ACS Green Student Chapter Activity: Hosting a Chemistry Debate

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Debates. The age-old forum for discussing controversial topics in a civilized, rational assembly. They help spread ideas by informing those involved in addition to an audience. Hot topics inspire onlookers to participate. The student chapter at the University of Connecticut held a debate on alternative energies during which the club was split into teams. Each had to argue for a different alternative energy to fossil fuels such as wind, solar, hydropower, or biofuels. With their combined skills, team members researched and prepared discussions about the economy, efficiency, and viability of their assigned power source.

Using logic, drawing on emotion, and gaining credibility are key tools for debaters, but what about those who are organizing the event? In this document, you'll find everything needed to successfully host a green chemistry themed debate at your college or university.

Sustainable and green chemistry in simple terms is just a different way of thinking about how chemistry and chemical engineering can be done. Over the years different principles have been proposed that can be used when thinking about the design, development and implementation of chemical products and processes. These principles enable scientists and engineers to protect and benefit the economy, people, and the planet by finding creative and innovative ways to reduce waste, conserve energy, and discover replacements for hazardous substances.

It's important to note that the scope of these green chemistry and engineering principles go beyond concerns over hazards from chemical toxicity and include energy conservation and waste reduction, as well as life cycle considerations such as the use of more sustainable or renewable feedstocks and designing for end of life or the final disposition of the product.

By incorporating sustainable and green chemistry into your student chapter's activities you can:

- Become a spokesperson on your campus for sustainability and the solutions chemistry can bring through green chemistry
- Start a movement of sustainability across your campus and in the community
- Make a difference through chemistry
- Have a positive impact on human health, the environment & the future
- Improve the "image" of chemistry

Chapters who engage in at least three green chemistry outreach and educational activities during the school year are eligible to win a Green Chemistry Student Chapter Award.

Green Chemistry Themes to Consider[1]

It is better to:
Prevent waste than to treat or clean up waste after it is formed
Minimize the amount of materials used in the production of a product
Use and generate substances that are not toxic
Use less energy
Use renewable materials when it makes technical and economic sense
Design materials that degrade to innocuous products at the end of their usable life

[1] Middlecamp, Catherine, ed. *Chemistry in Context: Applying Chemistry to Society*. 8th ed. New York: McGraw Hill, 2014. Print

So you want to host a debate. There are a few key logistics to sort out for any event to be successful. A time, date, and place are essential.

Evenings are likely to be convenient for students or professors who want to be part of the debate, as well as for anyone who wants to watch. Consider whether or not the selected **date** is convenient for members of your ACS student chapter to dedicate their time. Then think about scheduling the event around the midterms, exams, holidays, major campus events, etc. for maximizing the number of potential attendees.

If the **location** usually requires a reservation; be sure to inquire about its availability at least a couple of weeks in advance (i.e. before the event is advertised). A location needs to have space for debating teams as well as observers: a lecture hall, theatre, or even an art gallery would be suitable. If your campus or community has a particularly "green" building, such as one that is LEED certified, look into reserving a space there if your budget allows.

Time will be needed for advertising, making reservations, and keeping the event itself on track. How long should the debate last? This can vary depending on the number of teams participating, the breadth of the subject, and if questions posed from the audience will be allowed.

Advertising through word of mouth is an important part of hosting any campus event. Invite professors to form or sponsor debate teams. Be sure to ask them about available chemistry department **funds** for materials, booking fees, or refreshments that may be provided. Getting faculty involved can also encourage students to attend if only to see their instructors outside the classroom. Do some research on green chemistry before speaking to a faculty member so you can confidently explain why the event is important to the department, students, and the community.

Even if the rules are emailed out beforehand it's important to go through them step-by-step when participants have gathered for the event. This way there are no misunderstandings about the kind of environment they are entering (respectful, scientific, time limits, etc.). And of course, be sure to **thank everyone** for their participation.

A brief introduction to green chemistry may be beneficial at the beginning of the debate. Have a representative from your student chapter open the debate with a summary of what green chemistry is and why it's important to discuss.

Making Teams

For a debate to be successful participants must **sign up** beforehand. Remind students that signing up is a commitment and that they must prepare arguments in advance. Solicit the event in a high-traffic, low-stress area such as in a dining hall or at a club fair. A sign-up sheet should require names and email addresses so it's possible to **send details and reminders**. If you're concerned about debaters actually showing up, consider collecting a small monetary deposit (that will be returned immediately after the debate) or offering prizes to all participants.

On the next page you'll find a sample sign-up sheet. It includes the main question and topic of debate and gives the people who are signing up a choice for which argument they'd like to defend. In addition, if these debate teams are being led by a faculty sponsor, their name can be included under their respective team.

Remember that many students won't have heard of green chemistry before. Be sure to have resources, examples, or visuals on hand to explain the importance of the topic.

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Question: A $2 million grant can be used to either clean up existing superfund sites or prevent new ones from forming.

