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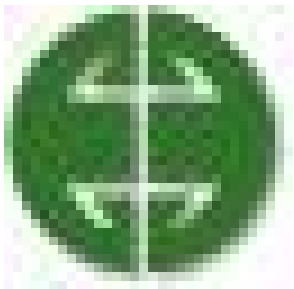

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American Institute of Chemists

315 Chestnut Street Philadelphia, PA 19106-2702

Phone: (215)873-8224

Fax: (215)925-1954

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Editorial

The marks the second issue in the new format for The Chemist. In this issue you will find three excellent papers that address the breadth and width of the disciplines that one encounters as a member of the AIC. This issue also contains a number of in depth book reviews. For those who have recently submitted a book review and do not see it in this issue, do not lose heart since we are blessed with an abundance of book reviews and will obviously publish them in subsequent issues. The lifeblood of any journal such as The Chemist is manuscripts and the editors are most appreciative of those who have submitted manuscripts but we ask that you contact you help us continue with The Chemist by either submitting a manuscript for review or contacting a colleague to submit a manuscript. The journal is well recognized with rapid review and presently rapid publication cycles. We were most gratified with the response to the first issue that was placed on the AIC website. The list of members has been complied and we are working through a mechanism to provide copies of these electronic journals to those without email access. Please contact the AIC office or one of the editors should you have any questions, concerns about the journal or wish to discuss a submission. We look forward to hearing from you.

W. J. Hurst, PhD., FAIC, CPC

Galvanized Steel Corrosion Under Strong and Weak Acid Rain Conditions

by

Dana M. Barry, Paul McGrath, Hideyuki Kanematsu, and Takeo Oki

abstract: This international effort was initiated to address the challenges that our ever-changing environment places on various protected steel structures due to acid corrosion. A variety of hot-dip galvanized steel samples were fabricated in Japan and tested in both strong and weak acid rain conditions, using a rotating wheel and dip tank in the environmental aging laboratory at Clarkson University in the U.S. The experimental results provide useful information about the effect of acid rain on the service life of structural materials being used throughout the world.

Introduction

Today a major concern is acid rain corrosion of galvanized steels used to make items such as bridges and buildings. The service life of these structural materials is of great importance to the economy and safety of our global community. Acid rain (a form of industrial pollution) refers to acidic forms of precipitation including rain and snow. This investigation was carried out to determine and compare how a variety of hot-dip galvanized steels react under strong and weak acid rain conditions. A rotating wheel and dip tank were designed to test metals in a simulated acid rain environment (1). In this project three types of galvanized steels (pure zinc, 5% Al-Zn, and 55% Al-Zn film specimens), with and without silicone sealer, were tested in both strong and weak simulated acid rain conditions. The experimental setup and results are provided.

Experimental Setup

A stainless steel rotating wheel and dip tank, which holds about 92 liters of acid rain solution, were used to environmentally age the metals. The wheel had a constant speed of three revolutions per minute (RPM). Samples were attached to the periphery of the 1 meter diameter wheel by stainless steel bolts and tested for 168 consecutive hours. See Figure 1. During testing each sample was submerged in the dip tank for half of the wheel cycle and then exposed to air for the other half of the cycle. The samples were mounted such that their surfaces were perpendicular to the direction of motion in the test solution contained in the dip tank.

For the strong acid rain simulation, the solution used in the dip tank had an average pH of 2.6, an average conductivity of 1.2 milli siemens per centimeter (1.2 mS/cm), and an average temperature of 21°C (2). For the weak acid rain simulation, the solution used in the dip tank had an average pH of 5.08, an average conductivity of 29.6 micro siemens per centimeter (29.6µS/cm), and an average temperature of 20°C (1). In both cases, the solution was checked and adjusted daily to maintain the pH and conductivity. The solutions were prepared with sulfuric and hydrochloric acid, together with the following salts: potassium sulfate, ammonium sulfate, magnesium chloride, sodium chloride, sodium nitrate, and calcium nitrate (3).

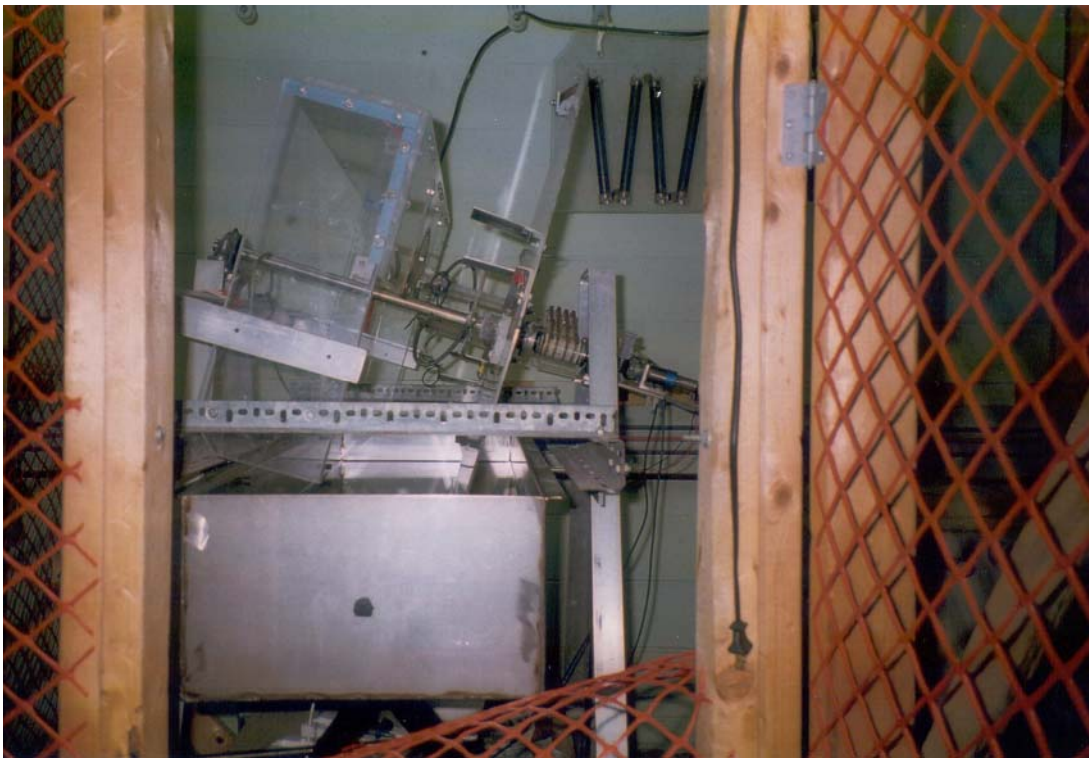

FIGURE 1. Rotating Wheel (with samples attached) and Dip Tank

Samples

For each acid rain simulation, a total of 9 samples were tested simultaneously. The samples included a substrate, three different hot-dip galvanized steel samples, and five different test panels from D & D Co. in Japan. In all cases the substrate was carbon steel (JIS SS 400). The hot-dip samples had films of 5% Al - 95% Zn, 55% Al - 45% Zn and 100% Zn. For simplicity these samples are referred to as 5, 55, 100, and in addition, sub (substrate). The samples from D & D Co. include the following: Test Panel 1: plated metal with pure zinc film plus sealer, Test Panel 2: plated metal with 5% Al - Zn film plus sealer, Test Panel 3: plated metal with 55% Al - Zn film plus sealer, Test Panel 4: metal spray sample plus sealer, and Test Panel 7: metal spray sample without sealer. For simplicity these specimens are referred to as 100P (pure Zn), 5P (5% Al), 55P (55% Al), MSS (metal spray with sealer), and MS (metal spray).

Sample lengths and widths were measured to the nearest millimeter. Each sample was cleaned with a standard industrial degreaser (1,1,2 - Trichlorotrifluoroethane 99%) and labeled with permanent ink (sub, 5, 55, 100, 5P, 55P, 100P, MS, and MSS). The dry samples were weighed to the nearest hundredth gram before and after aging, using a 5300 D Fisher Scientific digital balance. Hydrophobicity tests (using the sessile drop method) were performed on each sample before and after acid rain exposure. To aid in discerning changes in physical appearance, each dry sample was placed on a table and photographed before the experiment started and again after its completion. Also samples were observed throughout the investigation.

Results

For both acid rain investigations, all samples were tested simultaneously for 168 hours. With the exception of the substrate and sample 100, most samples appeared to exhibit very small changes in mass during the weak acid rain investigation (pH of 5.08). The substrate gained 0.06 grams after 24 hours of testing. This increase may be due to the formation of significant rust (Fe_2O_3) on its surface. Sample 100 lost 0.08 grams, which was the most mass loss of all the tested galvanized steel samples. This mass change is suggestive of some loss of the 100% zinc film used for its protective coating having dissolved in the acid solution. Samples 55P and MSS did not change in appearance throughout this experiment. It should be noted that Sample 100 also changed the most in mass during the strong acid rain investigation. During this experiment all samples displayed some rust and corrosion. However, only small amounts were detected on the samples containing sealants.

The hydrophobicity tests provided some interesting contact angle information. At the completion of both the strong and weak acid rain experiments, samples 100, 5, 55, MS, and the substrate had contact angles of 0 degrees. These samples, which did not contain sealants, seem to be the first to become completely wet. They were seen to exhibit a tendency to corrode and rust at a faster rate than those samples with final contact angles greater than 0 degrees.

Our acid rain simulation experiments environmentally aged the galvanized steels, which had a

surface area of about 0.005 m^2 . Since the tested samples were from Japan, the average corrosion rate due to acid rain in Japan was used (15 grams/m^2/year) for the calculations. This rate was provided by Rhombic Corporation (now called D & D Co.) in Japan. The loss of mass in grams (during the investigation) was converted to years of aging for each sample tested. See the Aging Chart. For example: Sample 100 lost 2.14 grams in the strong acid experiment. Therefore this sample aged about 28.5 years.

(2.14 grams divided by 0.005 m^2) / 15 = 28.5 years.

