8.08	67.78
	Gas Analyses, %	93B	**290**	41.29	57.18	0.38	0.71	0.11	0.00	0.05	0.09	0.04	0.05	0.05	0.05	1.163
	Conversion, %				4.47	0.64	1.19	0.37	0.02	0.26	0.47	0.24	0.35	0.42	0.51	3.83
	Selectivity, %					14.25	26.57	8.39	0.34	5.87	10.62	5.28	7.93	9.30	11.45	85.75
	Gas Analyses, %	93C	**292**	62.34	36.03	0.367	0.883	0.112	0.002	0.064	0.057	0.036	0.038	0.027	0.041	1.259
	Conversion, %				6.52	0.95	2.29	0.58	0.01	0.50	0.44	0.37	0.39	0.35	0.64	5.57
	Selectivity, %					14.59	35.10	8.93	0.17	7.59	6.81	5.71	6.00	5.29	9.81	85.41
	Gas Analyses, %	93D	**297**	62.17	36.06	0.378	0.945	0.123	0.028	0.063	0.080	0.031	0.044	0.030	0.038	1.381
	Conversion, %				7.03	0.97	2.44	0.63	0.14	0.48	0.62	0.32	0.45	0.39	0.58	6.06
	Selectivity, %					13.85	34.63	9.01	2.05	6.88	8.82	4.54	6.39	5.53	8.29	86.15
Alfa Aesar #44575 2.0 wt% Ru on Al2O3	Gas Analyses, %	96A	**256**	41.70	57.09	0.628	0.280	0.032	0.013	0.017	0.072	0.016	0.046	0.070	0.037	0.582
	Conversion, %				3.52	1.06	0.47	0.11	0.04	0.08	0.37	0.11	0.31	0.59	0.37	2.46
	Selectivity, %					30.16	13.43	3.05	1.23	2.39	10.37	3.11	8.84	16.88	10.55	69.84
	Gas Analyses, %	96B	**270**	44.91	53.13	0.571	0.715	0.074	0.020	0.038	0.138	0.033	0.084	0.114	0.115	1.331
	Conversion, %				6.56	1.00	1.26	0.26	0.07	0.20	0.73	0.23	0.59	1.01	1.22	5.56
	Selectivity, %					15.31	19.18	3.94	1.07	3.06	11.06	3.56	8.95	15.32	18.55	84.69
	Gas Analyses, %	96C	**288**	32.65	62.52	1.025	2.323	0.341	0.025	0.153	0.272	0.116	0.178	0.188	0.218	3.815
	Conversion, %				12.32	1.44	3.26	0.96	0.07	0.65	1.14	0.65	1.00	1.32	1.84	10.88
	Selectivity, %					11.67	26.44	7.76	0.57	5.24	9.29	5.28	8.12	10.72	14.91	88.33
	Gas Analyses, %	96D	**290**	56.80	38.18	1.318	2.540	0.302	0.017	0.152	0.165	0.091	0.140	0.071	0.182	3.660
	Conversion, %				16.99	2.87	5.52	1.31	0.07	0.99	1.08	0.79	1.21	0.77	2.38	14.13
	Selectivity, %					16.86	32.50	7.72	0.42	5.84	6.33	4.66	7.14	4.54	13.98	83.14
	Gas Analyses, %	96E	**290**	60.08	24.39	11.495	3.568	0.385	0.012	0.212	0.130	0.105	0.127	0.077	0.162	4.778
	Conversion, %				44.01	26.39	8.19	1.77	0.05	1.46	0.90	0.96	1.17	0.88	2.23	17.61
	Selectivity, %					59.98	18.62	4.02	0.12	3.32	2.03	2.19	2.66	2.00	5.07	40.02

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/ActRptParticles Oct05 to Aug07/Tablesof 05 - 07 Report/Table 7 (Runs 93 96).xls

Table 8

Result Summary: Fischer-Tropsch Experimental Series with Jelam Prepared Ru & Pd Catalysts
Runs 2121-103, 107

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE989 1.1 wt% Ru on Al2O3 coated SiO2 Gel	Gas Analyses, %	103A	**259**	42.46	56.63	0.78	0.07	0.01	0.02	0.00	0.02	0.00	0.01	0.01	0.01	0.138
100 micron Silicycle support	Conversion, %				1.86	1.34	0.12	0.03	0.05	0.02	0.10	0.02	0.06	0.07	0.05	0.52
	Selectivity, %					72.28	6.33	1.45	2.79	0.98	5.37	0.89	3.28	3.77	2.85	27.72
	Gas Analyses, %	103B	**276**	41.21	57.36	1.13	0.15	0.02	0.03	0.01	0.04	0.01	0.04	0.01	0.01	0.322
	Conversion, %				3.15	1.91	0.25	0.07	0.09	0.03	0.21	0.04	0.30	0.09	0.14	1.23
	Selectivity, %					60.85	8.06	2.29	3.02	1.11	6.60	1.24	9.57	2.95	4.31	39.15
	Gas Analyses, %	103C	**298**	39.90	57.68	1.610	0.458	0.066	0.062	0.020	0.109	0.015	0.045	0.033	0.053	0.860
	Conversion, %				5.62	2.63	0.75	0.22	0.20	0.10	0.54	0.10	0.29	0.27	0.52	2.98
	Selectivity, %					46.90	13.34	3.83	3.58	1.77	9.56	1.70	5.18	4.84	9.30	53.10
	Gas Analyses, %	103D	**296**	58.09	34.35	6.699	0.526	0.086	0.040	0.025	0.084	0.011	0.035	0.026	0.026	0.859
	Conversion, %				19.41	15.72	1.23	0.40	0.19	0.18	0.59	0.11	0.33	0.30	0.36	3.69
	Selectivity, %					80.98	6.36	2.08	0.96	0.90	3.06	0.54	1.69	1.55	1.87	19.02
	Gas Analyses, %	103E	**294**	54.74	26.57	17.452	0.789	0.128	0.038	0.038	0.103	0.017	0.048	0.030	0.056	1.247
	Conversion, %				42.63	37.68	1.70	0.55	0.16	0.25	0.66	0.15	0.42	0.33	0.73	4.95
	Selectivity, %					88.39	4.00	1.30	0.38	0.58	1.56	0.34	0.98	0.76	1.71	11.61
JE1033 9 wt% Pd on Al2O3 coated SiO2 Gel	Gas Analyses, %	107A	**258**	41.88	56.57	1.384	0.076	0.026	0.032	0.000	0.017	0.000	0.001	0.007	0.005	0.165
100 micron Silicycle support	Conversion, %				2.92	2.38	0.13	0.09	0.11	0.00	0.09	0.00	0.01	0.06	0.05	0.54
	Selectivity, %					81.47	4.49	3.03	3.77	0.00	2.98	0.02	0.26	2.15	1.84	18.53
	Gas Analyses, %	107B	**271**	39.03	58.35	2.189	0.219	0.064	0.085	0.001	0.026	0.016	0.003	0.002	0.042	0.459
	Conversion, %				5.09	3.56	0.36	0.21	0.28	0.00	0.13	0.10	0.02	0.02	0.41	1.53
	Selectivity, %					69.95	7.00	4.10	5.46	0.09	2.52	2.05	0.36	0.38	8.09	30.05
	Gas Analyses, %	107C	**291**	37.92	59.39	1.484	0.602	0.173	0.000	0.155	0.000	0.082	0.010	0.055	0.115	1.192
	Conversion, %				6.65	2.33	0.95	0.54	0.00	0.73	0.00	0.51	0.07	0.43	1.08	4.31
	Selectivity, %					35.10	14.24	8.19	0.00	10.98	0.00	7.74	0.98	6.50	16.26	64.90
	Gas Analyses, %	107D	**292**	60.08	24.39	11.495	3.568	0.385	0.012	0.212	0.130	0.105	0.127	0.077	0.162	4.778
	Conversion, %				44.01	26.39	8.19	1.77	0.05	1.46	0.90	0.96	1.17	0.88	2.23	17.61
	Selectivity, %					59.98	18.62	4.02	0.12	3.32	2.03	2.19	2.66	2.00	5.07	40.02
	Gas Analyses, %	107E	**291**	31.99	48.97	12.91	2.69	0.53	0.54	0.15	1.04	0.10	0.59	0.78	0.31	6.72
	Conversion, %				37.82	16.39	3.41	1.35	1.38	0.57	3.95	0.49	2.99	4.94	2.35	21.43
	Selectivity, %					43.34	9.03	3.57	3.64	1.51	10.44	1.29	7.90	13.06	6.23	56.66

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/ActRptParticles Oct05 to Aug07/Tablesof 05 - 07 Report/Table 8 (Runs 103 107).xls

Table 9

Result Summary: Fischer-Tropsch Experimental Series with CAER 0.4 g Co Catalysts
Runs 2121-130, 134, 137

