出國報告（出國類別：開會）

參加第22屆綠色化學及工程年會

服務機關：行政院環境保護署毒物及化學物質局
姓名職稱：蕭寶桂特約高級環境技術師/洪靜宜專員
派赴國家/地區：美國/波特蘭
出國期間：107年6月16日至6月24日
報告日期：107年11月23日

摘要

行政院環境保護署毒物及化學物質局，自 105 年 12 月 28 日成立後，依據聯合國國際化學物質管理策略方針訂定我國化學物質管理 5 大目標 9 項指標，其中在「降低風險」及「知識建立」目標中，本局以綠色化學教育推廣作為推動策略之一，參考美國綠色化學 12 項原則及德國 10 項黃金準則，希冀建立適合本國大專校院之綠色化學課程，課程建立過程中並配合產業訪視瞭解產業需求、部會合作瞭解部會推動相關策略，進而建立產、官、學、研鏈結。106 年的推動成果中，獲得產業、學術、部會的回饋，為瞭解國際在綠色化學推動的方向及成果，並希冀能將本國經驗與國外產、官、學、研交流，整理後以「The Green Chemistry Education and Promotion in Taiwan- Experience from Taiwan Toxic and Chemical Substances Bureau」投稿美國化學會辦理第 22 屆綠色化學與工程年會 （22nd Annual Green Chemistry & Engineering Conference, GC&E），並獲大會接受以口頭報告方式發表。

美國奧勒岡州波特蘭市(Portland, Oregon)舉行的第 22 屆綠色化學與工程年會會議主題為「應用綠色化學原則發展創新產品 (Product innovation using greener chemistries)」，藉由綠色化學在教育及產業之創新作為及理念建立產、學交流，議題涵蓋綠色設計、綠色產業、綠色產品、環境正義、綠色化學之教育推廣及實施策略等面向。此年會為各國相關領域專家學者交流之平臺，並且藉由年會的辦理，串聯產業的需求，建立學術的資訊。

本次以行政院環境保護署毒物及化學物質局之名義，投稿參與國際研討會，除可與國際學者交流綠色化學推動策略，並交換相關教育推動、政策推動經驗及需求，並使國際瞭解本國推動情形。此次與會收穫頗豐，包含與美國提出綠色化學 12 項原則教授 Paul Anastas 交流綠色化學 12 項原則推動教育的重點及成果，並取得奧勒岡大學教授 Julie Haack 同意分享其建置之大專校院綠色化學課程，並與參與會議之產業交流產業對於綠色化學的想法，以及瞭解民間環保公益團體對於綠色化學改善環境的期待，並由分享我國推動經驗中建立未來互動之管道。

目錄

一、 目的

行政院環境保護署毒物及化學物質局，自 105 年 12 月 28 日成立後，依據聯合國國際化學物質管理策略方針訂定我國化學物質管理 5 大目標 9 項指標，其中在「降低風險」及「知識建立」目標中，本局以綠色化學教育推廣作為推動策略之一，參考美國綠色化學 12 項原則及德國 10 項黃金準則，希冀建立適合本國大專校院之綠色化學課程，課程建立過程中並配合產業訪視瞭解產業需求、部會合作瞭解部會推動相關策略，進而建立產、官、學、研鏈結。106 年的推動成果中，獲得產業、學術、部會的回饋，為瞭解國際在綠色化學推動的方向及成果，並希冀能將本國經驗與國外產、官、學、研交流，整理後以「The Green Chemistry Education and Promotion in Taiwan- Experience from Taiwan Toxic and Chemical Substances Bureau」投稿美國化學會辦理第 22 屆綠色化學與工程年會(22nd Annual Green Chemistry & Engineering Conference, GC&E)，並獲大會接受以口頭報告方式發表。

本次以行政院環境保護署毒物及化學物質局之名義，投稿參與國際研討會除可與國際學者交流綠色化學推動策略，並可交換相關教育推動、政策推動經驗及需求，並使國際瞭解本國推動情形。

二、 過程

美國化學會綠色化學研究所今（107）年於美國奧勒岡州波特蘭市舉辦第 22 屆綠色化學及工程年會（22nd Annual Green Chemistry & Engineering Conference），其討論議題涵蓋綠色設計、綠色產業、綠色產品、環境正義、綠色化學之教育推廣及實施策略等面向，為各國相關領域專家學者之交流平臺。本次的會議主題為「應用綠色化學進行產品創新 Product innovation using greener chemistries」，提供國際創新綠色化學作法作為產業應用與高等教育訓練上之參據。

