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## Why Demand for the SediGraph Endures

*Paul A. Webb*

The SediGraph method for particle sizing has been used in laboratories worldwide since 1967. Although more 'modern' alternatives have been developed for determining particle size, the SediGraph method continues to satisfy best many applications. The reasons for the continued viability of the SediGraph method is the subject of this abbreviated version of an article located on our web site at [www.micromeritics.com](http://www.micromeritics.com).



### **THE SEDIGRAPH METHOD**

The SediGraph has been objectively compared to various other particle sizing techniques and found to be a reliable and repeatable method. In a guide to particle size characterization (1) published by the National Institute of Standards and Technology (NIST), the SediGraph is described as being based on a robust technique, providing rapid analyses, being well-suited for industrial environments, relatively inexpensive, not requiring highly skilled operators, and having the capability to be used over a broad size range with minimal changes.

Anyone shopping for an instrument for particle sizing has a wide selection from which to choose. The wisest choice will be made with a thorough understanding of the model upon which the measurement technique is based. Since size is seldom measured directly, one needs to understand what characteristics of the particle the instrument is measuring and how this measurement relates to size (2). This article answers those fundamental questions for the SediGraph method, and helps to explain why the reliance on the SediGraph method has endured the test of time.

### SIZE DETERMINATION

The SediGraph method is based on two well-established and well-understood physical phenomena—gravitational sedimentation and low energy X-ray absorption.

Stokes' law describes the gravitational sedimentation of a particle stating simply that the terminal settling velocity of a spherical particle in a fluid medium is a function of the diameter of the particle. The SediGraph actually measures the time required for a particle to fall (settle) a known distance, thus establishing its settling velocity from the well-known '*distance equals velocity times time*' relationship. The velocity value and parameters associated with the liquid and solid are substituted into Stokes' law, which then is solved for particle size. Thus, the SediGraph can report measured settling velocities as well as particle sizes.

### MASS FRACTION MEASUREMENT

A thin, horizontal beam of X-rays is projected through the sedimentation cell as the means to determine directly the change in mass concentration in the liquid medium as sedimentation proceeds. This is done by first measuring the intensity of a baseline or reference X-ray beam that has been projected through the liquid medium prior to the introduction of the sample, the analysis sequence being illustrated in the accompanying Figure. As liquid circulation continues, solid sample is added to the liquid reservoir and mixed until a homogeneously dispersed suspension of solid sample and dispersion liquid is being

pumped through the cell. More X-ray energy is absorbed by the solid than the liquid, therefore the transmitted X-ray beam is attenuated compared to the reference beam. Since the mixture of the flowing suspension is homogeneous, attenuation is greater under this condition than it will be when the particles are allowed to settle out of suspension.

Flow of the mixture is stopped and the homogeneous dispersion begins to settle and separate over time, the transmitted X-ray intensity being constantly monitored during the sedimentation process. The vertical position of the X-ray beam is precisely known and at any time the size of particles that have had sufficient time to settle below the beam can be determined even if they began settling at the top of the cell. Of course, largest particles are first to settle below the measuring zone and, finally, all particles settle below this level leaving only clear liquid. During the process, attenuation of the X-ray beam diminishes from maximum to the value established during the baseline measurement. The intensity of the transmitted X-ray beam at any time is directly related to the mass concentration of the remaining suspended particles.

Initially, the position of the X-ray beam is near the bottom of the cell to allow the larger, fast-settling particles to be quantified before falling below the measurement zone. As the larger particles settle out, the position of the X-ray beam is stepped upward in order not to have to wait for the smaller, slower-settling particles to settle as great a distance. This

technique greatly decreases the analysis time, even when working with slow-settling particles.

Of course, the baseline and full scale measurements and the analysis processes as described above are automated.

### APPLICATIONS

Particle size distribution can be determined by a number of techniques (2). However, certain techniques are clearly more applicable than others in certain tests. Take, for example, study of marine silts and sediments. Since the transport of solid components and the subsequent deposition are dependent upon sedimentation rate in water, the SediGraph technique is an ideal method since it, too, is based on sedimentation. Rather than determining particle size by some other technique, then calculating settling velocity from the equivalent spherical size, the SediGraph provides settling velocity information directly and the size of the particle need not even be considered.