AGING CHART					
SAMPLES	Years of Aging (pH = 5.08)	Loss of Mass in Grams (pH = 5.08)	Years of Aging (pH = 2.6)	Loss of Mass in Grams (pH = 2.6)	
55	0.4	0.03	17.6	1.32	
100	1.06	0.08	28.5	2.14	
5	0.53	0.04	25.6	1.92	
5P	0.26	0.02	2.6	0.20	
55P	0.26	0.02	0.26	0.02	
100P	0.4	0.03	0.93	0.07	
MS	0.0	0.0	19.7	1.48	
MSS	0.4	0.03	2.0	0.15	

Conclusions

Overall, all samples other than the substrate showed good corrosion resistance in weak acid rain conditions over an extended period of time (168 consecutive hours). Also very small changes in mass were detected for the samples in this experiment. On the other hand, the results of the strong acid rain investigation had a large range of mass changes and sample aging. Keep in mind that corrosion properties depend on the thickness and chemical makeup of the protective coating of films and sealers used. Both investigations showed that the hot dip galvanized steels coated with pure zinc films had the least corrosion resistance. The use of alloy film coatings and sealers improved the metal's resistance to corrosion. Also samples coated with both alloy films (especially 55% Al-Zn) and sealers appeared to have the highest corrosion resistance and the longest service life. Sample 55P (coated with both an alloy film and sealer) aged about 0.26 years in the strong acid environment, while Sample 100 (coated with pure zinc film) aged over 28 years.

The silicone sealers (from Japan) used in this investigation have high stability in ultraviolet light. They usually penetrate into the pores of surface films and stick to the substrate. This is the way they increase corrosion prevention in spray-coated films (4). A high level of corrosion resistance was also found in the non-spray coated films with sealers. The surfaces of these samples are concave-convex at the microscopic level, and not as porous as those that are spray coated. Therefore the sealers penetrated the metals' concave portions to increase adhesiveness and anti-corrosive properties. The results indicate that the stable silicone sealers can be successfully applied to steel structures exposed to acid rain and ultraviolet light in the natural environment (2).

Galvanized steel samples (fabricated in Japan) were successfully aged in both weak and strong acid rain environments, by using a rotating wheel and dip tank at a Clarkson University laboratory in the U.S. The experimental results provide useful information about the effect of acid rain on the service life of structural materials being used in bridges and buildings throughout the world (5). We found that galvanized steel samples coated with both alloy films (especially 55% Al-Zn) and silicone sealers had the greatest resistance to corrosion and the longest service life.

Acknowledgment: Special thanks to Japan's Galvanizers Association and to the D & D Co. of Japan, for providing the samples used in this investigation.

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Authors

Dr. Dana M. Barry is President of Ansted University's Scientific Board and Technical Writer / Editor of Clarkson University's Center for Advanced Materials Processing (P.O. Box 5665 CAMP, Clarkson University in Potsdam, New York 13699, USA)

Dr. Paul McGrath is a Professor in the Department of Electrical and Computer Engineering at Clarkson University (P.O. Box 5720 CAMP, Clarkson University in Potsdam, New York 13699, USA)

Dr. Hideyuki Kanematsu is Associate Professor in the Department of Materials Science and Engineering at Suzuka National College of Technology in Shiroko-cho, Suzuka, Mie 510-0294, Japan

Dr. Takeo Oki is Professor Emeritus at Nagoya University at 3-39, Tennodori, Tsuhima, Aichi 496-0807, Japan

Glucose, Lactate, and Blood Gases: Clinical, Analytical and Management Perspectives

Robert F. Moran, PhD, FCCM, FAIC, CLC, FACB, FIUPAC, Asst Professor of Chemistry, Wentworth Institute of Technology, Boston, Massachusetts

Author's note: This report is intended to give the reader an overview of some key analytical-operational issues inherent in the field of critical care-related laboratory testing. In designing instrumentation for the critical care laboratory, one needs to look not only at what measurements are needed, but the clinical need for simultaneity in obtaining results. The references at the end go beyond the immediate issues related to the paper to include examples of some seminal papers in the analytical aspect of this type of testing. Much of the current analytical work is application of the underlying principles and is done in manufacturer-sponsored environments-thus is proprietary. Analytical purism may sometimes be compromised in currently available multi-component critical care analyzers, but pH is still pH, and potassium ion is still potassium ion. Measurement options are currently limited to a few choices for each analyte, as is evidenced by the fact that all current analyzers use the basic technology known and used, in some cases for decades[#]. The combination of analytes important in critical care using the unique sample of labile human tissue make for some interesting combinations of chemistry, physics, biochemistry, and fluidics, but most of all computer technology. The latter is used mostly to control the measuring devices and manipulate their output to get results concordant with the slower but analytically "better" measurement technology. I hope you enjoy the read-it may not be a Ludlum novel, but it represents some novel applications of mature technology.

INTRODUCTION

Over the last several decades, pH and blood gas analyses have been among the primary STAT analytes needed to assess the status of critically ill patients. Recent technology advances have made it possible to also include **lactate** and **glucose** and other determinations in the same analytical system as the **blood gases**, as well as other clinically or analytically related measurements.

Technological feasibility does not necessarily equate with clinical needs. However, concerns about the timely availability of many of the se analytes have been driving factors in the development of systems to ensure more rapid results, including better pneumatic tube systems for sample transport and simpler analyzers for use in near patient testing (NPT) or point of care testing (POCT) environments.

With all this, technical feasibility, clinical necessity, and operational responsibility are blurred in a maelstrom of competing marketing claims, white papers and pronouncements by the clinical *avant-garde.*

[#] D'Orazio P. Electrochemical sensors: A review of techniques and applications in point of care testing. *J Point of Care*. 3:2; 49-59, 2004

Considering this is the Laboratory Scientists-Manager, who must make real decisions based on resources available, staffing, reliability of systems, cost (however defined), and clinical/operational measures of "outcome". The "Catch-22" of this situation is that while choice of an institution's or department's analyzer(s) should be based on the mission of the institution and department, patient-test ordering patterns, as well as clinical turnaround time requirements, today's decisions by a "Laboratory Administrator", will also be subject to after the fact scrutiny by legal authorities such as HCFA's Office of the Inspector General (OIG), who will be looking for patterns of ordering and billing abuse by laboratories - fraud. This is especially true with regard to tests packaged together as "profiles". Thus, while it's important to be aware of current trends in analytical and operational technology, an understanding of true clinical requirements in different situations and the latest perspectives on reimbursement policies may take precedence.

This report will look at application of some operational and clinical principles for the inclusion of multiple analytes in systems that also measure the blood gases. Special focus will be taken on the clinical and analytical rationale for the addition of glucose and lactate.

CURRENT STATUS:

Multichannel systems designed to measure blood gas/pH and electrolytes have been widely accepted in high volume laboratories staffed by trained analysts and in low volume situations such as central laboratories of small institutions or "satellite" laboratories near direct patient care areas. The resource-intensive nature of such testing, however, raises issues as to it's true effectiveness in the light of clinical need and costs, especially when test menus are frequently being added to include analytes that may have either marginal or only theoretical clinical advantages.

Planning for critical care testing and the acquisition of operational and analytical devices should incorporate laboratory staff, treating clinicians and the financial/legal support staff of an institution. In order to reach the optimal clinical, resource, and financial solution, with this information at hand, the clinician and laboratorian can work together in determining the appropriate instrumentation and other requirements to meet the clinical needs. An environment in which the clinical requirements and the available technology are considered in total by all who would be using the information, is where true quality can be reached.

Today, as measuring systems become more complex and capable, it also makes sense for marketing, sales and technical staff of a vendor be included as part of an advisory group for major institutional purchases. This consultative role on the part of the manufacturer's representatives requires them to be well informed about the customer's situation and the real clinical applications of the products being considered – something that may be a departure from past approaches, and marketing strategies.

CRITICAL ANALYTES:

While "critical" connotes a very high level of clinical importance, for purposes of testing management it combines importance with a high degree of timelines. The frequent operational issue in assuring timely results is one of resource management, since different, and sometimes arbitrary, definitions of both the importance and the necessary timelines may be used in the same institution. More than a

decade ago, the American Association for Clinical Chemistry (AACC), through its Quality Assurance Committee, recognized the need for a more principled approach to this contentious issue and developed a set of guidelines[∂] to be used by laboratories. While the "STAT" test list included in the AACC publication needs updating in the light of new analytical and therapeutic approaches, the principles behind that list are still valid. They can be briefly restated as:

Urgent *(AACC Test Category 1)*

Cause or Effect Marker for Immediate Life-Threatening Condition

Specific and Immediate Therapeutic Action Based on Analyte Level

Timeliness, Reliability ***Crucial*** Factors

Important (AACC Test Category 2)

Necessary for Diagnosis, Triage, Follow-on Therapy

Timeliness ***Key*** Factor

The use of these criteria, when combined with information based on an institution's typical patient population and therapeutic possibilities can be very useful. However, in today's clinical, reimbursement and regulatory environment, one might add a third category, which might be referred to as "responsible" or "responsive".

Responsible/Responsive

Patient Care Management/Clinically Related Quantities

Frequency of Need for One Quantity "Simultaneously" with Others

Single Blood Specimen/Analytically Related Technology

Resource Utilization/Cost of treatment vs. No Treatment/Total Costs

Timeliness ***Significant*** Factor

[∂] Guidelines for providing quality stat laboratory services, AACC Press, Washington DC, 1987.

This category takes into account the strict clinical requirements as noted in the original AACC guideline, but supplements them with criteria which add a new perspective to both the management in a clinical and laboratory environment and the design of systems by manufacturers. Further, third party payers might consider this approach when looking at reimbursement policies, and understand that in critical care situations, legitimate physician orders and ordering patterns may not always fit criteria pre-determined by non-clinically trained staff.

Clinical, Analytical & Operational Synergy

Assurance of clinical and operational synergy is incumbent primarily on those responsible for laboratory operations. Selection of instrumentation to meet clinical needs for information in an accurate and timely manner must consider the instrumentation available and its analytical/operational reliability. In addition, the frequency that measurement groups/profiles are performed on the same patients, sample collection requirements, and the economics of care (Both costs of care and reimbursement policies/budget allowances) must be considered. In order to be effective in this process of selection and operation of urgent care instrumentation, the laboratory manager-scientist must avail himself of the expertise of clinicians, the manufacturer's scientists, engineers and marketing staff as well as of economic/regulatory experts, in order to make the most appropriate decisions.

Urgent Care Instrumentation Concept:

- Similar Clinical Indications +
- Compatible Measuring Technology +
- Same Sample Required/Convenient +
- Care Economics/Test-Profile Legalities =

➢ **Selection of Optimal Analytical System**

FUNDAMENTAL HOMEOSTATIC SYSTEMS:

Homeostasis, the dynamic balance between opposing systems or within synergistic systems, is a characteristic that can be applied to a number of areas in human physiology, including hematopoiesis, hemostasis, and acid-base/ bioenergetic balance. While the characteristics of each of these can become critical, and thus deserve urgent attention by testing facilities, there are three such systems that stand out as being usually critical, clinically related, and analytically related or compatible. The three fundamental homeostatic systems are acid-base, blood gases, and electrolytes, as well as the determinants, mediators and substrates of those systems.

Urgent Test Selection:

Application of the AACC criteria allows the development of an urgent test list.