表 1. 出國行程與內容概要：

日　期	工 作 內 容 概 要
107.06.16	啟程，搭機前往美國波特蘭
107.06.17	研討會前報告準備
107.06.18~23	參加第 22 屆綠色化學與工程年會 （22nd Annual Green Chemistry & Engineering Conference） 拜會當地致力於推動綠色化學之學者專家交流相關經驗 參訪當地推動綠色化學教育單位
107.06.23~24	返程，搭機返回臺灣

表 2.年會相關議題重點摘錄說明如下

議題	主講人	內容摘錄
提供針對發展中國家推廣及應用綠色化學的指導策略 Providing Guidance for a Wide Distribution & Implementation of Green Chemistry to Developing Countries Brainstorming Workshop	Paul Anastas	耶魯大學產業發展組織(industrial developing organization)推動綠色化學的策略及想法如下： 1. 建議推動綠色化學應從毒性化學物質的風險認知及知識優先推行； 2. 鼓勵使用綠色化學相關產品，而綠色化學產品思考角度除考量產業尺度亦應全方位考量全球化尺度。 3. 政府應策略性投資綠色化學科技，並應規劃國家型計畫整合及推動產業、政府及社會合作； 4. 政府補助計畫將有助於綠色化學整體推動； 5. 綠色化學推動作為應包含制定綠色化學相關法律，由政府部會，特別是化學相關部會共同著手； 6. 鼓勵教師將綠色化學納入課程； 7. 在哥倫比亞、南非、埃及等開發中國家辦理一系列工作坊，包含： (1) 1 day Awareness Raising workshop (2) 5 days Train the facilitators workshop (3) University curriculum (4) Technology Compendium (5) Guidance Documents: roadmap
產業應用綠色化學與工程原則 Industrial Applications of Green Chemistry & Engineering Principles	Thomas McKeag, Barbara J Henry	1. UC Berkeley 設立綠色化學研究中心，推動策略為建置綠色化學相關課程，包含教育、研究和強化資訊鏈結，強化由化學特性及功能找出可能替代物，並瞭解程序及系統中的化學品基礎原理； 2. 由源頭設計規劃產製更安全的產品，而非在後續程序及工程控制進

議題	主講人	內容摘錄
		行改善； 3. 針對可能替代物進行化學品危害評估； 4. 近期研究包含使用新式科技導入現有紡織產品，使其防水、防油。例如因應 PFCs 毒害環境之議題，在產品設計中改使用短鍊氟化物於外套類織品，並評估其是否為低毒性，以取代產品設計中 PFCs-EC。 5. 在奈米發展議題上，提出應考慮現有污水處理設施能力，因目前無法由處理設備中移除奈米纖維，因此會影響全球環境。
培養綠色「化學樹」 Nourishing the Green ChemisTREE	Julie Zimmerman	1. 綠色化學在過去 20 年間發表論文研究的數量逐漸成長，證實綠色化學推動逐步獲得重視，且推動綠色化學不能僅單靠綠色化學原則推廣，需考量加入實際議題及溝通語言，例如教育化學專業人員瞭解產業及經濟議題、以生活化方式導入綠色化學觀念及行銷，引導學生學習； 2. 綠色化學於科學分析的研究重點之一為溶劑的取代； 3. 實施綠色化學最大的挑戰是如何在社會環境中量化利益，吸引產業投入，由關注利害關係人角度推動綠色化學，進行市場行銷；
綠色化學創新課程 Rapid Fire Session	Jane Wissinger, Michael Wentzel	1. 鼓勵閱讀期刊論文發表,啟發學生瞭解綠色化學並參與相關研究； 2. 為提升綠色化學推動成果效能,具備基礎科學知識相當重要，例如為了提升能源效率，應具備熱力學和動力學知識、為使能源有效運用，須配合生命週期評估。
綠色化學教育、研究與創新的系統	Jim Hutchison	1. 教育的設計應有系統性的思維,單元之間應有明確的連結與回饋。

議題	主講人	內容摘錄
思維 Systems Chemistry: An Introduction to Systems Thinking in Green Chemistry Education, Research & Innovation		2. 透過設計給化學家參與的課程範例，提供設計課程的參考： (1) 思考如何獲得 1 杯咖啡； (2) 設計安全實驗室的全面性考量； (3) 設計合成藥物實驗方法。

(二) 致力於推動綠色化學之學者專家交流相關經驗：

1. 訪問美國耶魯大學教授-Julie Zimmerman，瞭解耶魯大學的綠色化學課程系統如何將綠色化學和綠色工程原理應用於產品、工程和系統的創新設計，並提出綠色化學教育及產業推動需要跨領域的合作及資訊導入，以行銷及生活語言導入使化學等相關專業人員關注大眾議題，並藉由課程設計誘發學生興趣。