Another benefit of the SediGraph method is realized most acutely by those who employ other sizing techniques in addition to that of the SediGraph. This has to do with understanding how reported data are affected by analyzing particles that do not fit the theoretical model upon which the instrument is based. Sedimentation is a comparatively simple mechanism. It is much easier to understand, for example, how non-spherical particles settle compared to spherical particles and, thus, understand what shifts in reported size interpretation are to be expected. This is any-

thing but true when it comes to predicting what effects will be observed in the size data obtained from analyzing non-spherical particles with a laser light scattering system.

### SUMMARY

Particle size is studied in many applications of science and technology. It is easy to understand why particle sizing equipment is available in such a variety of configurations since particle sizes can range from nanometers to millimeters and involve essentially any material, liquid or solid, suspended in a liquid or a gas. The SediGraph is only one of many choices and, because of its time-proven capabilities, continues to hold its place as the most relied-upon method of particle sizing in certain applications.



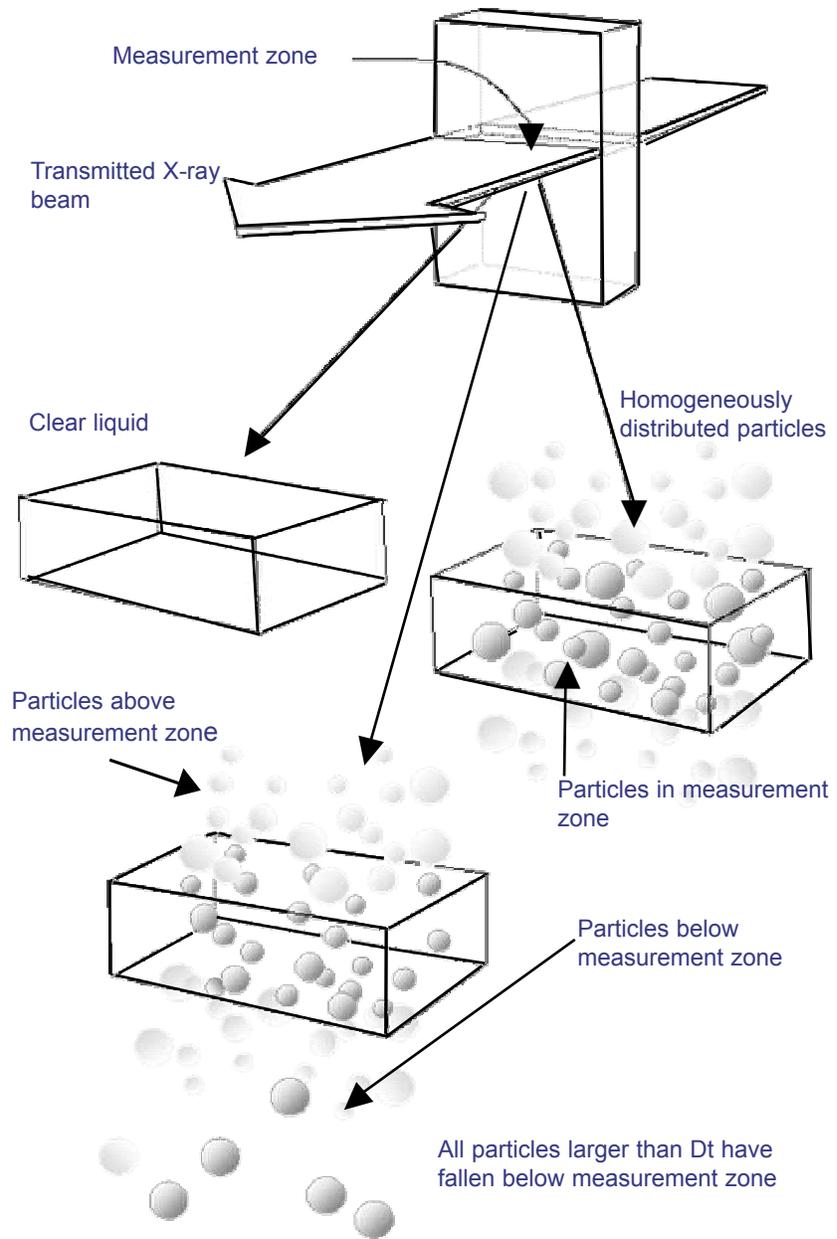
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Webb, P.A.



**Upper:** Diagram of SediGraph sample cell penetrated by a horizontally collimated X-ray beam. The volume of the sample cell through which the X-ray beam passes defines the measurement zone. **Lower:** Measurement zone shown at three stages of an analysis. First, only clear suspension liquid circulates through cell. Next, sufficient sample is introduced to produce a suitable attenuation of the X-ray beam. Finally, circulation is stopped and the suspension is allowed to settle, thus separating the particles by size. Sedimentation continues until all particles have settled below the measurement zone.