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
CAER 15% Co Catalyst	Gas Analyses, %	130A	**268**	43.41	55.86	0.212	0.299	0.033	0.019	0.011	0.050	0.008	0.026	0.031	0.034	0.509
	Conversion, %				2.25	0.37	0.52	0.11	0.06	0.06	0.26	0.06	0.18	0.27	0.36	1.88
	Selectivity, %					16.46	23.22	5.06	2.87	2.56	11.55	2.45	7.92	11.92	15.98	83.54
	Gas Analyses, %	130B	**287**	39.51	58.38	0.526	0.985	0.079	0.037	0.031	0.143	0.024	0.079	0.090	0.131	1.598
	Conversion, %				6.28	0.84	1.58	0.25	0.12	0.15	0.69	0.15	0.51	0.72	1.26	5.43
	Selectivity, %					13.45	25.18	4.04	1.88	2.39	10.99	2.44	8.05	11.55	20.04	86.55
	Gas Analyses, %	130C	**286**	61.36	35.45	0.321	1.999	0.138	0.025	0.075	0.174	0.056	0.087	0.132	0.178	2.863
	Conversion, %				13.83	0.78	4.86	0.67	0.12	0.55	1.27	0.54	0.84	1.60	2.60	13.05
	Selectivity, %					5.64	35.14	4.84	0.88	3.97	9.17	3.94	6.08	11.57	18.78	94.36
CAER 15% Co w/ 0.5% Pt Catalyst	Gas Analyses, %	134A	**272**	5.78	72.37	12.965	5.496	0.453	0.070	0.188	0.897	0.179	0.539	0.737	0.366	8.925
	Conversion, %				30.34	12.48	5.29	0.87	0.14	0.54	2.59	0.69	2.08	3.55	2.11	17.86
	Selectivity, %					41.14	17.44	2.88	0.45	1.79	8.54	2.27	6.84	11.69	6.97	58.86
	Gas Analyses, %	134B	**288**	4.38	54.13	25.976	10.370	0.891	0.091	0.385	1.441	0.271	0.728	0.853	0.458	15.488
	Conversion, %				50.31	23.85	9.52	1.64	0.17	1.06	3.97	0.99	2.67	3.92	2.52	26.46
	Selectivity, %					47.40	18.92	3.25	0.33	2.11	7.89	1.98	5.32	7.79	5.01	52.60
	Gas Analyses, %	134C	**288**	19.32	2.19	26.751	41.503	3.691	0.009	2.821	0.650	1.125	0.370	0.984	0.429	51.582
	Conversion, %				97.85	26.30	40.80	7.26	0.02	8.32	1.92	4.42	1.45	4.84	2.53	71.55
	Selectivity, %					26.87	41.70	7.42	0.02	8.50	1.96	4.52	1.49	4.94	2.59	73.13
CAER 25% Co Catalyst	Gas Analyses, %	137A	**268**	15.45	77.13	2.196	3.151	0.189	0.056	0.061	0.447	0.168	0.350	0.430	0.361	5.213
	Conversion, %				15.13	2.42	3.47	0.42	0.12	0.20	1.48	0.74	1.54	2.36	2.38	12.71
	Selectivity, %					15.97	22.92	2.75	0.82	1.32	9.76	4.88	10.19	15.62	15.76	84.03
	Gas Analyses, %	137B	**285**	6.00	75.00	8.675	6.820	0.491	0.097	0.156	0.998	0.138	0.550	0.626	0.395	10.270
	Conversion, %				27.45	8.39	6.60	0.95	0.19	0.45	2.90	0.54	2.13	3.03	2.29	19.06
	Selectivity, %					30.56	24.03	3.46	0.69	1.65	10.55	1.95	7.74	11.03	8.34	69.44
	Gas Analyses, %	137C	**287**	20.91	19.77	32.683	37.040	2.801	0.046	1.351	1.286	0.312	0.433	0.459	0.464	44.192
	Conversion, %				82.21	29.40	33.32	5.04	0.08	3.65	3.47	1.12	1.56	2.06	2.51	52.81
	Selectivity, %					35.76	40.53	6.13	0.10	4.43	4.22	1.37	1.90	2.51	3.05	64.24

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 10

Result Summary: Fischer-Tropsch Experimental Series with 0.1 g Co Catalysts
Runs 2121-141, 144, and 146

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
CAER 15% Co Catalyst (0.100 g)	Gas Analyses, %	141A	**267**	65.81	33.07	0.095	0.685	0.024	0.012	0.012	0.072	0.014	0.046	0.039	0.124	1.028
	Conversion, %				6.46	0.27	1.94	0.14	0.07	0.11	0.61	0.16	0.52	0.54	2.11	6.19
	Selectivity, %					4.16	29.99	2.09	1.07	1.63	9.44	2.45	8.11	8.43	32.62	95.84
	Gas Analyses, %	141B	**281**	64.61	32.79	0.164	1.699	0.078	0.020	0.039	0.167	0.038	0.092	0.117	0.194	2.443
	Conversion, %				13.10	0.43	4.50	0.41	0.10	0.31	1.33	0.40	0.98	1.54	3.08	12.67
	Selectivity, %					3.32	34.36	3.14	0.79	2.38	10.16	3.07	7.47	11.78	23.53	96.68
	Gas Analyses, %	141C	**294**	60.93	32.60	0.334	4.356	0.317	0.031	0.148	0.391	0.120	0.196	0.305	0.273	6.136
	Conversion, %				25.95	0.76	9.89	1.44	0.14	1.01	2.67	1.09	1.78	3.46	3.72	25.19
	Selectivity, %					2.92	38.12	5.55	0.54	3.88	10.27	4.19	6.85	13.34	14.34	97.08
JE-1162b Co Catalyst (0.1 g)	Gas Analyses, %	144A	**266**	66.12	33.89	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(11.4% Co by ALD on Al2O3/SiO2)	Conversion, %				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(350 C reduction in H2)	Selectivity, %					0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
	Gas Analyses, %	144B	**283**	66.37	33.63	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
	Conversion, %				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Selectivity, %					0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
	Gas Analyses, %	144C	**295**	66.49	33.34	0.173	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
	Conversion, %				0.52	0.52	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Selectivity, %					98.63	1.25	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Continued JE-1162b Co Catalyst (0.1 g)	Gas Analyses, %	146A	**272**	62.92	36.35	0.045	0.448	0.029	0.008	0.020	0.054	0.019	0.027	0.043	0.047	0.694
(11.4% Co by ALD on Al2O3/SiO2)	Conversion, %				3.88	0.12	1.19	0.15	0.04	0.16	0.43	0.20	0.28	0.57	0.75	3.76
(Further reduced in H2 at 400 C)	Selectivity, %					3.07	30.56	3.97	1.09	4.01	10.96	5.13	7.31	14.69	19.22	96.93
	Gas Analyses, %	146B	**285**	61.97	36.50	0.131	0.930	0.071	0.010	0.046	0.089	0.038	0.043	0.075	0.095	1.397
	Conversion, %				7.35	0.33	2.36	0.36	0.05	0.35	0.67	0.39	0.43	0.95	1.45	7.01
	Selectivity, %					4.53	32.14	4.91	0.70	4.76	9.17	5.26	5.87	12.92	19.73	95.47
	Gas Analyses, %	146C	**296**	60.14	36.88	0.225	1.950	0.165	0.012	0.115	0.135	0.075	0.044	0.130	0.142	2.767
	Conversion, %				12.47	0.53	4.63	0.78	0.06	0.82	0.96	0.71	0.41	1.54	2.02	11.94
	Selectivity, %					4.28	37.11	6.29	0.47	6.59	7.69	5.72	3.31	12.34	16.19	95.72

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 11

Result Summary: Fischer-Tropsch Experimental Series No. 2 with 0.1 g Co Catalysts
Runs 2121-152, 154

Catalyst Evaluated		Run No. 2121-	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1157b Co Catalyst (0.1 g)	Gas Analyses, %	152A	**273**	66.95	32.77	0.168	0.067	0.007	0.007	0.002	0.015	0.002	0.004	0.003	0.003	0.109
(9.4% Co by ALD on Al2O3/SiO2)	Conversion, %				1.12	0.51	0.20	0.04	0.04	0.02	0.14	0.02	0.05	0.05	0.05	0.61
(350 C reduction in H2)	Selectivity, %					45.44	18.10	3.57	3.52	1.87	12.42	1.62	4.54	4.06	4.87	54.56
	Gas Analyses, %	152B	**286**	66.66	32.82	0.283	0.153	0.019	0.010	0.006	0.031	0.004	0.008	0.008	0.007	0.244
	Conversion, %				2.17	0.84	0.46	0.11	0.06	0.05	0.28	0.04	0.10	0.12	0.12	1.33
	Selectivity, %					38.81	20.95	5.13	2.72	2.30	12.67	1.92	4.44	5.62	5.43	61.19
	Gas Analyses, %	152C	**299**	66.16	32.67	0.444	0.487	0.058	0.012	0.011	0.074	0.013	0.019	0.023	0.021	0.718
	Conversion, %				4.93	1.29	1.42	0.34	0.07	0.10	0.65	0.15	0.22	0.33	0.36	3.64
	Selectivity, %					26.20	28.73	6.82	1.36	1.98	13.15	3.02	4.56	6.79	7.40	73.80
JE-1157b Co Catalyst (0.1 g)	Gas Analyses, %	154A	**273**	66.25	32.31	1.113	0.192	0.021	0.007	0.009	0.035	0.006	0.013	0.014	0.016	0.313
(9.4% Co by ALD on Al2O3/SiO2)	Conversion, %				5.09	3.27	0.57	0.12	0.04	0.08	0.31	0.08	0.15	0.20	0.28	1.83
(Further reduction in H2 at 400C)	Selectivity, %					64.17	11.09	2.38	0.84	1.52	6.07	1.48	3.00	3.95	5.50	35.83
Note: theCO2 yield of the 154A series	Gas Analyses, %	154B	**285**	66.00	32.64	0.768	0.410	0.031	0.008	0.017	0.052	0.013	0.022	0.016	0.025	0.593
is exceptionally high considering the data of	Conversion, %				5.31	2.23	1.19	0.18	0.04	0.15	0.45	0.15	0.25	0.23	0.44	3.08
all of the other runs.	Selectivity, %					41.95	22.41	3.34	0.82	2.80	8.54	2.73	4.74	4.40	8.26	58.05
	Gas Analyses, %	154C	**296**	65.34	32.56	0.878	0.857	0.079	0.008	0.048	0.086	0.029	0.027	0.046	0.045	1.225
	Conversion, %				8.53	2.47	2.41	0.44	0.05	0.40	0.72	0.32	0.30	0.65	0.76	6.06
	Selectivity, %					28.91	28.22	5.20	0.53	4.74	8.50	3.81	3.50	7.64	8.95	71.09