2. 訪問執行 EPA safer choice, Toxic release inventory 兩套線上公開系統顧問公司執行經理- TJ Pepping，瞭解美國環境保護署如何鼓勵永續化學推動工作。

   (1) Safer Choice program 是民間自主參加制度，廠商可備妥自家商品之原料成分，送 EPA 認可之專家審查，通過成分審查之商品，將可獲得相關標示，提供大眾有更多替代商品選擇。參加該制度認證之商品成分可於 EPA 網站（https://www.epa.gov/saferchoice）中搜尋相關資料。

   (2) 推行的困難點為因屬於自主參加制度，非所有廠商均提供資料，以及如何尋求相關利害關係人參加，並將此制度推動至大眾及社區。

(三) 參訪當地推動綠色化學教育單位：

訪問奧勒岡大學化學與生物學系教授 Jim Huchison，瞭解在奈米議題上，如何使奈米材料及製程符合綠色化學原則，在教育課程推動上，以系統性思考導入專業化學教育，設計使化學課程更容易被學生接受及跨學科交流。

三、 心得與建議

參與會議後發現，美國綠色化學年會主要以產業及研發參與居多，藉此每年固定辦理之年會平臺可使研發有展示空間及獲取回饋，產業亦可瞭解綠色化學相關新穎安全永續作法，以及上、下游產業對於綠色化學取代、應用及推廣之作為。

2018 年美國化學會辦理之綠色化學、工程年會發表較多的議題包含藥品設計、美妝、清潔劑、生活品設計、乾洗業操作流程，顯見與生活相關的化學品製造、設計及使用為美國產業關注之重點，且由與會者積極對答中顯示美國產業及教育對於綠色化學的推動頗為重視。

此次研討會參與者隸屬公務機關單位者較少，主要以學術界、產業為主。透過論文發表本局於臺灣推動綠色化學之初步成果及面臨之困難處頗獲與會者之重視，因此獲大會以口頭方式安排於 Green Chemistry: Environmental Justice to Social Equity 發表。

建議臺灣未來推動綠色化學大專校院教育可參考奧勒岡大學 Julie Haack 的教材，其設計之綠色化學課程及教材融入通識及基礎化學概念，較為淺顯易懂，且富吸引力。

四、 附錄

附錄一：年會議程
附錄二：投稿摘要
附錄三：出國剪影

附錄一


22nd Annual
Green Chemistry &
Engineering Conference
Product innovation using greener chemistries
PORTLAND, OR | JUNE 18 - 20, 2018
ACS
Chemistry for Life®
American Chemical Society
ACS
Green Chemistry
Institute®
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MONDAY, JUNE 18, 2018
AT-A-GLANCE

7:15 – 8:15 a.m. Networking Breakfast	Pavilion Ballroom
8:15 – 9:30 a.m. Keynote by Joe DeSimone, Ph.D., "Digital Sustainability: How Carbon's Light Synthesis Can Usher in a New Level of Societal & Environmental Benefits"	Pavilion Ballroom
9:30 – 9:45 a.m. Networking Break	Plaza Foyer
9:45 a.m. – 12:30 p.m. Concurrent Sessions	
Providing guidance for a wide distribution & implementation of green chemistry to developing countries brainstorming workshop	Atrium Ballroom
Bidirectional communication in the electronics supply chain to drive green chemistry	Broadway I/II
Decision science for real-world chemical selection	Broadway III/IV
Transforming consumer & industrial products by material & chemical innovations	Galleria North
Chemistry in water: Following nature's lead	Galleria South
Innovation for bio-based & renewable chemicals	Skyline II
12:30 – 1:30 p.m. Lunch on own	

1:30 – 2:55 p.m. Concurrent Sessions	
Green chemistry: Environmental justice to social equity	Atrium Ballroom
Bidirectional communication in the electronics supply chain to drive green chemistry	Broadway I/II
Real-world sustainability challenges: Incentives and barriers to the use of green chemistry in products	Broadway III/IV
Greener design in the pharmaceutical industry: From discovery to commercial processes	Galleria North
Achieving sustainable products through molecular design with reduced toxicity	Galleria South
Industrial applications of green chemistry & engineering principles	Skyline II
2:55 – 3:15 p.m Networking Break	Plaza Foyer
3:15 – 4:35 p.m. Concurrent Sessions Continued	
4:35 – 4:55 p.m Networking Break	Plaza Foyer
4:55 – 5:55 p.m. Concurrent Sessions Continued	
6:30 – 8:00 p.m. Welcome Reception	Skyline I/II

