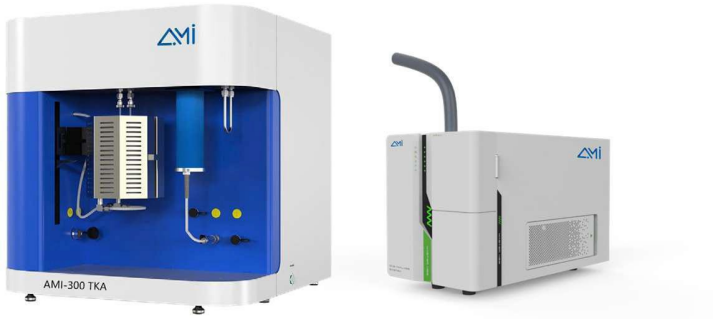
AMI-300 SSITKA

Steady-State Isotopic Transient Kinetic Analysis Instrument

INTRODUCTION

"Complete Chemisorption &Reactor Solutions - Precision without the Premium"

The **AMI-300 SSITKA** is a high-performance chemisorption analyzer integrated with Steady-State Isotopic Transient Kinetic Analysis (SSITKA) capabilities. Compared to conventional chemisorption analyzers, the **AMI-300 SSITKA** employs SSITKA technology to enable in-depth investigation of catalyst reaction mechanisms and properties. The instrument rapidly switches the isotopic composition of a reactant within the reaction system while monitoring the relaxation dynamics of labeled products in real time. This methodology facilitates precise analysis of reaction mechanisms, measurement of kinetic parameters, catalyst characterization, and differentiation of parallel reaction pathways.



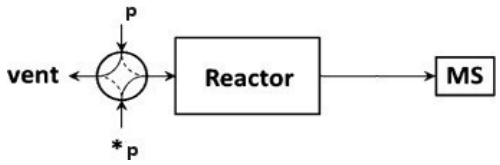
Chemisorption Analyzer + Mass Spectrometer

AMI-300 SSITKA Functions:

- Steady-State Isotopic Transient Kinetic Analysis (SSITKA)
- Temperature-Programmed Desorption (TPD)
- Temperature-Programmed Reduction/Oxidation (TPR/O)
- Temperature-Programmed Surface Reaction (TPSR)
- Pulse Chemisorption
- Dynamic BET
- Vapor Dosing (option)

The **AMI-300 SSITKA** distinguishes itself through its SSITKA experimental capability, which initiates isotopic switching only after the reaction system reaches steady-state conditions. For elements with negligible isotope effects (predominantly non-hydrogen systems), the instrument enables isotope tracing while maintaining continuous steady-state operation, achieving non-invasive in situ analysis. This methodology provides real-time tracking of surface active sites, quantifies intermediate species lifetimes, and resolves dynamic evolution of reaction pathways without perturbing catalytic processes.

The SSITKA experimental setup, as illustrated in the diagram below, comprises three core components: a gas delivery system, reactor, and mass spectrometry analysis unit. The gas delivery system is specifically designed for steady-state transient operations, enabling rapid switching between gas phases while maintaining stable pre- and post-switch conditions. Concurrently, the mass spectrometer ensures prompt detection response to track isotopic transients with millisecond-level temporal resolution.



SSITKA Experimental Procedure:

Catalyst Preparation -> Steady-State Reaction Stabilization ->Isotope Tracer Introduction -> Isotope Signal Monitoring ->Kinetic Data Analysis

Common isotopes and isotopic compounds include:
$^{12}CO/^{13}CO$, $^{12}CO_2/^{13}CO_2$, $^{14}NO/^{15}NO$, $^{14}N_2/^{15}N_2$, $^{16}O_2/^{18}O_2$, H_2/D_2, etc.

