Quantachrome
INSTRUMENTS
1900 Corporate Drive
Boynton Beach, Florida 33426
800.989.2476
561.731.4999

Product Sales Announcement

Product: ChemStar-TPx™

Date: July 13, 2015

PSA#:

INTERNAL USE ONLY- NOT FOR CUSTOMER DISTRIBUTION
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PRODUCT SALES ANNOUNCEMENT (PSA)

Effective SKU Code(s):

08-200-B-110-1, 08-200-B-220-1,
08-200-P-110-1, 08-200-P-220-1

New Model Number(s):

TPx 110V TPx 220V
TPx+ 110V TPx+ 220V

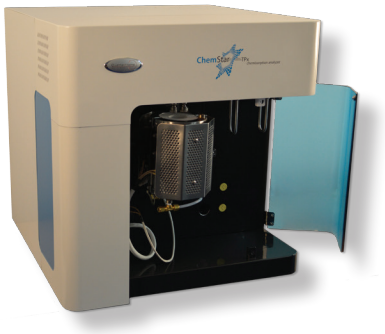
Product Line(s) Used with:

Optional external Gas Mixer; stand-alone Mass Spectrometer.

KEY WORDS:

Catalyst Characterization
Dynamic Flow Chemisorption
Temperature Programming
Desorption
Oxidation
Reduction
Reaction
Pulse Titration
Flow BET Analysis

SUMMARY



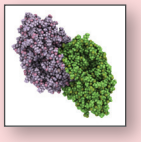
The ChemStar-TPx series of automated flow chemisorption analyzers extend the capabilities of ChemBET Pulsar, ChemBET TPD/TPR and including the Autosorb iQ-C products by providing full automation, multiple mass flow controllers, built-in gas mixing and vapor introduction in a unit designed for precise temperature ramping and pulse titration tasks. These features and additional options of the ChemStar™ are in high demand by modern research laboratories dealing with catalyst characterization and applications involving reactive solid surfaces.

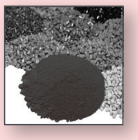
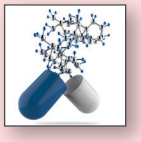
BENEFITS

The ChemStar™ provides new hardware and software features that substantially extend the programming and automation capabilities of the existing products to include high precision mass flow controllers, built-in gas mixing, vapor introduction, pulse injection, heated components and fast cooling capabilities. These competitive features make the ChemStar™ the instrument of choice by research facilities focused on flow (vs. vacuum) characterization and reactivity evaluation techniques.

INTRODUCTION

Quantachome Instruments is thrilled to add the ChemStar-TPx™ series to its portfolio of chemisorption analyzers! The ChemStar™ is a fully automated dynamic flow chemisorption analyzer that provides easily programmable functions along with high precision mass flow controllers to carry out built-in gas mixing, calibrated loop injection, vapor introduction, heated components, temperature ramping, fast cooling, and all with minimal operator intervention. The software performs a virtually unlimited number of programmable steps to extract valuable information about surface and catalytic properties of a sample, such as active and reactive surface areas, metal dispersion, nanocluster particle size, acid/base site distribution, and sorption energetics.



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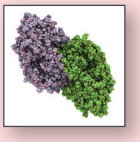


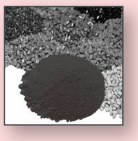
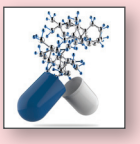

GENERAL FEATURES AND BENEFITS OVERVIEW

The ChemStar™ is ideally suited for the characterization of heterogeneous catalysts and related materials. Its fully programmable functions and robust design enable it to undertake both standard quality control evaluations and highly sophisticated R&D tasks with equal ease. Having upto ten (10) gas input ports, along with built-in gas blending and mixing capabilities via multiple high precision mass flow controllers, gives the ChemStar™ superior flexibility among instruments that monitor changes in flowing gas or condensable vapor concentrations. Its heated lines and valves are coupled with a clamshell furnace capable of performing experiments up to 1,200 ºC using easily programmable linear ramping, holding, and fast-cooling steps. In addition, the ChemStar's safety and ergonomic design features were crafted for compliance with regulations practiced by leading industrial, academic, and government laboratories.

COMPETITIVE FEATURES

Stable baseline and quality data:
Ensured by 3 standard (and 1 optional) high-precision electronic mass flow controllers with 0.08% thermal drift in the standard 0-50 cm^3/min range (with optional ranges available up to 1 L/min).

Reduced peak spreading:
Dead volume is minimized through the use of 1/16" stainless steel tubing.

Easy loading and unloading of samples:
By the use of a clamshell furnace with flexible mounting arrangement and sample cells covering a range of geometries for powders, pellets and cores.

Wide temperature range:
Ambient to 1200°C at programmable rates of 1°C/min to 30°C/min is standard. Optional sub-ambient accessory extends the lower limit to -100°C.

Condensation and adsorbate retention eliminated:
By controlling the temperature of all tubing and valves downstream of the sample up to the detector at up to 80 ºC (standard) or 150 ºC (optional).

Precise measurements:
Through the use of a highly linear Thermal Conductivity Detector (TCD), along with interchangeable loops, automated loop and manual pulse injection options.

Wide dynamic range:
Through software controlled detector resolution.

Maximum chemical compatibility and sensitivity:
With choices of sealing materials and TCD filaments to suit the individual needs of each lab.

No need for pre-mixed gases:
A built-in gas blender with in-line static gas mixer provides custom-blended gases with exceptional homogeneity. This gas blender also allows for multi-point BET surface area analysis.

Built-in vapor saturator:
With controlled temperature for precise feed of condensable adsorptives.

Unattended operation:
All functions of the experiment are fully automated and controlled by a PC, which also collects and stores the acquired data.

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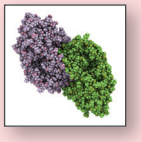


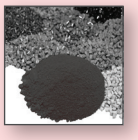
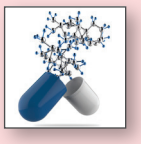

COMPETITIVE FEATURES

Short analysis times and high throughput:
Enhanced by forced air cooling of the furnace.

Ultimate safety:
Ventilated cabinet, support for gas sensors, interlocking doors, and front-mounted emergency kill switch are all available for optimal safety.

Flexible user interface:
Windows® based software provides a flexible interface for setting up experiments, controlling instrument functions, and displaying data.

Direct link to optional Mass Spectrometer and additional gas detectors:
For live displays of changes in gas composition data analysis.

Ready to use:
The system is supplied complete and ready for operation.

QUANTACHROME CHEMISORPTION PRODUCT LINE COMPARISON

Quantachrome has a long-standing reputation for providing reliable chemisorption analyzers with state-of-the-art capabilities. Chemisorption analyses can be performed in both static vacuum or dynamic flow modes. Each mode offers distinct advantages for specific markets.

The ChemStar™ was specifically introduced to extend the capabilities of our dynamic flow products to include enhanced automation, temperature programming, flowing vapor feed, and in-line gas mixing capabilities. This was done in a system that enables fast-response kinetics, which allow the ChemStar™ to be used as a reactor for simultaneous catalyst characterization and evaluation purposes. Therefore, Quantachrome's chemisorption product portfolio now includes three distinct products:

(a) The ChemBET Pulsar™;
(b) The ChemStar TPx™; and
(c) The Autosorb iQ™-C.

All these products are built with analytical flexibility in mind. Therefore, each product includes a wide range of modular and incremental options. These options allow customers to select the features that best fit their analytical needs and budgets. **Table 1** outlines the progression of main features encountered in Quantachrome's chemisorption products.

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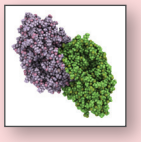


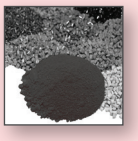
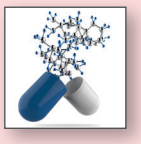

Table 1. Overview of Quantachrome Chemisorption Product Features.

Feature	ChemBET		ChemStar	ASiQ	
	TPx	Pulsar	TPx	C	TPx
Dynamic Flow Techniques	√	√	√	√	√
Temperature Programming	√	√	√	√	√
TCD Detector	√	√	√	--	√
Manual Pulse Injection	√	√	√	--	√
Interchangeable Loops	√	√	√	--	√
Automated Pulse Chemisorption	--	√	√	--	√
Fast Furnace Cooling	--	√	√	√	√
Automated Gas Switching	--	√	√	√	√
Partial/Full (**P/F**) System Automation	--	**P**	**F**	**F**	**F**
Automated Gas Mixing/Blending	--	--	√	--	--
Mass Flow Controllers	--	--	3+	1[b]	1[b]
Vapor Introduction/Sorption	--	--	√	√[b]	√[b]
Heated Lines/Valves	--	--	√	√[c]	√[c]
Intergrated MS Detector Option	√[1]	√[1]	√[3]	√[2]	√[2]
Other Intergated Detector Options[a]	--	--	√	--	--
High Pressure Capability	--	--	--	--	--
Static Vacuum Techniques	--	--	--	√	√
Mesoporosity	--	--	--	√	√
Multi-Stations	--	--	--	√	√
Microporosity	--	--	--	--	√

[a]FID, FTIR, GC | [b]Optional | [c] Heated Manifold (50°C)
[1] MS option available, but not fully integrated; temperature signal in the MS data.
[2] MS option available, but not fully integrated; synchronized filament and scan.
[3] MS option available, and fully integrated; MS data integrated with ChemStar data.