TUESDAY, JUNE 19, 2018
AT-A-GLANCE

7:15 – 8:15 a.m. Networking Breakfast	Pavilion Ballroom
8:15 – 9:30 a.m. Keynote by Don Sadoway, Ph.D., "Electrochemical Pathways towards Sustainability"	Pavilion Ballroom
9:30 – 9:45 a.m. Networking Break	Plaza Foyer
9:45 a.m. – 12:30 p.m. Concurrent Interactive Discussion Sessions	
Implementation strategies for greener chemistry in products: What are the barriers, opportunities and key elements for making sustainable consumer goods?	Atrium Ballroom
Minimizing ecotoxicity and persistence in chemicals and materials	Broadway I/II
Building green businesses	Broadway III/IV
Systems chemistry: An introduction to systems thinking in green chemistry education, research and innovation	Galleria North
Metrics: Advances and limitations in determining the greenness of drug manufacturing	Galleria South
Beyond actives: Increasing personal care product sustainability by holistic design	Skyline I
12:30 – 1:30 p.m. Lunch on own	

1:30 – 2:55 p.m. Concurrent Sessions	
Educational initiatives in sustainable polymers and materials	Atrium Ballroom
Commercial applications of biobased monomers for the polymer industries	Broadway I/II
Developing products for a more sustainable future	Broadway III/IV
Emerging technologies to enable sustainable organic synthesis: Special organic chemistry student session	Galleria North
Supplanting petroleum with renewable carbon	Galleria South
Continuous processing: An enabling technology for green chemistry	Skyline I
2:55 – 3:15 p.m Networking Break	Plaza Foyer
3:15 – 4:35 p.m. Concurrent Sessions Continued	
4:35 – 6:35 p.m Poster Session & Reception and Product Showcase	Pavilion Ballroom
6:30 – 8:00 p.m Green chemistry, equity and environmental justice: Educational resources and research collaboration workshop	Galleria North
6:45 – 9:00 p.m. ACS GCI Industrial Roundtable Poster Reception **Invited only with ticket**	Atrium Ballroom
7:00 – 9:30 p.m. Performing Art of Science Workshop **Pre-registered only with ticket**	Broadway I/II

WEDNESDAY, JUNE 20, 2018
AT-A-GLANCE

5:45 a.m. Meet for Fun Run/Walk to leave at 6 a.m.	Hotel Lobby
7:15 – 8:15 a.m. Networking Breakfast	Pavilion Ballroom
8:15 – 9:30 a.m. Keynote by Julie Zimmerman, Ph.D., "Nourishing the green chemisTREE"	Pavilion Ballroom
9:30 – 9:45 a.m. Networking Break	Plaza Foyer
9:45 a.m. – 12:30 p.m. Concurrent Sessions	
Green chemistry innovations in the classroom: Rapid fire session	Atrium Ballroom
Green chemistry and engineering for peptides, oligos and ADCs	Broadway I/II
Accelerating development of sustainable products and processes through start-ups and SMEs	Broadway III/IV
Towards safer design strategies: Using toxicology tools and concepts with chemistry courses and programs	Galleria North
Innovation chemistry and process development for sustainable small molecule manufacturing	Galleria South
Charting the course to sustainable chemistry in the supply chain workshop: Lessons learned	Skyline I
12:30 – 2:00 p.m. Lunch on own	

2:00 – 3:25 p.m. Concurrent Sessions	
Green chemistry innovation in the classroom: Rapid fire session	Atrium Ballroom
Bioenzymatic approaches to solve activity and selectivity challenges in process development	Broadway I/II
Accelerating development of sustainable products and processes through start-ups and SMEs	Broadway III/IV
Towards safer design strategies: Using toxicology tools and concepts with chemistry courses and programs	Galleria North
Biobased chemicals: Beyond drop-in replacements	Galleria South
Charting the course to sustainable chemistry in the supply chain workshop: Gaps, challenges and needs	Skyline I
3:25 – 3:45 p.m Networking Break	Plaza Foyer
3:45 – 5:05 p.m. Concurrent Sessions Continued	
6:15 – 8:15 p.m Green Chemistry on Tap Pub Crawl	Hotel Lobby

Thanks to the GC&E Advisory Committee

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附錄二：投稿摘要

SUBMISSION ROLE: 22nd Annual Green Chemistry & Engineering Conference
CONTROL ID: 2964024
ABSTRACT SYMPOSIUM NAME: Green Chemistry: Environmental Justice to Social Equity (Oral)

AUTHORS (FIRST NAME, LAST NAME): Pao Kuei Hsiao[1], Yen-Rui Hsieh[1], Yi-Kuen Liu[1], Sung Ching Lin[1], Yu-Chun Wang[2], Yu-kai Lin[3], Hung-Te Hsu[3]
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TITLE: The Green Chemistry Education and Promotion in Taiwan- Experience from Taiwan Toxic and Chemical Substances Bureau

