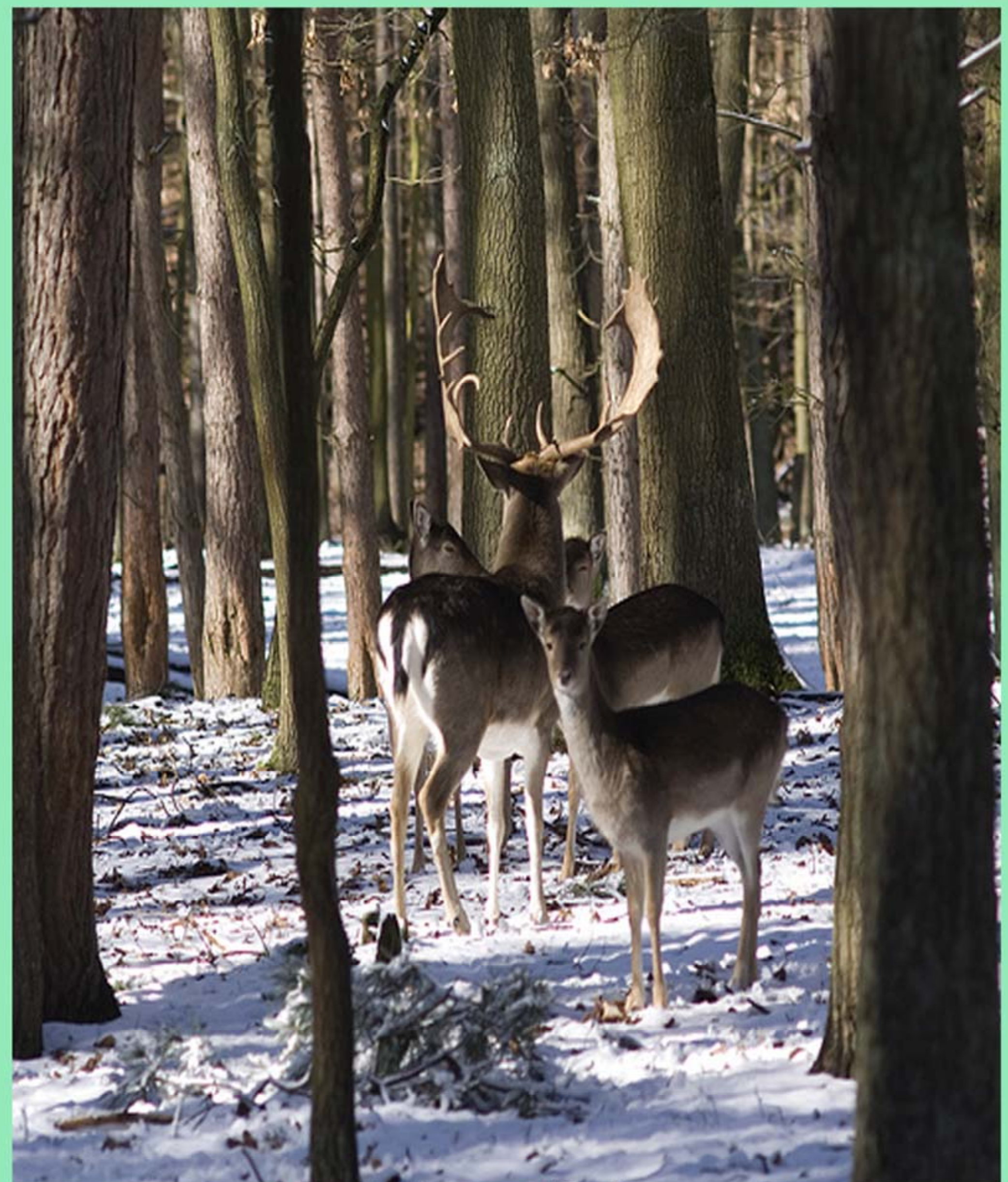
綠色/永續化學通訊

Green/Sustainable Chemical Communication

Vol.4, No.2, 2009



國科會化學中心

GREEN / SUSTAINABLE
GSCC
CHEMICAL COMMUNICATION
VOL. 4, NO. 2, 2009

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化學通訊

Green / Sustainable Chemical Communication

Preface

As you all know, typhoon Morakot bore down on Taiwan on Aug 7, 2009. The severe flooding and mudslides were blamed as the cause of disaster. Because of Morakot, everyone acknowledges the unpredictable power of nature and admits having neglected the fact that the real cause of damage is lying in our environment, not just the typhoon itself. I hope that our nation will face this problem seriously.

This second issue of Green/Sustainable Chemical Communication (G/SCC No. 2) continues to denote the invaluable information in the fields of education, chemical engineering, industry, chemistry and biochemistry related to new inventions and developments of sustainable solutions which may be helpful for us to protect and improve our environment in the near future. In addition, a workshop "2009 永續合成化學工作坊" will be held on Feb 1, 2010 to provide an opportunity of green/sustainable education for university teachers. Please come join us to save the earth for our children.

Wen-Shan Li
Academia Sinica
Aug 2009


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RESOURCE SHARING

3 NEWater 解決水荒的希望

淡水的短缺是世界性的,但有些地區這個問題甚至嚴重到威脅國家的安全及經濟發展,我們的近鄰新加坡就是其中之一。新加坡四百四十萬人口每年需 1.36 兆公升水,但新加坡沒有水源，水是從鄰國馬來西亞以三根大水管從運來。雖然有長期條約保障，（內容是馬來西亞不能斷水而且水費便宜，每一千加侖(一加侖等於 3.8 公升)不到美金一分錢）。不過這些條約有的將在 2011 年到期（另外有些則到 2061 年）,新的水價可能是現在的 20 至 30 倍是可預期的。所以尋求水源是新加坡政府長期苦腦的問題, 自 1998 年開始解決方法之一是挖水塘來儲雨水,如今全國有一半地方是水塘，但是還不夠。其二是淡化海水,目前大約可生產 10%的用水,最後一個是所謂的 NEWater﹒就是廢水再潔淨再利用。

(新加坡挖水塘來儲雨水)