*For a detailed description of the SediGraph technique refer to ISO 13317-3:2001 Determination of particle size distribution by gravitational liquid sedimentation methods - Part 3: X-ray gravitational technique.*

# Characterization of Vanadia Catalysts Supported On Different Carriers by TPD, TPR

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## Introduction

Since  $V_2O_5/TiO_2$  catalysts were successful in the oxidation of oxylyene, vanadium-containing catalysts were widely used in the oxidation of other aromatic and paraffinic hydrocarbons [1]. The characterization of these catalysts has been investigated by a great number of physical and chemical methods in many laboratories. But their redox property is not without controversy. TPR (Temperature-programmed Reduction) and  $NH_3$  TPD (Temperature-Programmed Desorption) are powerful methods to characterize the redox property and the surface acidity of solid catalysts [2,3]. In this article, the influence of different supports on the redox property and the acidity of  $V_2O_5$  catalysts will be clarified by TPR and  $NH_3$  TPD.



## Experimental

**1. Catalyst preparation.** Two systems of catalysts were prepared by the wet impregnation. They were indicated as VxA (for  $V_2O_5/Al_2O_3$ ) and VyT (for  $V_2O_5/TiO_2$ ), where x and y are the loadings of vanadium expressed in wt. %. Alumina (BET surface area =  $195\text{ m}^2/\text{g}$ ) and Titania (BET surface area =  $55\text{ m}^2/\text{g}$ ) were impregnated with vanadium oxalate aqueous solution, followed by drying at  $110\text{ }^\circ\text{C}$  for 14h and calcination at  $650\text{ }^\circ\text{C}$  and at  $450\text{ }^\circ\text{C}$  (for VxA and VyT, respectively) for 3h.

Table 1.  $T_{\max}$  in  $NH_3$ \_TPD and TPR of VxA and VyT

Sample	Support	% wt. $V_2O_5$	Theoretical monolayer coverage <sup>(a)</sup>	$T_{\max}$ ( $NH_3$ _TPD)			$T_{\max}$ (TPR)		$V_2O_5$ bulk
				Weak	Medium	Strong	Mono-vanadate	Poly-vanadate	
	$Al_2O_3$	0		192.1	369.1				
V2A	$Al_2O_3$	2	0.07	191.8	368.8		458		
V8A	$Al_2O_3$	8	0.28	173.7	379.0		446.0		
V10A	$Al_2O_3$	10	0.35	184.2			444.0		
	$TiO_2$	0			-		-		-
V2T	$TiO_2$	2	0.25	172.6		443.0	493.5	629.6	
V8T	$TiO_2$	8	1.00	166.4		418.0	506.7	618.2	
V10T	$TiO_2$	10	1.25	168.8	356.4	417.5	507.1	618.8	758.3

<sup>(a)</sup> Theoretical Monolayer Coverage of  $V_2O_5$  equals  $0.145\%V_2O_5/m^2$  [1,4]

**2. Characterization of catalysts.** Temperature-Programmed Reduction (TPR) with hydrogen and Temperature-Programmed Desorption (TPD) of  $\text{NH}_3$  were carried out in a Micromeritics AutoChem II 2920 analyzer.

In the TPR experiments, the sample without pretreatment was reduced with a 10%  $\text{H}_2/\text{Ar}$  mixture (25 ml/min) by heating at  $10^\circ\text{C}/\text{min}$  to  $800^\circ\text{C}$ . In the TPD experiments, the sample, after decontaminating at  $300^\circ\text{C}$ , was saturated with 10%  $\text{NH}_3/\text{He}$  (15 ml/min) at  $100^\circ\text{C}$  for 1h, and then was purged with pure He for 1h. For the desorption, it was heated ( $10^\circ\text{C}/\text{min}$ ) to  $500^\circ\text{C}$  in flowing He (25 ml/min).

## Results and Discussion

$\text{NH}_3$  TPD of  $\text{V}_x\text{A}$  contrasted with that of  $\text{V}_y\text{T}$ . When the loadings of vanadia rose, the  $\text{NH}_3$  TPD profiles of  $\text{V}_x\text{A}$  shifted to low temperature, showing that the amount of weak acid sites increased and the amount of medium and strong acid sites decreased. Contrarily, on  $\text{NH}_3$  TPD profiles of  $\text{V}_y\text{T}$ , the strong acid sites increased as loadings of vanadia increased. Above monolayer ( $\text{V}_{10}\text{T}$ ), a third peak appeared at the middle temperature range.