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The shaded boxes indicate basic features and upgrades in progressing from left to right in the columns of **Table 1.** For example, consider the standard ChemBET product line, which included both the ChemBET-TPR/TPD (TPx) and the ChemBET-Pulsar models. These dynamic flow instruments were designed with economy in mind, with the Pulsar model offering enhanced automation features namely, automated pulse chemisorption, fast furnace cooling, and programmable gas switching capabilities.

For many years the ChemBET-TPR/TPD had been the instrument of choice for laboratories seeking economical chemisorption and temperature programming capabilities. However, modern laboratories increasingly demand enhanced automation and speed capabilities. Since many of these capabilities already existed on the ChemBET-PULSAR, the ChemBET-TPR/TPD product was discontinued as of April 8, 2015. The PULSAR took over the task of continuing to provide both affordability and automation in a compact, bench-top flow chemisorption and TPD/TPR analyzer.

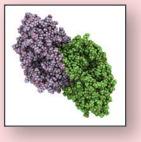
For more demanding industrial and R&D laboratories, which may require expanded data collection and analysis capabilities combined with vapor introduction and internal gas mixing using high precision mass flow controllers, users will now be able to rely on the new ChemStar™ automated flow chemisorption analyzer. The ChemStar™ is unique among Quantachrome chemisorption analyzers in its versatility to fully program and analyze dynamic flow experiments. Multiple hardware and software features are provided to serve the needs of the most demanding research facilities in a package that also meet robustness and safety demands of quality assurance laboratories. As noted above, **Table 1** highlights in shaded boxes the added features that distinguish the ChemStar™ from other chemisorption products. Compared to the ChemBET-PULSAR, the ChemStar™ provides full automation including feed gas mixing/blending, a minimum of three high precision mass flow controllers, condensable vapor introduction, programmable heating of plumbing and valves downstream from the reactor, and software integration of a multitude of optional detectors, including a mass spectrometer (MS), flame ionization detector (FID), Fourier transform infrared detector (FTIR), gas chromatograph (GC), etc.

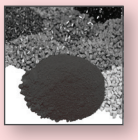
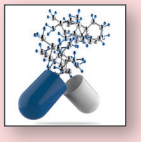
The ChemStar™ is indeed a fully automated state-of-the-art dynamic flow instrument for the analysis of catalysts and other chemisorption applications. Its intuitive software interface allows the user to program and run a variety of temperature-programmed analyses as well as flow BET surface area determination and pulse titration experiments. Standard capabilities include:

- Temperature Programmed Desorption (TPD)
- Temperature Programmed Reduction (TPR)
- Temperature Programmed Oxidation (TPO)
- Temperature Programmed Reaction (TPRx)
- Pulse Titration
- Pulse Calibration
- Catalyst Treatment
- Catalyst/Nanocrystallite Particle Size
- Catalyst Dispersion
- Flow BET Surface Area
- Active Surface Area
- Surface Acidity/Basicity/Reactivity

Experimental conditions are fully programmable and up to 99 consecutive treatments and/or analyses can be strung together for completely unattended ChemStar™ operation.

Users wishing to further expand their analytical capabilities on a single instrument to apply static vacuum volumetric techniques can rely on the time-tested Autosorb iQ-C products. As highlighted in the shaded boxes in **Table 1,** the ASiQ-C models include both dynamic flow and static vacuum capabilities. Static vacuum capabilities are required when users wish to characterize the meso-and-microporosity of their samples, along with their chemisorption uptakes and temperature programming responses, without the added burden or expense of switching analytical instruments.



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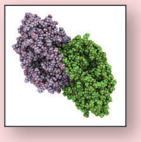


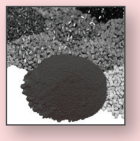
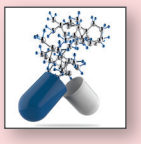

APPEARANCE:

The ChemStar™ is a new product with a unique design that is consistent with Quantachrome Instruments' brand appearance. The bench-top unit design includes blue doors and is accessible from the front of the instrument. Gas connections are located at the back of the unit. Its compact dimensions (WxHxL = 56x60x61 cm) and light weight (55 kg) minimize bench space requirements.

Figure 1. ChemStar™ Front View.

COMPATIBILITY:

The hardware and electronics of ChemStar™ series units are unique and independent of other Quantachrome chemisorption models.

COMPARISON OF DYNAMIC FLOW VS. STATIC VACUUM CHEMISORPTION METHODS:

Both the ChemBET-Pulsar and the ChemStar base their operations on dynamic flow techniques. The ASiQ-C-TPx expands this capability to include static vacuum volumetric techniques. Dynamic flow techniques involve the continuous flow of gases, gas mixtures or vapors through a bed of sample. The changes in gas concentration upon adsorption/desorption/reaction with the sample are conveniently monitored using a thermal conductivity detector (TCD) or, optionally, alternative gas detectors (FTIR, FID, GC). In contrast, static vacuum techniques consist of sequentially dosing increasing amounts of gas into an evacuated and closed cell containing the sample. In this case, changes in cell pressure after equilibrium is achieved are converted using standard gas laws to adsorbed gas or vapor volumes. A more detailed comparison of features is given in **Table 2.**

For practical purposes, it should be noted that, in general, flow chemisorption techniques yield faster results than the equilibrated vacuum volumetric techniques. Temperature programming techniques (other than sample treatments) are also carried out more efficiently under dynamic flow conditions. These features make dynamic flow analyzers more popular for quality control applications and fast-paced analytical laboratories. In contrast, static vacuum volumetric techniques are often preferred for the physical characterization (surface area, pore size distribution) of solids. Static techniques allow the assessment of both strong and weak chemisorption, and are more consistent with predictions from equilibrium sorption models. Therefore, static vacuum systems are frequently found in advanced research facilities where full equilibration and ample experimental versatility are desired.

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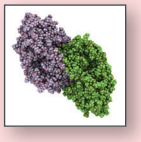
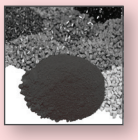
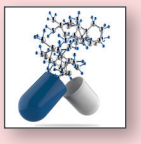
Table 2. Comparison of Dynamic Flow vs. Static Vacuum Techniques.

Instrument/Characteristic	Dynamic Flow	Static Vacuum
ASiQ-C	√	√
ChemStar	√	--
Analysis Speed	Faster	Slower
Calibration	Direct (matching pulses)	Indirect (reference volumes)
Temperature Programming	√	--
Pulse Titration	√	--
Bulk Reactivity	√	--
Handles Gas Mixtures	√	--
Equilibrum Uptakes	Equal or Lower than Static	Yes
Pore Size Distribution	--	√
Weak Adsorption	Only at subambient temperatures	Yes (can evaluate hydrides, spillover, etc.)
Strong Adsorption	√	√
BET Area	√	√
Main Detector	Conductivity	Pressure
Main Operating Mode	Isobaric	Isothermal
Adsorption Medium	Inert carrier gas	Partial vacuum
Sensitivity to Pretreatment	Sample may have finite vapor pressure	Needs high vacuum
Calorimetry	Indirect[a]	Indirect or Direct[b]

[a] Indirect via isotherm generation at multiple temperatures.

[b] Direct via optional Calorimeter Interface.



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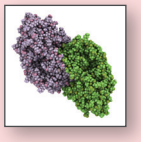


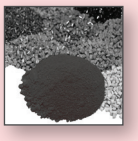
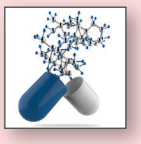

CUSTOMER-FOCUSED SALES STRATEGY CONSIDERATIONS

Table 3 lists selected technical advantages of the ChemStar-TPx analyzers when paired with one of its competitors. These features, along with optional capabilities and safety enhancements, give the ChemStar a competitive edge on which to base pertinent initial discussions. Additional advantages that apply to specific applications (such as high pressure options, sulfur-tolerant versions, etc.) will be considered as needed to support sales and marketing efforts.

Table 3. Overview of Competitive Advantages of ChemStar-TPx Analyzers.