NEWater 來自用過的水(used water),（不用污水(sewage)這名詞是降低心理厭惡的因素）。用過的水經過微過濾(microfiltration)及逆滲透之後再以紫外線處理得到潔淨的水,將這種水注入自來水廠儲水池中，和天然水一起經過處理而得到食用水,原理和方法都不複雜,其實這方法在美國已實行之有年,早在 1978 年美國維吉尼亞州北部就上述的方法，得到的淨水也是注入水廠儲水槽，再以一般自來水方式處理。加州橘郡也以用同樣的方法回收水，不過是把得到的水注入地下之後才再利用。新加坡的貢獻是將這程序大規模化,新加坡現有四座淨水廠，第五座正在建造中。大量的生產使得價格降低,生產每一立方米(或一噸)NEWater 需美金 0.3 元，遠比淡化海水便宜(一立方米水要美金 2.2 元),目前 NEWater 提供了 15%的用水量,第五座淨水廠完成後可望提高到 30%,終極的目標是 70%。

但這並不是沒有代價，新加坡政府在過去五年投入 35 億美金,未來五年將同樣數字將投入。但淨水廠愈蓋愈大，不但增加就業機會，讓水能再利用的成本降低,不但解決了本身的水荒，也明顯指出一條解決淨水短缺的路。

缺水帶來的影響在台灣也許不如地震來的明顯,但雨水逐年減少而工業用水是逐年增加是不爭的事實，也是我們要以新加坡為借鏡的時候了。
(甘魯生教授 改寫)
(取材自 BBC NEWS http://news.bbc.co.uk/2/hi/business/7371463.stm)。

永續化學的教育(Education in sustainable/green chemistry)

古人說「未雨綢繆」。這次莫拉克颱風造成中南部令人哀痛的空前災害，「未雨綢繆」做的不夠是主因之一。由此想到：「永續發展」與「化學」汲汲相關，台灣化學界一般不重視永續化學很可能是一大隱憂。今年的第一期 GSCC 中已說明聯合國訂定 2005~2014 年為「永續發展教育的十年（DESD）」，故永續發展教育已是當前許多國家的教育發展重點，但臺灣的教育領導者和眾多教育界人士卻不予重視。五年後其他國家已完成此一階段性的教育發展。若台灣不速予補救，屆時新世代年輕人必難與國際競爭者匹敵，而台灣的前景可慮。台灣化學界的實力與前瞻性一向領先許多其他學科，故拙見以為應可及早「未雨綢繆」，也有能力自我救濟──在大學推動「永續化學」之教學。何況「防患於未然」本是永續化學十二原則第一項之精神所在！

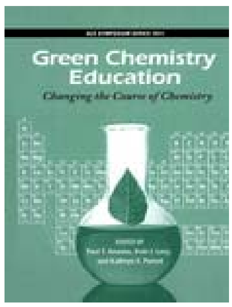
最近有兩件新資料問世，現分別介紹於下。

(1)新資源:

(1) ***Green Chemistry Education：Changing the Course of Chemistry,***
ACS Symposium Series 1011 (2009)

此書係依 2007 及 2008 兩次圓桌討論會，專家發表的意見所編成。共分 13 章。其預期效果有三：

1. Attracting students to the field of chemistry who otherwise may never have seen themselves as potential chemists or even as scientists.
2. Providing chemists with an essential skill set that will be needed as the basis of a sustainable world.
3. Bringing a new generation of innovators to engage some of the greatest challenges our society and our civilization face today.



Green Chemistry Education

Changing the Course of Chemistry

第 1 章為導論，第 13 章為展望。其餘則分與不同領域或不同程度之教學相關。各章的摘要為：

Chapter 1. Changing the Course of Chemistry (pp. 1-18), by Paul T. Anastas and Evan S. Beach

The education of chemists and all those interested in chemistry is an ever-evolving endeavor to keep up with the latest innovations, discoveries, concepts, perspectives and techniques of the field. One of the most exciting developments in recent years is the development of Green Chemistry – the design of chemical products and processes that reduce or eliminate the generation of toxic substances. This chapter seeks to provide an overview of the approaches to building Green Chemistry into the chemistry curriculum by highlighting some of the outstanding work in the field.

Chapter 2. Using Green Chemistry to Enhance Faculty Professional Development Opportunities (pp. 19-36) by Margaret E. Kerr1 and David M. Brown

Of the plethora of benefits that derive from practicing green chemistry, one that is not often considered, or at least discussed, is its application toward enhancing the professional development of faculty as they advance through the ranks. Opportunities within the areas of teaching, scholarly activities (research and related), and service (both community and institutional) abound as the field advances rapidly. Within the context of developing new green chemistry educational materials, herein is presented a discussion of multiple professional development opportunities taken from both the authors' personal experiences as well as from the numerous contributions of others in the field.

Chapter 3. The Garden of Green Organic Chemistry at Hendrix College (pp. 37-54) by Thomas E. Goodwin

The Hendrix College organic chemistry laboratories were converted to microscale experiments in 1988 to minimize possible adverse environmental impact, increase lab safety, and decrease generation of waste and costs of waste disposal. As we became aware of the green chemistry movement in university research labs and chemical industry in 2000, we wiped the slate clean and did a thorough reevaluation of our

laboratory philosophies, practices, procedures, and experiments. An account of our ruminations and conclusions has been published (J. Chem. Educ. 2004, 81, 1187-1190). This chapter, while briefly reviewing our green lab philosophies, will focus primarily on the presentation of practical green organic experiments. Some of these have been adapted from prior experiments, while others we have modified from the primary literature including our own research. We believe that as the menu of green experiments grows in size and variety, the energy of activation for going green at more colleges and universities will be lowered, to the benefit of us all.

Chapter 4. Integrating Green Chemistry throughout the Undergraduate Curriculum via Civic Engagement (pp. 55-77）by Richard W. Gurney and Sue P. Stafford

The quantity of information that a chemical educator feels obligated to convey to majors and non-majors alike has resulted in the overly formulaic delivery of content that is often devoid of contextual frameworks. Correspondingly, efforts to deliver Chemistry in Context have begun to gain widespread popularity. Empirical evidence over the past 7 years at Northwestern University and Simmons College has indicated that introducing green chemistry both in context and through civic engagement is particularly effective. When introduced to Green Chemistry in context, students are driven to learn so that they are able to effectively educate and advocate for green chemistry in their community. Herein, three distinctly different green chemistry lecture-based courses are detailed and the design and outcome of the corresponding civic-engagement projects are described.