ABSTRACT: Toxic and Chemical Substances Bureau (TCSB) under the Taiwan Environmental Protection Administration has substantially enhanced the quality and quantity of management of toxic and chemical substances since 2016. TCSB has being playing an active role on greener chemistry, requiring greener manufactural processes, education course design and environmental health and safety on campus. TCSB cooperated with Department of Education on continuing education in green chemistry education and toxicological disaster prevention trainings in tertiary institutions to achieve the goals of green chemistry promotion and prevention and responses to toxicological changes. In 2017, we conducted the assessment for the implementations and limitations of “12 principles of Green Chemistry” in five corporations in various industries. These five sustainable manufacturing companies in Taiwan have devoted to achieve the same goal: efficient and safe production processes as well as sustainability. Generally, we found the “12 principles of Green Chemistry” have been well implied in the product design and manufacturing processes. However, they planed the progress on the life-cycle assessment without been fully introduced the concepts of these principles implying the insufficiency and importance of public and environmental education on green chemistry. Meanwhile, green chemistry courses were summarized and rescheduled
to proceed to make the students comprehend the rules of green chemistry in higher education. Moreover, activities like green chemistry seminars, toxicological disaster prevention education and promotion, field trips and demonstrations of emergency response equipment were simultaneously conducted to educate the public concepts of environmental protection, safety and social responsibility, the core spirit of TCSB.

附錄三：出國剪影

(1) EPA safer choice, Toxic release inventory線上公開系統

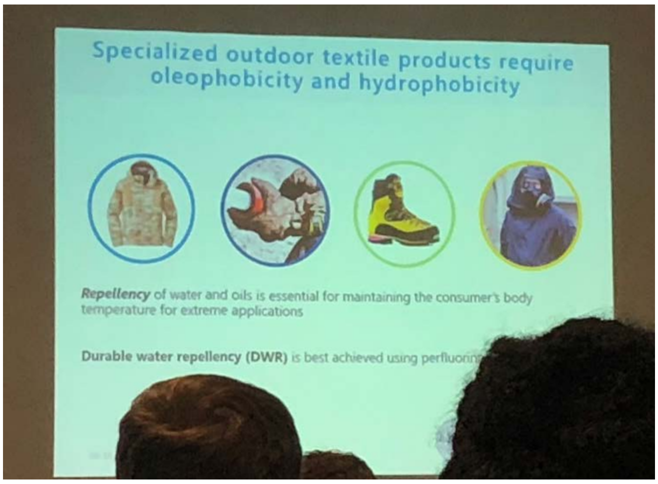
與談者：TJ Pepping (EPA委外顧問公司)

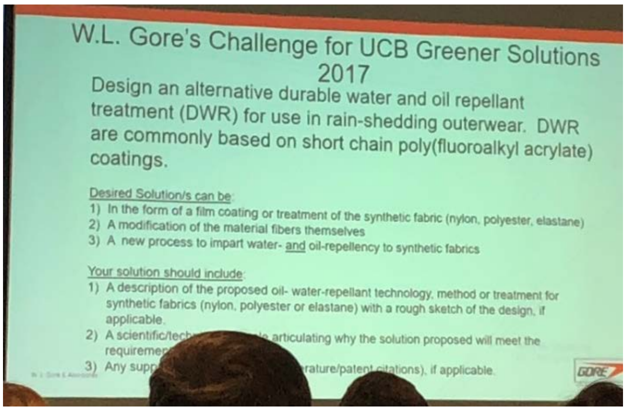
(2)Section: Providing Guidance for a Wide Distribution & Implementation of Green Chemistry to Developing Countries Brainstorming Workshop