The TPR of  $\text{V}_2\text{O}_5/\text{Al}_2\text{O}_3$  showed only one peak at lower temperature. It was attributed to the reduction of the monovanadate species. There are two reduction peaks in the TPR

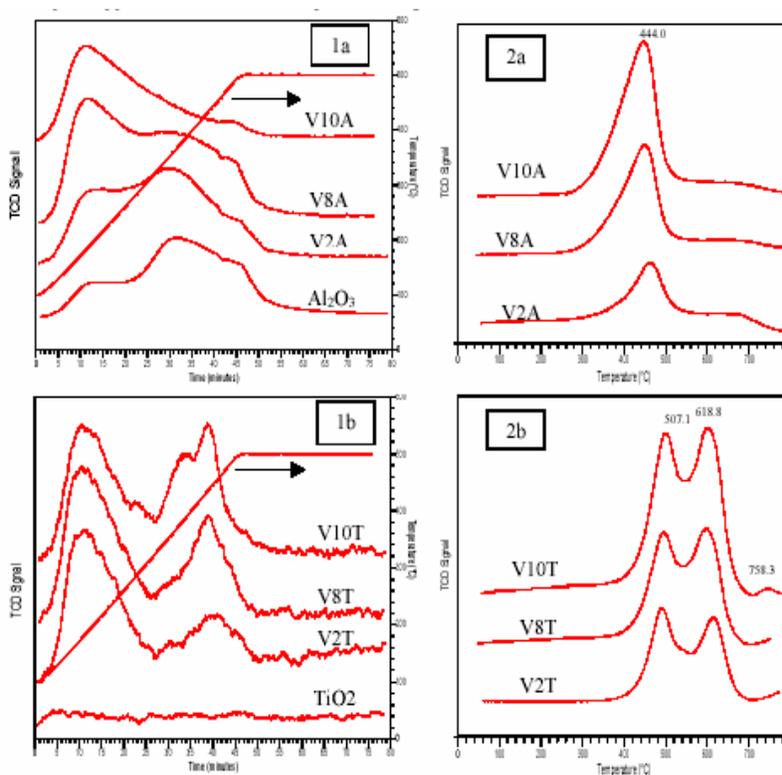


Figure 1.  $\text{NH}_3$  TPD of  $\text{V}_x\text{A}$  (a) &  $\text{V}_y\text{T}$  (b)

Figure 2. TPR of  $\text{V}_x\text{A}$  (a) &  $\text{V}_y\text{T}$  (b)

profiles of  $\text{V}_2\text{O}_5/\text{TiO}_2$  under monolayer coverage ( $\text{V}_2\text{T}$  and  $\text{V}_8\text{T}$ ): they were attributed to the reduction of mono- and poly-vanadate species. When the coverage was over the monolayer ( $\text{V}_{10}\text{T}$ ), a third peak appeared at higher temperature, it might be the reduction of  $\text{V}_2\text{O}_5$  crystallites.

## Conclusions

1. When the loadings of vanadia rose, the amount of weak acid sites on  $\text{V}_x\text{A}$  increased whereas, the quantity of strong acid sites on  $\text{V}_y\text{T}$  increased.

2.  $\text{V}_2\text{O}_5$  supported on  $\text{Al}_2\text{O}_3$  was reduced more easily than on  $\text{TiO}_2$  because its theoretical monolayer coverage was lower.

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## Julio Robles of Mexico Named Atlantic Rim Distributor of the Year

Micromeritics is pleased to announce that Julio Robles of SIMEX Mexico has earned the title of Distributor of the Year for the Atlantic Rim Region. Julio attributes this outstanding success to his emphasis on providing good service to his customers in Mexico. Previously Julio was a Micromeritics Service Engineer, so he was already familiar with our products when he took over the territory of Mexico. One of his first steps was to contact the Micromeritics customer base in Mexico to offer service support to them.

Micromeritics has always had a commitment to providing service and applications support to our customers. Our distributors have a similar commitment. Micromeritics manufactures high-quality equipment, but even the best equipment needs periodic and occasional maintenance. We are aware that our customers need to be confident that Micromeritics, either directly or in the form of our Distribution partners, will be there to assist when necessary.