Chapter 5. Integrating Green Chemistry into the Introductory Chemistry Curriculum (pp. 79-92) by Marc A. Klingshirn1 and Gary O. Spessard

Green chemistry education offers a solution to our current environmental problems because it provides the opportunity to train future scientists and political leaders, thus helping move us toward a more sustainable society. Green chemistry, while becoming more commonplace in today's curricula, has seen the greatest degree of implementation in the organic chemistry laboratory. It is only recently that introduction of green chemistry principles into the first year chemistry courses has been addressed. This in spite of the need for such education to be uniform throughout a student's chemistry curriculum from the beginning courses onward. Successful case studies and examples of implementation of green chemistry into the lecture and laboratory of first-year courses will be covered. Two redesigned experiments relating to the formula of a hydrate and metal complexation will be discussed in addition to key drivers and major barriers to green chemistry implementation.

Chapter 6. Greening the Chemistry Lecture Curriculum: Now is the Time to Infuse Existing Mainstream Textbooks with Green Chemistry (pp.93-102) by Michael C. Cann

It is essential that we infuse green chemistry across the curriculum from non-majors courses to majors courses. Over the last 16 years, since the beginnings of green chemistry at the EPA, green chemistry education has made significant strides but we still have a long way to go. Green chemistry educational materials have been developed, but these tend to be supplementary materials (at first outside but more frequently within existing textbooks) that are easily ignored by instructors trying to cover traditional materials in an already overcrowded course. A survey of undergraduate chemistry textbooks revealed that 33 out of 141 books contained at least some coverage of green chemistry, but the majority only mentions green chemistry once or twice in a cursory manner and generally as supplementary material. Several textbooks that "stand out in the crowd" are discussed and recommendations for improving the coverage of green chemistry in existing textbooks are given.

Chapter 7. Green Analytical Chemistry: Application and Education (pp. 103-116) by Liz U. Gron

Green chemistry seeks to reduce the hazard to the environment from chemicals and chemical processes. The most effective pollution prevention method is to avoid the use or creation of dangerous materials, rather than relegating toxins to post-processing cleanup. Despite the important role analytical chemists play in assessing environmental health, the analytical community is a relative newcomer to the field of green chemistry. Significant environmentally benign method innovations have been developed, but these are rarely described as "green". Expansion of the practice and application of green analytical chemistry will require educating our undergraduates to green principles while advancing the state of the art. Green education has made significant strides within organic chemistry, but materials for the broader undergraduate chemistry curriculum are just beginning to appear. At Hendrix College we have developed laboratories to teach green analytical chemistry using environmental samples for our introductory courses. This chapter will discuss green analytical chemistry innovations and education.

Chapter 8. Linking Hazard Reduction to Molecular Design Teaching Green Chemical Design (pp. 118-136) by Nicholas D. Anastas and John C. Warner

Green chemistry, defined as the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances, is making its way into all aspects of the chemical enterprise as well as into the middle school, high school and university chemistry curriculum. An important component of green chemistry is minimizing toxicity and other hazards as part of the chemical design phase. Often missing from the instruction of chemists, however, is the connection between molecular structure and hazard. Students and practicing synthetic chemists need to be aware that the hazardous nature of a substance can be controlled through structure manipulation. Through careful molecular design, chemists can develop new substances that maintain functionality while minimizing hazard. This chapter outlines the basic components that must be included in an approach that links hazard reduction to molecular design as part of a comprehensive and systematic approach to green chemical design.

Chapter 9. Integrating Green Engineering into Engineering Curricula (pp. 137-146) by Julie Beth Zinimcrman and Paul T. Anastas

The introduction of Green Engineering is taking place in colleges and universities around the U.S. and the World. Currently there are books that have been developed, courses and lecture materials being generated and a wide range of approaches to infusing Green Engineering Principles into the curriculum. This chapter will review the various approaches that are taking place and discuss specific techniques to introduce Green Engineering to students at both the undergraduate and graduate levels.

Chapter 10. Green Laboratories: Facility-Independent Experimentation (pp. 147-156) by Kenneth M. Doxsee

By virtue of its focus on the reduction of intrinsic chemical risk rather than solely on minimization of exposure, Green Chemistry allows for laboratory investigations in settings that would be inappropriate for "conventional" chemical experimentation. The benefits of a Green curriculum are numerous, ranging from enhanced safety and cost savings to the facilitation of the (re)introduction of experimental chemistry, particularly at the K-12 and community college levels, where facility limitations have often curtailed laboratory investigation. A Green curriculum thereby promises enhancement of both the numbers and the diversity of students gaining knowledge of the practice of modem chemistry.

Chapter 11. Student Motivated Endeavors Advancing Green Organic Literacy. (pp. 155-166) By Irvin J. Levy and Ronald D. Kay

While great strides have occurred during the past decade in the areas of green chemistry and green chemistry education, informal surveys of undergraduate college science students indicate that a broad knowledge of this topic is still lacking. Nonetheless, we have observed in various venues that the green chemistry vision can be very motivational for typical undergraduate students attending organic chemistry courses. Our experience indicates that students can develop a powerful voice facilitating the paradigm shift toward green chemistry, simply by sharing the ideas of green chemistry with others. Here we report the activities of our Green Organic Literacy Forum (GOLum), in which organic chemistry students have developed and implemented projects designed to introduce green chemistry to a broad audience, and offer specific strategies to equip instructors to engage in similar outreach. We also discuss the impact of these activities on our students, our department, and our institution.

Chapter 12. K-12 Outreach and Science Literacy through Green Chemistry (pp. 167-185) by Amy S. Cannon' and John C. Warner

Green Chemistry is a call to arms for the next generation of students to study the physical sciences. The philosophy of green chemistry puts a subject, which is generally considered abstract and difficult, into a familiar context relevant to thedaily lives of students. The practice of green chemistry ensures a sustainable future with safer alternatives to chemicals products and processes. Within the United States
there is a general decline in the percentage of students studying in the physical sciences. The message of green chemistry resonates with students and can inspire students to pursue the sciences. Green Chemistry materials and programs are needed at all educational levels in order to provide content for learning about the field. Beyond Benign, a non-profit dedicated to green chemistry education and outreach, is actively involved in K-12 outreach and curriculum development and training. This chapter describes three ways Beyond Benign is engaging teachers and students with green chemistry: through interactive classroom visits, curriculum development and teacher training. By providing materials and training at the K-12 level, students and teachers alike can be engaged in the subject of chemistry and learn about the science within a sustainable framework.