Feature	Competitor A	ChemStar	Advantages
Max. Furnace Temperature [°C]	1,100	1,200	Wider experimental range, most useful for high temperature reactions; faster programmable heating rates for faster analysis and more detailed surface energy evaluations. Optional MFC flow rate ranges expandable up to 1 L/min.
Heating Rate [°C/min] to T_{max}	10	30	
Flow rate range [cm^3/min]	10-75	5-50 expandable	
Internal system volume	Low	Lower	Using 1/16" stainless steel tubing, minimizes peak spreading.
Max. Heated Zone Temperature [°C]	150	80 (150 optional)	Minimizes vapor condensation (but 150°C not needed in most cases).
Vapor generator	Optional	Included	Useful for aromatic amines and heavy hydrocarbons.
Clamshell furnace design	Fixed	Movable	Slides to improve ease and safety of sample loading.
Available auto-sampling loop volumes	0.5, 1 or 5 mL	0.005-10 mL	Much wider range for optimum effluent quantification.
Built-in gas mixing via multiple MFCs	Yes	Fast response	Minimize signal perturbations due to pressure/ temperature changes.
Integrated MS, IR, GC, FID options	MS only	All	Wider choice of detector configurations for data analysis.
Multiple MS gas sampling ports	No	Yes	Can sample at reactor exit to minimize response time.
Peak deconvolution options	Standard	Advanced	Auto-fitting to user-selected regions for maximum versatility.
Virtually unlimited programmable steps	Included	Extended	Extended to Include intuitive preconfigured blocks for TPD/TPO/TPR/TPRx/Pulsing.
Safety interlock door	No	Yes	Superior and high quality safety features.
Emergency stop button	No	Yes	
Extensive system alarm package	No	Yes	
Historical trending of all signals	No	Yes	Simplifies data archiving and statistical trend assessment.

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EXTENSIVE SAFETY FEATURES AND INTERLOCK OPTIONS

The **ChemStar™** effectively meets standard safety demands as already practiced in commercial chemisorption testing laboratories worldwide. However, in order to compete more effectively in the most demanding markets, a set of optional safety features have been added. This collection of optional features is to be called the Interlock Options and consists of two parts as described below. Referring to these features as the Interlock Options avoids giving the wrong impression that the ChemStar™ may not have been inherently safe to begin with. These additional safety features will allow the ChemStar™ to compete more effectively with BEL, particularly in the Japanese market, and will give us a competitive advantage over MM worldwide.

The standard ChemStar™ includes the following built-in safety features:

1. Independent thermocouples to detect over-temperature conditions of the furnace and other heated zones and cut off power.

2. Pressure relief valves to prevent over-pressurization.

3. Exhaust gases are vented through fittings that can be routed to a ventilation system.

4. The cabinet is ventilated with an exhaust fan to prevent build-up of gas inside in the event of a leak.

5. User-defined alarm matrix to monitor instrument functions and take appropriate action.

6. Flow switch turns off TCD filaments if flow stops.

7. Software prevents entering setpoints that are outside the safe operating limits of the instrument.

8. In the event of a power failure, all valves close, stopping the gas flow.

The basic Interlock Option consists of the following features:

1. Enclosed furnace with door interlock to prevent access to high temperature components.
   a. The door will be latched closed when the furnace temperature is > 50°C.

   b. A blue indicator light will be lit on front panel when the furnace temperature is > 50°C.

   c. A manual override key will allow access when power is off.

   d. The analysis cannot start if the door is open.

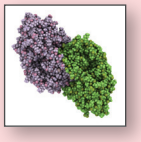
2. Earthquake mounts for securing the instrument to a lab bench.

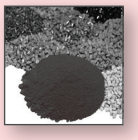
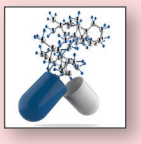
3. Emergency shutdown button.
   a. A red, recessed button is mounted on the front panel of the instrument.

   b. Activating this button will disengage the master contactor (MCA), which in turn will disable all the valves, heaters, and MFCs.

   c. The MCA can only be re-enabled by pressing a reset button on the rear of the instrument.

   d. The exhaust fan of the cabinet and the communication with the computer will continue to operate.



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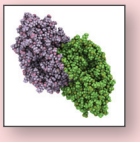


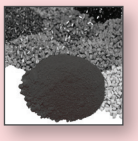
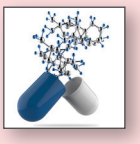

The advanced Interlock Option consists of the following features:

1. Input from lab gas sensors for corrective action.
   - *a. Three inputs will be provided for gas sensors.*
   - *b. Each input will have a corresponding output (relay closure).*
   - *c. An active input will turn off all heaters, abort the current run, flush gas lines with inert gas, and display a pertinent message on the computer monitor.*
   - *d. Inputs will use the standard 4–20mA current loop protocol.*

2. Flow switch for reactor tube breakage or input gas source depletion.
   - *a. If the flow is unexpectedly interrupted during a run, the run will abort.*
   - *b. If this occurs, a pertinent message will be displayed on the computer monitor.*

3. Pressure transducer for utility air and corrective action.
   - *a. Loss of pressure on utility air will trigger a warning message to be displayed on the computer monitor.*
   - *b. Analysis will be allowed to continue uninterrupted; however, if this condition is not corrected quickly the data will probably not be meaningful.*

4. Input from room seismoscope (earthquake detector).
   - *a. An input will be provided for a seismoscope, along with its corresponding output (relay closure).*
   - *b. Asserting this signal will disengage the master contactor (MCA), which in turn will disable all the valves, heaters, and MFCs.*
   - *c. The MCA can only be re-enabled by pressing a reset button on the rear of the instrument.*
   - *d. The exhaust fan of the cabinet and the communication with the computer will continue to operate, and an error message will be displayed on the computer monitor.*

In the spirit of continuous improvement, all the above optional features are subject to change as market needs evolve.

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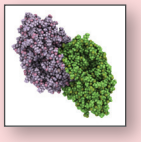
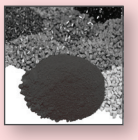
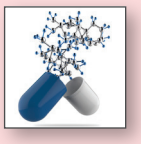
NEW STOCK CODE(S):

Table 5 lists of the initial product offerings and the Options & Accessories of the ChemStar™.

Table 5. Overview of ChemStar™ Series Products.

ChemStar™ Series Model	Part Number
ChemStar TPx 110V W/S/K - Basic Catalyst and Chemisorption Analyzer, 110V	08-200-B-1
ChemStar TPx 220V W/S/K - Basic Catalyst and Chemisorption Analyzer, 220V	08-200-B-220-1
ChemStar TPx+ 110V W/S/K - Catalyst and Chemisorption Analyzer with Premium Seals, 110V	08-200-P-1
ChemStar TPx+ 220V W/S/K - Catalyst and Chemisorption Analyzer with Premium Seals, 220V	08-200-P-220-1
Options & Accessories	**Part Number**
Fourth MFC Option - for gas blending	08-200-M4
Optional 1–100sccm MFCs, instead of 1–50sccm	08-200-MFC100
Subambient Option, temp. -100°C to +1200°C	08-200-SA
Basic Interlock Option including interlocking door and kill switch	08-200-SP
Advanced Interlock Option including gas detector inputs and outputs	08-200-SP2
Viton seals for ChemStar TPx, in place of Buna-N	08-200-VITON
EPDM seals for ChemStar TPx+ in place of Kalrez	08-200-EPDM
PTFE seals for ChemStar TPx+ in place of Kalrez	08-200PTFE
Gold coated tungsten filaments for TCD	08-200-AUW
High temperature valve box, up to 150°C instead of standard 80°C	08-200-HT
Software support for full integration of mass spectrometer	08-200-MSSW
Regulator, 2 stage 0–100psi for inert carrier gases	01207-1
Regulator, 2 stage 0–100psi for hydrogen or gas mixtures	01207-H-100
Regulator, 2 stage 0–100psi for ammonia	01207-AM
Regulator, 2 stage 0–60psi for carbon dioxide	01207-CO2



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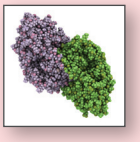


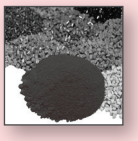
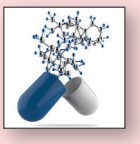

SOFTWARE

All ChemStar functions are fully controlled through its Windows®-based software. ChemStar software is pre-loaded on the computer supplied with the instrument. The instrument Manual (on a separate CD) and the Ethernet interface cable are also supplied with the instrument. The Chemstar software icon (a blue star icon on white background) gives access to both the data acquisition and data reduction functions.

Once the password is entered, users have access to analysis and calculation windows illustrated in (but not limited to) **Figures A1-A15 in Appendix A**. All valves, mass flow controller flow rates, programmable zone temperatures, and other parameters shown in **Figures A1-A2** are fully accessible in "manual mode" by clicking or scrolling through icons and settings on the main instrument screen. Users and agents can also access all functions in "*Demo*" mode to access system functions and demonstrate flow paths to potential clients without having the software connected to an instrument.

To set up an analysis, users would access the window shown in **Figure A3**, and select up to 99 consecutive steps from the list of Macro functions shown in **Figures A4-A8**. During analyses, the software displays flow paths and current operations in color screens, as illustrated in **Figures A9-A12**. The location of an optional 4th Mass Flow Controller is shown in **Figure A13**. A particularly useful feature of the ChemStar software is its ability to collect Historical Trending data for all system variables, including signals from an optional mass spectrometer and other detectors (see **Figure A14**). For completion, **Figure A15** illustrates selected data reduction calculations and peak fitting capabilities of the ChemStar software. All these functions make this state-of-the-art flow chemisorption analyzer the most powerful analytical tool of its kind available in the market today.