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/ActRptParticles Oct05 to Aug07/Tablesof 05 - 07 Report/Table 11 (Runs 152 154).xls

Table 12

Result Summary: F-T Experimental Series No. 3 with 0.1 g 17% Co on Al2O3 Catalysts
Runs 2121-157 and 159

Catalyst Evaluated		Run No. 2121-	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1209 Co Catalyst (0.1 g)	Gas Analyses, %	157A	**272**	66.07	32.89	0.330	0.487	0.024	0.005	0.015	0.056	0.017	0.025	0.033	0.052	0.713
(17 % Co by ALD on Al2O3 on SiO2)	Conversion, %				4.99	0.95	1.41	0.14	0.03	0.13	0.48	0.19	0.29	0.48	0.89	4.04
(350 C reduction in H2)	Selectivity, %					19.10	28.17	2.78	0.59	2.66	9.64	3.82	5.74	9.61	17.89	80.90
	Gas Analyses, %	157B	**284**	65.11	32.82	0.579	1.060	0.062	0.007	0.043	0.101	0.038	0.038	0.070	0.081	1.499
	Conversion, %				9.25	1.60	2.93	0.34	0.04	0.36	0.84	0.42	0.42	0.96	1.34	7.64
	Selectivity, %					17.32	31.69	3.72	0.40	3.89	9.05	4.55	4.51	10.41	14.46	82.68
	Gas Analyses, %	157C	**295**	63.81	32.87	0.408	2.151	0.161	0.007	0.109	0.139	0.074	0.054	0.119	0.103	2.917
	Conversion, %				14.02	1.07	5.63	0.84	0.04	0.85	1.09	0.78	0.56	1.56	1.61	12.96
	Selectivity, %					7.61	40.13	6.02	0.26	6.07	7.79	5.53	4.00	11.09	11.51	92.39
	Gas Analyses, %	157D	**304**	61.70	32.61	0.576	3.955	0.332	0.007	0.206	0.154	0.115	0.071	0.148	0.127	5.115
	Conversion, %				20.75	1.40	9.61	1.61	0.03	1.50	1.13	1.12	0.69	1.80	1.85	19.35
	Selectivity, %					6.75	46.33	7.77	0.17	7.23	5.43	5.38	3.34	8.66	8.94	93.25
JE-1209 Co Catalyst (0.1 g)	Gas Analyses, %	159A	**267**	65.72	32.75	0.593	0.664	0.032	0.004	0.028	0.060	0.027	0.025	0.044	0.064	0.947
(17 % Co by ALD on Al2O3 on SiO2)	Conversion, %				6.83	1.69	1.89	0.18	0.02	0.24	0.51	0.31	0.28	0.63	1.09	5.14
(Further reduction in H2 at 400C)	Selectivity, %					24.70	27.66	2.68	0.30	3.46	7.45	4.50	4.08	9.16	16.00	75.30
	Gas Analyses, %	159B	**283**	64.27	32.76	0.727	1.624	0.097	0.005	0.088	0.112	0.067	0.045	0.099	0.104	2.241
	Conversion, %				12.60	1.94	4.33	0.52	0.03	0.70	0.90	0.72	0.47	1.32	1.66	10.66
	Selectivity, %					15.40	34.40	4.11	0.22	5.56	7.14	5.68	3.77	10.52	13.21	84.60
	Gas Analyses, %	159C	**294**	62.49	32.58	0.990	2.895	0.249	0.006	0.178	0.143	0.116	0.063	0.157	0.141	3.947
	Conversion, %				19.12	2.46	7.19	1.24	0.03	1.32	1.06	1.15	0.62	1.95	2.11	16.67
	Selectivity, %					12.85	37.58	6.46	0.15	6.92	5.57	6.01	3.24	10.21	11.01	87.15
	Gas Analyses, %	159D	**300**	60.46	32.30	1.374	4.328	0.372	0.006	0.270	0.154	0.161	0.212	0.200	0.165	5.869
	Conversion, %				25.78	3.16	9.95	1.71	0.03	1.86	1.06	1.48	1.95	2.29	2.28	22.62
	Selectivity, %					12.25	38.59	6.64	0.11	7.22	4.13	5.75	7.57	8.90	8.85	87.75

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

Table 13

Result Summary: F-T Experimental Series No. 3 with 0.1 g 17% Co and 2% Pt on Al2O3 Catalysts
Runs 2121-162 and 165

Catalyst Evaluated		Run No. 2121-	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1218 Co Catalyst (0.1 g)	Gas Analyses, %	162A	**270**	54.68	32.18	1.082	8.509	0.699	0.006	0.656	0.019	0.560	0.163	0.615	0.823	12.050
(17% Co & 2% Pt by ALD on Al2O3/SiO2)	Conversion, %				42.65	1.93	15.16	2.49	0.02	3.51	0.10	3.99	1.16	5.48	8.80	40.72
(350 C reduction in H2)	Selectivity, %					4.52	35.56	5.84	0.05	8.23	0.24	9.35	2.73	12.84	20.64	95.48
	Gas Analyses, %	162B	**283**	44.08	29.99	3.391	17.774	1.506	0.010	1.234	0.172	0.439	0.264	0.738	0.443	22.580
	Conversion, %				55.61	5.02	26.31	4.46	0.03	5.48	0.76	2.60	1.56	5.46	3.93	50.59
	Selectivity, %					9.03	47.31	8.01	0.05	9.86	1.37	4.68	2.81	9.82	7.07	90.97
	Gas Analyses, %	162C	**297**	28.10	18.11	12.031	34.539	2.652	0.009	1.781	0.162	0.983	0.311	0.809	0.536	41.782
	Conversion, %				79.48	13.63	39.13	6.01	0.02	6.05	0.55	4.46	1.41	4.58	3.64	65.85
	Selectivity, %					17.15	49.23	7.56	0.02	7.61	0.69	5.61	1.77	5.77	4.58	82.85
JE-1218 Co Catalyst (0.1 g)	Gas Analyses, %	165A	**270**	55.06	32.58	0.948	8.376	0.701	0.007	0.687	0.021	0.513	0.167	0.616	0.325	11.411
(17% Co & 2% Pt by ALD on Al2O3/SiO2)	Conversion, %				38.75	1.78	15.75	2.63	0.02	3.87	0.12	3.86	1.26	5.79	3.66	36.96
(400 C further reduction in H2)	Selectivity, %					4.60	40.64	6.80	0.06	9.99	0.30	9.96	3.24	14.93	9.46	95.40
	Gas Analyses, %	165B	**283**	46.16	31.98	2.585	14.685	1.287	0.009	1.106	0.087	0.759	0.223	0.666	0.636	19.459
	Conversion, %				51.90	3.89	22.08	3.87	0.03	4.99	0.39	4.56	1.34	5.01	5.74	48.02
	Selectivity, %					7.49	42.55	7.46	0.05	9.61	0.76	8.79	2.58	9.65	11.06	92.51
	Gas Analyses, %	165C	**283**	32.25	24.06	9.905	27.349	2.299	0.009	1.630	0.114	0.921	0.267	0.676	0.455	33.718
	Conversion, %				70.66	12.08	33.34	5.61	0.02	5.96	0.42	4.49	1.30	4.12	3.33	58.58
	Selectivity, %					17.09	47.19	7.93	0.03	8.43	0.59	6.35	1.84	5.83	4.71	82.91

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 14

Result Summary: Fischer-Tropsch Experimental Series with 0.1 g Co Catalysts of CAER
Runs 2121-141 185 and 2241-4