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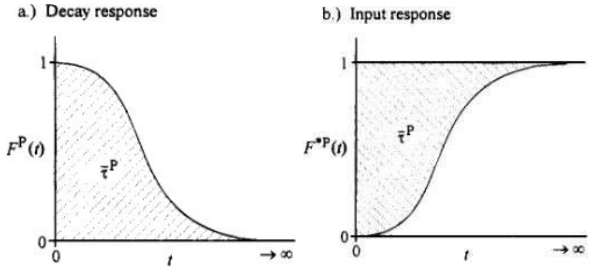
The transient response curves obtained from the SSITKA experiment can be used to determine:

- Reaction Mechanisms- Helps identify the step-by-step process of catalytic reactions.
- Kinetic Parameters - Determines reaction rates, activation energies, and rate constants.
- Surface Intermediates - Provides insights into intermediate species and their lifetimes.
- Catalyst Performance - Assesses the efficiency, stability, and activity of the catalyst.
- Parallel Reaction Pathways - Differentiates between main and side reaction pathways.

The Transient Response Curves



KEY FEATURES

Precision flow control system

High-precision MFCs with flow rates from 2-100 sccm.

Pressure Equalization and valve switching

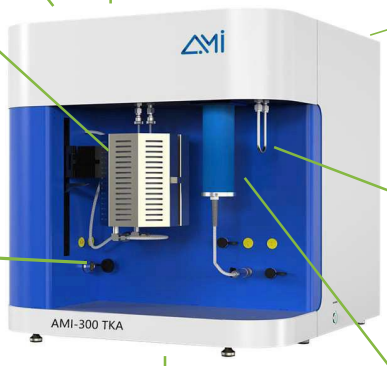
SSITKA experiments require precise pressure equalization between two streams and rapid valve switching to minimize pressure spike variations in the mass spectrometer signal, ensuring accurate measurements.

Valve oven temperature control

The instrument's internal pipelines are heated by an oven, reaching a maximum temperature of 150°C. This ensures uniform heating, preventing "cold spots" in the stainless steel pipelines, valves, and TCD detector, thereby maintaining stable operation and accurate measurements.

High-Stability Programmed Temperature Reaction System

Engineered with precision temperature control up to 1200°C, this system achieves linear heating rates from 0.1 to 50°C/min with ±0.1°C regulation accuracy.



High-Precision TCD Detector

The instrument comes standard with a high-precision rhenium-tungsten filament TCD (Thermal Conductivity Detector), featuring a constant temperature system capable of maintaining temperatures up to 200°C.

Rapid Cooling

Featuring automated control, the system enables rapid furnace cooling via air purging to reduce experimental duration.

Cold Trap

The sample tube downstream is equipped with a dedicated cold trap filled with desiccant, designed to remove condensables prior to the gas stream entering the TCD.

Minimal Dead Volume

As an instrument capable of performing SSITKA experiments, the AMI-300 SSITKA utilizes 1/16 tubing with an optimized compact design, effectively minimizing dead volume.

Safety

The instrument features a proprietary over-temperature cutoff system for heating furnaces, pressure relief valves on the reactor and sparger, and firmware alarms at hardware limits. User-configurable alarms enhance lab safety by allowing customized alerts based on specific protocols.

Vapor Generator

The system is compatible with a vapor generator to vaporize liquid adsorbate for subsequent analysis, with a maximum operating temperature of 100°C.

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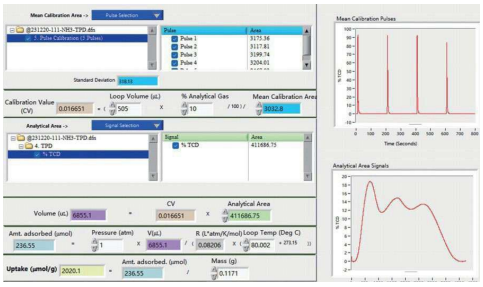
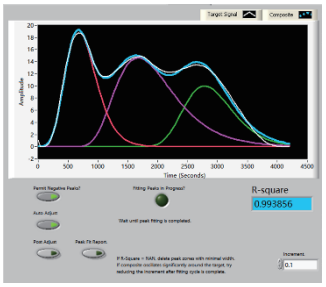
SOFTWARE CAPABILITIES

The **AMI-300 SSITKA** software delivers comprehensive control and analytical capabilities, supporting flexible configuration of TPD, TPO, TPR, TPRS, pulse calibration, and other experiments through programmable sequences (up to 99 steps). This automated system performs advanced spectral processing including peak deconvolution, integration, differentiation, and superposition analysis to extract critical catalyst characteristics such as surface acid/base site distribution, activation energy values, and reaction kinetic parameters.