Chapter 13. Green Chemistry Education: Toward a Greener Day (pp. 187-194) by Mary M. Kirchhoff

Green chemistry began infiltrating the curriculum in the late 1990s, when several enterprising faculty members started introducing greener laboratory experiments, stand-alone courses, and green chemistry modules into their teaching. Widespread coverage of this important topic, however, has been slow to catch on. This is not unusual in education, as curriculum reform is frequently evolutionary rather than revolutionary, and new concepts may take a generation to become embedded within the curriculum. In light of the increasing pressures placed on the planet by humanity, the need to develop a cadre of chemistry professionals who are dedicated to developing and implementing green chemistry practices is more important than ever before. This chapter highlights some of the challenges, opportunities, and strategies for the future in green chemistry education.

各章皆列出重要參考資料。第一章敘及 Collins 教授 2008 年在 Carnegie Mellon 大學授課的教學目標，甚有參考價值。亦列於下。

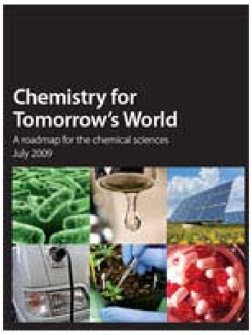
1. To understand sustainability ethics as they apply to chemistry and establish the arguments for recognizing "green" criteria.
2. To reflect on motives and forces that have entrenched technologies that are obviously or potentially harmful to the environment.
3. To define "green chemistry", place its development in a historical context, introduce the 12 Principles, and study successful examples of green technologies.
4. To identify the key challenges facing green chemistry and consider what will be required to solve them.
5. To identify reagents, reactions, and technologies that should be and realistically could be targeted for replacement by green alternatives.
6. To understand the history, meaning, and importance of persistent and bioaccumulative pollutants and endocrine disrupters which present major environmental and health threats.
7. To become familiar with leading research in green chemistry and the related fields of public health and sustainability science.

(2) *Chemistry for Tomorrow's World* (RSC, 2009)

這是英國皇家化學會今年七月發佈，列出未來15年內具全球挑戰性之重要化學相關的研究發展課題，共41項。分七領域 (priority areas, www.rsc.org/roadmap)。

1. Energy: Creating and securing environmentally sustainable energy supplies, and improving efficiency of power generation, transmission and use.

2. Food: Creating and securing a safe, environmentally friendly, diverse and affordable food supply.



3. Future cities: Developing and adapting cities to meet the emerging needs of citizens.

4. Human health: Improving and maintaining accessible health, including disease prevention.

5. Lifestyle and recreation: Providing a sustainable route for people to live richer and more varied lives.

6. Raw materials and feedstocks: Creating and sustaining a supply of sustainable feedstocks, by designing processes and products that preserve resources.

7. Water and air: Ensuring the sustainable management of water and air quality, and addressing societal impact on water resources (quality and availability).

其中10項屬於「攻頂挑戰」(Top-ten challenges)，應在5-10年內完成，因皆與永續發展密切相關，乃予列出以供參考。包括：

1. Agricultural productivity

Significantly and sustainably increase agricultural productivity to provide food, feed, fiber and fuel.

2. Conservation of scarce natural resources

Develop alternative materials to conserve precious resources and new processes to extract valuable materials from untapped sources.

3. Conversion of biomass feedstocks

Develop biorefineries using different types of biomass to provide energy, fuel and a range of chemicals with zero waste.

4. Diagnostics for human health

Enable earlier diagnosis and develop improved methods to monitor diseases.

5. Drinking water quality

Use new technologies to help provide clean, accessible drinking water for all.

6. Drugs & therapies

Harness and enhance basic sciences to transform drug discovery, development and healthcare, delivering new therapies more efficiently and effectively.

7. Energy conversion and storage

Improve the performance of energy conversion and storage technologies, such as batteries, and develop sustainable transport systems.

8. Nuclear energy

Ensure the safe and efficient harnessing of nuclear energy, through the development of fission and investigation into fusion technologies.

9. Solar energy

Develop existing technologies into more cost efficient processes and develop the next generation of solar cells to realize the potential of solar energy.

10. Sustainable product design

Take into account the entire life cycle of a product during initial design decisions to preserve valuable resources Scientists are investigating materials that can withstand the extremely hot plasmas created in nuclear fusion trials – fusion could play a pivotal role in our future clean energy mix.

(2)講課參考資料:

不符永續發展原則的生質乙醇燃料

從熱力學和光合作用的基本原理分析，可知自植物取得醣類，加工製成生質乙醇用為燃料，不但不符永續發展原則，也不切實際效益。劉廣定教授從下列五項議題中思微精密的剖析:

(1) 生質乙醇的缺點

(2) 熱力學原理

(3) 光合作用

(4) 葉綠素製造醣類需要多少太陽能？

(5) 每公頃土地生產多少生質乙醇？

推知在台灣並不適合發展「生質乙醇」或其他「生質燃料」。一般人之錯誤觀念乃源於對一些基本科學，如熱力學的簡單原理不甚了解，而且這也是認識永續發展之必需。

當前的高中基礎科學教育忽略熱力學，不獨水準落後英美等國，推展當下全球重視之永續發展教育，亦難矣！

(取材自:科學月刊第四十卷第七期 台大名譽教授劉廣定)

重視永續發展——臺灣當前大學通識教育之我見

「教育」是藉以增進知識能力，培育人格修養的一種手段。任何層次的「教育」都是由相關之學識程度較高，能力較強，見解較為深遠，經驗較為豐富的人來「教」導，和培「育」前來就學的人。劉廣定教授強調目前的高中課綱及明年度將實施的新課綱皆因配合其建議而規劃時有許多缺失，主要有三;**其中之一缺失即是當下國際積極推動的「永續發展教育」未受重視。**文中提及「永續發展」是約自1950 年代開始，有些經濟強國人士因察覺工業和農業快速擴展造成對環境、生態、人類健康禍害之嚴重性，提倡而逐漸形成的重要思潮和具體行動。2002 年底聯合國決定依據 1992 年里約熱內盧大會通過的「21 世紀待辦事項」(Agenda 21）訂出以 2005~2014 年為「永續發展教育的十年（Decade of Education for Sustainable Development)」之教育計畫，目的為藉不同層次的「教育」普遍灌輸正確「永續發展」的觀念及知識於人心。並特別說明「永續發展教育遠超過環境教育」之觀念。期望人們能以正確、公平的方式，促成維護生態與發展經濟同步進行，以促使未來的研究、發展均能符合「永續」原則，而達「永續」之目的。故已是當前許多國家的教育發展重點。

(取材自:《通識在線》23 期 6-8 頁，2009 年 7 月; 台大名譽教授劉廣定)

(3)學生實驗參考資料:

Chemistry in Sustainable Development and Global Environment

This piece was prompted by a call to all departments from the Chancellor of Chapman University to define their roles within a sustainable development and global environment. Because of the wide-ranging impact of the subject matter, we believe that our point of view will benefit the general public beyond Chapman University. How, then, can any chemistry department help in this effort? Chemistry is a specific discipline in science that tries to understand and explain the makeup and changes of all things that have mass and occupy space. Over the years, chemistry has steadily advanced into the study of complete molecular structures in science and related areas. Surely, a subject as all-encompassing as chemistry can play a role in sustainability.