FUNCTIONAL IMPROVEMENTS

Features that make the ChemStar stand out among flow chemisorption analyzers of its kind include:

(a) full automation through easily programmable functions;

(b) high precision mass flow controllers capable of performing built-in gas mixing functions;

(c) automated calibration loop injection;

(d) vapor introduction capability thanks to a built-in sparger and heated system components;

(e) temperature ramping capabilities up to 1,200 ºC;

(f) fast cooling by forced air circulation; and

(g) all new functions performed with minimal operator intervention.

Enhanced safety features and a powerful data acquisition and reduction package provide a multitude of additional improvements that go well beyond those of previous models.

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APPENDIX A. ChemStar™ Software Windows and Functions.

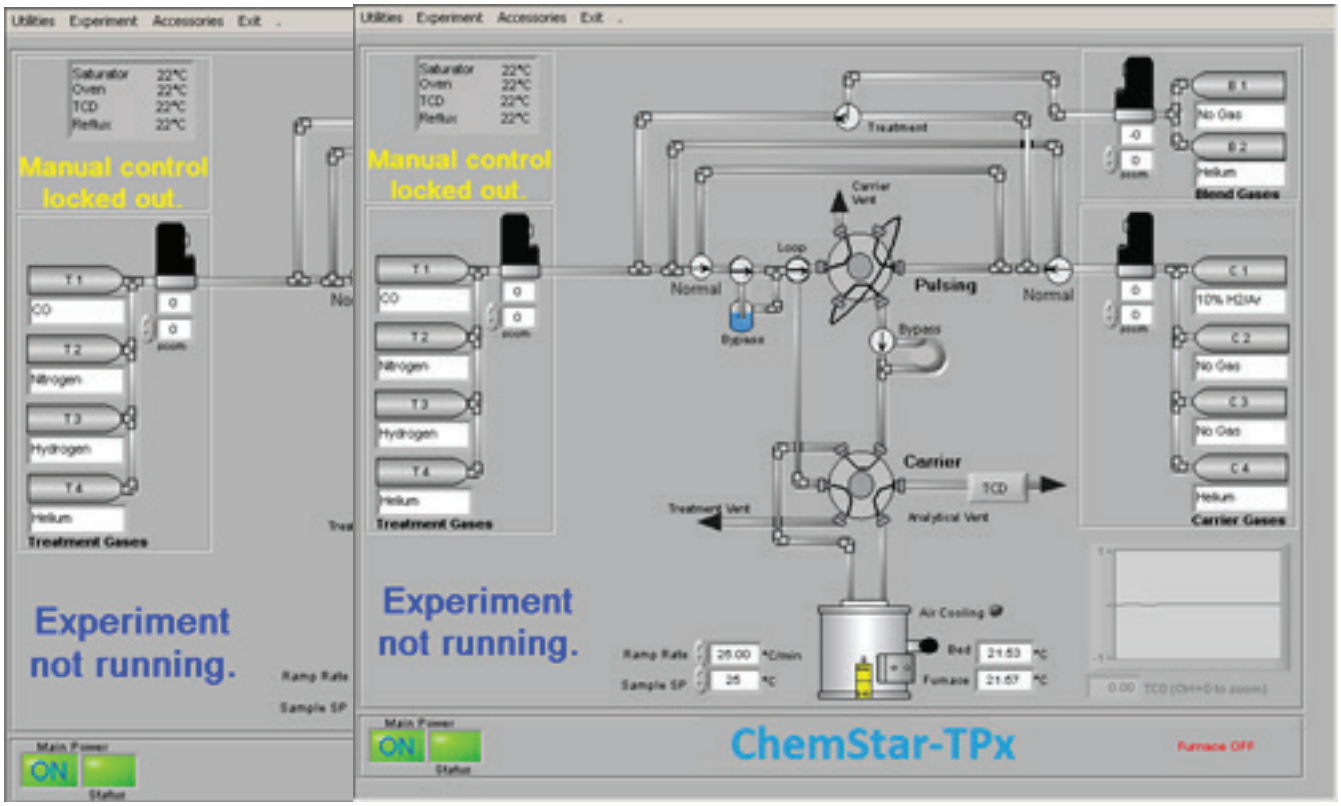

Figure A1. Main Software Screen.

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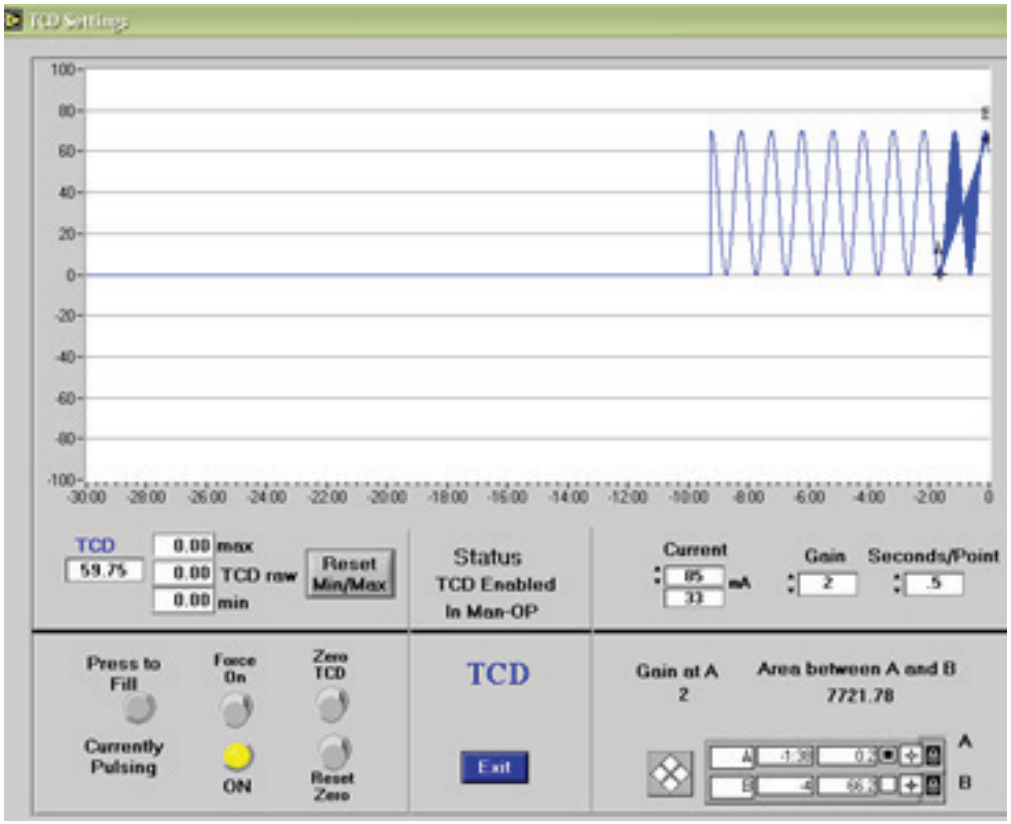

Figure A2. TCD Screen.

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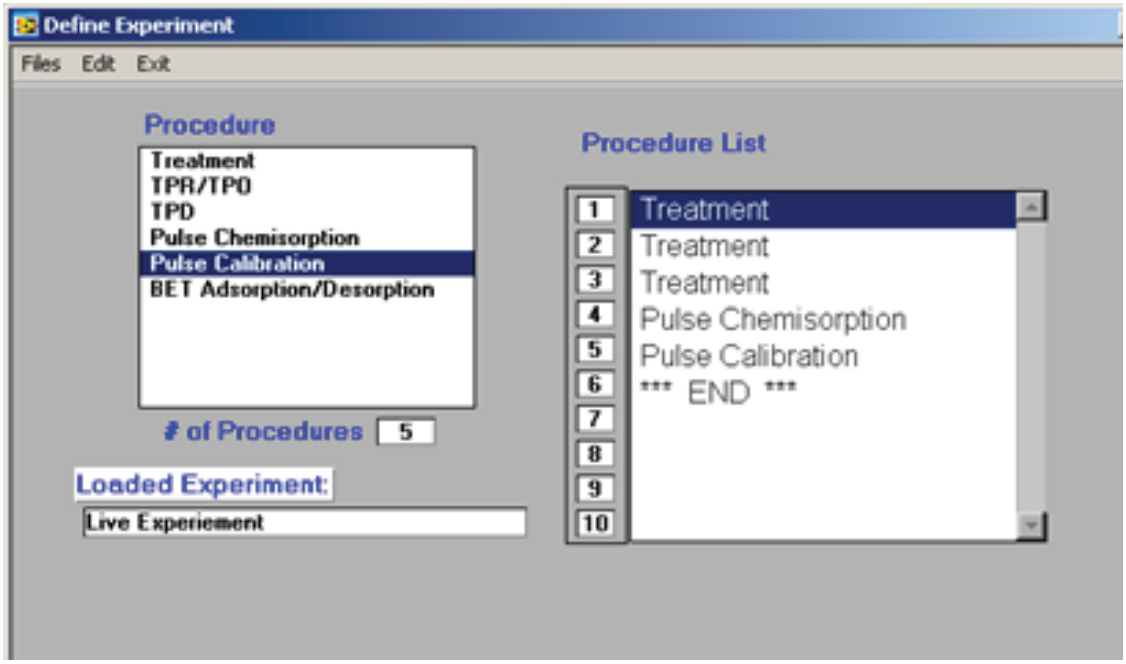

Figure A3. Experimental Setup.

