聲明

本檔案之內容僅供下載者自我學習或推廣化學教育之非營利目的使用。並請於使用時註明出處。 例如「本頁取材自○○○教授演講內容」

2030年永續發展議程下的綠色/永續化學教育新思維

凌永健

清華大學化學系 綠色質譜實驗室

2016年化學年會 中興大學 化學教育分組

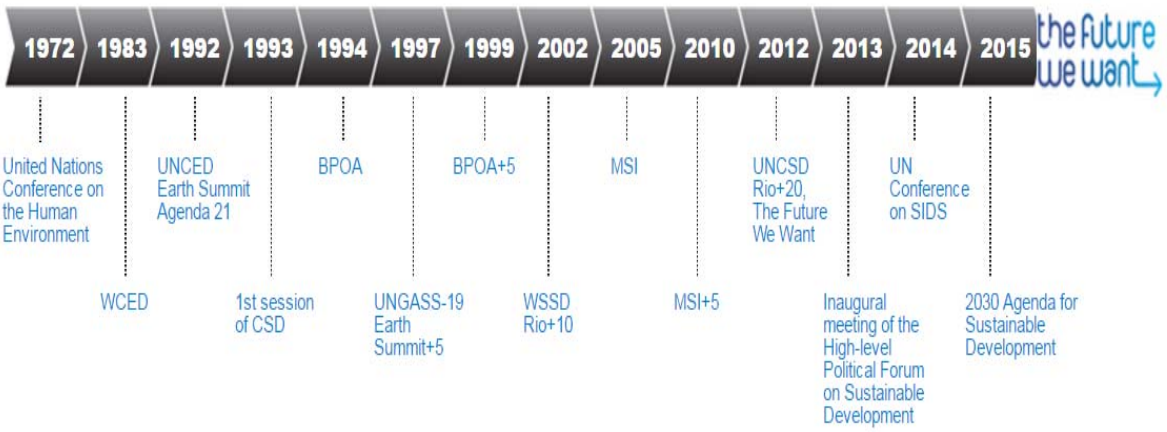
2016/12/03

改變我們的世界－2030永續發展議程

TRANSFORMING OUR WORLD:

THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

本議程是為人類、地球及繁榮制訂的行動計畫，旨在加強世界和平及增加自由。我們認識到，消除一切形式及層面的貧窮，包括消除極端貧窮，是全球最大的挑戰，也是實現永續發展必不可或缺的。59個宣言、17個永續發展目標、169個細項目標。



17項永續發展目標 SDGs

宣言 34

我們確認，永續的城市發展及管理對於我們人民的生活品質至關重要。

我們將減少城市活動及危害人類健康及環境的化學品產生的不利影響，包括以無害環境的方式管理及安全使用化學品，減少廢物，回收廢物及提高水及能源的使用效率。

International Programme on Chemical Safety

http://www.who.int/ipcs/en/

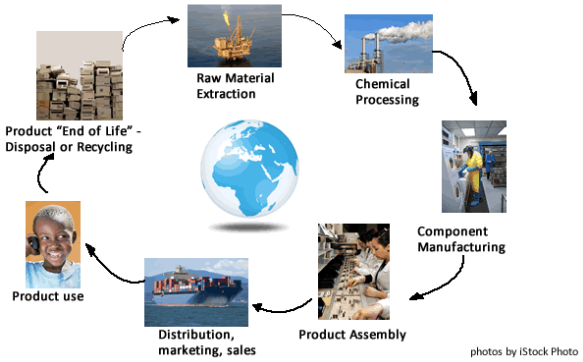
Overview of the Chemicals Management Plan

http://www.chemicalsubstanceschimiques.gc.ca/fact-fait/overview-vue-eng.php

目標 12 確保永續的消費與生產模式

12.4：在西元2020年以前，依據議定的國際架構，在化學藥品與廢棄物的生命週期中，以符合環保的方式妥善管理化學藥品與廢棄物，大幅減少他們釋放到空氣、水與土壤中，以減少他們對人類健康與環境的不利影響。

Where's the Harm – Toxics Across The Product Lifecycle



Toxics: Pb, Hg, Cd, BFRs

http://www.electronicstakeback.com/toxics-in-electronics/

Green Chemistry

It's important to recognize that many chemistry graduate programs don't ever talk about toxicity of chemicals, or require students to take even one course on toxicology.

http://www.electronicstakeback.com/toxics-in-electronics/green-chemistry/

目標3 確保健康及促進各年齡層的福祉

3.9：在西元2030年以前，大幅減少死於危險化學物質、空氣污染、水污染、土壤污染以及其他污染的死亡及疾病人數。

目標6：確保所有人都能享有水及衛生及其永續管理

6.3：在西元2030年以前，改善水質，減少污染，消除垃圾傾倒，減少有毒物化學物質與危險材料的釋出，將未經處理的廢水比例減少一半，提高全球的回收與安全再使用率。

Waste Hierarchy

to improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials

Chemicals and Waste International Treaties

Basel Convention
Most comprehensive global environmental agreement on hazardous and other wastes

Rotterdam Convention
Covers pesticides and industrial chemicals banned or severely restricted for health or environmental reasons

Stockholm Convention
Global treaty to protect human health and the environment from persistent organic pollutants