Catalyst Evaluated		Run No. 2121-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
CAER 15% Co Catalyst (0.100 g)	Gas Analyses, %	141A	**267**	65.81	33.07	0.095	0.685	0.024	0.012	0.012	0.072	0.014	0.046	0.039	0.124	1.028
Pretreated in H2 at 350oC	Conversion, %				6.46	0.27	1.94	0.14	0.07	0.11	0.61	0.16	0.52	0.54	2.11	6.19
	Selectivity, %					4.16	29.99	2.09	1.07	1.63	9.44	2.45	8.11	8.43	32.62	95.84
	Gas Analyses, %	141B	**281**	64.61	32.79	0.164	1.699	0.078	0.020	0.039	0.167	0.038	0.092	0.117	0.194	2.443
	Conversion, %				13.10	0.43	4.50	0.41	0.10	0.31	1.33	0.40	0.98	1.54	3.08	12.67
	Selectivity, %					3.32	34.36	3.14	0.79	2.38	10.16	3.07	7.47	11.78	23.53	96.68
	Gas Analyses, %	141C	**294**	60.93	32.60	0.334	4.356	0.317	0.031	0.148	0.391	0.120	0.196	0.305	0.273	6.136
	Conversion, %				25.95	0.76	9.89	1.44	0.14	1.01	2.67	1.09	1.78	3.46	3.72	25.19
	Selectivity, %					2.92	38.12	5.55	0.54	3.88	10.27	4.19	6.85	13.34	14.34	97.08
CAER 15% Co Catalyst (0.100 g)	Gas Analyses, %	185A	**229**	67.22	32.59	0.000	0.120	0.004	0.005	0.003	0.009	0.003	0.013	0.011	0.019	0.186
Pretreated in H2 at 400oC	Conversion, %				1.23	0.00	0.36	0.02	0.03	0.03	0.08	0.03	0.16	0.17	0.34	1.23
	Selectivity, %					0.00	29.69	1.98	2.22	2.22	6.52	2.77	12.65	13.95	28.01	100.00
	Gas Analyses, %	185B	**247**	66.71	32.69	0.000	0.405	0.012	0.008	0.008	0.040	0.010	0.033	0.037	0.053	0.607
	Conversion, %				3.72	0.00	1.19	0.07	0.05	0.07	0.36	0.12	0.39	0.54	0.94	3.72
	Selectivity, %					0.00	32.02	1.91	1.33	1.95	9.54	3.26	10.38	14.47	25.15	100.00
	Gas Analyses, %	185C	**274**	63.63	32.62	0.368	2.383	0.161	0.017	0.084	0.185	0.085	0.132	0.163	0.166	3.378
	Conversion, %				16.82	0.94	6.08	0.82	0.09	0.64	1.41	0.87	1.35	2.08	2.54	15.88
	Selectivity, %					5.58	36.12	4.89	0.53	3.83	8.41	5.17	8.02	12.34	15.12	94.42
	Gas Analyses, %	185D	**282**	59.93	32.69	0.512	4.944	0.363	0.024	0.222	0.326	0.179	0.226	0.337	0.244	6.865
	Conversion, %				27.89	1.13	10.91	1.60	0.11	1.47	2.15	1.58	1.99	3.72	3.23	26.76
	Selectivity, %					4.05	39.11	5.75	0.38	5.27	7.72	5.65	7.14	13.33	11.59	95.95
	Gas Analyses, %	185E	**290**	54.90	32.19	1.125	8.814	0.689	0.032	0.445	0.381	0.303	0.335	0.475	0.320	11.792
	Conversion, %				39.14	2.13	16.66	2.60	0.12	2.52	2.16	2.29	2.53	4.49	3.63	37.01
	Selectivity, %					5.43	42.58	6.66	0.31	6.44	5.52	5.85	6.47	11.48	9.27	94.57
		2241-														
CAER 15% Co 0.5% Pt Catalyst (0.100 g)	Gas Analyses, %	4A	**229**	65.71	33.73	0.000	0.357	0.011	0.008	0.011	0.034	0.013	0.033	0.025	0.069	0.561
Designated ZYQ036	Conversion, %				3.58	0.00	1.02	0.06	0.04	0.09	0.29	0.15	0.38	0.36	1.19	3.58
Pretreated in H2 at 400oC	Selectivity, %					0.00	28.50	1.80	1.20	2.58	8.04	4.05	10.59	10.01	33.22	100.00
	Gas Analyses, %	4B	**244**	64.26	34.01	0.124	1.067	0.047	0.011	0.036	0.081	0.043	0.086	0.110	0.132	1.613
	Conversion, %				9.37	0.33	2.84	0.25	0.06	0.29	0.64	0.46	0.92	1.46	2.11	9.04
	Selectivity, %					3.53	30.33	2.67	0.63	3.09	6.87	4.91	9.82	15.63	22.52	96.47
	Gas Analyses, %	4C	**273**	52.64	32.53	2.096	8.988	0.789	0.025	0.571	0.373	0.445	0.708	0.584	0.263	12.745
	Conversion, %				43.11	3.67	15.72	2.76	0.09	3.00	1.96	3.11	4.95	5.11	2.76	39.45
	Selectivity, %					8.50	36.46	6.40	0.20	6.95	4.53	7.21	11.49	11.84	6.40	91.50
	Gas Analyses, %	4D	**283**	45.82	28.65	5.712	17.225	1.579	0.034	1.131	0.594	0.684	0.568	0.646	0.730	23.191
	Conversion, %				60.54	7.87	23.72	4.35	0.09	4.67	2.46	3.77	3.13	4.45	6.03	52.67
	Selectivity, %					12.99	39.19	7.19	0.15	7.72	4.06	6.23	5.17	7.34	9.97	87.01

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
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Table 15

Result Summary: F-T Experimental Series No. 3 with 0.1 g 16% Co
Runs 2121-168 and 173

Catalyst Evaluated		Run No. 2121-	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1210 Co Catalyst (0.1 g)	Gas Analyses, %	168A	**271**	66.42	32.91	0.360	0.214	0.013	0.003	0.005	0.025	0.005	0.010	0.016	0.025	0.316
(16% Co on SiO2, only)	Conversion, %				2.91	1.06	0.63	0.08	0.02	0.04	0.22	0.06	0.12	0.23	0.44	1.85
(350 C reduction in H2)	Selectivity, %					36.49	21.66	2.66	0.61	1.46	7.60	2.07	4.18	8.01	15.27	63.51
	Gas Analyses, %	168B	**281**	65.53	32.91	0.071	0.598	0.025	0.010	0.013	0.079	0.013	0.034	0.040	0.048	0.858
	Conversion, %				4.87	0.20	1.73	0.15	0.06	0.11	0.68	0.15	0.39	0.57	0.83	4.67
	Selectivity, %					4.21	35.44	2.99	1.17	2.26	13.97	3.16	7.97	11.75	17.08	95.79
	Gas Analyses, %	168C	**294**	64.43	32.64	0.088	1.403	0.075	0.015	0.040	0.181	0.037	0.006	0.132	0.098	1.987
	Conversion, %				10.31	0.24	3.86	0.41	0.08	0.33	1.49	0.41	0.07	1.81	1.61	10.07
	Selectivity, %					2.34	37.40	3.98	0.82	3.21	14.49	3.93	0.64	17.56	15.64	97.66
	Gas Analyses, %	168D	**300**	63.41	32.28	1.182	2.193	0.130	0.017	0.074	0.258	0.061	0.095	0.162	0.139	3.128
	Conversion, %				17.67	3.01	5.59	0.67	0.09	0.57	1.97	0.62	0.96	2.06	2.13	14.66
	Selectivity, %					17.06	31.65	3.76	0.48	3.22	11.15	3.51	5.46	11.66	12.05	82.94
JE-1210 Co Catalyst (0.1 g)	Gas Analyses, %	173A	**273**	64.41	33.23	0.008	1.675	0.097	0.007	0.078	0.068	0.074	0.067	0.142	0.140	2.348
(16% Co on SiO2, only)	Conversion, %				11.79	0.02	4.45	0.52	0.03	0.62	0.54	0.79	0.71	1.88	2.23	11.77
(400 C further reduction in H2)	Selectivity, %					0.18	37.71	4.39	0.29	5.25	4.58	6.70	6.02	15.94	18.94	99.82
	Gas Analyses, %	173B	**281**	62.88	33.08	0.028	2.859	0.225	0.008	0.150	0.094	0.128	0.099	0.253	0.202	4.019
	Conversion, %				18.43	0.07	7.05	1.11	0.04	1.11	0.69	1.26	0.98	3.12	2.99	18.36
	Selectivity, %					0.37	38.25	6.03	0.22	6.03	3.76	6.86	5.30	16.95	16.23	99.63
	Gas Analyses, %	173C	**297**	55.65	31.54	1.294	8.460	0.750	0.011	0.553	0.363	0.345	0.209	0.462	0.363	11.516
	Conversion, %				39.66	2.48	16.19	2.87	0.04	3.18	2.08	2.64	1.60	4.42	4.17	37.18
	Selectivity, %					6.24	40.82	7.23	0.11	8.01	5.25	6.66	4.02	11.15	10.52	93.76

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

Table 16

Result Summary: F-T Experimental Series No. 3 with 0.1 g 16% Co plus 2% Pt on SiO2, only, Support
Runs 2121-176 and 178