Iyere, Peter Abeta. *J. Chem. Educ.* **2008,** *85,* 1604.

Microwave Synthesis of a Long-Lasting Phosphor

Efficient glow-in-the-dark materials are usually difficult to synthesize and need complex experiments with long reaction times that are not appropriate for conventional lab teaching. Therefore, we describe a new experimental procedure that allows the production of one of the most efficient "glow-in-the-dark" materials ($SrAl_2O_4$:Eu:Dy), in less than four minutes using a microwave oven and only basic experimental skills. The material, once charged under sun light, glows green in the dark for hours. We extended this chemical route to other oxides such as $CaAl_2O_4$:Eu:Dy that shows a blue fluorescence and phosphorescence. This lab work can be viewed as an appealing introduction to solid-state synthesis, lanthanide chemistry, and photochemistry in the solid state.

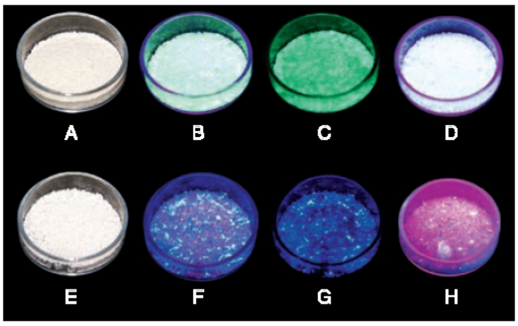


Figure 1. $SrAl_2O_4$:Eu:Dy, formed after the microwave combustion method, in sunlight (A) and with UV light exposure: green fluorescence (B), and after UV light exposure, in the dark: green phosphorescence (C). Undoped $SrAl_2O_4$ with UV light (D).$CaAl_2O_4$:Eu:Sr in sunlight (E), with UV light exposure: blue florescence (F), and after UV light exposure, in the dark: blue phosphorescence (G). $SrAl_2O_4$:Eu:Sr, low-urea content, with UV light exposure: red fluorescence (H). The colored version is available in the table of contents and in the online PDF.

Filhol, Jean-Sébastien; Zitoun, David; Bernaud, Laurent; Manteghetti, Alain. *J. Chem. Educ.* **2009,** *86*, 72

Greening Up Auto Part Manufacturing: A Collaboration between Academia and Industry

Historically, manufacture of automotive electronic components and screen-printing of automotive instrument clusters at DENSO Manufacturing Tennessee, Inc. required washing of equipment such as screens, stencils, and jigs with sizable quantities of volatile organic compounds and hazardous air pollutants. Collaborative efforts between the Maryville College Department of Chemistry and DENSO resulted in a reduction in the use of such solvents, and DENSO remains in compliance with the EPA's requirements. Individual projects were initiated during an analytical chemistry course when students met with DENSO associates to discuss pressing research problems. During the semester, students designed and performed preliminary experiments and drafted a research proposal that the instructor submitted to DENSO. Funded work was completed under the supervision of the instructor during the summer, and results and recommendations were included in a final report to DENSO. The nature of the collaboration is discussed, as are the results and positive outcomes of the projects.

Kneas, Kristi A.; Armstrong, Drew L.; Brank, Alice R.; Johnson, Amanda L.; Kissinger, Chelsea A.; Mabe, Adam R.; Sezer, Özge; Fontinell, Mike. *J. Chem. Educ.* **2009,** *86,* 212.

Determination of the Formula of a Hydrate: A Greener Alternative

We are currently in the process of incorporating green chemistry throughout the chemistry curriculum. In this article we describe how we applied the principles of green chemistry in one of our first-semester general chemistry courses, specifically in relation to the determination of the formula of a hydrate. We utilize a copper hydrate salt that shows both a visual color change upon dehydration and ease of rehydration upon exposure to steam.

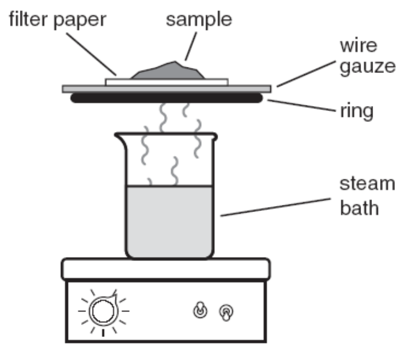


Figure 1. Apparatus used for sample rehydration.

Klingshirn, Marc A.; Wyatt, Allison F.; Hanson, Robert M.; Spessard, Gary O. *J. Chem. Educ.* **2008,** *85,* 819.

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RESEARCH BREAKTHROUGHS

High Rates of Oxygen Reduction over a Vapor Phase–Polymerized PEDOT Electrode

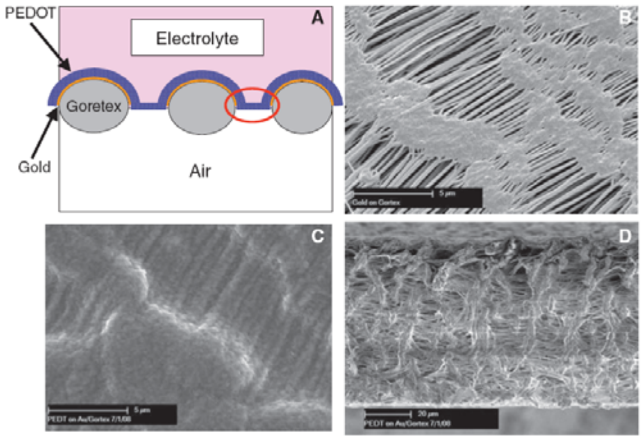
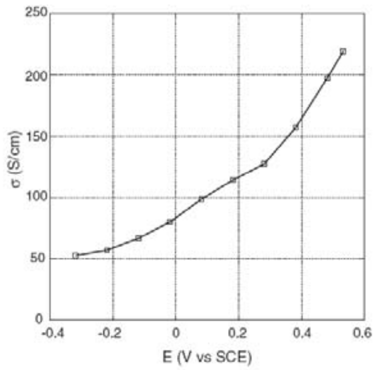


Fig. 1. (**A**) Schematic representation of the PEDOT/Goretex air electrode. (**B** to **D**) Scanning electron micrograph images: (B) The Goretex membrane coated with gold. Scale bar, 5 μm. (C) The PEDOT/Goretex structure. Scale bar, 5 μm. (D) Cross-section of the electrode with thickness measurements of the PEDOT layer. Scale bar, 20 μm.