Urgent Blood Analytes:

Blood Gases, pH, (BE/Bicarbonate)	Prothrombin-PT
Hb or Hct/PCV	Partial Thromboplastin - PT
Na, K, iCa	Platelets,
Glucose	(Activated Clotting time-ACT)

In this list for both institutions and manufacturers to consider, are a combination of analytes from the original AACC list and analytes those that fit the criteria, but were not listed in the original AACC publication (In parentheses).

Examining this list for analytes that are likely to be clinically needed at the same times, on the same patients and with similar frequency, gives us some useful guidelines for designing new analytical systems (Manufacturers) and selecting or using existing systems (care-providers). While clearly a number of these are related, discussion of all goes beyond the scope of this report. Focusing on blood gases/acid-base and bioenergetic requirements.

Blood Gases. Clearly, as markers of fundamental homeostatic mechanisms, the classic blood gas (pH, PCO_2, PO_2) has been and still is the best laboratory-based test profile for assessing **acid-base status and gas exchange** in hemodynamically stable patients. With the blood gas quantities, both measured and derived (e.g. Base excess), we have the basis of understanding acid-base balance and oxygenation status but we are still missing some physiologically key elements, at least. In some situations, the lack of this information can have important clinical impact as well. Looking at the "blood gases" in a bit more detail can help us understand the clinical & physiological "missing links".

Blood Gas and pH

Markers of Fundamental Homeostatic Mechanisms
Acid-Base (Respiratory & Non-Respiratory)
Ventilation
Oxygenation/ Gas Exchange

Acid-Base. Looking at acid-base stepwise, the measurement of **pH** or **hydrogen ion concentration (cH^+)** provides us with a current assessment of acid-base level, but with no indication of cause. The addition of the **carbon dioxide tension of arterial blood - PCO_2 (aB)** leads to an ability to assess the extent of the respiratory or ventilatory component of any acid –base disorder. When these are combined with the **base excess of blood – BE (aB)** and/or the **base excess of extracellular fluid – BE (ecf)**, an assessment of the non-respiratory component of any acid-base disturbance can begin.

In many patients, this acid-base assessment is sufficient. However, in the more critically ill, the production of **lactic acid/lactate** can be critically significant in both treatment and outcome, and the estimate of its contribution to the acid-base status using the traditional blood gas and calculated base-excess may be insufficient. More about **lactate/lactic acid** later.

Oxygenation. The basic blood gas panel includes the most important indicator of oxygenation status for most patients, the **oxygen tension of arterial blood – *P*O_2 (aB)**. Molecular oxygen –O_2 - is present in the air we breathe, and it is the form of oxygen which, in combination with products of **glucose** metabolism, is utilized in the cell's mitochondria to manufacture the bioenergy storage compound, adenosine triphosphate – ATP. When oxygen reaching the cell is insufficient or otherwise unutilizable, other metabolic pathways are put into effect to manufacture energy and at the same time produce **lactate/lactic acid** and **hydrogen ions - pH.**

Hemoglobin and derivatives. Other aspects of oxygenation - oxygen transport, uptake and utilization - mandate measurement of total hemoglobin, oxygen content and saturation as well as hemoglobin derivatives such and carboxyhemoglobin in many clinical situations and justify inclusion of these determinations along with the blood gases. Details of those issues are best discussed in more detail elsewhere.

Electrolytes. The addition of **potassium** to the basic set of measurements is most appropriate in the critical care setting when one considers potassium's effect on cardiac efficiency and output. The high probability of significant parenteral therapy involving electrolytes in the critically ill also supports the addition of other electrolytes such as **sodium** and **chloride**, frequently needed in the same time frame as the blood gases. **Ionized calcium** may also be required in the critical care setting, albeit in somewhat more restricted clinical conditions than Na/K. The calcium in patients receiving massive transfusions of citrated blood is chelated by the citrate, causing significant lowering of the ionized calcium level. Resultant cardiac and neuromuscular effects can have profound impact on patient morbidity

The well documented need for measurements of sodium (and chloride) when parenteral therapy is in use, and the clear analytical compatibility of the electrolytes, makes the combination of all, along with the blood gases, an operationally and clinically prudent course of action in a wide range of clinical testing environments.

Among the fundamental homeostatic mechanisms, then, the physiologic integration of blood gases, glucose and lactate/lactic acid is clear. It's also clear that despite their essential inclusion as markers of fundamental homeostatic mechanisms, the blood gases alone cannot tell the whole physiological story of acid-base or oxygenation.

Glucose. The addition of glucose to an urgent care profile is especially appropriate in the light of recent studies on critically ill and surgical patients. Clear evidence shows that the morbidity and mortality of patients undergoing the stress of complex surgery (Especially neurosurgery) or the stress of intensive care is significantly increased if glucose levels are not adequately controlled. This is true of diabetics and non-diabetics alike, and thus is even more significant in its broad implications. Since the other critical blood analytes may be monitored on a frequency compatible with the glucose monitoring needs, good clinical practice is compatible with measurement of all together on the surgical and intensive treatment patients at risk.

Glucose

Brain, Nerve Tissue Essential Substrate

Bioenergy Source.

Evidence of Increased Morbidity if Elevated Or Decreased During Surgery, Intensive Therapy

Diabetics, Non-Diabetics Affected

Surgical or Therapeutic Stress:

Parenteral Therapy Using D5W Common

"Important" Test Selection:

In the above discussions, the linkage between the fundamental homeostatic systems has been shown, and related to the AACC's most urgent test category (Level 1) and the corresponding list of analytes. Glucose, an analyte that clearly can be urgently required for both diagnosis and treatment, has been related both physiologically and clinically to the blood gases.

Using the AACC criteria as before, and combining current understanding of clinical diagnostic and therapeutic realities, a list of "Important" analytes (AACC level 2), might now look as shown.

Important Blood Analytes:

All "Urgent" analytes +

(Oxygen Saturation & Content, COHb, MetHb)

(Lactate)

Urea, Creatinine, Fe, NH_4, Bilirubin, Ketones, ALT, AST, Amylase, HCG

Leukocytes, Differential, Fibrinogen

(CK-MB, Troponins T & I)

New measurement technology (e.g. direct "whole blood" lactate or ionized magnesium using ISE's) makes it possible to readily obtain quantitative information not feasible in the past. Similarly, the possibility of significant therapeutic intervention only recently made available, makes analytes such as CKMB, that were only collected "stat" in the past, into analytes that are needed now to validate the need for rapid therapeutic intervention. Considered in the light of the AACC level 2 criteria, its simple to see

how the analytes listed parenthetically above fit into the category and why others, despite their analytical compatibility may not "fit".

Considering, again, the need to keep clinically and analytically related tests together, the important analytes should be considered as were the "urgent" list. Thus the inclusion of the oxygenation quantities in the "important" list, as well as the acid-base quantity: **lactate/lactic acid**. As noted earlier, the former is best discussed elsewhere. Lactate, however, is appropriately considered.

The remaining items on the "important" list seem not to pass the test for clinical, analytical and operational compatibility with the other analytes on either the "Urgent" or "Important" lists. Other analytes such as ionized magnesium, which are analytically feasible and available on some "stat" analyzers, may need to be reconsidered for appropriateness in the future. While they may hold promise, there is no clear relationship to the combined criteria in any of the testing categories discussed in this report. If one considers reimbursement for profiles and the associated legal and regulatory issues, one must use caution in assessing application of these quantities as an urgent care profile.

Lactate. In the case of lactate, the relationship to blood gases as well as electrolytes is incontrovertible; lactate is an electrolyte, it makes hydrogen ions available and it elevates in cases involving decreased tissue oxygen (hypoxia).

Measurement of plasma lactate (in whole blood) is important in determining the cause and prognosis in certain **acid-base disorders**. The pre-analytical, analytical and standardization characteristics of earlier technology prevented reliable lactate measurements from being routinely available in urgent or important clinical situations. The technological developments that allow the reliable manufacture of direct "whole blood" measurement of plasma lactate now permit a more complete assessment of acid-base disturbances. Plasma lactate can now be much more reliably performed by available staff, instead of requiring the most experienced analyst. This allows better and more widespread use of the measurement in situations involving the more dire patient prognoses, and thus directs the physician toward the most effective therapeutic intervention.

Lactate

Quantitative Assessment of Anaerobic Metabolism

Signal of Dire Prognosis In MOF, Sepsis

Anecdotal Advantage In Individual Patients, Especially Infants, Young Children

Assessment of Both Acid-Base & Oxygenation Status

Physiologically, lactate is produced when there is insufficient oxygen available for production of ATP by the process known as oxidative phosphorylation. In a sufficiently aerobic environment ATP production is maximized. Without molecular oxygen availability, the energy requirement still exists,

but is met by a process that is more than six times less efficient. During that anaerobic process **lactic acid/lactate** is produced.

In normal, healthy, individuals **lactic acid/lactate** is produced by increased levels of muscular activity, but is kept in check by other metabolic processes. Athletes, in fact can condition themselves to tolerate very high lactate levels for extended periods of time.

Lactate, can be and frequently is elevated in a series of events that have dire prognostic implicated implications if not addressed aggressively. Sepsis and multiple organ failure (MOF), account or a large proportion of morbidity and mortality in intensive care areas. Some studies have indicated that, subsequent to diagnosis, the mortality rate is between 40 and 60 percent of the patients affected.

The personal implications for the patient and their family are obvious and frightening, but the implications for health care in general are equally frightening. The health care implications of sepsis/MOF are serious because of two factors that are currently, irreversibly linked: the inability to reliably predict sepsis/MOF and its progress either toward improvement or toward death, and the costs of care during the hours, days, or weeks that elapse as the situation resolves.

Since the processes involved in sepsis/MOF are complex, but do involve development of a lactic acidosis, the current approach in patient management often includes, or should include measurement of lactate.

The clinical understanding and therapeutic interventions associated with sepsis/MOF are evolving. Concurrent with the clinical evolution, the availability of reliable, simple to perform lactate analysis has only occurred recently. As a result, many clinicians are not yet aware that lactate can be performed without the delays and sample handling issues that made the test less likely to be ordered.

Operational Issues:

The combination of multiple analytes on the same analytical system certainly provides some real operational and even clinical advantages, but at the same time may require re-education on certain issues with the sample processing, and the significance of costs, availability of the measurements and even billing practices.

The following charts summarize some of the major areas in which rapid whole blood analysis and clinical needs match and some operational needs for consideration.