Catalyst Evaluated		Run No. 2121-	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1217 Co Catalyst (0.1 g)	Gas Analyses, %	176A	**268**	54.48	33.34	0.523	8.701	0.698	0.004	0.677	0.139	0.498	0.114	0.504	0.321	11.655
(16% Co 2% Pt by ALD on SiO2, only)	Conversion, %				37.45	0.98	16.32	2.62	0.01	3.81	0.78	3.74	0.85	4.73	3.61	36.47
(350 C reduction in H2)	Selectivity, %					2.62	43.58	6.99	0.04	10.17	2.08	9.97	2.28	12.63	9.64	97.38
	Gas Analyses, %	176B	**277**	48.77	32.01	2.206	12.957	1.078	0.005	0.976	0.171	0.675	0.181	0.596	0.344	16.983
	Conversion, %				47.74	3.60	21.16	3.52	0.02	4.78	0.84	4.41	1.18	4.86	3.37	44.13
	Selectivity, %					7.55	44.32	7.38	0.03	10.01	1.75	9.24	2.48	10.18	7.06	92.45
	Gas Analyses, %	176C	**287**	36.16	18.32	12.476	26.863	2.132	0.005	1.669	0.049	0.959	0.259	0.723	0.437	33.095
	Conversion, %				76.58	15.96	34.36	5.45	0.01	6.40	0.19	4.91	1.32	4.62	3.36	60.62
	Selectivity, %					20.84	44.87	7.12	0.02	8.36	0.24	6.41	1.73	6.04	4.38	79.16
	Gas Analyses, %	176D	**293**	32.21	7.54	18.559	34.560	2.586	0.001	1.833	0.142	0.992	0.216	1.018	0.559	41.907
	Conversion, %				91.14	21.83	40.64	6.08	0.00	6.47	0.50	4.66	1.02	5.99	3.95	69.31
	Selectivity, %					23.95	44.60	6.67	0.00	7.09	0.55	5.12	1.11	6.57	4.33	76.05
JE-1217 Co Catalyst (0.1 g)	Gas Analyses, %	178A	**252**	59.87	33.90	0.044	4.458	0.291	0.004	0.321	0.169	0.269	0.092	0.357	0.227	6.188
(16% Co 2% Pt by ALD on SiO2, only)	Conversion, %				24.76	0.10	9.90	1.29	0.02	2.14	1.12	2.39	0.82	3.96	3.02	24.66
(400 C further reduction in H2)	Selectivity, %					0.39	39.97	5.21	0.07	8.64	4.54	9.65	3.31	16.00	12.21	99.61
	Gas Analyses, %	178B	**263**	55.02	33.84	0.926	7.456	0.553	0.005	0.575	0.202	0.436	0.127	0.452	0.404	10.209
	Conversion, %				35.67	1.76	14.17	2.10	0.02	3.28	1.15	3.31	0.97	4.30	4.61	33.91
	Selectivity, %					4.93	39.73	5.89	0.05	9.20	3.23	9.28	2.71	12.05	12.91	95.07
	Gas Analyses, %	178C	**281**	39.70	22.24	10.660	21.802	1.827	0.007	1.603	0.220	0.839	0.218	0.608	0.369	27.494
	Conversion, %				69.67	14.54	29.73	4.98	0.02	6.56	0.90	4.58	1.19	4.15	3.02	55.13
	Selectivity, %					20.87	42.68	7.15	0.03	9.41	1.29	6.57	1.71	5.95	4.34	79.13

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/ActRptParticles Oct05 to Aug07/Tablesof 05 - 07 Report/Table 16 (Runs 176 178).xls

Table 17

Result Summary: F-T Experimental Series No. 3 with 0.1 g 25% Co
Runs 2264-8 and 12

Catalyst Evaluated		Run No. 2264	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1264 Co Catalyst (0.1 g)	Gas Analyses, %	8A	**230**	65.97	33.81	0.000	0.141	0.004	0.003	0.002	0.008	0.003	0.009	0.010	0.038	0.219
(25% Co on SiO2, only)	Conversion, %				1.50	0.00	0.41	0.03	0.02	0.02	0.07	0.03	0.11	0.15	0.67	1.50
(400 C reduction in H2)	Selectivity, %					0.00	27.37	1.71	1.05	1.22	4.61	2.10	7.15	10.11	44.67	100.00
	Gas Analyses, %	8B	**243**	66.03	33.47	0.072	0.264	0.061	0.005	0.004	0.021	0.005	0.018	0.020	0.034	0.433
	Conversion, %				2.73	0.21	0.77	0.36	0.03	0.04	0.18	0.06	0.20	0.29	0.59	2.53
	Selectivity, %					7.65	28.09	13.01	1.06	1.34	6.76	2.21	7.44	10.68	21.75	92.35
	Gas Analyses, %	8C	**272**	64.25	33.40	0.185	1.556	0.071	0.013	0.044	0.119	0.048	0.087	0.113	0.119	2.168
	Conversion, %				11.20	0.49	4.14	0.37	0.07	0.35	0.95	0.51	0.93	1.50	1.90	10.71
	Selectivity, %					4.39	36.92	3.35	0.61	3.10	8.45	4.56	8.28	13.39	16.95	95.61
JE-1265 Co Catalyst (0.1 g)	Gas Analyses, %	12A	**230**	66.61	33.16	0.033	0.131	0.005	0.004	0.003	0.011	0.003	0.008	0.012	0.017	0.194
(25% Co on Al2O3 on SiO2)	Conversion, %				1.29	0.10	0.39	0.03	0.03	0.03	0.10	0.04	0.09	0.18	0.31	1.19
(400 C reduction in H2)	Selectivity, %					7.62	30.14	2.17	2.03	2.01	7.69	3.05	7.02	14.19	24.09	92.38
	Gas Analyses, %	12B	**248**	65.91	33.46	0.085	0.361	0.012	0.008	0.007	0.036	0.009	0.029	0.033	0.048	0.543
	Conversion, %				3.52	0.25	1.04	0.07	0.04	0.06	0.31	0.10	0.34	0.47	0.83	3.28
	Selectivity, %					6.96	29.54	1.96	1.24	1.82	8.94	2.98	9.56	13.47	23.53	93.04
	Gas Analyses, %	12C	**277**	64.12	33.02	0.017	1.919	0.106	0.016	0.071	0.148	0.065	0.109	0.136	0.130	2.699
	Conversion, %				13.13	0.04	5.05	0.56	0.08	0.56	1.17	0.69	1.14	1.78	2.06	13.09
	Selectivity, %					0.34	38.45	4.23	0.64	4.27	8.88	5.23	8.71	13.57	15.68	99.66

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

Table 18

Result Summary: F-T Experimental Series No. 3 with 0.1 g 25% Co + Pt
Runs 2264-16 and 20

Catalyst Evaluated		Run No. 2264	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
AH040 Co Catalyst (0.1 g)	Gas Analyses, %	16A	**230**	66.42	32.91	0.360	0.214	0.013	0.003	0.005	0.025	0.005	0.010	0.016	0.025	0.316
(25% Co + 0.67% Pt on SiO2, only)	Conversion, %				2.91	1.06	0.63	0.08	0.02	0.04	0.22	0.06	0.12	0.23	0.44	1.85
(400 C reduction in H2)	Selectivity, %					36.49	21.66	2.66	0.61	1.46	7.60	2.07	4.18	8.01	15.27	63.51
	Gas Analyses, %	16B	**242**	65.53	32.91	0.071	0.598	0.025	0.010	0.013	0.079	0.013	0.034	0.040	0.048	0.858
	Conversion, %				4.87	0.20	1.73	0.15	0.06	0.11	0.68	0.15	0.39	0.57	0.83	4.67
	Selectivity, %					4.21	35.44	2.99	1.17	2.26	13.97	3.16	7.97	11.75	17.08	95.79
	Gas Analyses, %	16C	**282**	64.43	32.64	0.088	1.403	0.075	0.015	0.040	0.181	0.037	0.006	0.132	0.098	1.987
	Conversion, %				10.31	0.24	3.86	0.41	0.08	0.33	1.49	0.41	0.07	1.81	1.61	10.07
	Selectivity, %					2.34	37.40	3.98	0.82	3.21	14.49	3.93	0.64	17.56	15.64	97.66
AH043 Co Catalyst (0.1 g)	Gas Analyses, %	20A	**230**	63.41	32.28	1.182	2.193	0.130	0.017	0.074	0.258	0.061	0.095	0.162	0.139	3.128
(25% Co + 0.51% Pt on Al2O3 on SiO2)	Conversion, %				17.67	3.01	5.59	0.67	0.09	0.57	1.97	0.62	0.96	2.06	2.13	14.66
(400 C reduction in H2)	Selectivity, %					17.06	31.65	3.76	0.48	3.22	11.15	3.51	5.46	11.66	12.05	82.94
	Gas Analyses, %	20B	**243**	64.41	33.23	0.008	1.675	0.097	0.007	0.078	0.068	0.074	0.067	0.142	0.140	2.348
	Conversion, %				11.79	0.02	4.45	0.52	0.03	0.62	0.54	0.79	0.71	1.88	2.23	11.77
	Selectivity, %					0.18	37.71	4.39	0.29	5.25	4.58	6.70	6.02	15.94	18.94	99.82
	Gas Analyses, %	20C	**275**	62.88	33.08	0.028	2.859	0.225	0.008	0.150	0.094	0.128	0.099	0.253	0.202	4.019
	Conversion, %				18.43	0.07	7.05	1.11	0.04	1.11	0.69	1.26	0.98	3.12	2.99	18.36
	Selectivity, %					0.37	38.25	6.03	0.22	6.03	3.76	6.86	5.30	16.95	16.23	99.63

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/ActRptParticles Oct05 to Aug07/Tablesof 05 - 07 Report/Table 18 (Runs 16 20).xls