與談者：Paul Anastas

(3) Industrial Applications of Green Chemistry & Engineering Principles

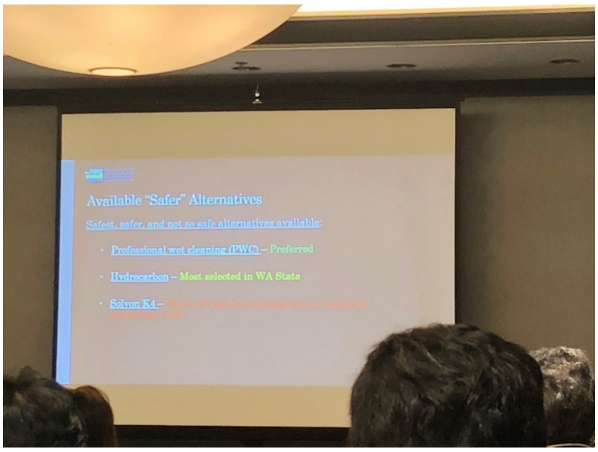
主持人：Thomas McKeag, Barbara J Henry

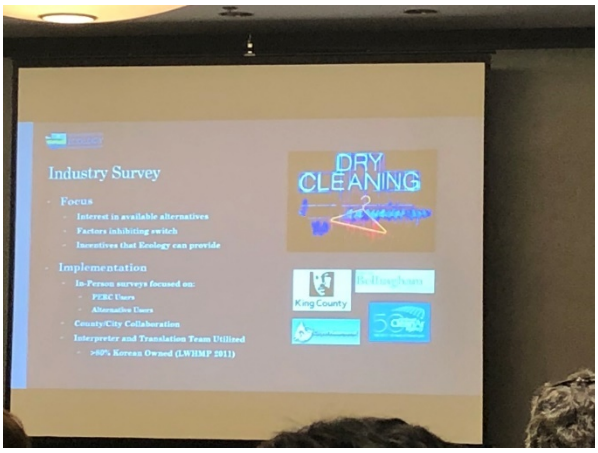


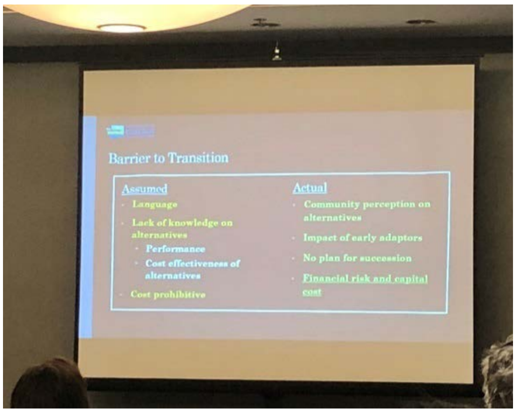


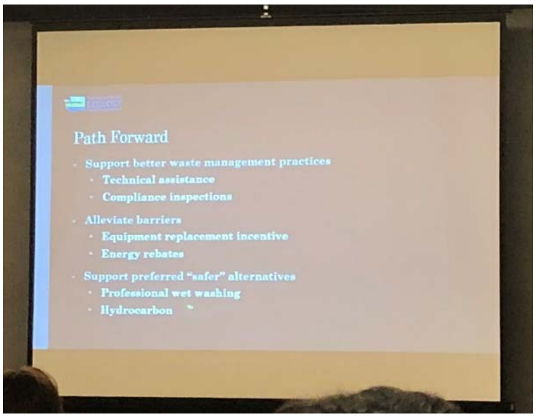
(4) Real-World Sustainability Challenges: Incentives & Barriers to the Use of Green Chemistry in Products (GC&E 57: Washington State dry cleaning industry profile: Exploring incentives toward safer cleaning methods)

主持人：Myles Perkins



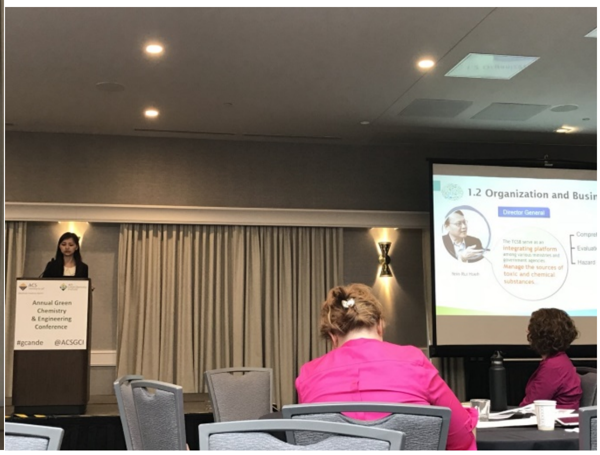






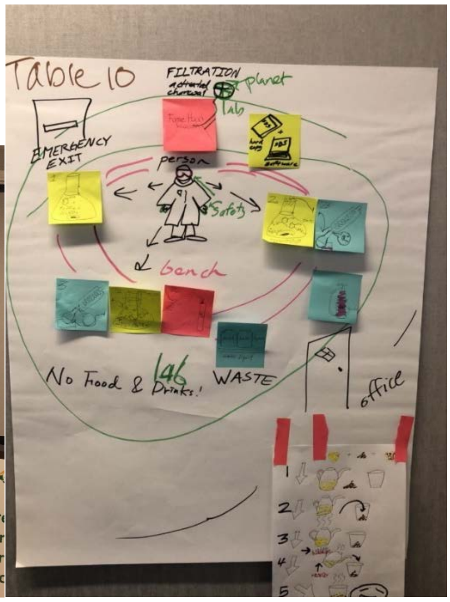
(5) Green Chemistry: Environmental Justice to Social Equity