Organ or Function Related Test Groups

Diabetic Keto-Acidosis(DKA): **Glucose,** Electrolytes, **Blood Gas, Lactate**

Sepsis/MOF: **Blood Gas, Lactate**, **Glucose,** Saturation, Oxygen Content, Carboxy- & Methemoglobin

Malnutrition, Dehydration, Parenteral Therapy, Plasma Water Changes: Electrolytes, **Glucose, Lactate**

Timing and Urgency Related Test Groups: Clinical and Operational Compatibility

*Similar Ordering Situations, Frequency

*Compatible Degree of Urgency

*Usually "Simultaneous" Need for Profile Elements
- -Critical or Critical + Important
- -NOT Routine/Experimental

*Compatible Sample Handling & Anticoagulants

*Measurement Technology
- -Compatible Maintenance Intervals, Sensor Life & Calibration, Reagents
- -Calibration/Calibrators
  - -Appropriate levels
  - -Match Reference Methods/ Materials
- -Minimization of interference effects
- - Selectability of Analytes Measured

Considering all the above, and depending on the institutional environment, there are several options currently available to the clinical laboratory, to meet the clinical and operational requirements for urgent, important and responsible testing. The choices allow for flexibility based on a particular care unit's patient population and specialties, but some available instrumentation allows more flexibility than others

Common Urgent Testing Profiles

pH, PCO_2, PO_2 + Derived HCO_3^-, BE (B), BE (ecf) - **Basic "Blood Gas"**

Blood Gas + Electrolytes - **Basic Urgent Testing Profile**

Blood Gas + Electrolytes + Glucose/Lactate - **Enhanced Urgent Testing Panel.**

Add Oximetry or tHb/Hct to Any of Above -**Complete, Site Specific Panel**

In looking at "profiling", one must consider that the operational convenience may be outweighed by clinical inappropriateness of some test combinations for particular patients. Certainly having more inclusive profiles, without having the flexibility to be selective on a patient-to-patient basis, stretches the limits of clinical need, as well as of operational and economic responsibility. The latter may be especially important when considering some third party reimbursement criteria, especially those enforced by HCFA's Office of the Inspector General (OIG).

As clinician's needs for better turnaround time increases, as acceptable sample size gets smaller; as technology takes some of the art and science from laboratory measurement and makes it possible to move it outside the laboratory the paradigm continues to shift. How are the seemingly incompatible demands of highest accuracy in patient testing reconciled with requirements that seem to push accuracy in the opposite direction? How are scientists and clinicians to reconcile quality patient care with economic and the requirements of the authorities that pay for the care? Difficult questions to

answer, but at least if we maintain awareness of the basic issues, individual situations can be better assessed.

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Is a Picture Really Worth a Thousand Words?

The Role of Scanning Probe Microscopy as an Educational Tool In the Chemistry Curriculum

Jennifer Schuttlefield and Vicki H. Grassian*

Department of Chemistry

University of Iowa

Iowa City, Iowa 52242

Abstract

Atoms! Molecules! When a student experiences the world of atoms and molecules through scanning probe microscopy for the first time, it can be an exciting experience. Viewing the world on atomic, molecular, and nanometer length scales can potentially lead to new perspectives and a better understanding of atomic and molecular structures that might not be attained through lectures or textbook readings. An overview of some of the ways scanning probe microscopy, which includes scanning tunneling and atomic force microscopy, is currently being used as a teaching tool in the chemistry curriculum is discussed here.

***Author to whom correspondence should be addressed.**

Introduction

Scanning probe microscopy (SPM), which includes scanning tunneling and atomic force microscopy, is becoming an increasingly important tool in modern chemical research. These two different types of SPM are now becoming more and more accepted as methods of analysis in other fields as well including physics, biology, geology, materials science, and engineering. The interaction of the probe tip with a sample can yield information on the nature of the sample surface including the spatial arrangement of atoms and molecules, magnetic field heterogeneities and the local electronic configuration on micrometer, nanometer and atomic length scales. SPM is rapidly becoming a quality control tool in industry due to its ability to have ultrahigh resolution and options of imaging in vacuum, air, and solutions. Until recently, the widespread use of SPM has been largely limited to graduate student access and research settings, however, this has now changed (1-11). Scanning probe microscopy techniques can produce three-dimensional images that provide a new view of the world. The most common SPM technique that undergraduate students have been exposed to thus far is scanning tunneling microscopy (STM). This is a relatively inexpensive and fairly easy technique to learn that can provide vivid pictures and allows students to visualize atoms, molecules, and surface features such as steps and pits. Using STM, students have the ability to measure heights of atoms, molecules, and nanostructures. Adsorbed molecules with different functional groups may also be visualized with STM images. In some sense, this technique could be thought of as molecular photography, whereby students get a "snapshot or picture" image that can provide a new perspective of atoms and molecules that students might not have been able to attain with other more traditional techniques commonly used in laboratory experiments. Consequently this technique has much appeal as a tool to be used in undergraduate laboratory courses. However, one must ask, is this

the limit of STM and SPM in general, which includes Atomic Force Microscopy (AFM), as a pedagogical tool? Here we review some of the ways in which SPM is being used in the chemistry curriculum at both the high school and undergraduate levels.

The Basics of Scanning Probe Microscopy

As noted above, the most common SPM technique used in the chemistry curriculum is STM. STM is a powerful technique that can be used to provide atomic level information on conducting solid surfaces. STM uses a sharp probe tip, ideally terminated with a single atom that is moved very close to the surface (see Figure 1). The current between the surface and the probe tip is then measured as a function of lateral and vertical position. The positioning of the tip is controlled via piezoelectric controllers, and is ideally terminated with a single atom. The tip is initially positioned extremely close to the surface, typically within a nanometer of the sample surface. At this distance, the electron orbitals of the sample and the tip do not overlap however quantum mechanical tunneling can occur between the tip and the sample.

When the tip is biased negative with respect to the sample, electrons of the tip may tunnel out of filled states, ψ_t, and through a potential barrier of height, *U,* and width, *d*, into unfilled states of the substrate, ψ_s. The tunneling current is then proportional to the coupling between ψ_t and ψ_s squared ($I \propto |\langle \psi_t | H | \psi_s \rangle|^2$, where H is the Hamiltonian operator) (4). Images can be obtained in one of two different modes, either constant height or constant current mode. In constant height, the electron tunneling current, I_t, is measured as the tip rasters, or scans the sample in the x, y, and z plane of the surface at the same time (4). The tunneling current is given approximately by

$$I_t = Ve^{-Cd}$$

where V is the bias voltage between the sample surface being imaged and the tip, C is a constant that is characteristic of the composition of the sample and the tip and is related to the work function of these materials, and d is the spacing between the tip and the sample (4). Thus changes in the current can be measured as a function of the distance between the tip and the surface. A graph of current as a function of position reproduces the surface morphology thereby producing a representation of the atomic surface (13).

In constant current mode, the tip scans along the surface in the x and y directions following along the surface shape in order to maintain the constant current. This position is then stored as the z component and is used to display the surface morphology as a function of brightness, with the brightest spots representing the highest levels of the surface (8).

Another type of SPM that has also been used in undergraduate laboratories due to its ease of setup, ability to operate, and quick output is the atomic force microscopy (AFM) (see Figure 1). Atomic force microscopy is different from STM in its ability to be used not only samples that conduct, but nonconducting, or insulating, samples as well. In AFM, a flexible, force-sensing cantilever is scanned in a raster pattern over the surface of the sample. During the scan, the force on the tip is held constant by the up and down motion of the tip, which provides topographic information. The most common method of detection is one in which a laser beam reflected off a specific spot on the cantilever and a segmented photodiode detects the motion of the probe as a function of the laser beam. Typically the sample is moved by a tubular piezoelectric device that moves the sample in the x, y, and z directions under the tip. The signal from the photodiode is the sent back to the piezoelectric transducer which causes the sample to move up and down thus maintaining a constant force between the tip and the sample (8).

There are two main modes of operation for the AFM, tapping and contact. In contact mode, the sample is in constant contact with the tip, and the force on the tip may not be low enough to avoid damage to the sample surface. When the tip comes into contact with the sample, this can cause damage to the sample and distortion in the image that is produced therefore another method, tapping mode, was introduced to minimize this problem.

In tapping mode, the cantilever oscillates at a frequency of a few hundred kHz. The oscillation is driven by a constant driving force and the amplitude is monitored continuously. The cantilever is position so the tip touches the surface only at the bottom of each oscillation cycle thus providing an accurate surface image as the photodiode and laser monitor the movements of the cantilever (8).

Students can benefit by exposure to these techniques in order to provide them with the opportunity to learn about surfaces and receive adequate preparation for possible future work in a variety of scientific fields that use these imaging techniques including nanoscience and nanotechnology.

A Review of the Implementation of SPM into the Chemistry Curriculum

Images as a Learning Tool. Typically, the initial experiment using SPM includes the use of STM to produce images of surfaces such as graphite. These images are then used to view atomic density, pits, molecular arrangements, possible steps, or even impurities on the surface. Calculations for the students typically consist of atomic heights calculation, estimating distances between atoms, or other distance calculations and possibly tunneling current calculations. But are the visual effects and these few measurements all that students can learn from producing

these images? To address whether students can learn even more from these experiments, we review here some examples of SPM experiments implemented into the chemistry curriculum.

There have been many different ways in which institutions have gone about implementing SPM into the undergraduate curriculum. Several universities including Duke, North Carolina, Colorado State, and Arizona State have implemented experiments and reported their methods and results (1, 2, 4-8). Duke University, as well as other institutions including the University of Rochester in cooperation with the Xerox Corporation, has also attempted to implement SPM into the high school classroom settings in order to provide these younger students with a potential better understanding of atomic and molecular structures through the use of visual images.

Faculty at Duke University introduced this technique to students in the early 1990s (1). STM experiments were implemented in different levels of the undergraduate program and in a high school outreach program. STM experiments were included in the upper-level analytical chemistry laboratory, as an undergraduate research project in conjunction with a National Science Foundation research experience for undergraduate program, and as an investigative tool performed by local high school students over the course of two summers. In the analytical chemistry laboratory course, students examined electrode surfaces before and after surface modification. The surface modification consisted of sonochemical deposition of 300 nm Cu particles on a gold surface or electrolytic deposition of various metals used in dental amalgams (1). This experiment produced images in which visible characteristics of the electrodes were present and students were able view the different surface morphology (1). According to Coury et al., these experiments were thought to be a success and the instructors at Duke University were committed to continue to incorporate SPM into the undergraduate curriculum.

The faculty at Arizona State University wanted to provide students with a multidisciplinary course in STM using affordable, state-of-the-art equipment (2). This course was offered to all science disciplines in order to help prepare students to work on interdisciplinary problems because of the importance of interdisciplinary research in many scientific fields. At Arizona State University, a laboratory was constructed to house four STM workstations. Each station is equipped to accommodate two students at a time.