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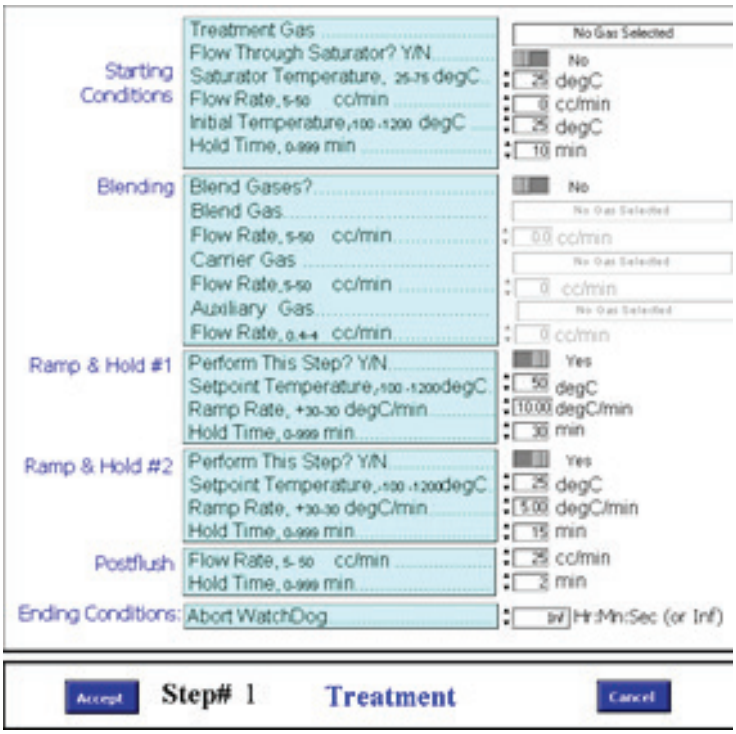

Figure A4. Sample Treatment Macro.

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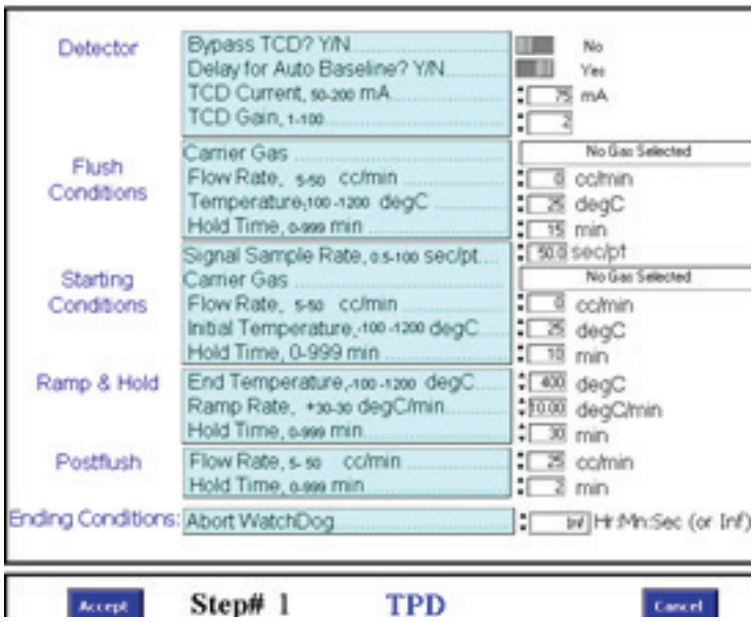
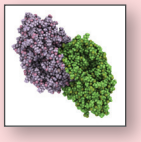
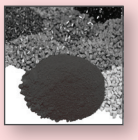
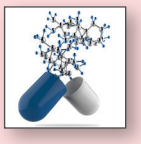


Figure A5. TPD Macro.



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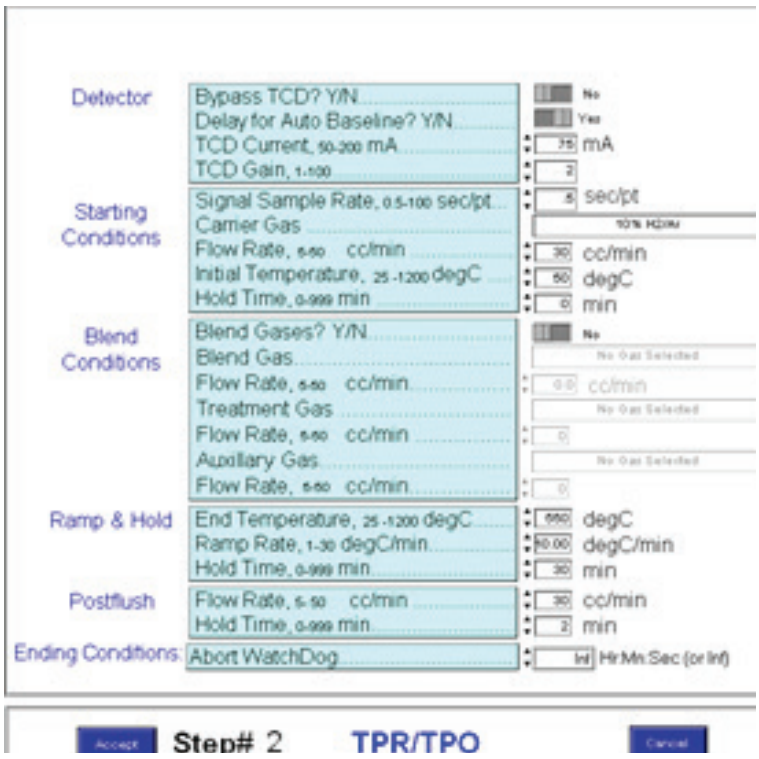

Figure A6. TPR/TPO Macro.

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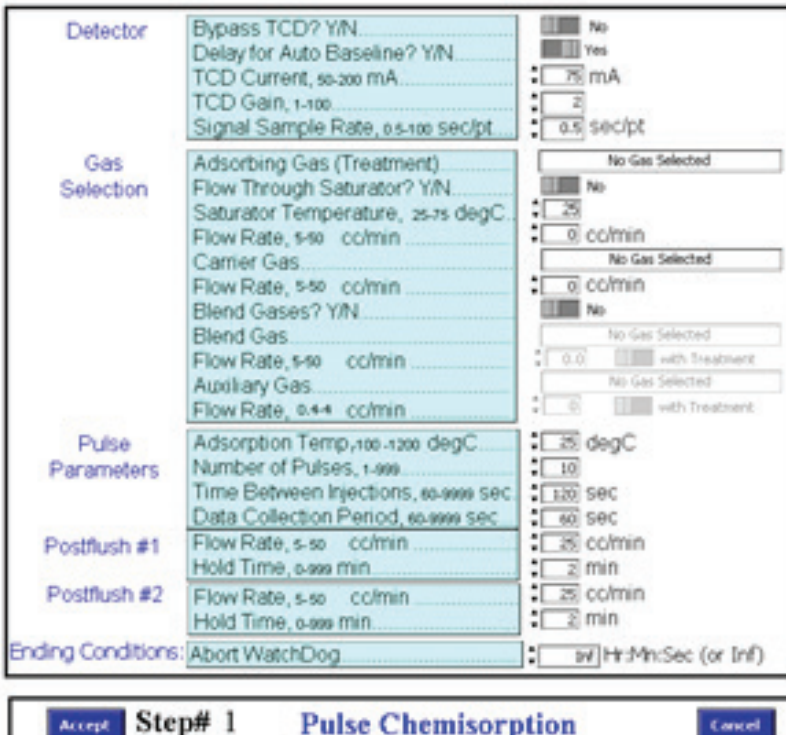
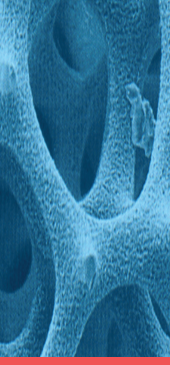
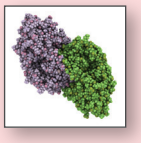
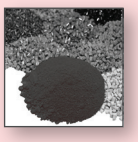
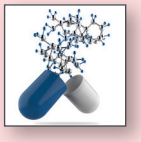


Figure A7. Pulse Chemisorption Macro.









