Chemisorption and AMI

Introduction

Chemisorption—the formation of chemical bonds between gas-phase molecules and surface atoms—is the foundational step in heterogeneous catalysis. On supported metal catalysts, this process occurs on small metal crystallites anchored to high surface area oxide materials. These chemisorbed species react with additional adsorbed molecules or gas-phase reactants to generate catalytic products.

The chemisorption behavior of a catalyst directly impacts both the **reaction rate** and **selectivity** toward desired products. Understanding and quantifying chemisorption is thus essential for both catalyst design and performance optimization.

The Link Between Chemisorption and Catalysis

Optimal catalytic performance requires a balance between the **strength** and **quantity** of chemisorbed species:

- **Binding Strength**:
  Too strong — hinders product formation as molecules adhere too tightly.
  Too weak — reactants desorb before reacting.
  Moderate-strength chemisorption yields the highest catalytic activity, illustrated by the classic **volcano curve** for reactions like ammonia synthesis.
- **Number of Sites**:
  The number of chemisorbed species correlates to the number of surface sites available. More sites translate to higher catalytic productivity.

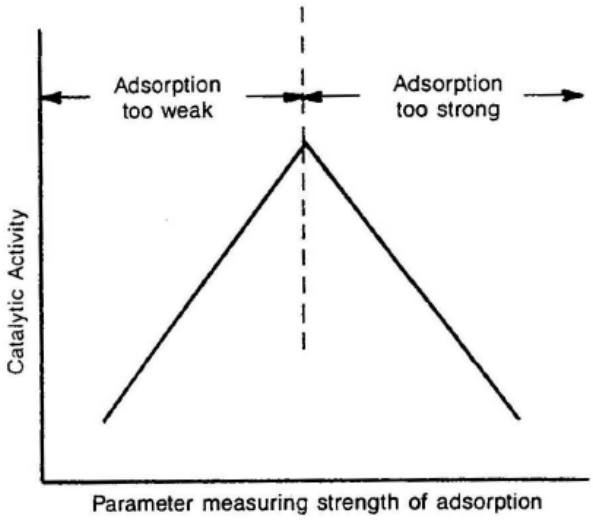

Figure 1: Volcano Curve

133 East Main Street, Twin Lakes, WI 53181• 262-877-3600 (Voice) • 262-877-3699 (Fax)
Email: info@ami-instruments.com
Visit our Website: www.ami-instruments.com

Measuring Chemisorption

Quantitative assessment of chemisorption requires techniques that can evaluate both the **number** and **strength** of adsorption sites:

Method	Measurement Focus
Static/Volumetric Chemisorption	Equilibrium uptake of gas molecules (closed system).
Pulse Chemisorption	Uptake of calibrated gas pulses.
Temperature-Programmed Desorption (TPD)	Desorption behavior upon heating — provides both site count and adsorption strength.

Among these, **TPD** offers the most comprehensive data, capturing both quantitative and qualitative characteristics of chemisorption sites.

Temperature-Programmed Desorption (TPD): Principles and Procedure

A standard TPD experiment involves:

1. **Sample Preparation**:
    - Catalyst reduced to yield clean metal crystallites.
    - Introduction of the chemisorbing gas (typically at ambient temperature).
2. **Gas Switching & Flushing**:
    - Replace chemisorbing gas with inert gas.
3. **Controlled Heating**:
    - Linear temperature ramp.
    - Desorption of chemisorbed species occurs at characteristic temperatures.
4. **Detection**:
    - Quantify desorbed species using calibrated detectors.
    - Calculate site quantity and evaluate adsorption strength.

Example:

For H_2 chemisorption on Ni/SiO_2 (H_2:Ni = 1:2), TPD reveals both the number of available Ni sites and the strength distribution of hydrogen binding.

AMI Solutions: Automated Chemisorption Analysis

AMI Chemisorption Analyzers automate the entire process:

- Precise **flow control** and **gas switching**.
- **Programmable temperature ramps**.

- **Quantitative detection** and **data analysis**.
- Fully customizable **experiment parameters** via user-friendly software.

The AMI platform delivers reproducible, operator-independent TPD and chemisorption measurements, empowering researchers to **optimize catalysts** and **advance reaction engineering**.

Conclusion

Chemisorption is not just a surface phenomenon—it is the gateway to catalytic function. Through advanced, automated analysis tools like the **AMI Chemisorption Series**, scientists can quantify and understand the key properties driving catalyst performance.