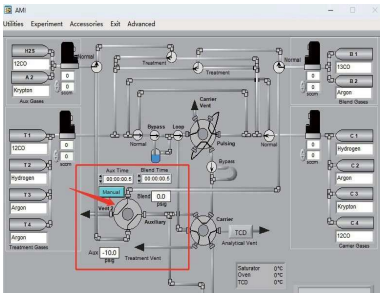


Adsorption capacity calculation



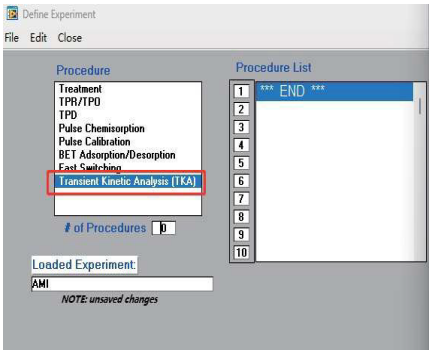
Peak fitting

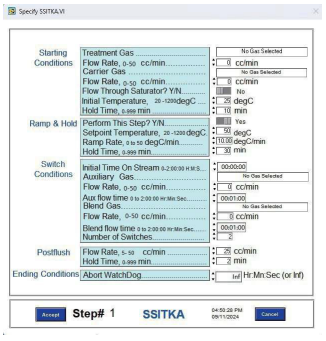
During SSITKA experiments, the system executes isotopic switching through specialized gas circuitry integrated with mass spectrometry detection. As illustrated in the schematic interface diagram, the gas flow control system employs a four-way valve (indicated by the red arrow) to perform transient switching between two feed streams. This valving mechanism enables the instantaneous transition of the reactant from ^{12}CO to ^{13}CO while maintaining experimental continuity.



AMI-300 SSITKA Software Interface

SSITKA experiments can be configured through the program interface shown below, featuring fully automated operation that eliminates the need for manual intervention. This streamlined process ensures operational reliability while minimizing human-induced errors, thereby ensuring precise test results.





SSITKA procedure setup

SPECIFICATIONS

Chemisorption Analyzer
AMI-300 SSITKA

Mass Spectrometer
Master 400

Mass Flow Controller Quantity	4
Gas Inlet Quantity	12
Temperature Range	Standard: Room Temp. – 1200°C Optional: -130°C-1200°C
Heating Rate	0.1°C – 50°C/min
Maximum Flow Rate	100 sccm
Vapor Function	Maximum Temperature 100°C (Optional)
Infrared Spectrometer	FTIR Analysis (Optional)

Mass Range	Optional:1-100/200/300 amu
Detection Limit	≤500 ppb
Scanning Rate	1 ms^{-16} s/amu
Sampling Pressure	0.5 bar - 1.5bar
Maximum Heating Temp. of Sample Tube	200°C
Filament Material	Iridium Filament
Detector	Faraday cup/ SEM electron Multiplier

APPLICATIONS

Ammonia Synthesis: Monitoring $^{15}N_2$ dissociation dynamics on iron-based catalysts to identify rate-determining steps.

Fischer-TropschSynthesis: Analyzing CO dissociation pathways on Co/Fe catalysts to optimize productselectivity.

Automotive Emission Control: Investigating transient surface intermediates (e.g., adsorbed NO, NH_3) during NO reduction reactions to enhance low-temperature activity in Pt-Rh catalysts.

CO_2 Reduction: Differentiating rate-determining steps between photogenerated electron transfer kinetics and surface reaction processes.

CO_2 Hydrogenation (Methanol/Hydrocarbon Synthesis): Tracking dynamic evolution of surface intermediates (e.g., formate/carbonate species) to map CO_2 activation pathways, enabling selective optimization of Cu-ZnO-based catalysts.

Methane Reforming: Characterizing carbon species accumulation/elimination mechanisms on Ni/Co-based catalysts to mitigate carbon deposition-induced deactivation.

Sulfur Poisoning Mechanisms: Investigate the poisoning effects of H_2S on catalysts (e.g., Ni-based systems), elucidating the dynamic processes of sulfur species coverage on active sites.

Surface Active Site Characterization: Differentiate the contributions of distinct surface active sites (e.g., step-edge sites, defect sites) to catalytic reactivity.