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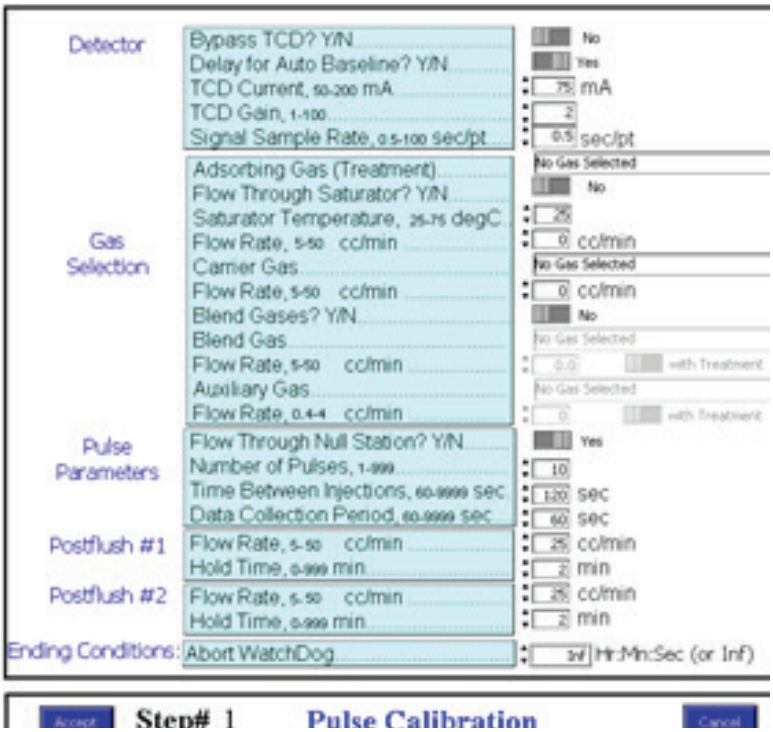

Figure A8. Pulse Calibration Macro.

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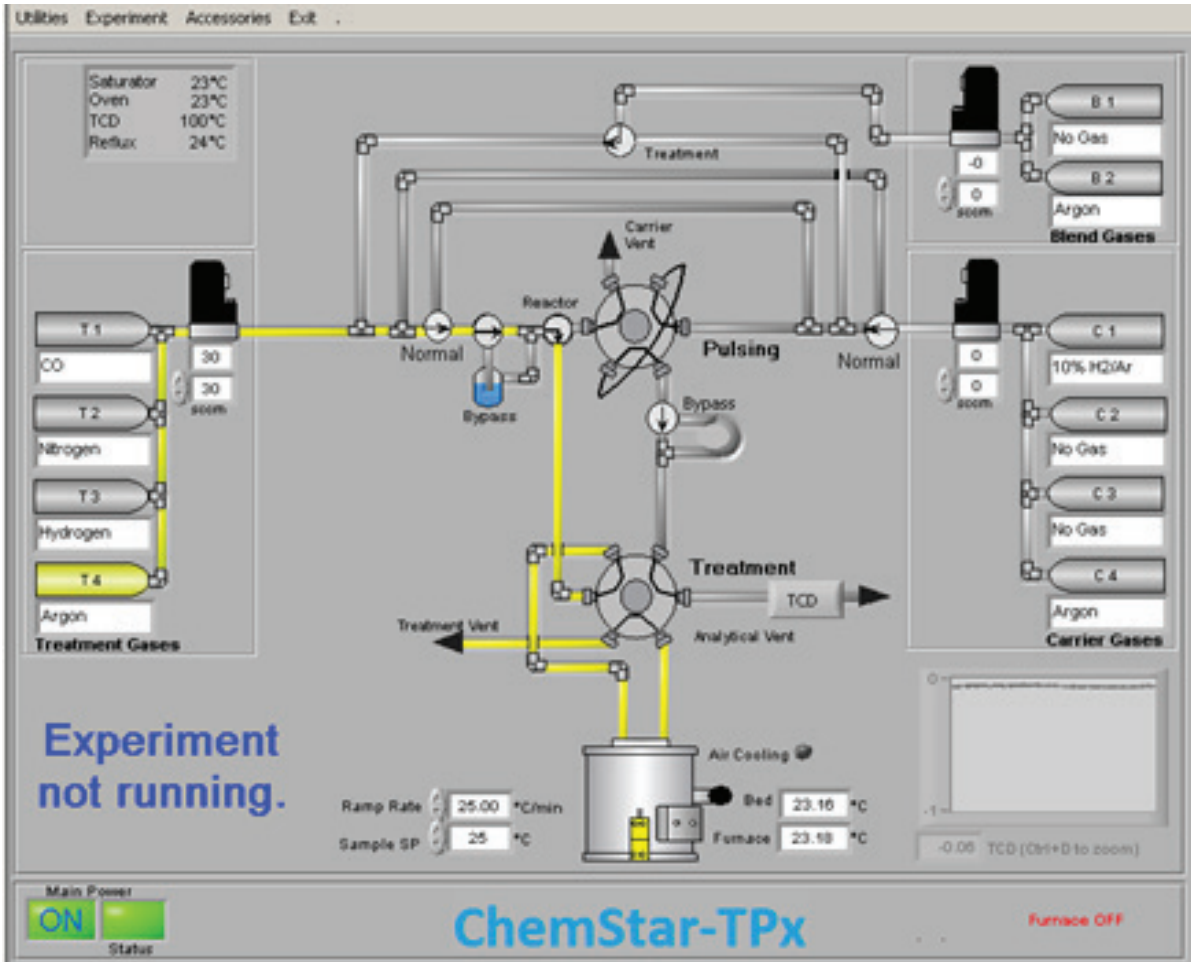
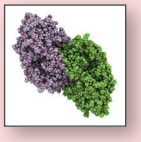
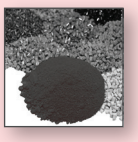
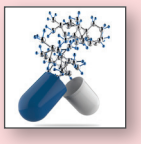


Figure A9. Example of Treatment Flow Path.



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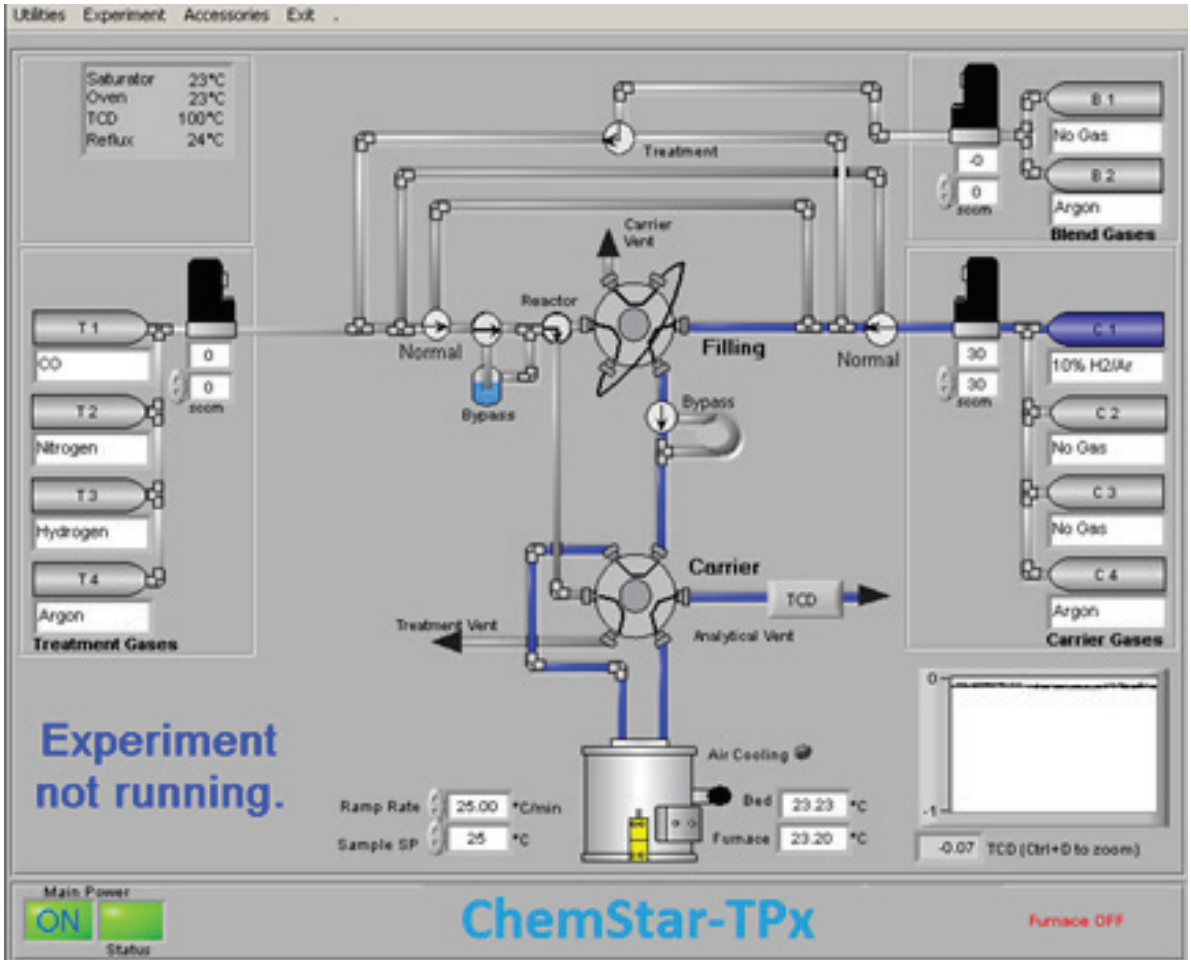

Figure A10. Example of TPR Flow Path.