Fig. 4. Conductivity (σ) versus potential (*E*): Conductivity in PEDOT air electrode (0.1 M phosphate buffer, pH 7).



The air electrode, which reduces oxygen (O_2), is a critical component in energy generation and storage applications such as fuel cells and metal/air batteries. The highest current densities are achieved with platinum (Pt), but in addition to its cost and scarcity, Pt particles in composite electrodes tend to be inactivated by contact with carbon monoxide (CO) or by agglomeration. We describe an air electrode based on a porous material coated with poly(3,4-ethylenedioxythiophene) (PEDOT), which acts as an O_2 reduction catalyst. Continuous operation for 1500 hours was demonstrated without material degradation or deterioration in performance. O_2 conversion rates were comparable with those of Pt-catalyzed electrodes of the same geometry, and the electrode was not sensitive to CO. Operation was demonstrated as an air electrode and as a dissolved O_2 electrode in aqueous solution.

Bjorn Winther-Jensen et al., *Science* **2008**, *321*, 671-674.

In Situ Formation of an Oxygen-Evolving Catalyst in Neutral Water Containing Phosphate and Co^{2+}

The utilization of solar energy on a large scale requires its storage. In natural photosynthesis, energy from sunlight is used to rearrange the bonds of water to oxygen and hydrogen equivalents. The realization of artificial systems that perform "water splitting" requires catalysts that produce oxygen from water without the need for excessive driving potentials. Here we report such a catalyst that forms upon the oxidative polarization of an inert indium tin oxide electrode in phosphate-buffered water containing cobalt (II) ions. A variety of analytical techniques indicates the presence of phosphate in an approximate 1:2 ratio with cobalt in this material. The pH dependence of the catalytic activity also implicates the hydrogen phosphate ion as the proton acceptor in the oxygen-producing reaction. This catalyst not only forms in situ from earth-abundant materials but also operates in neutral water under ambient conditions.

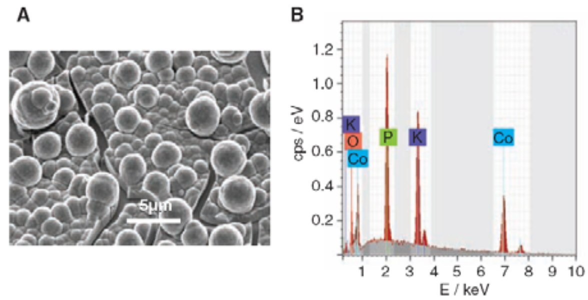


Fig. 2. **(A)** SEM image (30° tilt) of the electrodeposited catalyst after 30 C/cm^2 were passed in 0.1 M KPi electrolyte at pH 7.0, containing 0.5 mM Co^{2+}. The ITO substrate can be seen through cracks in the dried film. **(B)** Typical EDX histogram acquired at 12 kV. cps, counts per second.

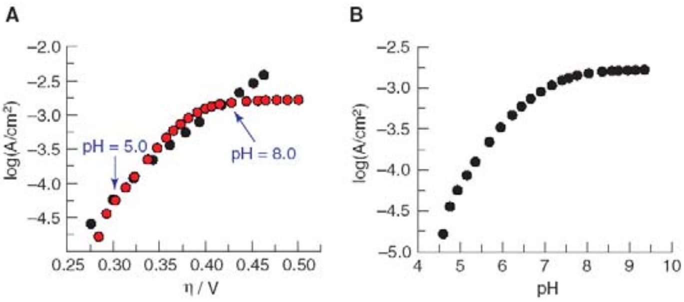


Fig. 4. **(A)** Tafel plot (black circles), $\eta = (V_{appl} - iR) - E(\text{pH } 7)$ (where V_{appl} is the applied potential), of a catalyst film on ITO in 0.1 M KPi electrolyte pH 7.0, corrected for the iR drop of the solution. pH data were converted into a Tafel plot (red circles), $\eta = (V_{appl} + 0.059\Delta\text{pH} - iR) - E(\text{pH } 7)$, assuming Nernstian behavior and correcting for the iR drop of the solution. The pH = 5 and pH = 8 data points are indicated by arrows. **(B)** Current density dependence on pH in 0.1 M KPi electrolyte. The potential was set at 1.24 V (versus NHE) with no iR compensation.

Matthew W. Kanan and Daniel G. Nocera, *Science* **2008**, *321*, 1072–1075.

Identification of Non-Precious Metal Alloy Catalysts for Selective Hydrogenation of Acetylene

The removal of trace acetylene from ethylene is performed industrially by palladium hydrogenation catalysts (often modified with silver) that avoid the hydrogenation of ethylene to ethane. In an effort to identify catalysts based on less expensive and more available metals, density functional calculations were performed that identified relations in heats of adsorption of hydrocarbon molecules and fragments on metal surfaces. This analysis not only verified the facility of known catalysts but identified nickel-zinc alloys as alternatives. Experimental studies demonstrated that these alloys dispersed on an oxide support were selective for acetylene hydrogenation at low pressures.

Jens K. Nørskov et al., *Science* **2008**, *320*, 1320–*1322*.