The course was offered as an upper-level elective undergraduate laboratory class. The course was organized into three different sections. In the first section, students learned about the fundamental principles involved in the STM. In the second section, several applications of STM were demonstrated to the students. In the third section, students used the STM on a special project in an area of research in which they had some interest. In the first two sections, several concepts were taught to the students such as instrument operation, surface structures and defects, surface modification, surface adsorption, characterization of materials, surface reactions, self-assembly, and nanofabrication. Examples of special projects done by students, in the third section, included experiments on: thin films, microelectronics, polymers, long-chain alkane adsorption, particulate analysis, carotenoids, DNA, and biological cells and plaque. Although the details from these experiments were not given, Glaunsinger et al. noted that due to the simplicity and flexibility of the SPM methods, combined with the low cost factor and speed, they hoped that their experiences would serve as a model for other institutions, to implement STM experiments in undergraduate laboratories (2).

University of Rochester in collaboration the Xerox Corporation created a workshop during the summer that allowed 20 high school teachers to learn STM (3). The teachers were trained so that they could implement this low cost technique into their classroom environment

and allow students the chance to view surfaces with atomic resolution. One teacher that attended the workshop did in fact implement STM into the high school classroom environment and allowed students to produce their own images. The students visualized the arrangements of atoms on the surface and calculated pit depths, heights of atom, distances between atoms, and diameter of atoms, which helped increased their understanding of the surfaces they were viewing. According to Rapp, students reacted with enthusiasm and viewed the STM as an atomic-sized "ruler" (3). This enthusiasm was also passed along to the faculty, parents, and administration who welcomed the idea of cutting-edge technology in the classroom at a relatively low cost (3).

Recently several other institutions including Calvin College, Colorado State University and State University of New York at Binghamton have also incorporated SPM into their undergraduate laboratory curriculum.

Calvin College introduced a new course during a three-week January interim term that allowed students from all science disciplines to take part in learning the techniques of SPM (6). Students from freshman to senior level were allowed to take part in the class. The course was divided into two components, an introductory background component and a project component. The introductory component consisted of lectures, laboratory demonstrations, and information on various resources including internet sources, web sites, textbooks, and review articles. The project portion of the course consisted of one-on-one training sessions of both STM and AFM, and they were introduced to different modes of operation (e.g. constant current, constant height, tapping, etc.), how to choose a tip, and cost saving techniques in the laboratory. Students were paired up and chose independent projects based on their particular interests (6).

A broad range of experiments were performed by the students from the visualization of DNA to analysis of microchip memory arrays and circuitry to visualization of filamentous actin and self-assembled monolayers on graphite. The experiments allowed students to visualize a variety of surfaces and adsorbed structures thereby gaining insights into their specific interests. However, no quantitative aspects of the images were attempted in this laboratory course (6).

Colorado State University has taken an interesting approach to initiating SPM into different levels of their undergraduate program through a discussion of nanotechnology (7). This program allows students at least three different opportunities to be exposed to SPM techniques.

The first time students become introduced to SPM techniques is in general chemistry though the use of demonstrations and posters. Demonstrations are given in "extra" laboratory time so that no time is taken away from normal lecture or laboratory hours. Students are given a brief explanation of STM and AFM and then shown various parts of the instrument. They are allowed to handle the tip and other parts of the instrument, but do no collect images at this point. Posters of images from STM and AFM samples are placed in the laboratory for the students to observe. The actual samples that the images were taken from are present in the lab for the students to handle. Student learning was evaluated through a questionnaire that was given at the beginning of the semester and then re-administered at the end of the semester. Learning was significantly increased as students could correctly draw a picture of the surface at the atomic level, knew what AFM was, and they could also identify different surface properties.

The second time students were exposed to SPM was though a hands-on experiment in the upper-level instrumental analysis course. Students were give instructions, but then expected to set up the instrument themselves. The experimental setup included replacing the tip, aligning the laser, determining the software parameters, and collecting multiple images. They were given

two 3 hour laboratory periods to complete this task and collect three AFM contact mode images. The types of experiments typically given to students were to examine the surfaces of glass-etching and crystal formation. The students were required to write a paper and give a presentation on their results.

The third time students had an opportunity to use SPM at Colorado State University was through undergraduate research. As of May 2003, there were four student currently involved with SPM projects, researching such areas as examining carbon particles, surface examination of fungi, modeling AFM tip-sample interactions with the computer program Mathematica, and actually building an STM and comparing the images with a purchased STM (7).

The incorporation of SPM into the program is thought to have been successful as 150 students had been given a demonstration, 13 upper-level students were proficient in using the instrument, 3 faculty members had been trained, and the undergraduate research had successfully obtained funding for more research in this area, at the time that this journal article was published. The integration seems to have been a successful endeavor incorporating quantitative learning into their curriculum and for students to get more out of their images.

Beyond Images – SPM as a More Quantitative Learning Tool. Two articles from instructors at the State University of New York (SUNY) at Binghamton have been published on SPM in the undergraduate curriculum (9,10). After surveying the department, it was determined that there was a lack of understanding by students of molecular interactions and their correlation with properties of materials (9). The objective here was to provide a hands-on experience for upper-divisional chemistry courses and possibly demonstrations for lower-level courses so that students would have a better understanding of these concepts.

In these experiments, chemical mapping of different functional groups through AFM was investigated. Methyl and carboxylic acid groups were chosen due to their very different types of molecular interactions. When imaged, these functional groups are easy to identify, because of their very different tip-sample interactions. It was determined from analyzing the van der Waals and hydrogen bonding interactions between the tip and the sample, that these types of experiments are ideal for inquiry based learning due to all of the factors that can be examined (9).

In addition to the above experiments, an experiment at SUNY-Binghamton was introduced in which both AFM and STM were used (10). The AFM was used to examine mica, and the STM was used to image graphite. Students were asked to determine features for each surface and recognize the surface topography (10).

To assess and evaluate the success of implementing these experiments, two surveys were given before and after the laboratory experiments were given to students. The survey questions addressed sizes of atoms and molecules, understanding of surface properties, and recognition of surface packing density. The students were found to have a very poor comprehension of atomic scale concepts prior to the laboratory experiment. After the laboratory experiment utilizing STM and AFM was completed, the final exam included the same types of questions that were included on the survey. It was determined that the students had a much better understanding after performing the experiments (10). Thus, from the experiments at SUNY-Binghamton and Colorado State University, it seems clear the student understanding was improved thereby reinforcing the importance of SPM as a pedagogical tool for undergraduate students.

Two other institutions, the University of North Carolina and Columbia University, have also recently utilized SPM in the undergraduate curriculum. These experiments were different

than the above in that SPM was used to obtain both quantitative and qualitative data thereby opening up new learning opportunities for students.

At the University of North Carolina, Poler designed a physical chemistry experiment that uses the STM to measure the kinetics of a surface reaction (5). In particular, the oxidation kinetics of a carbon surface was measured. The STM was found to provide interesting results because as the flat carbon surface was oxidized, surface structures such as pits were created. These pits were not very deep and were typically only one atomic layer thick. The experiment was designed to teach the concept of crystallography, surface diffusion, bonding, atomic defects, and reaction kinetics.

The experiment was designed to take up two laboratory periods. In the first period, the students learned to operate the STM. First they were expected to learn the theory behind the instrument, how to make their own tip, and to image a gold surface. During the second laboratory period, the students were to measure oxidation of highly oriented pyrolytic graphic (HOPG) by 5% $NO_{(g)}$ at a given temperature. Each student performed the experiment at a different temperature and then students submitted their data in spreadsheets via email to the instructor. The data was distributed to the entire class. From the class data, the students were to determine the activation energy of the oxidation reaction using the Arrhenius equation (5).

Student opinion of this experiment was found to be very high as the course evaluation showed many thought this was the laboratory experiment that they learned the most from and provided them with the greatest challenge to their intellectual and problem-solving skills. Students were able to reproduce results that were very close to the literature values most of the time. However, the quality of the graphite used was found to affect the results. According to Poler, when the reproduced values was not as accurate it taught the students more about the

actual scientific process and research experience by allowing them to ponder the reasons for the deviation from the reported value and what could be done to improve their results. Thus, students learned more about the scientific process than they would normally when the "expected" result is not obtained. This is because students need to account for the deviation from the literature values, and propose reasons and hypotheses of why their results deviated from what was expected.

At Columbia University, faculty combined STM imaging along with theoretical calculations into the upper-level physical chemistry laboratory (4). The goal of this effort was to get away from using the STM as a "snapshot" of the surface. They wanted the images to be used to identify chemically significant functional groups of adsorbates and to use the theoretical calculations, via the use of commercially available software programs (Spartan), to help interpret and compare to the experimental values (4). In this experiment, students initially investigated a bare graphite surface and then adsorbed 11-bromoundecanol on the graphite surface. Images were obtained and then students used Spartan to calculate frontier molecular orbitals (HOMO, LUMO, HOMO-1, LUMO+1). They used ab initio and semi-empirical methods of quantum mechanics, that were learned in lecture, to perform these calculations. Students were asked to sketch the orbitals to better compare them with their STM images and then consider which orbital represented was being imaged with STM.

Student response to this experiment was very enthusiastic as many students took their own initiative to search the literature for more detailed descriptions of the theory and operation of the microscope (4). From the examination of their laboratory write ups, the students seemed to grasp the major theoretical and experimental concepts of electron tunneling. They all correctly identified the orbitals that contributed to the STM images, by correlating the

localization of the wave function in the vicinity of the atom with the increase in tunneling current exhibited in the collected STM images. A survey was given at the end of the semester asking students what they thought about the laboratory exercise and the knowledge gained. The instructor also solicited constructive criticisms for improving the experiment. Feedback was overwhelmingly positive according to Giancarol et al. though some students felt a bit overwhelmed by the Spartan addition. The relationship between the theoretical calculations and the images were a bit difficult for some of the students to grasp, although some did think that the Spartan addition was very helpful (4).

The implementation of Spartan in the interpretation of the SPM images and the use of STM to get kinetic data demonstrates new ways of using SPM techniques as a more quantitative pedagogical tool in the undergraduate laboratory. These quantitative methods could be employed with very little modification to current SPM experiments in undergraduate laboratories. Implementing these quantitative changes into undergraduate laboratories can provide students with the opportunity to learn even more from SPM experiments and thus increase this technique as a pedagogical tool for undergraduate students.

Summary

A review of the efforts being taken at several institutions in implementing SPM into the chemistry curriculum show that it can be done fairly easily and with much success in providing students with the opportunity to experience the atomic world. In most cases, SPM is used as a "camera", in which the images are pretty and can be remembered for a lifetime, with the sole purpose of allowing students to visualize surfaces as well as atomic and molecular structures. This does in fact provide increase interest and excitement for students to see these pictures.