Micromeritics' Distributors receive the same service training provided to our own direct

offices and service engineers. Service training courses are conducted at Micromeritics' Training Center in Atlanta twice each year. Training on new products is conducted during sessions lasting three weeks each Spring and continuing education training on existing products is conducted during a three-week session each Fall. Our customers can be confident that a high level of service and maintenance proficiency is maintained by Micromeritics Service Engineers worldwide.

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## Micromeritics' New *confirm*™ Software for 21 CFR Part 11 Compliance

Micromeritics' all-new *confirm* software was developed to address the many requirements specified by the 21 CFR Part 11 Final Rule published by the U.S. Food and Drug Administration (FDA) to reduce time-to-market of new pharmaceutical products. This *confirm* software is now offered with a Micromeritics suite of products that includes: the Saturn DigiSizer® 5200 High Resolution Laser Particle Size Analyzer, ASAP

2020 Physisorption system, TriStar 3000 Surface Area and Porosimetry Analyzer, and the Gemini V Series Surface Area Analyzers.

Combined with Micromeritics' IQ and OQ services, the user can be assured that each system is validated for accuracy, reliability, and consistent performance. Original records cannot be altered and there is traceability to edited records. System access is limited to authorized individuals. Secure,

computer-generated, time-stamped audit trails are an integral part of the software program.



## Recent Papers Referencing Micromeritics Instruments

This is a partial list of papers recently published in scientific journals in October, November, and December of 2003. All reference the use of Micromeritics products in their research work. For a complete list of papers, visit our website [www.micromeritics.com](http://www.micromeritics.com).

### ASAP Series

Effects of PVB on the gelation behavior of BaTiO<sub>3</sub>-based dielectric particles and glass suspension

Cho, C.-W. / Cho, Y.-S. / Yeo, J.-G. / Kim, J. / Paik, U., *Journal of the European Ceramic Society*, Dec 2003

Dispersion of aqueous alumina suspensions using copolymers with synergistic functional groups

Liu, Y. / Gao, L., *Materials Chemistry and Physics*, Nov 2003

Effects of the granularity of raw materials on the hydration and hardening process of calcium phosphate cement

Liu, C. / Shao, H. / Chen, F. / Zheng, H., *Biomaterials*, Oct 2003

Isomorphic substitution and the hydration behavior of alinite cement

Kim, Y.-M. / Hong, S.-H. / Park, H.-M., *Journal of the European Ceramic Society*, Nov 2003

Nitridation reaction of aluminum powder in flowing ammonia

Qiu, Y. / Gao, L., *Journal of the European Ceramic Society*, Nov 2003

Catalytic decomposition of N<sub>2</sub>O over M<sub>x</sub>Co<sub>1-x</sub>Co<sub>2</sub>O<sub>4</sub> (M = Ni, Mg) spinel oxides

Yan, L. / Ren, T. / Wang, X. / Ji, D. / Suo, J., *Applied Catalysis B: Environmental*, Sep 2003

Synthesis and characterization of silica-supported transition-metal phosphides as HDN catalysts

Zuzaniuk, V. / Prins, R., *Journal of Catalysis*, Oct 2003

Dynamic phenomena during the photocatalytic oxidation of ethanol and acetone over nanocrystalline TiO<sub>2</sub>: simultaneous...

Coronado, J.M. / Kataoka, S. / Tejedor-Tejedor, I. / Anderson, M.A., *Journal of Catalysis*, Oct 2003

The catalytic hydrogenation of adiponitrile to hexamethylenediamine over a rhodium/alumina catalyst in a three phase...

Alini, S. / Bottino, A. / Capannelli, G. / Carbone, R. / Comite, A. / Vitulli, G., *Journal of Molecular Catalysis A: Chemical*, Oct 2003

## Events

### Pittcon

March 8 - 11, 2004

McCormick Place

Chicago, IL

Booths 1921 & 2021

### Netherlands Catalysis & Chemistry Conference 2004

March 8 - 10, 2004

The NH Leeuwenhorst Hotel

Noordwijkerhout, Netherlands

### International Pharmaceutical Industry Congress

March 16 - 18, 2004

Booth D220

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Javits Convention Center

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### Organic Reactions Catalysis Society