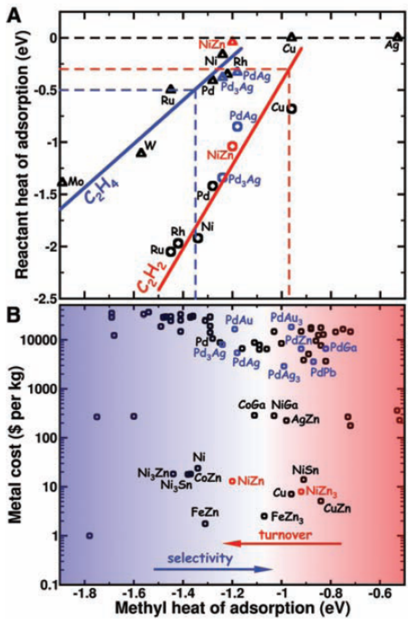


Fig. 2. (**A**) Heats of adsorption for acetylene (C_2H_2) and ethylene (C_2H_4) plotted against the heat of adsorption for methyl (CH_3). The adsorption energies are defined as the total energy of the surface with adsorbed species minus the sum of the total energy of the surface and the adsorbate in vacuum. The solid lines show the predicted acetylene (red line) and ethylene (blue line) adsorption energies from scaling. The dotted lines define the region of interest, where the ethylene binding energy is less than the barrier for further hydrogenation (blue) and where the reactivity of the acetylene hydrogenation step equals 1 s^{-1} per site (red). The adsorption geometry of ethylene on Ni and Rh has been accounted for by specifically choosing the methyl binding site to be on top of Ni and Rh (even though the most stable adsorption site is threefold), which corresponds to the site of adsorption of the carbons in ethylene. (**B**) Price (in 2006) of 70 binary intermetallic compounds plotted against the calculated methyl binding energies. The smooth transition between regions of low and high selectivity (blue) and high and low reactivity (red) is indicated.

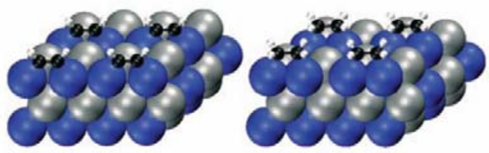


Fig. 3. Modeling of the NiZn catalyst in the bcc-B2 (110) structure. The unit cell is repeated twice in the *x* and *y* directions. The Ni atoms are shown as blue and Zn as gray. The adsorption of acetylene (left) and ethylene (right) is shown (small black and white structures).

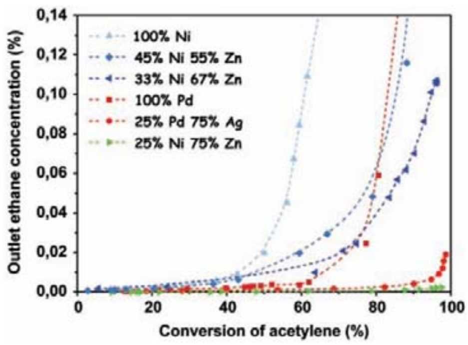


Fig. 4. Measured concentration of ethane at the reactor outlet as a function of acetylene conversion for seven catalysts. Ethane production is a measure of the selectivity of acetylene hydrogenation, and zero ethane corresponds to the most-selective catalyst. At the reactor inlet, the gas contained 1.33% ethylene, 0.0667% acetylene, and 0.67% hydrogen, with the remainder made up of Ar and N_2 in a total pressure of 1 bar. Experimental details are given in the supporting online material.

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NEWS DIGEST

19 Corn Waste Converted to Chemicals

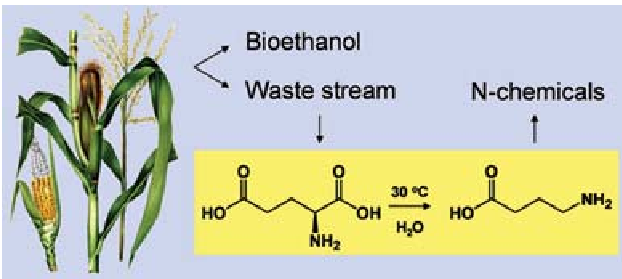
The application of glutamic acid α-decarboxylase for the valorization of glutamic acid

Biofuel waste could be turned into building blocks for industrial chemicals, thanks to an enzyme-based process developed by European scientists.

Tijs Lammens, at Wageningen University, the Netherlands, and colleagues studied the conversion of glutamic acid to -aminobutyric acid (GABA) using a decarboxylase enzyme. Glutamic acid is a major component of the waste formed when grains, such as maize, are converted into bioethanol. Because glutamic acid contains nitrogen, it could be used to make nitrogen-containing industrial chemicals more cheaply than the energy intensive, fossil fuel- and ammonia-based routes usually used.

GABA is a useful intermediate in the pathway from glutamic acid to industrial chemicals because it can be turned into many useful products, explains Lammens. Although the enzymatic conversion of glutamic acid to GABA is known, Lammens showed that the process could be scaled up for industrial production by immobilising the enzyme in a batch reactor.

'There is a scientific basis for making bulk chemicals from agricultural waste,' says Lammens. '[This study] shows industry that this process can be economically feasible using an enzyme.'



The waste from bioethanol production can be used to make nitrogen-containing chemicals

'Apart from being scalable, this process could also contribute to improving the green credentials and the economics of biofuel production,' comments Rafael Luque, a biofuel expert at the University of Cordoba, Spain. 'But the suitability of directly using an actual waste effluent containing glutamic acid requires further evaluation.'

Lammens acknowledges that the process would be too expensive if only glutamic acid produced by fermentation could be used. He says the next step is to 'investigate further if we can isolate amino acids, such as glutamic acid, from agricultural waste streams in a cost effective way.'

Carl Saxton, Chemical technology news from across RSC Publishing; Article citation: Tijs M. Lammens, *Green Chem.*, **2009**, DOI: 10.1039/b913741f.

The World's First Large Scale Floating Wind Turbine (Hywind by StatoilHydro)

StatoilHydro to build first full scale offshore floating wind turbine

StatoilHydro has decided to build the world's first full scale floating wind turbine, Hywind, and test it over a two-year period offshore Karmøy. The The company is investing approximately 400 million NOK. Planned startup is autumn 2009.

The project combines known technology in an innovative way. A 2.3 MW wind turbine is attached to the top of a so-called Spar-buoy, a solution familiar from production platforms and offshore loading buoys.

"If we succeed, then we will have taken a major step in moving the wind power industry offshore. Floating wind turbines can make a major contribution to providing the world with clean power, but there are major technical and commercial challenges that need to be resolved. If we are to succeed, we will need to cooperate closely with the authorities. As with other technologies for renewable energy, floating wind power will be dependent on incentive schemes to be viable," says Alexandra Bech Gjørv.