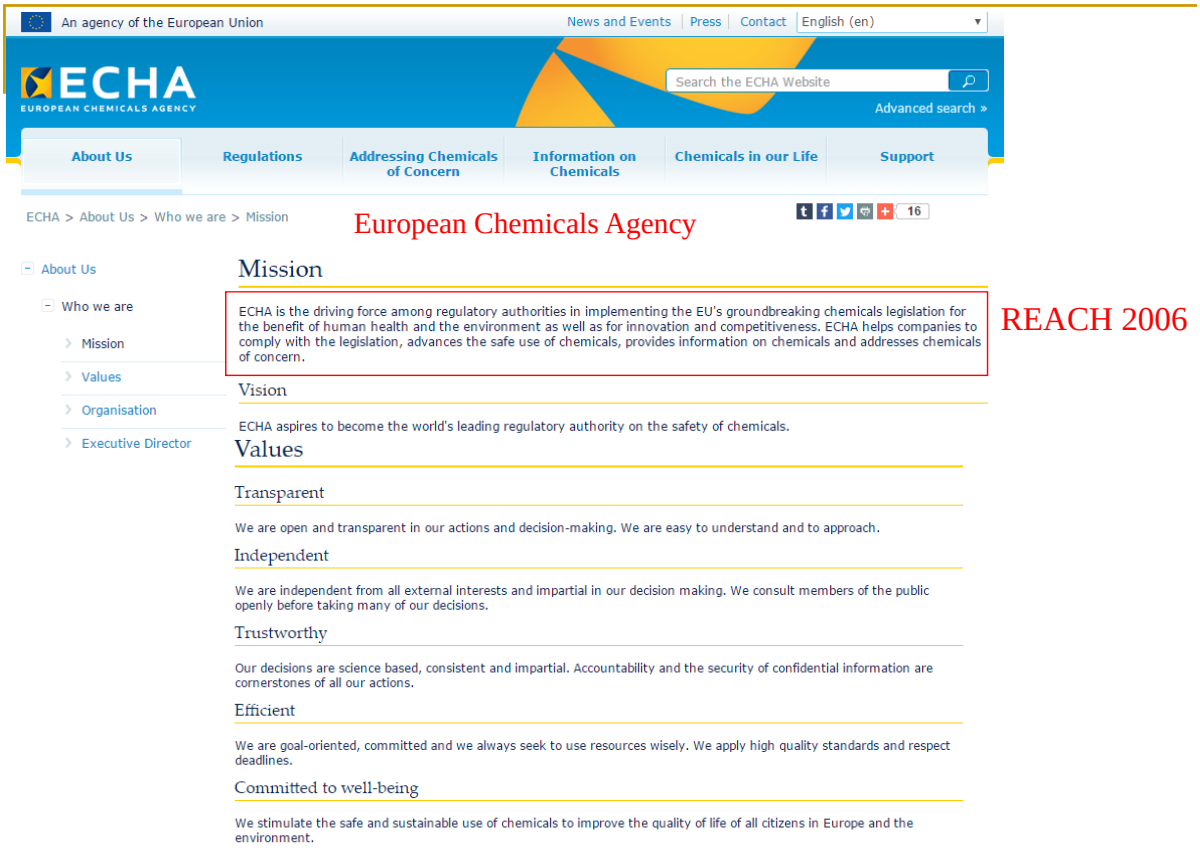
Minamata Convention
Global treaty to protect human health and the environment from the adverse effects of mercury

Strategic Approach to International Chemicals Management
Policy framework to foster the sound management of chemicals throughout their life-cycle to minimize significan the environment and human health

Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
The only global intergovernmental mechanism directly addressing the connectivity between terrestrial, freshwater, coastal and marine ecosystems

Montreal Protocol on Substances that Deplete the Ozone Layer
Designed to reduce the production and consumption of substances that deplete the ozone layer

Vienna Convention for the Protection of the Ozone Layer
Framework for efforts to protect the globe's ozone layer by promoting cooperation and adopting legislative or administrative measures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European Chemicals Agency
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Who we are
Mission
Values
Organisation
Executive Director
Mission
ECHA is the driving force among regulatory authorities in implementing the EU's groundbreaking chemicals legislation for the benefit of human health and the environment as well as for innovation and competitiveness. ECHA helps companies to comply with the legislation, advances the safe use of chemicals, provides information on chemicals and addresses chemicals of concern.
Vision
ECHA aspires to become the world's leading regulatory authority on the safety of chemicals.
Values
Transparent
We are open and transparent in our actions and decision-making. We are easy to understand and to approach.
Independent
We are independent from all external interests and impartial in our decision making. We consult members of the public openly before taking many of our decisions.
Trustworthy
Our decisions are science based, consistent and impartial. Accountability and the security of confidential information are cornerstones of all our actions.
Efficient
We are goal-oriented, committed and we always seek to use resources wisely. We apply high quality standards and respect deadlines.
Committed to well-being
We stimulate the safe and sustainable use of chemicals to improve the quality of life of all citizens in Europe and the environment.