March 21 - 25, 2004

Crown Plaza Resort

Hilton Head, SC

### American Chemical Society Spring Show

March 29 - 31, 2004

Anaheim Convention Center

Anaheim, CA

### Course in Tablet Technology

Sponsored by the University of Tennessee. Use of Micromeritics instruments in tablet production is a part of this course. For additional information, see this web site: <http://cop.utmem.edu/pharmacy/tabcourse>

Dates:

March 14-19

June 6-11

September 19-24

# Characterization of Acid Sites Using Temperature-Programmed Desorption

Jeffery Kevin, Ph.D

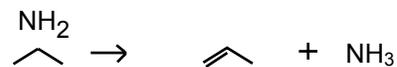
**T**emperature-Programmed Desorption (TPD) is one of the most widely used and flexible techniques for characterizing the acid sites on oxide surfaces. Determining the quantity and strength of the acid sites on alumina, amorphous silica-alumina, and zeolites is crucial to understanding and predicting the performance of a catalyst. For several significant commercial reactions (such as n-hexane cracking, xylene isomerization, propylene polymerization, methanol-to-olefins reaction, toluene disproportionation, and cumene cracking), all reaction rates increase linearly with Al content (acid sites) in H-ZSM-5<sup>6-11</sup>. The activity depends on many factors, but the Brønsted-acid site density is usually one of the most crucial parameters.

There are three types of molecular probes commonly used for characterizing acid sites using TPD: ammonia, non-reactive vapors, and reactive vapors. TPD of ammonia is a widely used method for characterization of site densities in solid acids due to the simplicity of the technique. Ammonia often overestimates the quantity of acid sites. Its small molecular size allows ammonia to penetrate into all pores of the solid where larger molecules commonly found in cracking and hydrocracking reactions only have access to large micropores and mesopores. Also, ammonia is a very basic molecule which is capable of titrating

weak acid sites which may not contribute to the activity of catalysts. The strongly polar adsorbed ammonia is also capable of adsorbing additional ammonia from the gas phase.

Larger non-reactive amines such as pyridine and t-butyl are often preferable alternatives to ammonia because their size permits access to the pore size range required for catalytic cracking reactions and they titrate only the strong and moderate acid sites. The most common application for these probes is the characterization of pyridine adsorption by infrared spectroscopy. However, the determination of extinction coefficients is difficult and IR of pyridine is typically used in a qualitative manner, rather than as a measurement of site densities.

The most commonly used reactive probes are the propyl amines. These amines are reactive and decompose to propylene and ammonia over Brønsted-acid sites. The temperature-programmed decomposition of amines is the most modern technique for measuring Brønsted-acid site concentrations. The method is based on the formation of alkylammonium ions (from adsorbed alkyl amines that are protonated by Brønsted sites) that decompose to ammonia and olefins in a well-defined temperature range *via* a reaction similar to the Hofmann-elimination reaction.



As long as the alkyl group can give up a hydrogen atom to form an olefin and the amine is small enough to access the Brønsted sites, the measured site densities are independent of the particular amine used to probe the sites. The technique is equally valuable for characterizing amorphous and crystalline solid acids.

The use of organic amines and other basic vapors is possible using Micromeritics' AutoChem Series of instruments which provides internal heating of the lines, valves, and detector to prevent condensation of the experimental vapors.

## Preparation

Samples are degassed at 100 °C for one hour in flowing helium to remove water vapor and to avoid pore damage from steaming which may alter the structure of zeolites. The samples are then temperature-programmed to 500 °C at a ramp rate of 10 °C/minute and held at that temperature for two hours to remove strongly bound species and activate the sample. Finally the sample is cooled to 120 °C in a stream of flowing helium.

## Adsorption

Next the sample is saturated with the basic probe at 120 °C; this temperature is used to minimize physisorption of the ammonia or organic amines. For ammonia, two techniques

are available to saturate the sample: pulsing the ammonia using the loop or continuously flowing ammonia. Pulsing the ammonia allows the user to compare the quantity of ammonia adsorbed (via pulse adsorption) to the quantity desorbed for the subsequent TPD.