	Gas Analyses, %	173C	**297**	55.65	31.54	1.294	8.460	0.750	0.011	0.553	0.363	0.345	0.209	0.462	0.363	11.516
	Conversion, %				39.66	2.48	16.19	2.87	0.04	3.18	2.08	2.64	1.60	4.42	4.17	37.18
	Selectivity, %					6.24	40.82	7.23	0.11	8.01	5.25	6.66	4.02	11.15	10.52	93.76

Table 19

Result Summary: Fischer-Tropsch Experimental Series No.4; JE with 0.1 g 25% Co
Runs 2264-27, 29, and 32

Catalyst Evaluated		Run No. 2264-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
JE-1350 25/0.1 Co&Pt ALD on SiO2 (0.1 g)	Gas Analyses, %	29A	**248.9**	63.39	30.10	0.207	4.615	0.286	0.005	0.278	0.146	0.246	0.102	0.339	0.279	6.296
(25% Co + 0.1% Pt both ALD on SiO2)	Conversion, %				27.53	0.50	11.11	1.38	0.03	2.01	1.05	2.37	0.98	4.08	4.03	27.04
(400o C reduction in H2)	Selectivity, %					1.81	40.34	5.01	0.09	7.28	3.83	8.61	3.57	14.81	14.64	98.19
	Gas Analyses, %	29B	**260.3**	57.09	29.52	0.805	0.948	0.715	0.009	0.666	0.207	0.502	0.161	0.523	0.318	4.049
	Conversion, %				30.57	1.89	2.23	3.36	0.04	4.70	1.46	4.73	1.51	6.15	4.49	28.68
	Selectivity, %					6.19	7.29	11.00	0.14	15.37	4.77	15.46	4.94	20.13	14.69	93.81
	Gas Analyses, %	29C	**264.9**	52.41	28.02	1.692	13.012	0.992	0.011	0.904	0.235	0.689	0.211	0.874	0.960	17.887
	Conversion, %				54.72	2.73	21.03	3.21	0.03	4.38	1.14	4.45	1.36	7.07	9.31	51.98
	Selectivity, %					5.00	38.43	5.86	0.06	8.01	2.08	8.14	2.49	12.91	17.02	95.00
JE-1351 25/0.1 Co CAER/Pt ALD (0.1 g)	Gas Analyses, %	32A	**246.9**	66.20	29.79	0.203	2.672	0.157	0.009	0.103	0.181	0.107	0.135	0.212	0.229	3.805
(25% CAER Co + 0.1% Pt by ALD)	Conversion, %				20.03	0.54	7.17	0.84	0.05	0.83	1.45	1.15	1.45	2.85	3.69	19.49
(CAER GJARG002 on Al2O3)	Selectivity, %					2.72	35.81	4.19	0.25	4.14	7.26	5.75	7.23	14.22	18.44	97.28
(400o C reduction in H2)																
	Gas Analyses, %	32B	**253.1**	63.34	29.65	0.362	4.040	0.263	0.012	0.186	0.254	1.002	0.259	0.343	0.283	6.642
	Conversion, %				33.19	0.82	9.10	1.18	0.05	1.26	1.72	9.03	2.33	3.86	3.82	32.37
	Selectivity, %					2.46	27.43	3.56	0.16	3.79	5.18	27.22	7.03	11.64	11.52	97.54
	Gas Analyses, %	32C	**266.1**	51.74	23.92	4.254	16.100	1.246	0.022	0.834	0.519	0.457	0.349	0.312	0.286	20.126
	Conversion, %				58.31	7.41	28.06	4.34	0.07	4.36	2.71	3.19	2.44	2.72	2.99	50.90
	Selectivity, %					12.72	48.13	7.45	0.13	7.48	4.65	5.47	4.18	4.67	5.13	87.28
JE-1352 25/0.1Co ALD on SiO2 on Al2O3	Gas Analyses, %	27A	**249.1**	68.13	30.52	0.079	0.878	0.040	0.006	0.035	0.065	0.037	0.045	0.084	0.086	1.275
(25% Co + 0.1% Pt on SiO2 all ALD on Al2O3)	Conversion, %				7.88	0.24	2.65	0.24	0.03	0.31	0.58	0.45	0.55	1.27	1.56	7.64
(400o C reduction in H2)	Selectivity, %					3.02	33.63	3.07	0.42	3.97	7.43	5.66	6.94	16.10	19.77	96.98
	Gas Analyses, %	27B	**256.8**	67.30	30.46	0.093	1.511	0.076	0.006	0.070	0.083	0.070	0.067	0.112	0.146	2.140
	Conversion, %				12.13	0.27	4.36	0.44	0.04	0.61	0.72	0.80	0.78	1.61	2.52	11.86
	Selectivity, %					2.21	35.91	3.61	0.29	5.00	5.90	6.62	6.41	13.29	20.75	97.79
	Gas Analyses, %	27C	**265.8**	65.62	30.40	0.150	2.732	0.214	0.007	0.159	0.135	0.133	0.076	0.184	0.186	3.826
	Conversion, %				18.89	0.40	7.29	1.14	0.04	1.27	1.08	1.42	0.81	2.46	2.98	18.49
	Selectivity, %					2.12	38.58	6.04	0.21	6.74	5.71	7.52	4.29	13.02	15.77	97.88

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/Additional 0.1 Pt Particles data/Table 21 (Runs 27 29 32)(H2 Corrected).xls

Table 20

Result Summary: F-T Experimental Series No. 4; CAER with 0.1 g 25% Co w&w/o 0.1 Pt
Runs 2264-53, 75, and 79

Catalyst Evaluated		Run No. 2264	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
GJARG001 CAER Prep	Gas Analyses, %	53ASpH2	**250.4**	69.91	28.29	0.064	1.162	0.047	0.012	0.028	0.054	0.034	0.120	0.098	0.178	1.733
(25% Co on Al2O3)	Conversion, %				11.74	0.20	3.63	0.30	0.07	0.27	0.50	0.42	1.50	1.53	3.33	11.54
(400 C reduction in H2)	Selectivity, %					1.70	30.90	2.51	0.62	2.27	4.29	3.56	12.79	13.01	28.35	98.30
	Gas Analyses, %	53BSpH2	**261.3**	67.22	28.25	0.254	3.016	0.147	0.016	0.100	0.196	0.103	0.174	0.218	0.142	4.111
	Conversion, %				21.05	0.71	8.43	0.82	0.09	0.84	1.64	1.15	1.94	3.05	2.37	20.34
	Selectivity, %					3.37	40.05	3.92	0.41	3.97	7.80	5.47	9.23	14.50	11.28	96.63
	Gas Analyses, %	53CSpH2	**269.5**	63.23	27.84	0.817	5.617	0.348	0.022	0.255	0.332	0.233	0.178	0.605	0.531	8.121
	Conversion, %				37.63	1.83	12.59	1.56	0.10	1.71	2.23	2.09	1.60	6.78	7.14	35.79
	Selectivity, %					4.87	33.45	4.14	0.26	4.55	5.93	5.54	4.24	18.02	18.99	95.13
GJARG001 CAER Prep	Gas Analyses, %	75A	**242.8**	64.71	34.07	0.015	0.782	0.029	0.008	0.019	0.068	0.023	0.056	0.084	0.138	1.206
(25% Co on Al2O3)	Conversion, %				7.33	0.04	2.13	0.16	0.04	0.15	0.55	0.25	0.60	1.14	2.26	7.29
(400 C reduction in H2)	Selectivity, %					0.56	29.01	2.18	0.58	2.06	7.56	3.47	8.24	15.52	30.82	99.44
	Gas Analyses, %	75B	**254.4**	62.87	34.39	0.150	1.863	0.085	0.011	0.054	0.106	0.057	0.091	0.161	0.169	2.596
	Conversion, %				12.90	0.38	4.72	0.43	0.05	0.41	0.81	0.57	0.92	2.03	2.56	12.52
	Selectivity, %					2.95	36.60	3.33	0.42	3.20	6.26	4.45	7.16	15.76	19.88	97.05
	Gas Analyses, %	75C	**263.5**	60.63	34.11	0.461	3.549	0.180	0.017	0.116	0.187	0.106	0.163	0.287	0.203	4.807
	Conversion, %				20.94	1.07	8.22	0.83	0.08	0.81	1.30	0.98	1.51	3.32	2.82	19.87
	Selectivity, %					5.10	39.27	3.98	0.37	3.86	6.22	4.69	7.20	15.85	13.46	94.90
HF-063 25/0.1 Co CAER/Pt ALD (0.1 g)	Gas Analyses, %	79A	**245.8**	62.20	34.55	0.102	2.224	0.100	0.008	0.082	0.141	0.094	0.114	0.226	0.161	3.151
(25% CAER Co + 0.1% Pt by ALD)	Conversion, %				15.09	0.25	5.47	0.49	0.04	0.61	1.04	0.92	1.12	2.77	2.38	14.84
(CAER GJARG002 on Al2O3)	Selectivity, %					1.66	36.23	3.25	0.27	4.03	6.88	6.10	7.44	18.36	15.77	98.34
(400o C reduction in H2)																
	Gas Analyses, %	79B	**255.3**	58.02	34.62	0.693	4.834	0.258	0.014	0.210	0.243	0.193	0.232	0.337	0.313	6.634
	Conversion, %				26.83	1.46	10.22	1.09	0.06	1.33	1.54	1.63	1.96	3.56	3.97	25.36
	Selectivity, %					5.46	38.08	4.07	0.22	4.96	5.74	6.08	7.32	13.27	14.81	94.54
	Gas Analyses, %	79C	**265.8**	51.79	33.35	2.480	9.441	0.660	0.024	0.441	0.430	0.321	0.357	0.420	0.377	12.472
	Conversion, %				40.79	4.40	16.76	2.34	0.08	2.35	2.29	2.28	2.54	3.73	4.01	36.39
	Selectivity, %					10.79	41.09	5.75	0.21	5.76	5.62	5.59	6.22	9.14	9.84	89.21