REACH 2006


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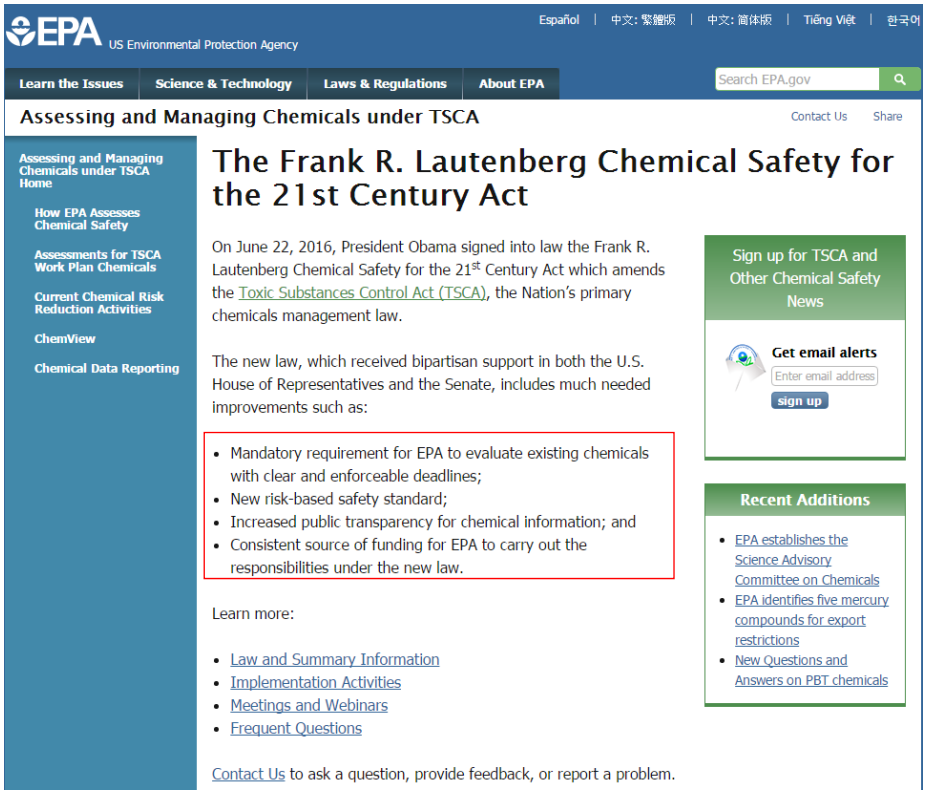
Chemicals in our Life
Chemicals are the building blocks of life. They are present in us, all around us, and in every product we buy.
Human beings and animals are made of chemicals; cooking food is all about chemistry; the drugs that prevent and treat illnesses are made of chemicals; and even the sun that enables life on earth is made of chemicals. Chemicals are both naturally occurring and manmade. Life would not exist without them.
In these web pages, we try to offer a perspective on how vital chemicals are, as well as how to use them safely .
Videos
Painting a Safer Europe
The Price You Pay
Infographs: safer use of chemicals
Less lead, more brain
Too itchy for your shoes?
How can I use chemicals safely?
Labels - Products - Workplaces
How European legislation on chemicals improves our lives
Hot topics

The Frank R. Lautenberg Chemical Safety for the 21st Century Act



EPA US Environmental Protection Agency

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Assessing and Managing Chemicals under TSCA

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- Assessments for TSCA Work Plan Chemicals
- Current Chemical Risk Reduction Activities
- ChemView
- Chemical Data Reporting

The Frank R. Lautenberg Chemical Safety for the 21st Century Act

On June 22, 2016, President Obama signed into law the Frank R. Lautenberg Chemical Safety for the 21st Century Act which amends the Toxic Substances Control Act (TSCA), the Nation's primary chemicals management law.

The new law, which received bipartisan support in both the U.S. House of Representatives and the Senate, includes much needed improvements such as:

- Mandatory requirement for EPA to evaluate existing chemicals with clear and enforceable deadlines;
- New risk-based safety standard;
- Increased public transparency for chemical information; and
- Consistent source of funding for EPA to carry out the responsibilities under the new law.

Learn more:

- Law and Summary Information
- Implementation Activities
- Meetings and Webinars
- Frequent Questions

Contact Us to ask a question, provide feedback, or report a problem.

Sign up for TSCA and Other Chemical Safety News

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Recent Additions

- EPA establishes the Science Advisory Committee on Chemicals
- EPA identifies five mercury compounds for export restrictions
- New Questions and Answers on PBT chemicals

https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/frank-r-lautenberg-chemical-safety-21st-century-act

行政院環境保護署毒物及化學物質局

（一）機關主要職掌：

1.毒性化學物質管理之政策規劃、法規研擬、執行及督導。

2.化學物質登錄制度之政策規劃、法規研擬、執行及協調。

3.毒性化學物質災害防制之政策規劃、法規研擬、執行及監督。

4.環境用藥管理之政策規劃、法規研擬、執行及督導。

5.化學物質資訊系統之規劃、建置、運用及協調事項。

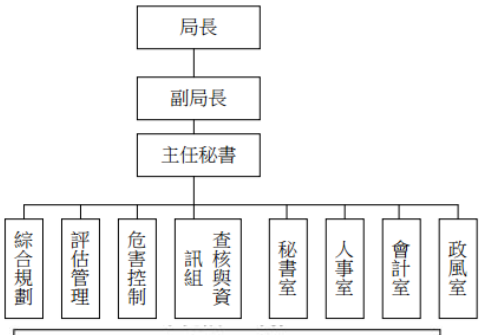
6.化學物質管理資訊整合、分析及化學物質運作之勾稽檢查。

7.毒性化學物質技術研究、發展及人員訓練。

維護食品安全，為攸關國人身體健康的重要課題，如何採取有效政策措施，確保國人能夠食的安心、吃的放心，乃政府責無旁貸的使命。而要落實食品安全，其中重要的工作之一，係採取源頭管理，從製成食品的原料端，將有毒物質與成分，透過整合各部會依法或權責所建立之化學物質管理資訊，包括認證、申報、登記、許可制度之相關資料，建立資料庫及流向追蹤之作法，期能從第一線把關，協助防止有毒物質流入食品，避免危害國人健康的風險。

爰此，行政院業將食品安全列為優先施政要項，刻正研訂「食安五環之推動政策」之總統政見，其中第一環即為「源頭控管，設立毒物管理機構」，本局即據此成立，配合中程施政計畫及核定預算額度，並針對經濟、社會情勢變化及本局未來發展需要，編定 106 年度施政計畫，其目標與重點如次：