Using the organic amines requires the use of a vapor generator; the sample must be saturated by using the built-in loop and pulse adsorption. The AutoChem vapor generator contains a temperature-controlled valve, reflux condenser, and flask for the probe liquid. This unique design allows precise control of vapor composition. Its use is imperative for liquids with high vapor pressures. The temperature zones for the AutoChem should be altered to reflect the use of vapors in the system; in particular, the temperature for the valves should be set to 110 °C. While using organic amines the vapor valve zone temperature should also be set to 110 °C to prevent condensation. The temperature of the condenser controls the liquid vapor pressure (and concentration of the vapor in the loop). An appropriate temperature can be obtained using the Antoine equation to calculate the temperature required to obtain a vapor pressure or 0.1 to 0.2 bar which translates to 10 to 20% vapor composition by Dalton's equation for partial pressures.

$$\log_{10}(P_v) = A - \frac{B}{T + C}$$

or

$$T = \frac{B}{A - \log_{10}(P_v)} - C$$

where:

$P_v$  = the vapor pressure in bar (1 bar = 750.0615613 mmHg)  
 $T$  = the condenser temperature in Kelvin.

Antoine constants are given in Table 1 for several common probes. The temperature of the liquid flask should be set to 5 or 10 °C above the temperature of the condenser but should remain below the boiling point of the liquid. The vapor generator is designed to provide constant vapor pressure and not boil the liquid.

After saturation with ammonia, pyridine, or propyl amine, the sample is purged for a minimum of one hour under a flow of helium to remove any of the physisorbed probe.

### Desorption

The temperature-programmed desorption is easily performed by ramping the sample temperature at 10 °C/minute to 500 °C. It is a good rule of thumb that the end temperature during the TPD not exceed the maximum temperature used in the preparation of the sample. Exceeding the maximum preparation temperature may liberate additional species from the solid unrelated to the probe molecule and cause spurious

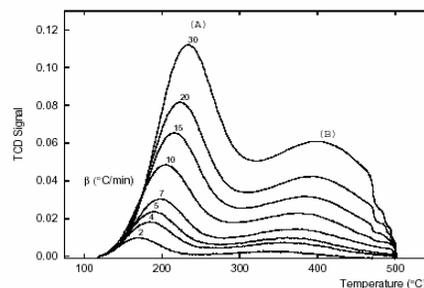


Figure 1. TPD of ammonia from ZSM-5

results.

During the TPD of ammonia or the non-reactive probes (pyridine or t-butyl amine), the built-in thermal conductivity detector (TCD) will monitor the concentration of the desorbed species. For the reactive probes (propyl amines), a mass spectrometer is required to quantify the density of acid sites. For these probes, several species may be desorbing simultaneously: amine, propylene, and ammonia.

TPD profiles for ammonia desorption are obtained by raising the sample temperature according to a specific heating rate. Eight TPD profiles, obtained at heating rates of 2, 4, 5, 7, 10, 15, 20, and 30 °C/min are shown in Figure 1. This zeolite clearly shows two distinct acid sites A and B. TPD profiles for pyridine desorption were obtained by using several different adsorption temperatures (150, 175,

Table 1. Antoine constants

	A	B	C	$T_{min}$ K	$T_{max}$ K
i-Propanol	4.861	1357.427	-75.814	329.92	362.41
n-Propylamine	4.05136	1044.028	-62.314	296.12	350.74
i-Propylamine	4.01507	985.65	-59.079	277.07	334.13
t-Butylamine	3.90694	992.719	-62.727	292.47	348.36
Pyridine	4.16272	1371.358	-58.496	340.4	426.04

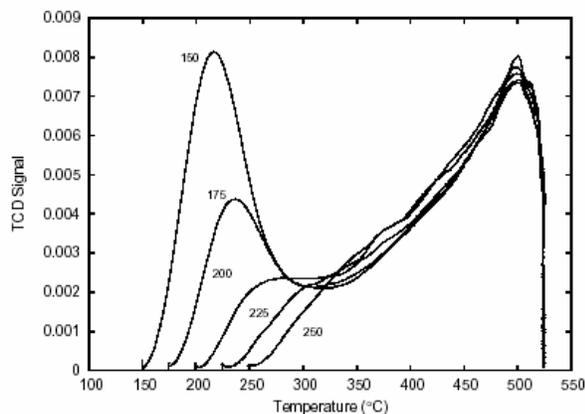


Figure 2. TPD of pyridine from ZSM-5

200, 225, and 250 °C) and then raising the sample temperature at 10 °C/min; these TPD profiles are shown in Figure 2. These TPD spectra of pyridine demonstrate the effect of temperature upon the quantity of weakly sorbed pyridine and also show that the quantity of strongly sorbed pyridine does not change with repeated cycling.