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.
File -- N:/DCC_ANL/FT_FETC/Reports/Additional 0.1 Pt Particles data/Table 20.xls

Table 21

Result Summary: F-T Experimental Series No. 4; 0.1 g 25% CAER Co w 0.1% CAER Pt
Runs 2264-59, 70, and 83

Catalyst Evaluated		Run No. 2264	Avg-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
GJARG002 CAER Prep	Gas Analyses, %	59A	**247**	62.35	34.62	0.171	1.940	0.076	0.008	0.066	0.120	0.073	0.146	0.162	0.266	2.857
(25% Co with 0.1% Pt on Al2O3)	Conversion, %				15.02	0.42	4.76	0.37	0.04	0.49	0.88	0.72	1.44	1.98	3.92	14.60
(Pt on after Calcined Co with Recalcination)	Selectivity, %					2.80	31.71	2.47	0.26	3.25	5.86	4.80	9.57	13.22	26.07	97.20
(400 C reduction in H2)																
	Gas Analyses, %	59B	**257**	58.66	34.95	0.494	4.358	0.219	0.012	0.195	0.212	0.177	0.111	0.297	0.320	5.899
	Conversion, %				24.09	1.07	9.47	0.95	0.05	1.27	1.38	1.54	0.96	3.22	4.17	23.01
	Selectivity, %					4.46	39.30	3.94	0.22	5.27	5.72	6.38	3.99	13.38	17.33	95.54
	Gas Analyses, %	59C	**266**	52.19	33.00	1.802	8.118	0.563	0.019	0.446	0.350	1.772	0.241	0.573	0.932	13.014
	Conversion, %				47.60	2.86	12.89	1.79	0.06	2.13	1.67	11.26	1.53	4.55	8.88	44.74
	Selectivity, %					6.01	27.08	3.75	0.13	4.47	3.51	23.65	3.21	9.55	18.65	93.99
GJARG002 CAER Prep (Repeat of Run 59)	Gas Analyses, %	70A	**247**	63.76	34.70	0.130	1.971	0.087	0.009	0.064	0.144	0.077	0.070	0.111	0.360	2.893
(25% Co with 0.1% Pt on Al2O3)	Conversion, %				15.20	0.32	4.82	0.42	0.05	0.47	1.05	0.75	0.69	1.35	5.28	14.88
(Pt on after Calcined Co with Recalcination)	Selectivity, %					2.09	31.68	2.78	0.30	3.11	6.93	4.96	4.52	8.88	34.75	97.91
(400 C reduction in H2)																
	Gas Analyses, %	70B	**257**	59.21	34.66	0.502	3.797	0.194	0.015	0.152	0.241	0.164	0.229	0.339	0.478	5.608
	Conversion, %				25.76	1.08	8.13	0.83	0.06	0.97	1.55	1.41	1.96	3.63	6.15	24.69
	Selectivity, %					4.17	31.56	3.23	0.24	3.78	6.02	5.47	7.60	14.07	23.85	95.83
	Gas Analyses, %	70C	**266**	54.17	33.75	1.813	7.614	0.523	0.024	0.351	0.418	0.273	0.336	0.503	0.346	10.386
	Conversion, %				37.03	3.38	14.20	1.95	0.09	1.96	2.34	2.04	2.51	4.69	3.87	33.65
	Selectivity, %					9.13	38.36	5.27	0.24	5.30	6.31	5.51	6.77	12.67	10.46	90.87
GJARG002 CAER Prep	Gas Analyses, %	83A	**246**	62.98	34.76	0.139	1.555	0.062	0.007	0.049	0.098	0.054	0.073	0.113	0.121	2.131
(25% Co with 0.1% Pt on Al2O3)	Conversion, %				10.48	0.36	4.01	0.32	0.04	0.38	0.75	0.55	0.75	1.46	1.87	10.12
(Pt added before Co Calcination)	Selectivity, %					3.42	38.24	3.06	0.35	3.59	7.21	5.28	7.15	13.90	17.80	96.58
(400 C reduction in H2)																
	Gas Analyses, %	83B	**256**	59.41	34.76	0.678	3.821	0.197	0.012	0.171	0.213	0.158	0.149	0.277	0.155	5.153
	Conversion, %				21.66	1.53	8.61	0.89	0.06	1.16	1.44	1.42	1.34	3.12	2.10	20.13
	Selectivity, %					7.06	39.77	4.10	0.26	5.34	6.65	6.56	6.18	14.39	9.70	92.94
	Gas Analyses, %	83C	**266**	51.65	33.77	3.135	9.094	0.587	0.020	0.407	0.367	0.249	0.354	0.494	0.414	11.987
	Conversion, %				40.66	5.51	15.98	2.06	0.07	2.15	1.94	1.75	2.49	4.34	4.36	35.15
	Selectivity, %					13.55	39.31	5.07	0.17	5.28	4.76	4.31	6.13	10.68	10.73	86.45

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

Table 22

Result Summary: Fischer-Tropsch "Last Series" with 0.1 g Co Catalysts
Runs 2264-90 and 95
File -- N:/DCC_ANL/FT_FETC/Data&Results 0.1g Particles last series/PLS-1 (Runs 2264-90&95).xls

Catalyst Evaluated		Run No. 2264-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
0.1% ALD/Ru on CAER 25% Co on Al2O3	Gas Analyses, %	90A	**238.78**	64.83	34.07	0.120	0.704	0.024	0.007	0.015	0.055	0.020	0.043	0.056	0.060	0.983
No. SC02015090	Conversion, %				5.51	0.33	1.95	0.13	0.04	0.12	0.46	0.22	0.48	0.78	0.99	5.17
(400o C reduction in H2)	Selectivity, %					6.04	35.46	2.37	0.75	2.25	8.31	3.95	8.74	14.08	18.04	93.96
[ICRu(DER)/O2 200-50-200-50 200oC]	Gas Analyses, %	90B	**247.71**	63.64	34.45	0.092	1.334	0.050	0.010	0.034	0.097	0.040	0.070	0.079	0.109	1.822
	Conversion, %				9.04	0.24	3.52	0.27	0.05	0.27	0.77	0.42	0.74	1.04	1.72	8.80
	Selectivity, %					2.69	38.94	2.93	0.59	2.94	8.49	4.68	8.18	11.50	19.06	97.31
	Gas Analyses, %	90C	**253.15**	62.36	34.39	0.140	2.032	0.091	0.012	0.064	0.139	0.075	0.155	0.157	0.388	3.112
	Conversion, %				16.95	0.34	4.91	0.44	0.06	0.46	1.01	0.72	1.50	1.89	5.63	16.61
	Selectivity, %					1.99	28.94	2.59	0.35	2.74	5.95	4.26	8.82	11.16	33.20	98.01
	Gas Analyses, %	90D	**261.89**	60.11	34.42	0.303	3.398	0.185	0.011	0.127	0.155	0.121	0.286	0.519	0.371	5.171
	Conversion, %				24.85	0.66	7.42	0.81	0.05	0.83	1.01	1.06	2.49	5.67	4.86	24.19
	Selectivity, %					2.66	29.85	3.24	0.18	3.35	4.07	4.26	10.03	22.80	19.54	97.34
0.1% ALD/Ru on CAER 25% Co on Al2O3	Gas Analyses, %	95A	**237.89**	64.52	34.43	0.000	0.742	0.024	0.007	0.016	0.057	0.020	0.043	0.057	0.090	1.055
No. SC02015088	Conversion, %				5.74	0.00	2.03	0.13	0.04	0.13	0.47	0.22	0.47	0.77	1.48	5.74
(400o C reduction in H2)	Selectivity, %					0.00	35.40	2.33	0.63	2.22	8.11	3.81	8.20	13.49	25.81	100.00
[ICRu(DER)/O2 300-50-300-50 100oC]	Gas Analyses, %	95B	**247.50**	63.23	34.52	0.077	1.551	0.060	0.009	0.044	0.106	0.052	0.080	0.116	0.154	2.171
	Conversion, %				10.95	0.20	4.00	0.31	0.05	0.34	0.82	0.54	0.83	1.50	2.38	10.75
	Selectivity, %					1.81	36.52	2.83	0.43	3.09	7.52	4.90	7.54	13.67	21.69	98.19
	Gas Analyses, %	95C	**252.78**	62.24	34.60	0.127	2.177	0.097	0.009	0.074	0.139	0.083	0.106	0.172	0.174	3.031
	Conversion, %				14.39	0.31	5.39	0.48	0.04	0.55	1.03	0.82	1.05	2.13	2.59	14.07
	Selectivity, %					2.18	37.45	3.32	0.31	3.79	7.19	5.69	7.29	14.79	18.00	97.82
	Gas Analyses, %	95D	**262.39**	58.90	34.52	0.400	4.700	0.262	0.016	0.200	0.237	0.171	0.202	0.225	0.174	6.185
	Conversion, %				23.53	0.89	10.41	1.16	0.07	1.33	1.58	1.52	1.79	2.49	2.31	22.64
	Selectivity, %					3.77	44.25	4.93	0.30	5.64	6.70	6.44	7.59	10.57	9.82	96.23