行政院環境保護署毒物及化學物質局組織系統圖



（二）年度關鍵績效指標

關鍵策略目標		關鍵績效指標	評估制	評估方式	衡量標準	106年度目標值
一	強化化學物質管理	1 完成毒物局設置及運作	1	進度控管	依「食安五環之推動政策」之總統政見，資成相關主管機關研訂各項具體措施，其中第一環即為「源頭控管，設立毒物管理機構」，為此積極辦理毒物及化學物質局之籌備，訂於106年1月1日完成設置。	掛牌運作
二	加強環境清潔及毒性化學物質、環境用藥的管理	2 化學物質標準登錄資訊收集累計案件數	1	統計數據	化學物質核准標準登錄件數，自103年起累計	9件
三	健全毒性化學物質災害防救體系	1 30分鐘提供毒災事故緊急諮詢比率	1	統計數據	提出支援請求通報後30分鐘內提供環境敏感緊急諮詢之件數佔當年總請求支援件數之比率	90%
四	資訊及查核	完成化學署系統建置		進度控管	106年1月1日完成化學署系統建置，供各部會運用。	系統完成建置

THE PUBLIC HEALTH IMPACT OF CHEMICALS: KNOWNS AND UNKNOWNS

International Programme on Chemical Safety

World Health Organization

METHODS TO QUANTIFY POPULATION HEALTH IMPACTS

The population attributable fraction (PAF) is the proportional reduction in death or disease that would occur if exposure to a risk were removed or maximally reduced to an alternative level. To quantify population health impacts from exposure to chemicals, a systematic literature review compiled estimates and summaries of chemical exposure and links between the respective chemicals and disease or injury. The preferred source was global estimates of population impacts for selected chemicals based on comparative risk assessment (CRA), followed by estimates based on more limited epidemiological data or, finally, expert opinion (see Prüss-Ustün et al, 2016[1] for details on methods).

CHEMICALS AND THE SUSTAINABLE DEVELOPMENT GOALS

Reducing exposure to hazardous chemicals is essential to achieving the Sustainable Development Goals (SDGs), which aim:

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

By 2020, to achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment (Target 12.4).

3 GOOD HEALTH AND WELL-BEING

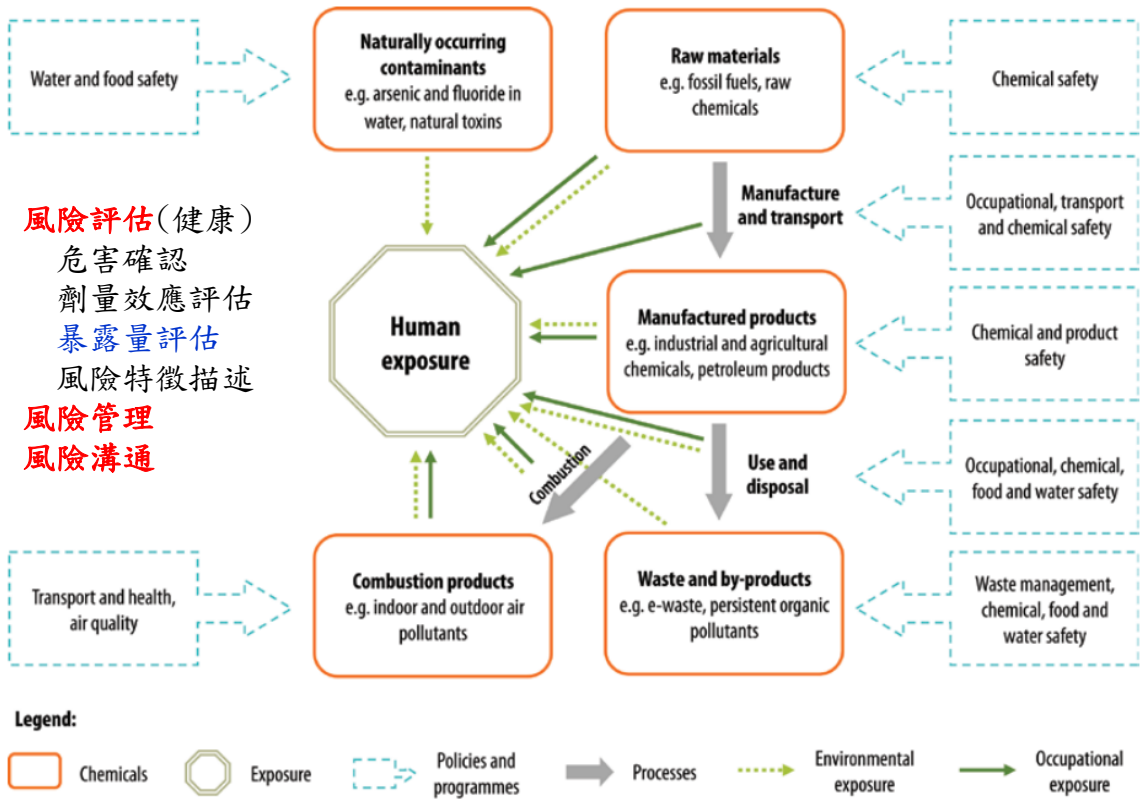
By 2030, to substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination (Target 3.9).