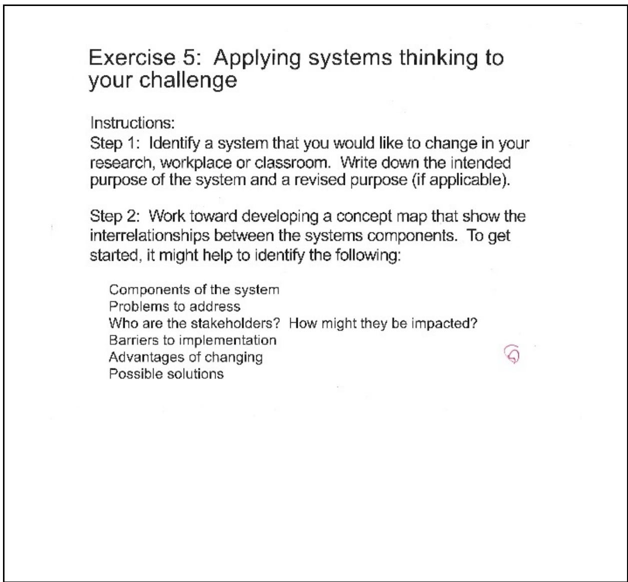
主持人：Edward Brush, Grace Lasker

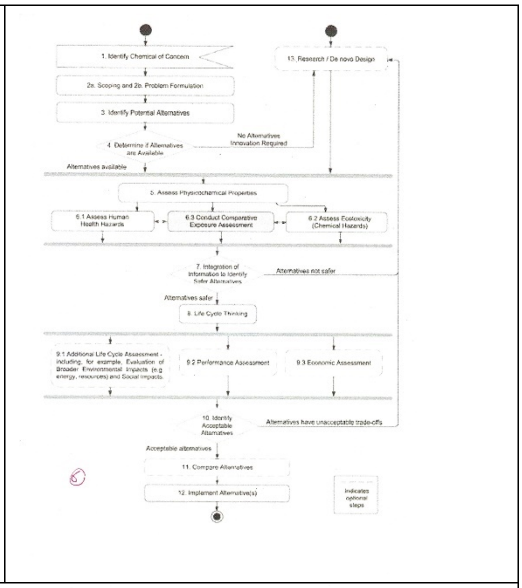


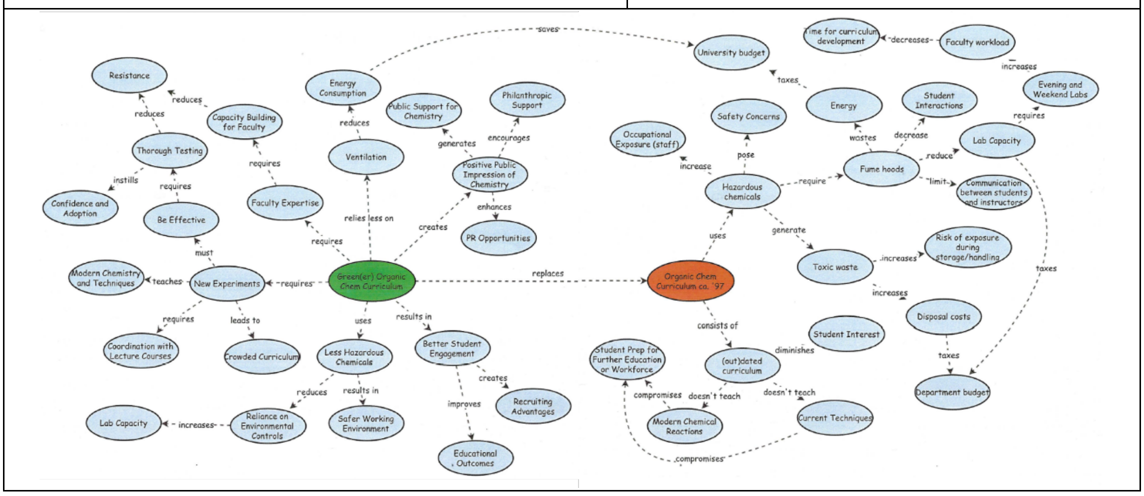
(6) Systems Chemistry: An Introduction to Systems Thinking in Green Chemistry