However, the learning capacity of these captured images could be increased by adding more quantitative and inquiry-based problems and experiments into their laboratory experience, at least in upper-level undergraduate laboratory courses.

The use of SPM in undergraduate courses provides a great learning environment for students due to the ease of operation, the low cost instrumentation, and the great images that can be capture a student's interest, but this technique perhaps is not being used to its full capabilities. In the future, faculty could potentially implement a more inquiry based learning environment in which students can examine effects of temperature, pH, and concentration or even study changes that occur on surfaces when exposed to different etching agents, rates of stirring, chemical mapping, or the adsorption of different functional groups. Though a picture can sometimes be worth a thousand words, quantitative aspects and inquiry-based experiments may further the use of SPM as a pedagogical tool.

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13) Note: The image created is actually a representation of the electron density of the surface orbitals not the actual atoms themselves.

Author Information

Title: Professor of Chemistry and Chemical and Biochemical Engineering

Affiliation: University of Iowa

Address: Department of Chemistry, Iowa City, IA 52242

Biography: Vicki H. Grassian received her B.S. degree in Chemistry from the State University of New York at Albany. From there, she did her graduate studies at Rensealaer Polytechnic Institute (M.S., 1982) and the University of California-Berkeley (Ph.D., 1987). At Berkeley, she was advised by Professors Earl Muetterties and George Pimentel. Following her Ph.D., she was a postdoctoral scientist at Colorado State University (1988) and a research associate at the University of California-Berkeley (1989). In 1990, she went to the University of Iowa as an Assistant Professor. Professor Grassian is currently a full professor of chemistry and holds a joint appointment in the Department of Chemical and Biochemical Engineering. At the University of Iowa, she has received a faculty-scholar award, a distinguished achievement award and a James Van Allen Natural Science Fellowship. Her research spans several areas of importance in environmental and atmospheric chemistry including heterogeneous atmospheric chemistry, environmental remediation, environmental molecular surface science and the environmental applications and implications of nanoscience and nanotechnology. In 2003, she received a special two-year creativity extension from the National Science Foundation for her research. She is currently the advisor for students in the chemical sciences track of the Environmental Science B.S. program and is involved in developing new experiments for undergraduate laboratories that focus on surface processes in environmental chemistry.

Title: Graduate Student

Affiliation: University of Iowa

Address: Department of Chemistry, Iowa City, IA 52242

Biography: Jennifer Schuttlefield received her B.S. degree in Chemistry and a B.A. Degree in Economics from the University of Iowa in 2003. During her undergraduate studies, she was employed as a lab tech at the Center for Advance Drug Development from 2000-2002. From there, Jenny was employed as a research scientist at Selim Laboratories, Inc. from 2002-2003 until she decided to continue her studies in chemistry and is now a graduate student at the University of Iowa in the Ph.D. program in chemistry. Her current interests include the chemistry of clay minerals as a reactive component of mineral dust aerosol and the effect of technology implementation into undergraduate laboratories and classrooms.

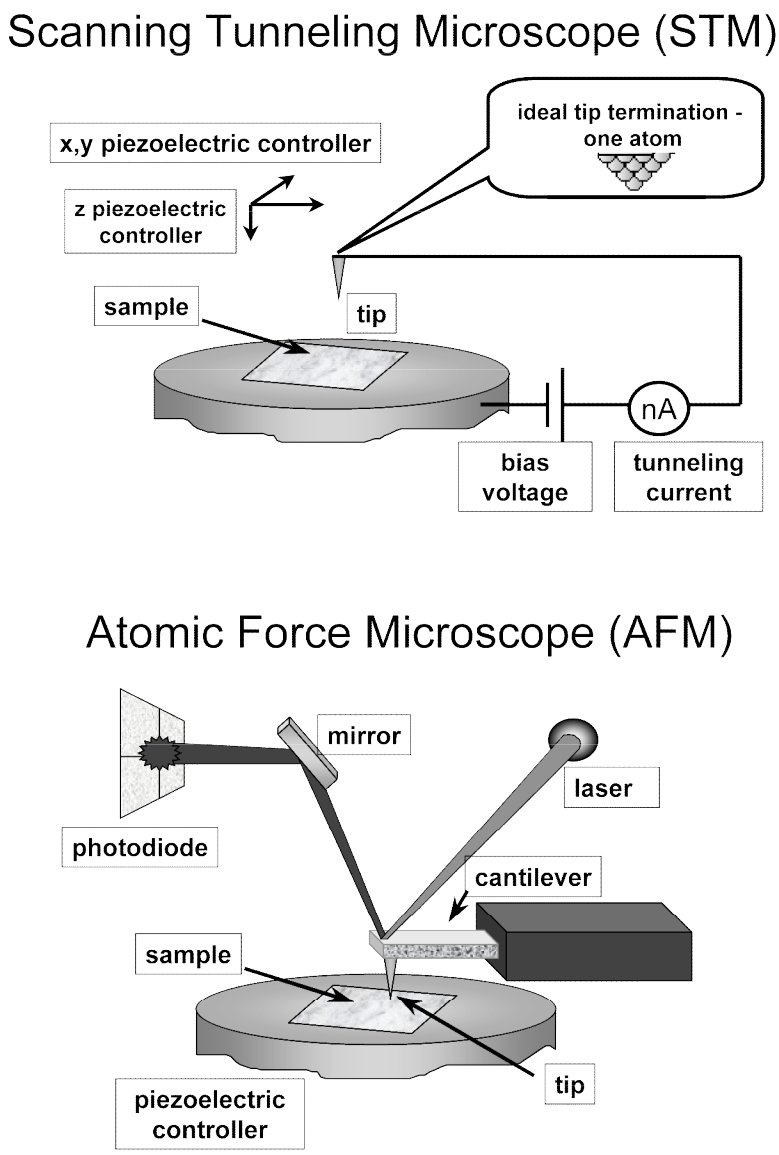

Figure 1. Schematic diagram of STM and AFM showing the different components for each of these techniques. In the STM diagram, the tip is controlled with piezoelectric controllers where as in the AFM diagram it is the sample stage that is moved. Either method has been employed for both techniques and depends on the particular instrument. (Adapted from Reference 12 with permission.)

BOOK REVIEWS

Clinical Chemistry: Concepts and Applications
Editors: Anderson, Shauna C., and Susan Cockayne
Publisher: McGraw-Hill Co., Inc.
ISBN#: 0-07-136047-6
Price: $79.95

This is an excellent undergraduate level clinical chemistry textbook. It was designed for use in either a four year (MT) or a two year (MLT) curriculum and has numerous teaching aids. The text has 723 pages, 21 contributing authors, 38 chapters, 2 appendices, and 1 index. The two appendices (adult reference ranges, and selected atomic weights) are attached to the inside front and back covers for easy availability. Additionally, there is an accompanying CD which includes: chapter outlines, teaching/learning objectives, review questions and answers, case studies with detailed explanations, and learning games (e.g. crossword puzzles).

The textbook is tied to the *Body of Knowledge* which is published by the American Society of Clinical Laboratory Scientists. The textbook can be subdivided into three major subsections: 1) laboratory methodologies and instrumentation, 2) specific analytes and the diseases associated with them, and 3) the assessment of special patient groups. The nine chapters on laboratory methodology cover topics on laboratory equipment, reagents, calculations, safety, quality assurance, method evaluation, preanalytical variables, spectrophotometry, molecular assays, immunoassays, laboratory automation and robotics, and computers and medical informatics. Twenty three chapters address specific groups of chemicals such as carbohydrates. Each of these chapters will address the classification of the medically relevant analytes found in that group and their chemical structures, the normal human metabolism and pathophysiology related to these analytes, clinical applications/laboratory diagnoses, methods of analyte measurement, concept applications, and chapter summaries. Specific chapter topics include: carbohydrates, lipids, proteins, inherited metabolic disorders, immunologic disorders, clinical enzymology, liver function, tumor markers, porphyrins, renal anatomy and physiology, nonprotein nitrogen compounds and renal function tests, electrolytes, acid-base and blood gas physiology, therapeutic drug monitoring, toxicology, hormones and endocrinology, hypothalamic and pituitary endocrinology, thyroid endocrinology, parathyroid endocrinology and calcium-phosphate metabolism, adrenocortical endocrinology, adrenal medullary endocrinology, reproductive endocrinology, and gastrointestinal and pancreatic function. There are six chapters which detail point of care testing and the biochemical assessment of specific patient groups. The chapter on point of care addresses the special issues associated with patients in the emergency room, critical care unit, or surgery. Additional chapters address the assessment of the nutritionally impaired patient, the neonatal and pediatric patient, the pregnant patient, the geriatric patient, and the psychiatric patient. This book is a teaching text not a reference book. However, there is a list of references (~100 references/chapter) included with each

chapter. A particularly nice feature is the use of bold printing for key terms used in the text and the inclusion of their definitions adjacent to the terms. Overall, this is a wonderful textbook for the beginning clinical chemist or medical technologist.
Reviewed by Margot Hall, Ph.D., FAIC, CPC, FACB, CChem MRSC

Chemometrics – From Basics to Wavelet Transforms
Foo-Tim Chau, Yi-zeng Liang, Junbin Gao, Xue-guang Shao
ISBN 0471202428
Price $99.95

Chemometrics is an essential but often overlooked tool in most modern scientific endeavors. If you work in a technology field, you are probably using chemometrics in one form or another. At first glance, this slight (316 pages) book might seem incapable of providing significant insight into this rapidly growing discipline. At second glance, it may seem too advanced for an introductory volume. Rather, it is an exciting discussion that immediately provides both mathematical rigor and concrete applications to commonplace analytical signal processing problems.

This book is an extremely valuable volume for anyone desiring an exhaustive survey of chemometric advances over the last two decades and how they directly relate to improved measurements. Each discussion provides sufficient examples and mathematical detail for the reader to understand exactly how the different approaches work. There are numerous worked examples, including many exemplary graphs, actual MATLAB programming codes, and references to additional sources. However, it is not quite suitable for a textbook, written in a more narrative than pedagogic style.

The book contains a very large collection of references on the subject of chemometrics, supplied immediately after each chapter for easy access and reference. The authors include not only references to the relevant papers and significant texts, but a plethora of references to current internet websites. In addition to literature references, the authors include a comprehensive index and an extremely useful appendix outlining the particular advantages and use of MATLAB in working with the equations developed in this book.