6 CLEAN WATER AND SANITATION

By 2030, to improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally (Target 6.3).

http://www.who.int/ipcs/publications/chemicals-public-health-impact/en/

Figure 2. Human exposure to chemicals throughout their life cycle and selected programmes relevant to their prevention

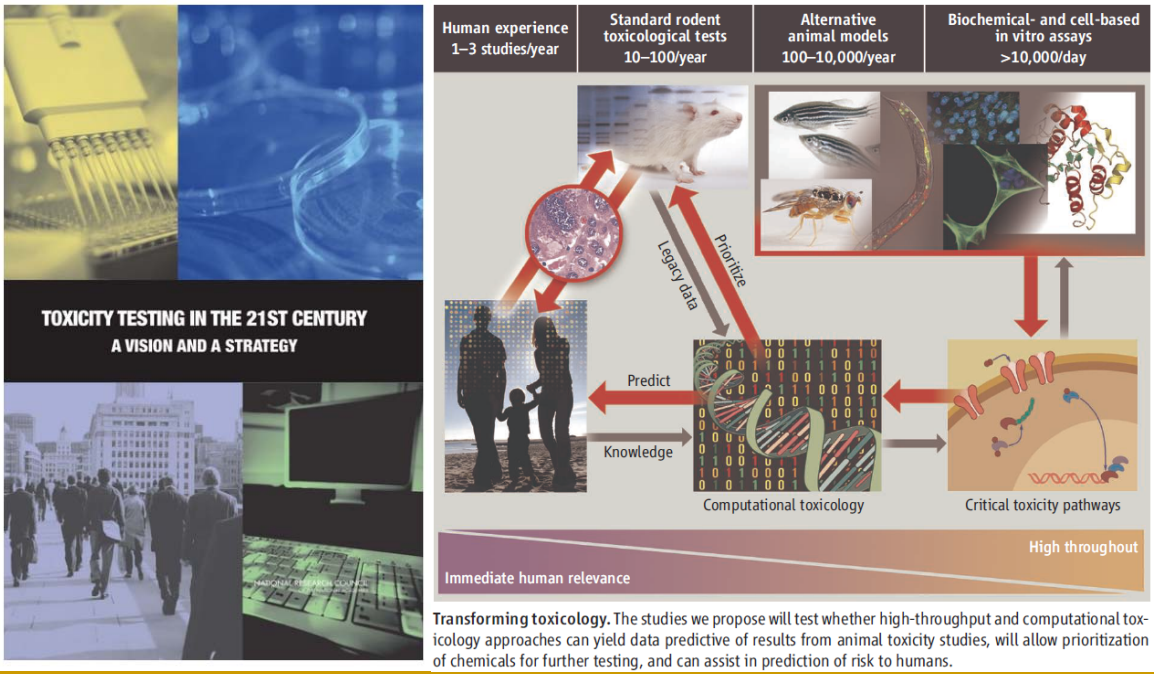


風險評估(健康)
危害確認
劑量效應評估
暴露量評估
風險特徵描述
風險管理
風險溝通

Source: Knowns and unknowns on burden of disease due to chemicals: A systematic review, Prüss-Ustün et al (2011).

21世紀的毒理測試 Transforming Environmental Health Protection

願景及策略NAP 2007 Science 2008



Transforming toxicology. The studies we propose will test whether high-throughput and computational toxicology approaches can yield data predictive of results from animal toxicity studies, will allow prioritization of chemicals for further testing, and can assist in prediction of risk to humans.

化學在創新永續未來的功能

nature chemistry

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NATURE CHEMISTRY | COMMENTARY

The role of chemistry in inventing a sustainable future

Stephen A. Matlin, Goverdhan Mehta, Henning Hopf & Alain Krief

Affiliations | Corresponding author

Nature Chemistry **7**, 941–943 (2015) | doi:10.1038/nchem.2389
Published online 09 November 2015

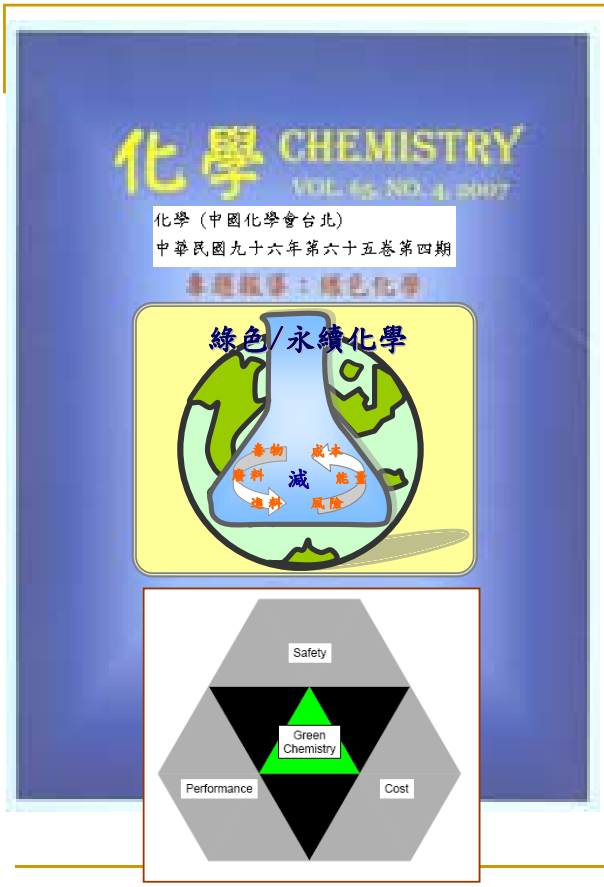
The Sustainable Development Goals adopted at a UN summit in September 2015 address many of the great challenges that our planet faces this century. Chemistry can make pivotal contributions to help realize these ambitious goals, but first it must undergo major changes in its priorities, approaches and practices.