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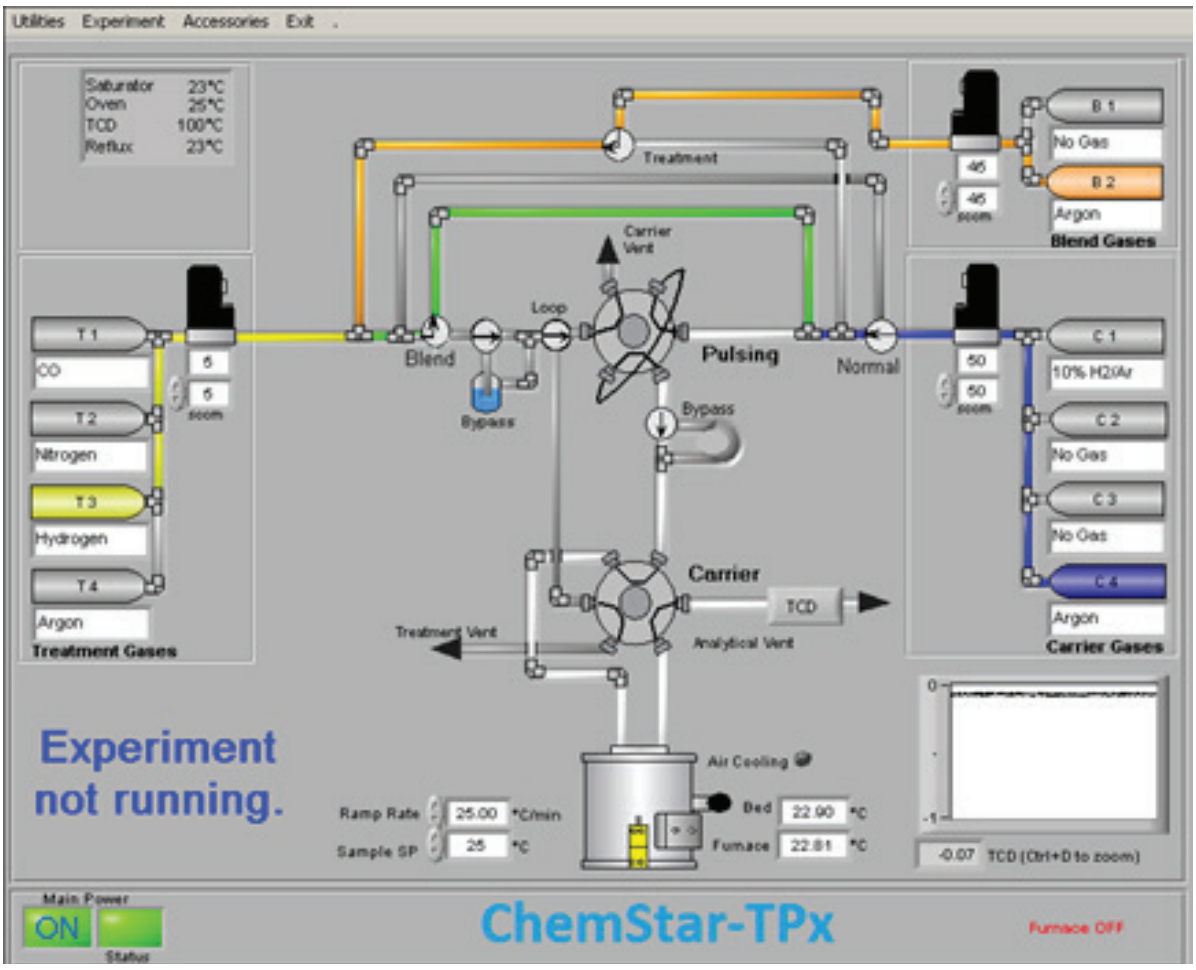

Figure A11. Example of Gas Mixing (10% H_2/Ar) for H_2 Chemisorption.

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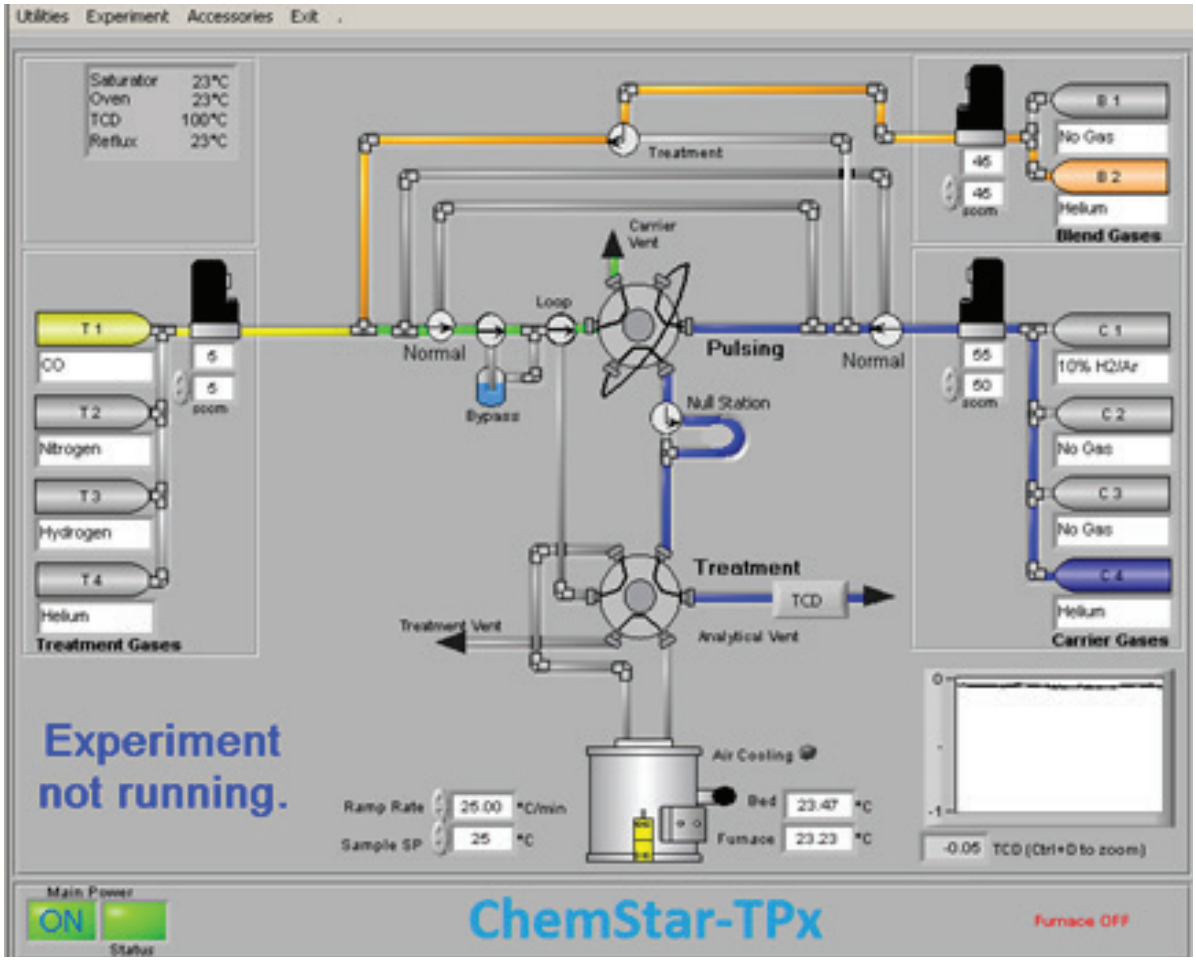

Figure A12. Example of Pulse Titration Flow Path.