The book is highly recommended to anyone working in the field of signal analysis, or wishing to understand exactly how the signal algorithms in their analyzers work, with a possible view to improving their analyses. It may be a very useful introduction to chemometrics at a University Senior level in chemistry, but it is not quite enough to warrant use as a primary textbook. It will certainly be an excellent read for anyone interested in the progression of signal analysis algorithms, from simple least-squares fitting to the newest wavelet transforms for data smoothing and compression.
Reviewed by Steven J. Cooke, CPC, CPChE, FAIC

Book Title: **Multidimensional Chromatography**
Editors: Luigi Mondello, Alastair C. Lewis, Keith D. Bartle
Publisher: John Wiley & Sons, Inc.
ISBN# 0-471-98869-3
Price $ 140.00

Multidimensional Chromatography authored by Luigi Mondello, Alastair C. Lewis, Keith D. Bartle is a book that will serve as an invaluable resource for a wide audience - research scientists and technicians. This volume will also serve as a textbook for graduate courses. This monograph, edited by pioneers in the field, is the first book to review all multidimensional techniques including LC-GC, GC-GC, and GC-Supercritical Fluid Chromatography. Separation Science is a mature and unified subject in which now conventional chromatographic and electrically driven processes are applied in the analysis of mixtures of compounds in a wide range of applications. As the boundaries between the distinct techniques becomes more blurred, it is becoming evident that a single theory may be applicable to chromatography whatever the physical state of the mobile phase. The different techniques can be regarded as special cases of the same procedure. In many of the applications the chromatography is combined with electrophoresis. Each chapter includes references specific to that chapter. The book has an index and is 436 pages in length.

This book is divided into two parts - an introduction to the various techniques and applications for a number of types of samples. Part 1 is entitled "General" and has nine chapters. Chapter one entitled "Introduction" includes items related to packed capillary column and unified chromatography, the resolving power of chromatographic systems, two-dimensional separations and multidimensional chromatography. Chapter two entitled "Coupled High Performance Liquid Chromatography with High Resolution Gas Chromatography." The topics of transfer techniques, vaporization with hot injectors, transfer of water-containing solvent mixtures and the indirect introduction of water are discussed. Chapter three entitled "Multidimensional High Resolution Gas Chromatography". This chapter presents practical two-dimensional gas chromatography and some practical examples. Chapter four entitled "Orthogonal GC-GC." The subsections include introduction to multidimensional gas chromatography, introduction to GC x GC Separation, introduction to modular technology, orthogonality of analysis, quantitative aspects, future opportunities and challenges of GC x GC technology. Chapter five entitled "Coupled-Column Liquid Chromatography" presents theoretical aspects and LC-LC techniques. Chapter six entitled "Supercritical Fluid Techniques Coupled with Chromatographic Techniques" discusses on-line coupling of Super Fluid Extraction (SFE) with chromatographic techniques, on-line coupling of Super Fluid Extraction (SFE) with capillary electrodriven separation techniques, and multidimensional to unified chromatography passing through supercritical fluids. Chapter seven entitled " Unified Chromatography: Concepts and Considerations for Multidimensional Chromatography" discusses the instrumentation, a phase diagram view, advantages and challenges for unified chromatography techniques in multidimensional systems and the column

efficiency and plate heights in Unified chromatography. Chapter eight entitled "Multidimensional Planar Chromatography"
discusses two-dimensional or multidimensional planar chromatography, coupling of techniques, and multiple directions. Chapter nine entitled "Multidimensional Electrodriven Separations" discusses many aspects of multidimensional electrokinetic separations. Part two entitled "Applications" has six chapters. Each of the chapters discusses applications for a specific type of sample or industry. The types of samples presented include: foods, flavors and fragrances; biomedical and pharmaceutical; industrial and polymers; environmental; oil; and forensic and toxicological applications.
Reviewed by Anne Sherren, Ph.D., FAIC

Book Title: **Inorganic Chemistry Highlights**
Editor: Gerd Meyer, Dieter Naumann, Lars Wesemann
Publisher: John Wiley & Sons, Inc.
ISBN# 3-527-30265-4
Price of Book: $ 90.00

Inorganic Chemistry Highlights edited by Meyer, Naumann and Wesemann is a book for the person looking for an insight in the inorganic world beyond the person's specific research area. The publishers hope that this will be volume one of a series for inorganic chemists similar to the series Organic Synthesis Highlights. The editors stress that this collection of highlights by no means covers the entire wealth of inorganic chemistry. This book contains nineteen chapters each written by a different specialist or group of specialists. Each chapter begins with an introduction and contains many figures and diagrams. Each chapter has a reference section at the end of the chapter. The book has a subject index and is 324 pages in length.

Chapter one entitled *Molten Zintl Alloys* has eight sections. Chapter 2 entitled *Structure and Bonding Around the Zintl Border* contains six sections. Chapter three entitled *Structure Prediction and Determination of Crystalline Compounds* contains five sections. Chapter 4 entitled *Multivalent Cation Conductors* contains five sections. Chapter five is entitled *The Potential of Pentagonal Building Blocks from Giant Ring-shaped to Spherical Polyoxometalate Clusters*. Chapter six with three sections is entitled *Molybdenum Peroxo Complexes as Catalysts* in Olefin Epoxidation. Chapter seven is entitled *Syntheses of Rare Earth Organometallics, Organo amides, and Aryloxides from the Metals*. It contains three sections. Chapter eight entitled *Enzyme Structure: Active Site Structural and Functional Aspects of Purple Acid Phosphatase and Catechol Oxidase* and has three sections. Chapter nine entitled *Aminotroponiminates as Ligands for Group 3 and Lanthanide Complexes - Coordination Chemistry and Catalysis* has four sections. Chapter ten entitled *Metalla-calix[4]arenes: How they Assist the Transformations of Hydrocarbons into Metalla-alkylidenes, of Dinitrogen into Metalla-nitrides, and of Carbon Monoxide into Metalla-carbides* has four sections. Chapter eleven is entitled *Metal Carbonyl Cations and their Derivatives - A New Class of Superelectrophiles.* Chapter twelve entitled *Borylene Complexes* has three sections. Chapter thirteen is entitled *Silaboranes*. Chapter fourteen entitled *Carbaalanes - A New Class of Compounds*

Containing Clusters of Aluminium and Carbon Atoms has seven sections. Chapter 15 entitled Molecular Aluminum and Gallium Subhalides has four sections. Chapter sixteen entitled *Recent Developments in the Chemistry of Covalent Main Group Azides* has seven sections. Chapter seventeen is entitled Silacalix-[n]-phosphinines:sp^2-phosphorus Equivalents of CO Matrices. Chapter 18 entitled Dinitrogen as a Raw Material: Is there a Future? has six sections. Chapter nineteen entitled Organoxenon Compounds has five sections. Upon examination of the topics one realizes that a wide breadth of inorganic chemistry is covered in the Highlight volume. ***Reviewed by Anne Sherren, Ph.D., FAIC***

Book Title: **Principles and Applications of Ion Scattering Spectrometry**
Editors: J. Wayne Rabalais
Publisher: John Wiley & Sons, Inc.
ISBN# 0-471-20277-0
Price of Book: $ 99.95

Principles and applications of Ion Scattering Spectrometry authored by J. Wayne Rabalais is a book that will serve as an invaluable resource for a wide audience - research scientists, students and technicians. This authoritative account will also serve as a textbook for graduate courses. This monograph authored by the leading researcher in the field merges theoretical fundamentals and cutting-edge practical applications. The first chapters are written for advanced undergraduates and graduate students and the latter chapters cover applications and cutting edge research. This book is part of the Wiley-Interscience Series on Mass Spectrometry. Each chapter includes references specific to that chapter. There are many diagrams and figures in each chapter. The book has an index and is 306 pages in length.

The book is divided into ten chapters. Chapter one entitled “Introduction” discusses ion scattering spectrometry, the importance of surfaces, ion-surface interactions, the historical development of ion scattering spectrometry, other types of ion spectrometries and features of ion scattering spectra. Chapter two entitled “Theoretical Descriptions of Atomic Collisions” includes the Kinematics and dynamics of atomic collisions and multiple collisions. Chapter three entitled “Experimental Methods” includes a general description of an ion-scattering spectrometer system (including the components. Also included in this chapter are discussions of a time-of-flight scattering and recoiling spectrometer, a coaxial scattering spectrometer, a scattering and recoiling imaging spectrometer, mass and charge selection of pulsed ion beams using sequential deflection pulses and ion scattering and recoiling from liquid surfaces. Chapter four entitled “ General Features of Ion Scattering and Recoiling Spectra discusses energy spectra, time-of-flight spectra (interpretation, intensities, sensitivity and examples of TOF spectra), recoiling spectra without scattering spectra, sampling depth, attributes of the ion-scattering technique and a comparison to other surface elemental analysis. The methods compared include diffraction methods, high-energy ion scattering, helium atom scattering, scanning microscopy, electron scattering and ionization and bonding-breaking techniques. Chapter five entitled “Structural Analysis from Time-of-Flight Scattering

and Recoiling Spectrometry" includes atomic collisions in the keV range, structural analysis, azimuthal alignment of the incident ion beam, TOF-SARS and LEED. Chapter six entitled "Real Surface Crystallography form Scattering and Recoiling Imaging Spectrometry (SARIS) includes the details of the technique, interpretation of the SARISgrams, quantitative analysis of the SARIS images and the advantages of SARIS. Chapter seven discusses the applications of TOF-SARIS and SARIS to Surface Structure Analysis. Areas included are clean surface reconstruction and relaxation, hydrogen surfaces, oxygen surfaces, metal oxide surfaces, organic molecules on surfaces, semiconductor surfaces and epilayers on nickel. Chapter eight presents the process and examples of Ion-Surface Charge Exchange and Inelastic Energy Losses. Chapter nine discusses hyperthermal reactive ion scattering for molecular analysis of surfaces. Chapter ten is a bibliography of ion scattering publications. ***Reviewed by Anne Sherren, Ph.D., FAIC***

Clinical Chemistry: Principles, Procedures, Correlations (5th Edition)

Editors: Bishop, Michael L., Edward P. Fody, and Larry Schoeff
Publisher: Lippincott Williams and Wilkins
ISBN#: 0-7817-4611-6
Price: $76.95

This is a very well written clinical chemistry textbook for undergraduate students. It targets students in two year (MLT) and four year (MT) college or hospital based programs. There are numerous teaching aids in the book. The text has 730 pages, 37 contributing authors, 33 chapters, 18 appendices, 1 glossary, and 1 index. Additionally, there is a list of selected adult reference intervals and a list of commonly ordered clinical chemistry tests attached to the inside front and back covers. The accompanying instructor's manual is on CD-ROM. It includes: case studies with questions and answers, chapter review questions and answers, learning exercises with problem solving activities, chapter overviews, key terms, chapter outlines, guidelines for a new instructor resource kit and an image bank.