The temperature-programmed decomposition of *i*-propyl amine should be monitored by a mass spectrometer (Figure 3). At temperatures less than 300 °C, the TPD product contains *i*-propyl amine. As the temperature exceeds 300 °C, the *i*-propyl amine is fully desorbed and the TPD products are propylene and ammonia from the Hoffman reaction. In Figure 3, it is clear that only the decomposition products desorb above 300 °C. It is also interesting to note the ammonia desorption lags the propylene desorption. This

is due to the readsorption of ammonia onto the ZSM-5. The quantity of the propylene desorbed is then used to calculate the number of acid sites.

#### Tips for Handling Amines

- Pyridine should be transferred to the vapor generator flask in a fume hood.
- To reduce the odor of pyridine – chill the vapor generator flask in ice for 30 minutes. After filling the flask with pyridine, return the flask to an ice bath to reduce the vapor pressure.
- Consult the MSDS of pyridine for proper handling and exposure limits.
- Purge the vapor valve (not the vapor generator) for 30 minutes after dosing amines. The vapor valve zone should be set to 110 °C during the inert purge.

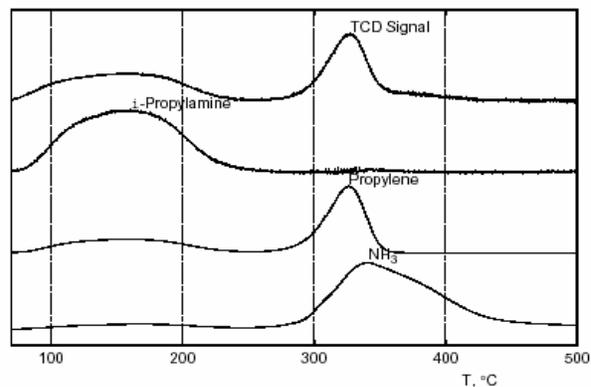


Figure 3. Temperature-programmed decomposition of *i*-propyl amine to propylene and ammonia using ZSM-5

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## Micromeritics Instrument Training Courses

Training is provided for most Micromeritics instrumentation at the time of installation. This training presents all the information required for a new operator to quickly become proficient operating the instrument. In cases where personnel changes occur or more advanced training is required, Micromeritics conducts a variety of classes for many of our instruments. These courses are held at our headquarters in suburban Atlanta, Georgia. The courses include:

### Detailed Operational Procedures

Items covered are effective sample file creation, use of analysis parameters, and manual sample entry. You'll learn how to utilize the full power and flexibility of the operating software.

### Automatic Analysis

Develop correct analysis procedures to optimize collection of accurate, reproducible data. Much of the class time is spent performing analyses in a controlled, tutorial environment.

### Systems Utilities

Discover all of the instrument software utilities which help you manage sample information files and directories, protect data, and select system options.

### Report Generation and Comprehension

Learn to configure reports and obtain useful information, as well as improve comprehension of the reports produced.

### User Maintenance

Practice routine maintenance procedures which improve operation, reduce downtime, and increase data accuracy.

### Troubleshooting

Learn techniques that enable you to locate and resolve instrument problems quickly.

### Theory Overview

Learn about the scientific theory upon which each instrument is based and how it applies to the critical factors relevant to successful sample preparation and analysis performance.

### Enrollment

Training courses are designed to provide hands-on, performance-based instrument knowledge. The course materials include a Study Guide, an instrument Operator's Manual, and other handout materials. Certificates of Completion are also awarded to all trainees.

For additional information or to register for the class of your choice, contact the Micromeritics Training Department at 770.662.3607. Early registration is recommended.

## Course Schedule

### Gemini™ V

February 17-18

### confirm™ Administrator

February 24

### Gemini/confirm

February 25 - 26

### Gemini/ with confirm Administrator

February 24 - 26

### AutoPore™ IV

April 13 - 15

### ASAP™ 2020 Physisorption

April 20 - 22

### ASAP™ 2020 Physi/Chemi

April 20-23

### SediGraph™ III 5120

May 4 - 5

### Saturn DigiSizer®

June 8 - 10

Visit our website at [www.micromeritics.com](http://www.micromeritics.com).

## ATTENTION AUTHORS

We welcome articles and information concerning particle technology applications performed with Micromeritics instrumentation. Everything from a single plot with operating conditions to an in-depth article on physisorption, chemisorption, etc. with supporting plots will be considered. If your material is published in The microReport, you will receive a copy of Analytical Methods in Fine Particle Technology by Paul A. Webb and Clyde Orr.

Send your article to:  
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Include your title, return address and phone number. Contributions cannot be returned, but each will be acknowledged.

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