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

Table 23

Result Summary: Fischer-Tropsch "Last Series" with 0.1 g Co Catalysts
Runs 2264-99 and 103
File -- N:/DCC_ANL/FT_FETC/Data&Results 0.1g Particles last series/PLS-2(Runs 2264-99&103).xls

Catalyst Evaluated		Run No. 2264-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
0.1% ALD/Ir on CAER 25% Co on Al2O3	Gas Analyses, %	99A	**239.86**	63.62	34.43	0.070	1.318	0.051	0.007	0.038	0.110	0.048	0.092	0.114	0.100	1.877
No. SC02015107	Conversion, %				9.64	0.18	3.46	0.27	0.04	0.30	0.86	0.50	0.96	1.50	1.57	9.46
(400o C reduction in H2)	Selectivity, %					1.91	35.87	2.79	0.38	3.06	8.94	5.24	9.99	15.53	16.30	98.09
[ICIr(AcAc)/O2 200-50-200-50 200oC]	Gas Analyses, %	99B	**241.67**	63.39	34.56	0.064	1.380	0.055	0.007	0.040	0.111	0.049	0.093	0.117	0.137	1.990
	Conversion, %				10.37	0.17	3.58	0.28	0.04	0.31	0.86	0.51	0.97	1.52	2.13	10.20
	Selectivity, %					1.60	34.53	2.74	0.37	3.01	8.34	4.90	9.33	14.68	20.50	98.40
	Gas Analyses, %	99C	**254.35**	59.42	34.94	0.416	3.778	0.197	0.011	0.162	0.234	0.172	0.226	0.281	0.160	5.220
	Conversion, %				21.82	0.93	8.45	0.88	0.05	1.09	1.57	1.53	2.02	3.14	2.15	20.89
	Selectivity, %					4.27	38.75	4.04	0.22	4.98	7.21	7.04	9.25	14.40	9.84	95.73
	Gas Analyses, %	99D	**264.17**	53.35	34.44	1.280	8.251	0.598	0.018	0.417	0.430	0.302	0.377	0.328	0.246	10.967
	Conversion, %				35.72	2.39	15.40	2.23	0.07	2.34	2.41	2.25	2.81	3.06	2.76	33.33
	Selectivity, %					6.69	43.12	6.25	0.19	6.54	6.74	6.31	7.87	8.58	7.72	93.31
CAER 25% Co on Al2O3 with 0.018% Pt	Gas Analyses, %	103A	**237.92**	64.97	34.30	0.040	0.373	0.032	0.007	0.017	0.064	0.021	0.050	0.060	0.063	0.687
(400o C reduction in H2)	Conversion, %				4.71	0.11	1.04	0.18	0.04	0.14	0.54	0.23	0.55	0.84	1.05	4.60
	Selectivity, %					2.36	22.01	3.80	0.80	2.92	11.36	4.95	11.73	17.81	22.26	97.64
Note; The recovered solids were shown to contain 25% Co and only 0.018% Pt	Gas Analyses, %	103B	**242.64**	64.20	34.38	0.048	0.971	0.037	0.007	0.025	0.074	0.030	0.058	0.078	0.099	1.378
	Conversion, %				7.38	0.13	2.62	0.20	0.04	0.20	0.60	0.32	0.63	1.05	1.60	7.25
	Selectivity, %					1.75	35.46	2.73	0.51	2.75	8.09	4.33	8.52	14.21	21.65	98.25
	Gas Analyses, %	103C	**255.83**	61.57	34.54	0.233	2.694	0.135	0.010	0.096	0.159	0.097	0.127	0.190	0.151	3.659
	Conversion, %				16.32	0.56	6.53	0.65	0.05	0.69	1.16	0.94	1.23	2.31	2.19	15.75
	Selectivity, %					3.46	40.00	4.00	0.29	4.25	7.10	5.79	7.54	14.14	13.43	96.54
	Gas Analyses, %	103D	**265.77**	57.95	34.32	0.913	5.160	0.292	0.015	0.208	0.267	0.183	0.207	0.287	0.196	6.815
	Conversion, %				26.36	1.96	11.07	1.25	0.06	1.34	1.72	1.57	1.78	3.08	2.52	24.40
	Selectivity, %					7.43	42.00	4.75	0.24	5.07	6.53	5.96	6.74	11.70	9.57	92.57

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

Table 24

Result Summary: Fischer-Tropsch "Last Series" with 0.1 g Co Catalysts
Runs 2264-107 & 117
File -- N:/DCC_ANL/FT_FETC/Data&Results 0.1g Particles last series/PLS-3(Runs 2264-107&117).xls

Catalyst Evaluated		Run No. 2264-	Mid-Bed Temp, C	H2	CO	CO2	C1	C2	C2=	C3	C3=	C4	All C4=	C5's	C6+	SUM C1+
0.1% ALD/Pt on CAER 25% Co on Al2O3	Gas Analyses, %	107A	**239.86**	64.97	33.70	0.067	0.908	0.034	0.006	0.022	0.072	0.029	0.053	0.076	0.068	1.268
No. SC02037119	Conversion, %				6.78	0.19	2.51	0.19	0.04	0.19	0.60	0.32	0.59	1.05	1.13	6.60
(400o C reduction in H2)	Selectivity, %					2.73	37.03	2.73	0.52	2.74	8.77	4.68	8.66	15.54	16.59	97.27
[IcPt(MeCp)Me3/O2 200-50-200-50 100oC]	Gas Analyses, %	107B	**243.22**	64.14	34.33	0.114	1.000	0.037	0.007	0.025	0.077	0.032	0.059	0.087	0.101	1.425
	Conversion, %				7.82	0.31	2.69	0.20	0.04	0.20	0.62	0.34	0.63	1.16	1.63	7.51
	Selectivity, %					3.91	34.36	2.53	0.49	2.60	7.94	4.38	8.06	14.87	20.85	96.09
	Gas Analyses, %	107C	**253.56**	61.77	34.59	0.185	2.515	0.120	0.010	0.087	0.156	0.092	0.118	0.192	0.168	3.457
	Conversion, %				15.81	0.45	6.12	0.58	0.05	0.63	1.14	0.89	1.15	2.34	2.45	15.36
	Selectivity, %					2.85	38.73	3.69	0.31	4.01	7.21	5.64	7.27	14.78	15.52	97.15
	Gas Analyses, %	107D	**262.06**	58.37	34.31	0.931	4.829	0.273	0.014	0.210	0.254	0.182	0.193	0.252	0.196	6.402
	Conversion, %				25.36	2.03	10.50	1.19	0.06	1.37	1.65	1.58	1.68	2.74	2.55	23.33
	Selectivity, %					7.99	41.42	4.69	0.25	5.39	6.53	6.24	6.62	10.82	10.07	92.01
0.1% IW/Ru on CAER 25% Co on Al2O3	Gas Analyses, %	117A	**240.1**	63.72	33.90	0.281	1.445	0.052	0.009	0.039	0.115	0.050	0.104	0.125	0.166	2.103
No. DCC2264-114-2	Conversion, %				11.82	0.73	3.76	0.27	0.05	0.30	0.90	0.52	1.08	1.62	2.60	11.09
(400o C reduction in H2)	Selectivity, %					6.19	31.80	2.29	0.38	2.54	7.58	4.38	9.15	13.71	21.98	93.81
Incipient wetness Ir(AcAc)3 on GJARG0001	Gas Analyses, %	117B	**247.5**	62.01	34.25	0.248	2.431	0.108	0.011	0.084	0.162	0.096	0.157	0.202	0.238	3.488
	Conversion, %				17.17	0.60	5.88	0.52	0.05	0.61	1.18	0.93	1.52	2.44	3.45	16.57
	Selectivity, %					3.49	34.24	3.05	0.30	3.53	6.85	5.41	8.85	14.20	20.08	96.51
	Gas Analyses, %	117C	**258.8**	56.32	33.88	1.148	6.476	0.426	0.018	0.286	0.336	0.234	0.250	0.352	0.270	8.646
	Conversion, %				31.65	2.32	13.06	1.72	0.07	1.73	2.03	1.89	2.02	3.55	3.27	29.34
	Selectivity, %					7.32	41.27	5.42	0.23	5.46	6.42	5.97	6.37	11.23	10.32	92.68
	Gas Analyses, %	117D	**268.4**	47.19	31.22	4.973	13.196	0.978	0.027	0.657	0.510	0.402	0.356	0.342	0.354	16.822
	Conversion, %				49.45	8.05	21.36	3.17	0.09	3.19	2.48	2.60	2.30	2.77	3.44	41.40
	Selectivity, %					16.28	43.20	6.40	0.18	6.46	5.01	5.26	4.66	5.59	6.96	83.72

Notes: 1. Gas analyses is reported as mol % normalized to N2 and O2 free
2. Conversion reported as mol % of the feed carbon in CO converted to the various components.
3. Selectivity is reported as the % of the reacted carbon in feed CO that was converted to the various components.

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