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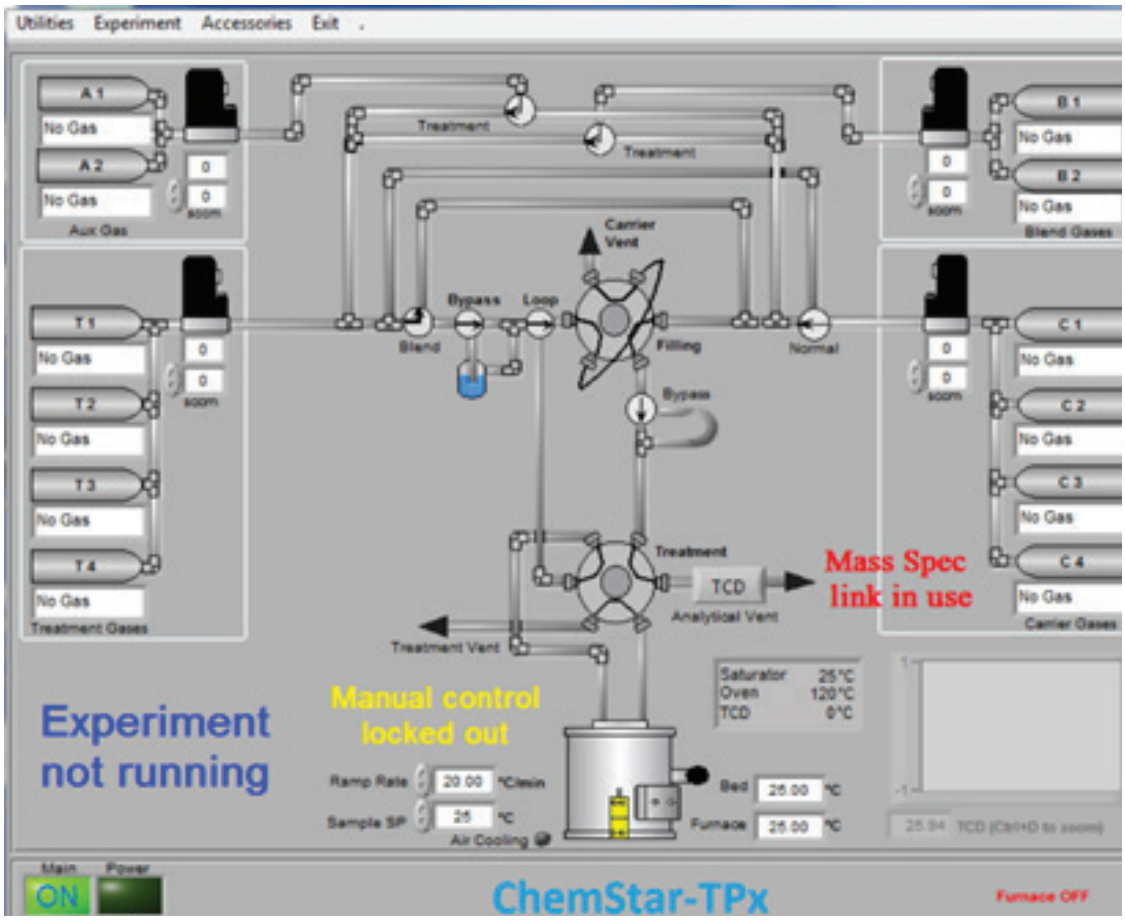
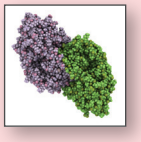
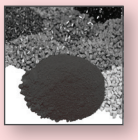
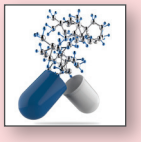


Figure A13. Example of 4th MFC and MS in Operation.



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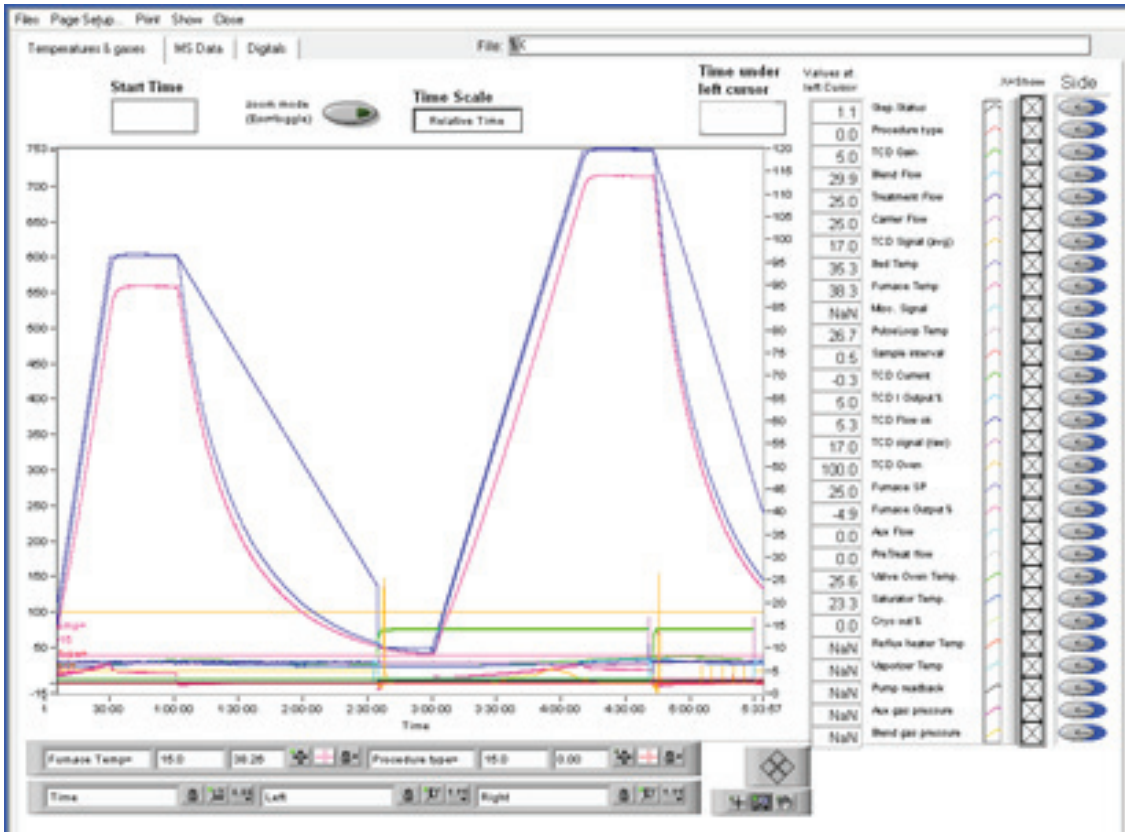

Figure A14. Historical Trending Profiles.

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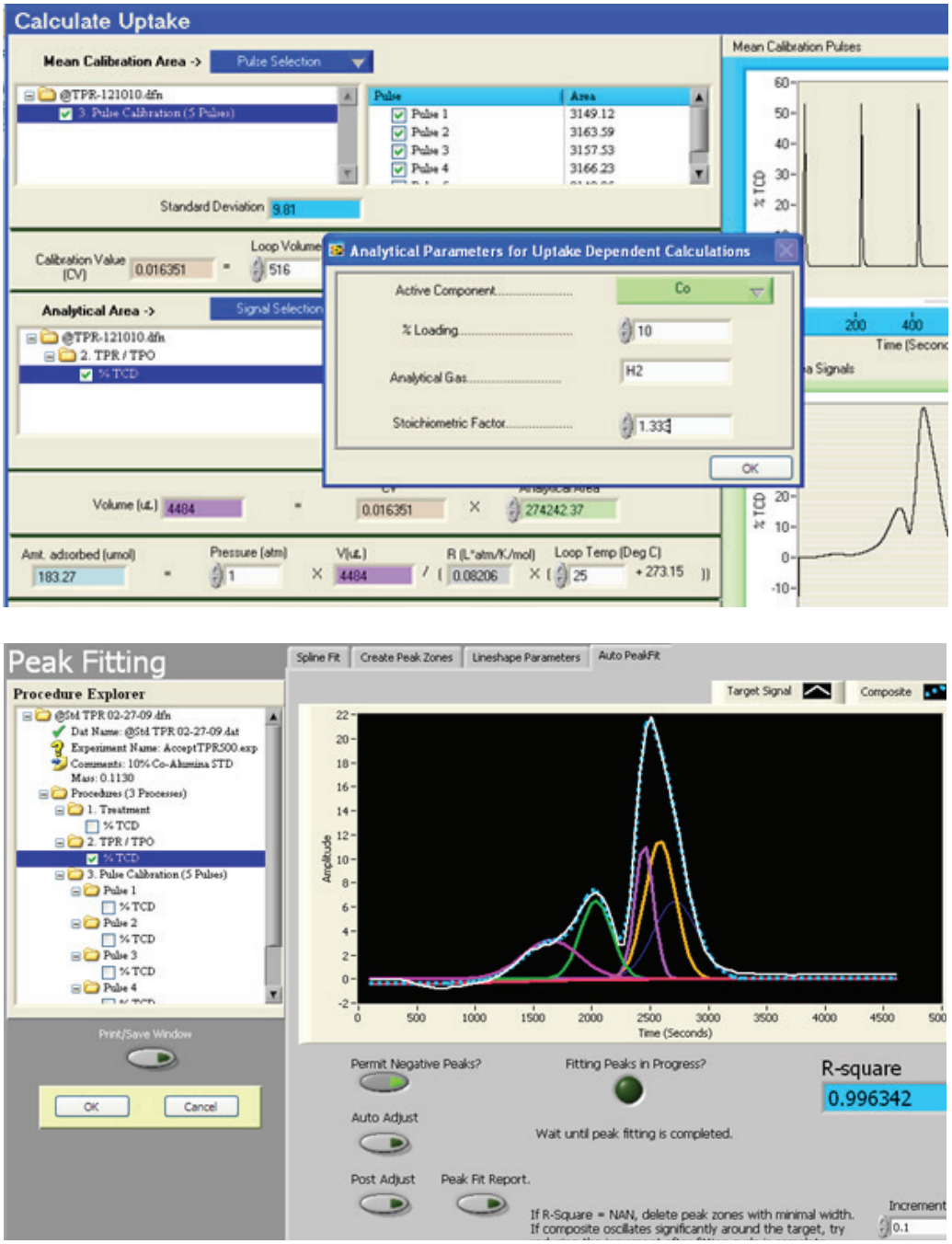

Figure A15. Illustration of Selected Data Reduction Calculations and Peak Fitting Capabilities.