(From StatoilHydro | N-4035 Stavanger Norway; http://www.statoilhydro.com/en/NewsAndMedia/News/2008/Pages/hywind_fullscale.aspx)

CONFERENCE INFORMATION

1. 8th Green Chemistry Conference: Universidad de Zaragoza, Paraninfo, Building Paraninfo, Zaragoza, Spain, September 9-11 2009 (http://8gcc.unizar.es/index.html)

2. ACS Short Course: **Introduction to Process Analytical Chemistry** (Course Code: PACM), Washington, DC, ACS Fall National Meeting, August 15-16, 2009; Chicago, IL, September 23-24, 2009. (http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_ARTICLEMAIN&node_id=273&content_id=WPCP_011342&use_sec=true&sec_url_var=region1&__uuid=882afc8e-6ddd-495a-8c25-2de121c548f9)

3. AAIC 21st Annual Meeting: 2009 International Conference: The Next Generation of Industrial Crops, Processes, and Products, Termas de Chillán, Chillán, Chile, November 14-19th, 2009 (http://www.aaic.org/2009_meeting.htm).

4. 2009 永續合成化學工作坊 will be held on Feb 1, 2010, TAIWAN. (Please contact Deputy Director Ito Chao in Institute of Chemistry, Academia Sinica for further information).

5. Gordon Research Conference---Green Chemistry, July 25-30, 2010, Davidson College, Davidson, NC

6. 3rd International IUPAC Conference on Green Chemistry, August 15-19, 2010, Ottawa Westin Hotel, Ottawa, Canada (http://www.icgc2010.ca/)

7. Fourth International Conference on SFC 2010, Stockholm, Sweden - September 2010. With the growth of supercritical fluid chromatography as a cutting edge technology, this conference provides a forum for new developments and applications. The Green Chemistry Group, a non-profit corporation, is dedicated to promote and encourage green and sustainable chemistry, including green analytical and purification techniques throughout the world.

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Opportunity

ACS GCI Pharmaceutical Roundtable
2010 Research Grant Program
Request for Proposals

Pre-proposals are due to the ACS GCI Pharmaceutical Roundtable on Friday, September 4, 2009 at 5 p.m. (EDT),

The RFP is attached and also will be posted shortly on www.acs.org/gcipharmaroundtable < http://www.acs.org/gcipharmaroundtable> .
The ACS GCI Pharmaceutical Roundtable requests submission of proposals for review for work on the following targeted research areas. Proposals will be accepted from public and private institutions of higher education worldwide.

Chemical Transformations of High Interest

- Amide formation avoiding poor atom economy reagents
- OH activation for nucleophilic substitution
- Amide reduction without hydride reagents
- Safe and environmentally friendly Mitsunobu reactions
- Oxidation/Epoxidation reactions without the use of chlorinated solvents

More Aspirational Transformations

- C-H activation of aromatics (cross couplings avoiding the preparation of haloaromatics)
- Chiral amine synthesis (aldehyde or ketone + NH_3 + ◀X↕)
- Asymmetric hydrogenation of unfunctionalized olefins/enamines/imines
- Green fluorination methods under mild conditions
- N-Centered chemistry avoiding azides, hydrazine, etc.

<u>Process Related Targets</u>

- Solventless reactor cleaning
- Green alternatives to polar aprotic solvents

The total award is limited to $150,000 for a grant period of 12 to 24 months. The selection of the awardee will be divided into a pre-proposal and a full proposal phase. ***Pre-proposals are due to the ACS GCI Pharmaceutical Roundtable on Friday, September 4, 2009 at 5 p.m. (EDT),*** no exceptions. Pre-proposals not received by the deadline will not be considered. Submissions must be a pdf file submitted via email to gcipr@acs.org. Only those PIs who have submitted a pre-proposal are eligible to submit full proposals. Investigators invited to submit a full proposal will be notified by Friday, October 9, 2009 with full proposals due by Monday, November 2, 2009 at 5 p.m. (EDT).

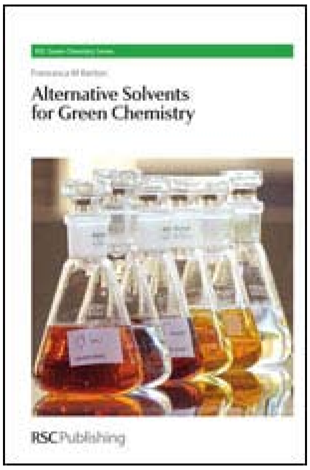
The RFP will be posted shortly on www.acs.org/gcipharmaroundtable < http://www.acs.org/gcipharmaroundtable> .

For additional information:
Website: www.acs.org/gcipharmaroundtable < http://www.acs.org/gcipharmaroundtable>
Email: gcipr@acs.org

NEW BOOKS

Alternative Solvents for Green Chemistry

By Francesca M. Kerton (Memorial University of Newfoundland, St. John's, Canada). From the RSC Green Chemistry Series. Edited by J. H. Clark (University of York, U.K.) and G. A. Kraus (Iowa State University, USA). Royal Society of Chemistry: Cambridge. 2009.



Everyone is becoming more environmentally conscious and therefore, chemical processes are being developed with their environmental burden in mind. This also means that more traditional chemical methods are being replaced with new innovations and this includes new solvents. Solvents are everywhere, but how necessary are they? They are used in most areas including synthetic chemistry, analytical chemistry, pharmaceutical production and processing, the food and flavour industry and the materials and coatings sectors. However, the principles of green chemistry guide us to use less of them, or to use safer, more environmentally friendly solvents if they are essential. Therefore, we should always ask ourselves, do we really need a solvent?

The book is aimed at newcomers to the field whether research students beginning investigations towards their thesis or industrial researchers curious to find out if an alternative solvent would be suitable in their work. (http://www.rsc.org/Shop/books/2009/9780854041633.asp)

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Visit our website at: http://gc.chem.sinica.edu.tw/

In order to improve the edition of Green/Sustainable Chemical Communication (G/SCC), please write your comments and suggestions to us (wenshan@chem.sinica.edu.tw). In addition, to gain information about green chemistry, please visit our website at http://gc.chem.sinica.edu.tw/.

Cover picture:

大雪後森林裡的鹿(歐洲大陸)---原始森林的維護，有助於水土保持，野生動物的生存；大自然的一切原始地形地貌呈現，您我都有責任。 (abstract from YiChi Jao)。

Acknowledgments:

We are indebted to two experts Prof. Kwang-Ting Liu (劉廣定教授) and Prof. Lou-sing Kan (甘魯生教授) who sincerely wrote and collected the information at several stages for their helpful and invaluable suggestions on how to construct a practicable communication.

I also wish to gratefully acknowledge two photographers, YiChi Jao and Steven Zan, who provided us a series of pictures about the nature and green world taken from many countries in Europe.