The editors subdivided the text into four major subsections: 1) basic principles and practice of clinical chemistry, 2) critical correlations and analytic procedures, 3) the assessment of organ system functions, and 4) specialty areas of clinical chemistry. Part one includes seven chapters covering such topics as laboratory mathematics, chemicals and glassware, laboratory safety, quality control and statistics, instrumentation and analytical techniques, automated instrumentation, immunoassays, nucleic probe techniques, and point of care testing. Part two has nine chapters addressing specific groups of chemical analytes. Each chapter will have a set of objectives, a list of key terms, a short description of the pathophysiology and clinical correlations for each analyte described in the chapter, methods of analysis, case studies, and review questions, and a list of references. Specific chapter topics include: amino acids and proteins, nonprotein nitrogen compounds, enzymes, carbohydrates, lipids and lipoproteins, electrolytes, blood gases, trace elements, and porphyrins/hemoglobin. Part three has eleven chapters covering the functional assessment of organs. Five of these chapters

cover the hormones associated with the pituitary, adrenals, gonads, thyroid, and parathyroid. Other chapters in this section address liver function, cardiac function, renal function, pancreatic function, gastrointestinal function, and body fluid analysis. The final section (Part four) has chapters on therapeutic monitoring, toxicology, tumor markers, vitamins, geriatric chemistry, and pediatric chemistry. This book has some especially useful features such as the glossary at the back of the book, the list of commonly ordered tests with the appropriate vacutainer tube (anticoagulant) and sample collection and storage information, and several very useful appendices. The list of references at the end of the chapters is limited (~5-20) and there is some unevenness in the amount of detail or the placement of information in the textbook. Overall, this is an excellent textbook for the beginning clinical chemist or medical technologist.
Reviewed by *Margot Hall, Ph.D., FAIC, CPC, FACB, CChem MRSC*

Tietz Fundamentals of Clinical Chemistry (5th Edition)
Editors: Burtis, Carl A., and Edward R. Ashwood
Publisher: W.B. Saunders Co.
ISBN#: 0-7216-8634-6
Price: $86.95

This superlative clinical chemistry textbook is designed for use by professors and students in upper division (junior/senior) undergraduate and graduate level courses. Compared with prior editions which targeted pathologists, the current edition of the textbook addresses the needs of clinical laboratory science teaching programs by including numerous teaching/learning aids and deemphasizing certain details found in those prior editions. The text has 1091 pages, 63 contributing authors, 46 chapters, and 1 index. Additionally, there is a table of contents, a periodic table, and a list of atomic weights attached to the inside front and back covers. The last chapter (#46) contains 10 tables/appendices with very useful and detailed reference information.

The textbook is subdivided into five parts: 1) laboratory principles, 2) analytical techniques and instrumentation, 3) laboratory operation, 4) analytes, and 5) pathophysiology. Part one has two chapters detailing specifics of laboratory techniques, general laboratory procedures, lab safety, specimen collection and preanalytical variables. Part two has twelve chapters covering in detail the theory and design of instrumentation. Topics included in this section are: spectrophotometry, light emission and scattering techniques, radioactivity and its measurement, electrochemistry and electrophoresis, chromatography, mass spectrometry, enzymology, immunochemistry and immunochemical techniques, nucleic acids and molecular techniques, automated instruments and automation in the laboratory. Part three starts with a chapter on the evaluation of methods with detailed statistical techniques. The other four chapters include the establishment and use of reference intervals, clinical laboratory informatics, laboratory management and quality control. Part four has fifteen chapters describing groups of analytes: including: amino acids, proteins, enzymes, tumor markers, nonprotein nitrogen compounds, carbohydrates, lipids and lipoproteins, electrolytes and blood gases, hormones, neurotransmitters, vitamins, trace elements, hemoglobin metabolites,

therapeutic drug monitoring, and clinical toxicology. Each of the chapters in this section will present the chemical structure of the major analytes to be discussed and their metabolism, a description of the major pathologies associated with these analytes plus a diagnostic approach, and a description of the methods of analyte measurement. Part five has thirteen chapters detailing organ system function and one chapter giving nomograms and tables of clinically relevant information. Table 46-8 has 58 pages of age referenced normal reference intervals for analytes listed for the usual specimens (blood, serum, plasma, urine, cerebrospinal fluid, amniotic fluid). Similarly, Table 46-9 presents 8 pages of reference intervals for therapeutic and toxic drugs. There is also, a very useful table with a list of critical values for selected analytes. The other chapters in this section include: 1) cardiac function, 2) renal function, 3) disorders of water, electrolyte and acid base metabolism, 4) liver function, 5) gastric, pancreatic, and intestinal function, 6) mineral and bone metabolism, 7) pituitary function, 8) thyroid function, 9) adrenocortical function, 10) reproductive endocrine function, 11) pregnancy, 12) inherited disease, and 13) nutritional assessment, therapy, and monitoring. Each of these chapters presents an overview of the anatomy, physiology, and biochemical functions of the specific organ/organ system. There is a description of each of the major diseases affecting the organ/organ system and this is followed by a diagnostic strategy. All chapters in the book have a list of learning objectives, and a list of key words found in that chapter with the definitions for those words. Each chapter has a list of references and suggested readings, however, compared with the prior edition there are fewer references. The chapters do not have case studies or chapter summaries, but there is a book (Tietz, Conn, and Pruden, *Applied Laboratory Medicine*, ISBN # 0-7216-6474-1) published by Saunders which has excellent case studies with wonderful discussions that could be used in conjunction with this book. One of the strengths of the book lies in the fact that the authors present the material from the perspective of the lab (analyte, diseases associated with, methods of analysis) and then later from the perspective of the physician/diagnostician (organ system function assessment). Overall, this is perhaps the most authoritative textbook on the subject. It is an excellent, user friendly read for upper level undergraduate students, medical students, and graduate students. It is strongly recommended for anyone working in the clinical chemistry laboratory and can serve as a first approach reference book as well.

Reviewed by *Margot Hall, Ph.D., FAIC, CPC, FACB, CChem MRSC*

Clinical Chemistry Theory, Analysis, Correlation Tietz (4th Edition)

Editors: Kaplan, Lawrence A., Amadeo J. Pesce, and Steven Kazmierczak
Publisher: Mosby, Inc.
ISBN#: 0-323-01716-9
Price: $89.95

This most remarkable textbook of clinical chemistry was written for students and faculty of upper division (junior/senior) undergraduate and graduate level courses. Prior editions of the textbook had a major section which detailed methods of analyte measurement. In this edition all methodological material has been transferred to an accompanying CD-ROM which also contains algorithms for clinical calculations, laboratory exercises, case

histories, review questions with answers, references (from the textbook) in EndNote file format connected to the web, and a urinalysis manual with color photomicrographs. The text has 1179 pages, 73 contributing authors, 57 chapters, 9 appendices, and 1 index. Additionally, there is a periodic table and a list of normal reference intervals attached to the inside front and back covers.

The textbook is subdivided into two parts: 1) laboratory techniques, and 2) pathophysiology. Part one has twenty three chapters detailing the principles of different laboratory techniques. Subjects covered in this section include: basic principles and techniques, lab management, preanalytical variables, spectroscopy, liquid and gas chromatography, mass spectrometry, radioisotopes, electrophoresis, immunological reactions and techniques, principles of competitive binding assays, measurement of colligative properties, electrochemistry, lab automation, point of care testing, lab informatics and statistics, reference intervals, quality control, method evaluation, and interference in chemical analysis. Part two has 34 chapters addressing organ and organ system pathologies and their diagnosis. Subjects covered in this section include: pathophysiology of water balance and electrolytes, acid base disorders, renal function, liver function, bone disease, pancreatic function, gastrointestinal function, cardiac and muscular disease, diabetes mellitus, coronary artery disease, alcoholism, heme metabolism, hemoglobinopathies, diseases associated with nutrition/trace elements and vitamins, pregnancy and fetal development, extravascular body fluids, nervous system diseases, endocrinology, disease of the thyroidal, gonadal and adrenal hormones and organ status, genetic diseases, molecular diagnostics, neoplasia, evaluation of transplant recipients and donors, toxicology, addiction and substance abuse, description of proteins-lipids and carbohydrates, enzymology, isoenzymes and isoforms, therapeutic drug monitoring, and urinalysis. Chapters in part two offer the reader chemical structures and normal and abnormal (pathologic) metabolic pathways for the major analytes. Major diseases are described with an approach to the assessment of the organ function. All chapters in the textbook have a list of learning objectives, a list of key terms with definitions, and a list of references and internet resources associated with the topic(s) found in the chapter. The material is organized into a very logical sequence with numerous aids for the student including such things as bold printed terms within the chapters. The appendices contain useful information and algorithms such as preparation of buffer solutions, conversions between conventional and SI units, and the determination of body surface area. A principal strength of the book lies in the accompanying CD-ROM with its case histories, review questions with answers, and laboratory exercises. Overall, this is a marvelous textbook which will appeal strongly to students and faculty in medical and graduate school and upper level undergraduates. It is strongly recommended for practicing laboratorians and can serve as a reference book as well.

Reviewed by *Margot Hall, Ph.D., FAIC, CPC, FACB, CChem MRSC*

Books Available for Review

The following books are available for review at the AIC National Office. Should you be interested in preparing a book review for inclusion in a subsequent issue of The Chemist, please contact the office. There is no guarantee that the books in this list will be available. As is the custom, you are welcome to keep the book that you select as thanks for performing this service,

Advances in Chemical Physics
Adsorbents: Fundamentals and Applications
Catalytic Membranes and Membrane Reactors
Chemometrics
Computational Geometry in C
Data Acquisition and Signal Processing for Smart Sensors
Enzyme Kinetics
Fundamentals of Classical and Statistical Thermodynamics
Genomes
Mass Spectrometry and Hyphenated Techniques in Neuropeptide Research
Hydrazine and It's Derivatives
Organic Chemistry
In-Situ Spectroscopy in heterogeneous Catalysis
Interfacial Enzyme Kinetics
Magnetism: Molecules to Materials
Measuring Mass
Modern Arene Chemistry
Molecular Modeling
Glycosciences
Principles and Modern Applications of Mass Transfer Operations
Process Dynamics
Propagators in Quantum Chemistry
Quantum Mechanics
Reactive Intermediate Chemistry
Relativistic Effects in Heavy Element Chemistry and Physics
Reviews in Computational Chemistry; Vol 9
The Raman Effect
Sediment Flux Modeling
Thermodynamics of Biochemical Reactions
On the Practice of Safety
Modern Practice of Gas Chromatography
General Chemistry
Chemical Principles