**Lesson Plan: Lecture 13**

**Real-World Cases in Green Chemistry**

**Description**

In this class students will learn about successful Green Chemistry technologies that have been awarded by the United States Environmental Protection Agency. Students will have the opportunity to research previous winners and discuss with their fellow classmates.

The lecture ppt file contains 7 case studies with a range of topic areas. The lecturer can elect to use all case studies in the lecture, or a selection based on the background of the students.

**Prior to Lecture**

Optional/ Supplemental Readings:

* PGCCA\_recipients\_1996-2016.pdf: “Presidential Green Chemistry Challenge: Award Recipients 1996-2016”, US EPA. <https://www.epa.gov/sites/production/files/2016-10/documents/award_recipients_1996_2016.pdf>

 – this file has a summary of award winners over a 20 year period and can be a good overview for understanding the breadth of winning technologies and applications.

* The lecturer can find the award application files for each of the 7 case studies in the ppt file. These application files provide more detail to the lecturer for understanding the chemistry involved and the greener benefits. If additional detail for one or more of the case studies is desired, these files can be beneficial.
	+ Files include:
		- Newlight Technologies: 2016-Newlight.pdf
		- Buckman International, Inc.: 2012-Buckman.pdf
		- Bruce Lipshutz: 2011-Lipshutz.pdf
		- SiGNa Chemistry, Inc.: 2008-SiGNa.pdf
		- Archer Daniels Midland and Novozymes: 2005-ADM.doc
		- Pfizer: 2002-Pfizer.pdf
		- Dow Chemical Company: 1996-Dow Chemical.pdf
* Some case studies have additional readings to supplement the award application files:
	+ Newlight Technologies: Additional articles for reading:
		- Popular Science, 2014: <http://bestofwhatsnew.popsci.com/newlight-technologies-aircarbon>
		- Plastics Today, 2016: <https://www.plasticstoday.com/materials/newlight-licenses-aircarbon-ikea/57710583724253>
		- Making Plastic from Pollution, January 11, 2017: <https://powerpalletinc.com/making-plastic-from-pollution/>
		- BCA Chemistry, 2013: <https://bcachemistry.wordpress.com/tag/aircarbon/> (includes a good overview of the chemistry, including Thermodynamics and polymer chemistry)
	+ Buckman: Additional resources for in-depth understanding:
		- Buckman\_PPI-2012-Greener-Pckg.pdf: A 2012 article is included with some further information (Pulp & Paper International (PPI))
		- Paper Facts 2017.pdf: 2017 Paper Fact Sheet from Green America’s Paper Project
		- State\_Of\_The\_Global\_Paper\_Industry\_2018.pdf: 2018 Environmental Paper Network report titled “State of the Global Paper Industry”, <http://environmentalpaper.org/wp-content/uploads/2018/04/StateOfTheGlobalPaperIndustry2018_FullReport-Final-1.pdf>
	+ Bruce Lipshutz: 3 additional papers are included for a more in-depth discussion of Lipshutz’s surfactants
		- Lipshutz, B., Current Opinion in Green and Sustainable Chemistry, 2018, 11: 1-8: <https://www.sciencedirect.com/science/article/pii/S2452223617300780>
		- Lipshutz, B., J. Org. Chem., 2017, 82, 2806-2816: <https://pubs.acs.org/doi/pdf/10.1021/acs.joc.7b00010>
		- Lipshutz, B., ACS Sustainable Chem. Eng., 2016, 4, 5838 – 5849: <https://pubs.acs.org/doi/pdf/10.1021/acssuschemeng.6b01810>
	+ Archer Daniels Midland and Novozymes, NovaLipidTM:
		- Additional information about trans fats and health effects: Mayo Clinic, <https://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/in-depth/trans-fat/art-20046114>
	+ Pfizer: Additional background readings on Zoloft greener synthesis for more in-depth discussion
		- Taber, G.P., Pfisterer, D.M., and Colberg, J., Organic Process Research & Development, 2004, 8, 385-388
		- Sertraline Case Study.doc – Background information on the Sertraline case study provided in the ppt
	+ Dow Chemical Company (Rohm and Haas):
		- Additional educational modules by Michael Cann, University of Scranton, <http://www.scranton.edu/faculty/cannm/green-chemistry/english/environmental.shtml>
		- Additional information on Marine anti-foulants: International Marine Organization: <http://www.imo.org/en/OurWork/Environment/Anti-foulingSystems/Documents/FOULING2003.pdf>

Videos

* [Newlight Technologies](https://www.youtube.com/watch?v=s3mEbSSDaNk)
* [Buckman Maximyze® Technology](https://www.youtube.com/watch?time_continue=2&v=42H7SsCX7zI)
* [SiGNa Technologies](http://www.signachem.com/resources/?fwp_languages=english&fwp_categories=videos)

**Topics to Cover**

* Presidential Green Chemistry Challenge Awards
	+ Award Categories and PGCCA description
	+ PGCCA Case Studies:
		- 2016: Newlight Technologies, AirCarbon: Greenhouse Gas Transformed into High-Performance Thermoplastic
		- 2012: Buckman International, Inc.: Enzymes Reduce the Energy and Wood Fiber Required to Manufacture High-Quality Paper and Paperboard
		- 2011: Professor Bruce H. Lipshutz, Towards Ending Our Dependence on Organic Solvents
		- 2008: SiGNa Chemistry, Inc.: New Stabilized Alkali Metals for Safer, Sustainable Syntheses
		- 2005: Archer Daniels Midland and Novozymes, NovaLipidTM: Low Trans Fats and Oils Produced by Enzymatic Interesterification of Vegetable Oils Using Lipozyme®
		- 2002: Pfizer re-design of Sertraline (ZOLOFT®)
		- 1996: Dow Chemical Company Designing an Environmentally Safe Marine Antifoulant

**Class Exercise**

Real-World Cases in Green Chemistry Exercise (RWCGC): This exercise can be performed in-class, or as a take home assignment. The RWCGC Exercise is designed for students to research more about one case study and produce a presentation or report on the green chemistry break through technologies. Students are given one Presidential Green Chemistry Challenge Award nomination package to learn more about the technology. Use the RWCGC Exercise file to guide students to learn more and report on the technology. 19 files are included for use within this exercise. For a full list of past award winners, see the U.S. EPA website: <https://www.epa.gov/greenchemistry/green-chemistry-challenge-winners>. The award nomination packages are publicly available. To request an award package that was not included, send an e-mail request to the Green Chemistry program at the EPA: Greenchemistry@epa.gov.