化學在創新永續未來的功能

化學本身可以重塑形象作為永續發展的倡導者和驅動者，轉變其形象其從經常被視為環境污染和退化的來源，到被認為是永續發展的核心科學。

面對二十一世紀全球最偉大的挑戰，化學為實用的、永續的和道德的解決方案的主要驅動者。要做到這一點，需要進行徹底改革，相當於重新設計範疇–涵蓋化學的形象、方法和實踐–這將影響到教育、科研和其補助模式，並參與其他學科、業界和社會。

我們認為這些轉變是令人稱心的，因為這個世界需要化學盡最大努力，以避免或減輕當前正在揭開中的諸多全球性危機。我們也認為，建議的改革會重振化學的整個領域，和改造它的吸引力，可作為無愧於社會的投資和推崇的倫理科學。…



未能適當透過教育、訓練、宣導、溝通，導致公眾對化學的認知不足、甚至誤解、乃至濫用，化學與永續發展漸行漸遠，化學恐慌(Chemophobia)流病隱然形成，對化學品的非理性的恐懼，時有所聞。

綠色化學透過減毒化物、減廢棄物、減進料的三減手段，達到降低成本、降低能源、降低風險的三低目標，得以朝向永續發展目標邁進。說明綠色化學的重要性，首在提昇化學的社會形象，重建化學的永續發展形象。

John C. Warner
President and Chief Technology Officer
The Warner Babcock Institute for Green Chemistry

綠色/永續化學

- 永續發展定義：要能滿足當代的需求，同時不損及後代滿足本身需求的能力，亦即在提升和創造當代福祉的同時，不能以降低後代福祉為代價。其原則：**善用所有生態體系的自然資源**，不可降低其環境基本存量，亦即在利用生物與生態體系時，仍須維持其永遠的再生不息。**綠色/永續化學**定義：對環境友好的化學過程，利用化學技術與方法，減少或排除有害物質的使用與產生，以保護地球環境生態，在**人類永續發展**旅途上，扮演者重要角色。

挑戰與機遇

危機、轉機、契機

國立清華大學
NATIONAL TSING HUA UNIVERSITY

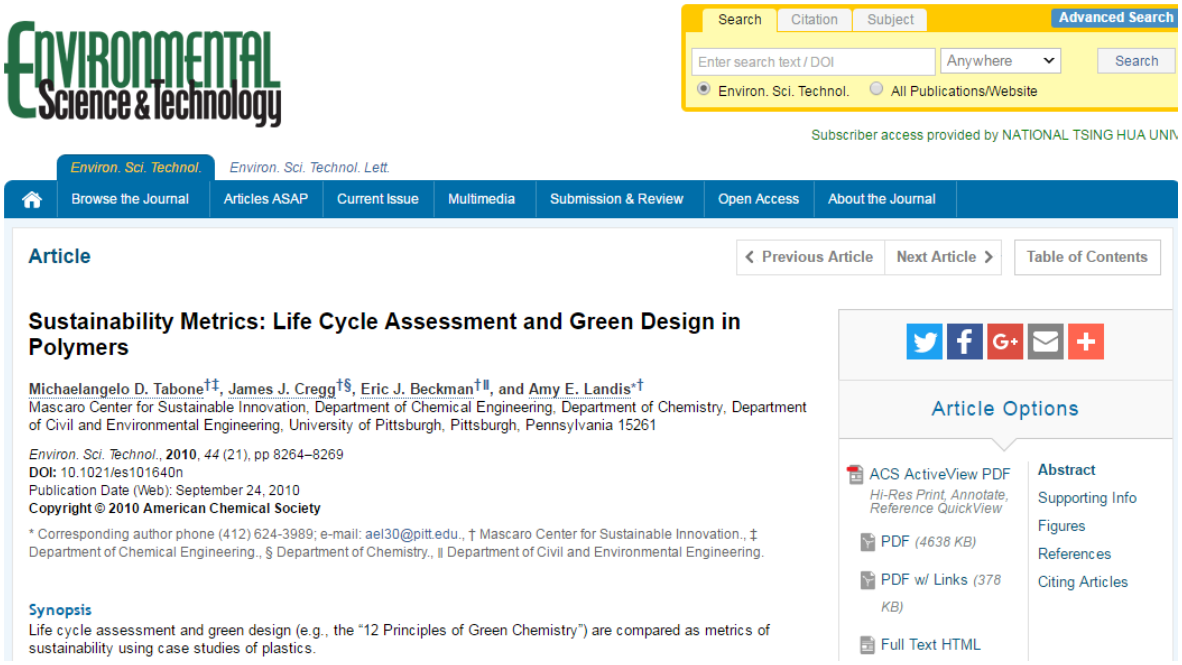
消費者化學

2016 年 11 月 4 日

【科普學術列車巡迴走透透-豐原高中】

主講人：
凌永健教授

國立清華大學
化學系



12 種高分子

- PolyEthylene Terephthalate (PET) 聚對酞酸乙二酯
- High Density PolyEthylene (HDPE) 高密度聚乙烯
- Low Density PolyEthylene (HDPE) 高密度聚乙烯
- PolyPropylene (PP) 聚丙烯
- PolyCarbonate (PC) 聚碳酸酯
- PolyVinyl Chloride (PVC) 聚氯乙烯
- General Purpose PolyStyrene (GPPS) 聚苯乙烯
- PolyLactic Acid (PLA)聚乳酸
  - General process (PLA-G)
  - Nature-Works LLC (PLA-NW)
- PolyHydroxyAlkanoate (PHA) 聚羟基脂肪酸酯
  - corn Grain (PHA-G)玉米粒
  - corn Stover (PHA-S)玉米秸稈
- hybrid bio/petroleum polymer; BioPolyethylene Terephthalate (B-PET)

Environ. Sci. Technol., **2010**, 44 (21), pp 8264–8269

Green Design Principles

12 Principles of Green Chemistry

GC 1. Prevention (Overall)
GC 2. Atom Economy
GC 3. Less Hazardous Chemical Synthesis
GC 4. Designing Safer Chemicals
GC 5. Safer Solvents and Auxiliaries
GC 6. Design for Energy Efficiency
GC 7. Use of Renewable Feedstocks
GC 8. Reduce Derivatives
GC 9. Catalysis
GC 10. Design for Degradation
GC 11. Real Time Analysis of Pollution Prevention
GC 12. Inherently Safer Chemistry for Accident Prevention