主講人：Jim Hutchison



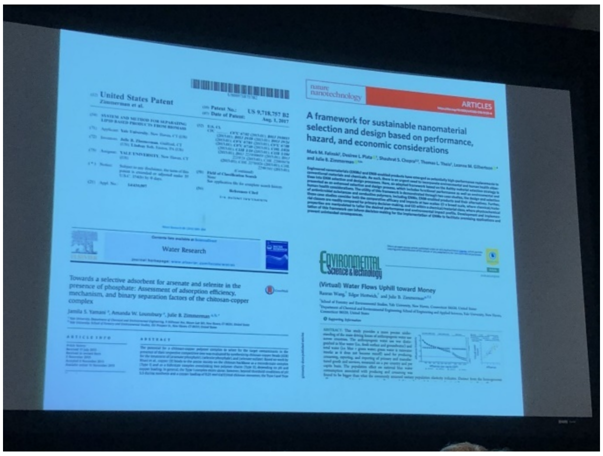




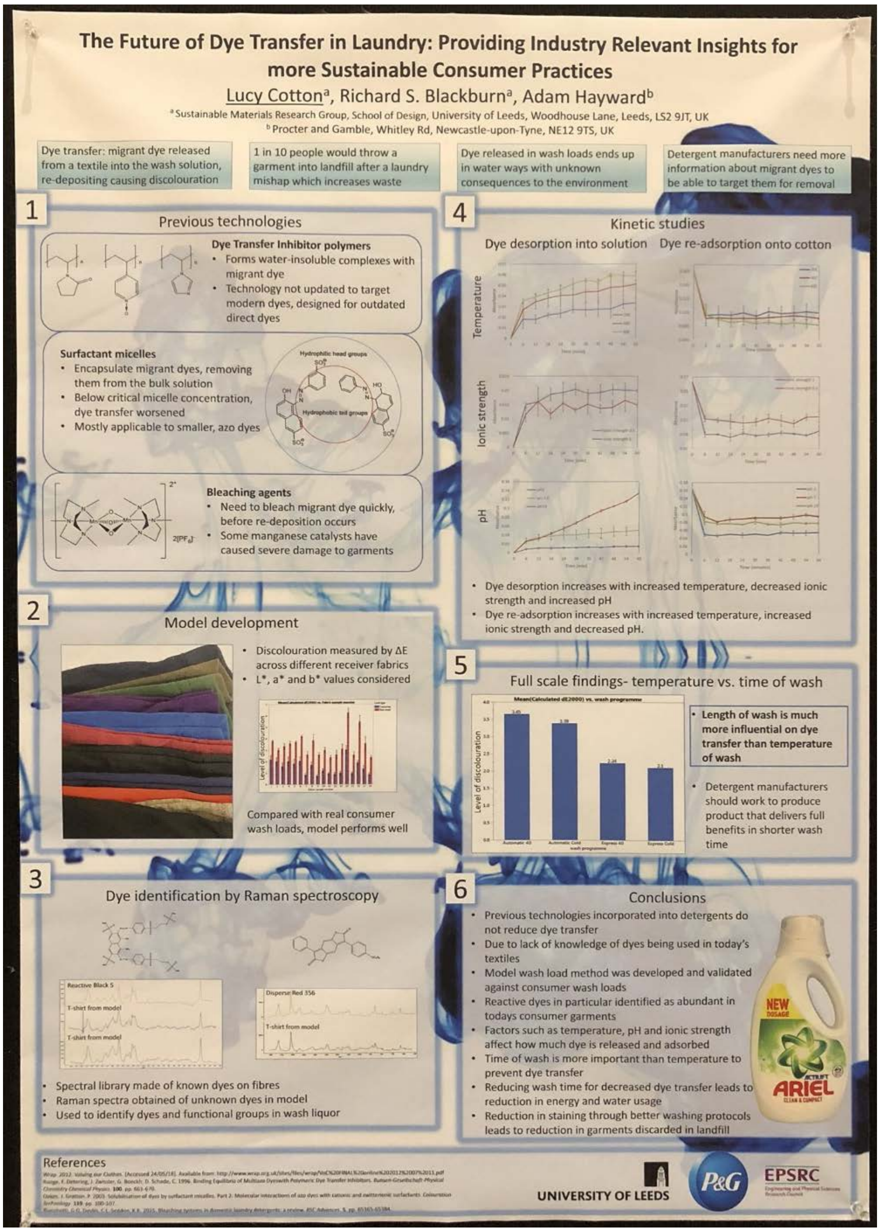


(7)Keynote : Nourishing the Green ChemisTREE

主講人：Julie Zimmerman



(8) Poster section: P&G新清潔方式開發



(9) 產業研發發表：華盛頓州乾洗業 綠色化學改良研究評估