12 Additional Principles of Green Chemistry

A 1. Identify byproducts; quantify if possible
A 2. Report conversions, selectivities, and productivities
A 3. Establish a full mass balance for the process
A 4. Quantify catalyst and solvent losses
A 5. Investigate basic thermochemistry to identify
A 6. Anticipate other potential mass and energy transfer
A 7. Consult a chemical or process engineer
A 8. Consider the effect of the overall process on
A 9. Help develop and apply sustainable measures
A 10. Minimize use of utilities and other inputs
A 11. Identify safety and waste minimization are incompatible
A 12. Monitor, report and minimize wastes

12 Principles of Green Engineering

GE 1. Inherent rather than circumstantial
GE 2. Prevention instead of treatment
GE 3. Design for separation
GE 4. Maximize mass, energy, space, and time
GE 5. Output-pulled versus input-pushed
GE 6. Conserve complexity
GE 7. Durability rather than immortality
GE 8. Meet need, minimize excess
GE 9. Minimize material diversity
GE 10. Integrate local material and energy flows
GE 11. Design for commercial "afterlife"
GE 12. Renewable rather than depleting

Table 1. Metrics for Green Design Principles

theme	metric	principles referenced
avoid waste	atom economy	GC 2, A1, A3
material efficiency	density	GE 8, GE 4
avoid hazardous materials/pollution	TRACI health and ecotoxicity impacts	GC 3−5, 11; GE 2
maximize energy efficiency	Total Energy Demand	GC 6, A 10, GE 3, 4, 10
use of renewable sources	percent from renewable sources	GC 7, GE 12
use local sources	feedstock distance	GE 10
design products for recycle	percent recycled	GE 3, 6, 9, and 11
design to degrade	biodegradability	GC 10
cost efficiency	price	GE 9

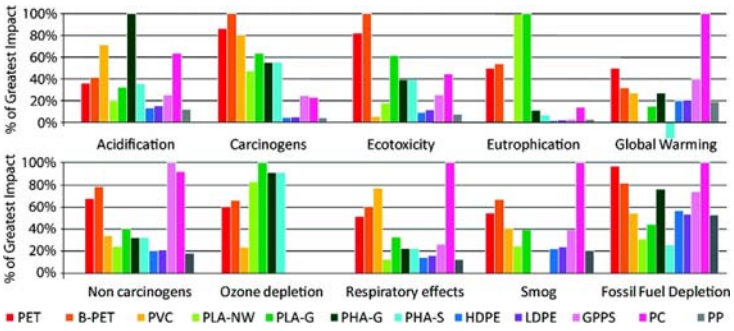


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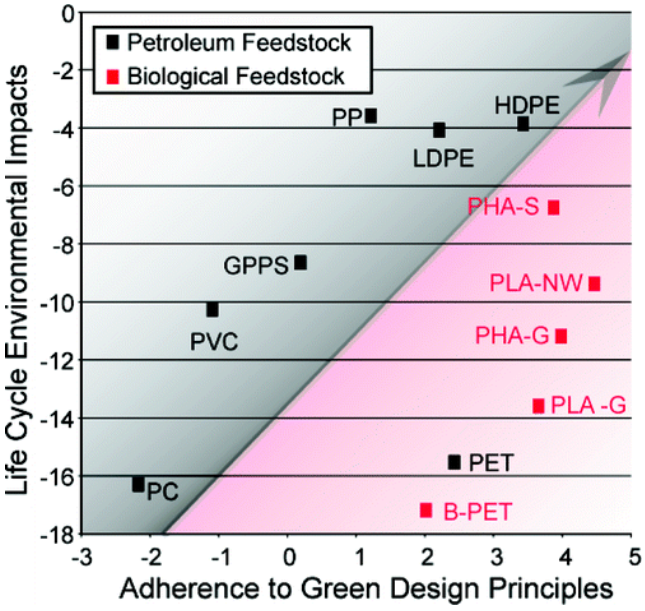
Table 3. Rankings for Each of the Polymers Based the Normalized Green Des Assessment Results and the Normalized Life Cycle Assessment Results

Material	Green Design Rank	LCA Rank
PLA (NatureWorks)	1	6
PHA (Utilizing Stover)	2	4
PHA (General)	2	8
PLA (General)	4	9
High Density Polyethylene	5	2
Polyethylene Terephthalate	6	10
Low Density Polyethylene	7	3
Bio-polyethylene Terephthalate	8	12
Polypropylene	9	1
General Purpose Polystyrene	10	5
Polyvinyl chloride	11	7
Polycarbonate	12	11



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購物用塑膠袋限制使用對象、實施方式及實施日期修正草案總說明

行政院環境保護署於九十一年七月開始推動「購物用塑膠袋及塑膠類（含保麗龍）免洗餐具限制使用政策」，依據廢棄物清理法第二十一條授權，公告「購物用塑膠袋及塑膠類(含保麗龍)免洗餐具限制使用對象、實施方式及實施日期」。復針對有店面餐飲業之管制進行檢討，於九十五年四月十八日修正公告；於九十五年六月九日廢止公告後，區分「購物用塑膠袋」及「免洗餐具」二部分於九十五年六月九日再分別重新公告。

為持續推廣自備購物袋鼓勵重複使用理念，減少用過即丟之一次用購物用塑膠袋，行政院環境保護署參考近年國際間塑膠袋管制趨勢、國內外海洋污染議題，將過去各界反映厚度限制、塑膠袋收費等建議事項納入考量。本次新增七大類管制對象，並取消共計十四大類管制對象之購物用塑膠袋厚度管制，以進一步減少塑膠使用量；維持付費取得機制（付費金額由業者自行訂定），且要求於購物用塑膠袋或提供場所標示鼓勵重複使用及妥善回收之宣導文字；並為使限制使用對象得以因應所涉相關管理規範要求，給予一定緩衝期間，爰擬具「購物用塑膠袋限制使用對象、實施方式及實施日期」修正草案，其修正要點如下：

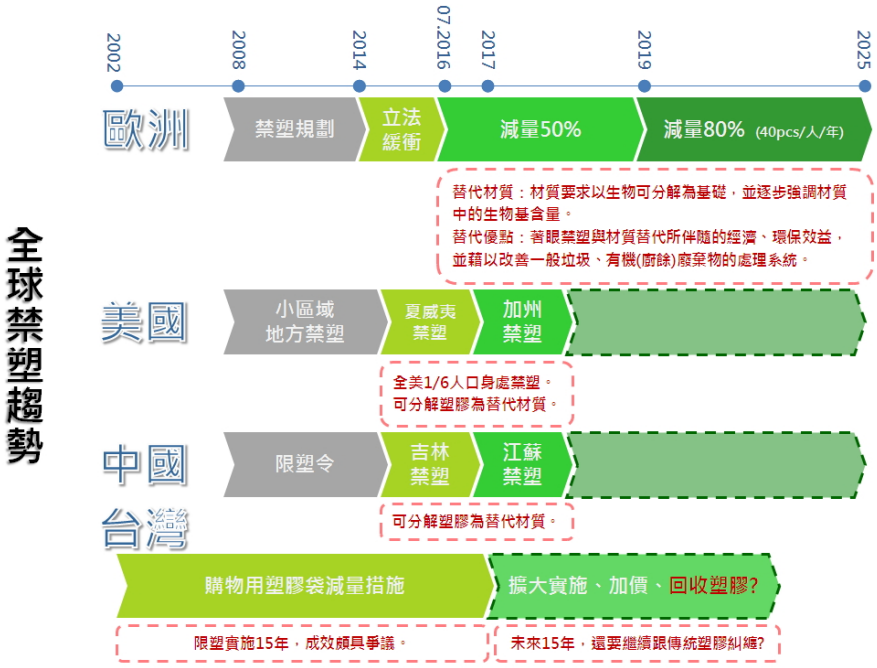
一、參酌國際對購物用塑膠袋之管理趨勢，新增藥局及藥粧店、醫療器材行、家電攝影資訊及通訊設備零售業、書籍及文具零售業、洗衣店業、飲料店業、西點麵包店業等七大類為限制使用對象。（修正公告事項一）

二、取消購物用塑膠袋厚度應達０．０六公釐之限制，回歸由限制使用對象依其使用性質自行選擇最適化之厚度。（修正公告事項二）

三、限制使用對象提供購物用塑膠袋應標示鼓勵重複使用及妥善回收之宣導文字，並鼓勵購物用塑膠袋與專用垃圾袋兩袋合一之減少塑膠袋使用方式。另增訂主管機關得派員檢查購物用塑膠袋限制使用執行情形，以強化監督。（修正公告事項三）

編號	品名	組成標示	購買地點/廠家	檢測結果
1	菲力家族環保分解清潔袋(大)	高密度聚乙烯、奈米碳酸鈣、環保玉米澱粉、植物香精油	竹北市寶雅	PE
2	卡柏綠活茶樹清潔袋(中)	高密度聚乙烯、奈米碳酸鈣、環保玉米澱粉、植物香精油	台中市向上	PE
3	OP玉米分解袋(小)	HDPE、玉米澱粉等原料	竹北市家樂福	PE
4	OP生物分解清潔袋(中)	d2w分解粒子、高密度PE	竹北市家樂福	PE
5	OP生物分解密封袋	d2w分解粒子、可分解PE(耐熱度-30˚C~70˚C	竹北市家樂福	PE
6	OP花香分解袋(中)	HDPE、玫瑰精油、玉米澱粉等OP環保配方	竹北市家樂福	PE
7	EP碳酸鈣清潔袋(中)	HDPE、CaCO3	竹北市寶雅	PE
8	碳酸鈣清潔袋(中)	HDPE+LLDPE+CaCO3	竹北市寶雅	PE
9	家荊屋除 香氛分解清潔袋	高密度聚乙烯、奈米碳酸鈣、薰衣草精油	竹北市家樂福	PE
10	百過達果香防渦清潔袋S	聚乙烯、碳酸鈣、檸檬香精	竹北市家樂福	PE
11	妙潔平底清潔袋L	高密度聚乙烯、碳酸鈣	竹北市寶雅	PE
12	一般垃圾專用袋	生物可分解塑膠	清華大學	PE
13	購物袋	100%生物可分解購物袋，不含4P(PE、PP、PS、PVC)--環保標章:選標字第10411號	新竹光復棉花田生機園地	不含4P
14	環保清潔袋	100%生物可分解可推肥環保袋，不含限用PE、PP、PS、PVC、PET等泛用塑膠，以天然玉米澱粉為主要原料	新竹市振興行	不含4P
15	(全家咖啡)塑膠袋	100%生物可分解購物袋	新竹市公學店	不含4P
16	(7-11咖啡)塑膠袋	100%生物可分解塑膠不含4P(PE、PP、PS、PVC)	新竹市南寮	不含4P
17	狗便袋	100% biodegradable compostable material.	台中市	不含4P
18	公版三斤袋	100%生物可分解塑膠不含4P(PE、PP、PS、PVC)	台中市	不含4P

禁塑 →生塑→綠質→永續的消費



誌 謝

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Ministry of Science and Technology, R.O.C.

- Ministry of Science and Technology
- National Tsing Hua University
- Green Chemistry and Mass Spectrometry Laboratory

新(個人)思維
全球及在地
管理及安全
風險及暴露
毒理及創新
永續發展指標
禁塑生塑綠質