It would be better to clean up existing Superfund sites.	The money should be used to prevent future Superfund sites from forming.
Name, Email	Name, Email
1	1
2	2
3	3
4	4
5	5
Faculty Sponsor:	Faculty Sponsor:

Debate Date, Time, and Location:

Attracting Participants and an Audience: How to Advertise Effectively

Who will attend your debate if no one knows about it? One of the most important parts of hosting an event is advertising. Here are a few tips for getting better attendance when designing posters or spreading the word online. Students are busy and many will be dissuaded from participating because the topic revolves around chemistry. Consider making a display showing the importance and relevance of chemistry. In addition, don't just advertise for the event itself; advertise the sign-ups and incentives you're offering to participants.

1. Remember, you will know the event you're presenting better than anyone looking at your flyers, posters, or probably even in attendance. Sometimes it's best to take a step back when you're very familiar with your own project. Think of how undergraduates, professors, etc. who have never heard of green chemistry would perceive it and tailor your message around the perceptions of the intended audience. Do some research to find out what they are most likely to care about and adjust the program to fit their needs.
2. Always approach advertising in a way that is SIMPLE, DIRECT, and RELEVANT. You don't need a sassy/witty marketing push. Stick true to your message and the purpose of the debate. People can instantly sense authenticity so try and be as clear as possible.
3. Make sure you have information access points for your program, such as a Facebook page, Tumblr or WordPress site, to give a more behind-the-scenes view. Also try to get your own URL and make it as short as possible so it can be remembered when read on your ads.
4. If you have an online presence, make sure all the facts are straightforward and easy to find. A simple page with the main details (time, date, place, description) and contact information should suffice. Find a tech-savvy friend to help you set up a website if you aren't sure how. There are a number of fairly simple drag-and-drop webpage builders.

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How Debates Work - The Rules of the Game

Everyone's taken their seats, the audience is eagerly awaiting the arguments, the first question is asked and the next thing you know there are incomprehensible shouts going back and forth between the teams! What's gone wrong? Following a few simple rules and making them clear to participants is the key to carrying out a peaceful discussion and preventing chaos.

- Perhaps the most important question to ask when hosting a debate is "is everything as equal and fair as possible?" i.e. neither team should feel they are at a disadvantage.
- A moderator is essential for keeping track of time. Opening and closing statements should be about 3 minutes and responses should be about 2 minutes.
- Practical considerations: are there enough chairs, microphones, glasses of water, tech equipment (such as a projector), etc. available for the participants?
- If there are enough students who wish to participate, consider having several sessions of different teams where each round addresses a different question.
- The moderator can choose by a coin flip which team speaks first.

Debate between Two Teams of 4-5 Students

1. The question will be asked.
2. Teams can make opening and closing statements of a specified length (about 3 minutes) to introduce and conclude their arguments.
3. The moderator will then indicate the first team to respond. This first response should be more in-depth than the opening statement, perhaps providing a detailed example of why the team holds a certain position. This first section should be about 5 minutes for each team.
4. The teams can then respond to each other's challenges and examples. Allow 60 seconds for discussion among the groups. Two minute responses are typical.
5. Each team then selects a speaker for the response. This speaker can change from response to response, but only one person may have the floor at a time.
6. When time is up for the teams to give answers about the main question, get the audience involved to create a town-hall style debate. Do they have any questions for the teams? These questions should be appropriate for both teams and members to answer. Questions from the audience can alternatively be collected before the

debate which may attract additional attendees who want to hear their questions addressed.

Variations

There are lots of ways to structure a debate – it can be flexible depending on the size of your college or university, who's likely to participate, and how interdisciplinary it is meant to be. Here are a few additional suggestions.

Two Teams of Faculty Members

The trick here is getting enough faculty members involved to make teams. Try to represent different departments so the teams are diverse. Even if you've never had a class with someone or don't know who would make a good candidate get a friend who is in that major to ask around. Another possibility is to send a school-wide email or give flyers directly to faculty and explain the significance of the event.

Tournament Style

This format is particularly suited for a larger college or university that can get many student participants. A series of five to seven debates would be appropriate, probably over the course of a semester. See the next page for a printable organizational chart for scheduling teams. This one just happens to be for eight teams, but of course that depends on how many sign-ups there are.

A panel of judges will be required. Consider asking faculty members from various departments if they would like to participate so the judging is as objective as possible. This panel will vote among themselves to determine which team moves on to the next round of debate.

As Part of a Larger Event or Theme

It's not so much a variation on format but choosing to hold the debate as part of a larger event can help draw a larger crowd. You'll have the benefit of any advertising the main event is doing without adding any cost or spending any extra time – whoever is running the other event will want it to be successful and put effort into advertising all parts of it. However, this doesn't mean you don't need to advertise! Universities and college often have semester-long themes that are tied to subjects like books, films, a lecture series, etc. Additionally, there are opportunities at almost any conference or workshop to put on a debate if you carefully tailor the topic for relevancy.

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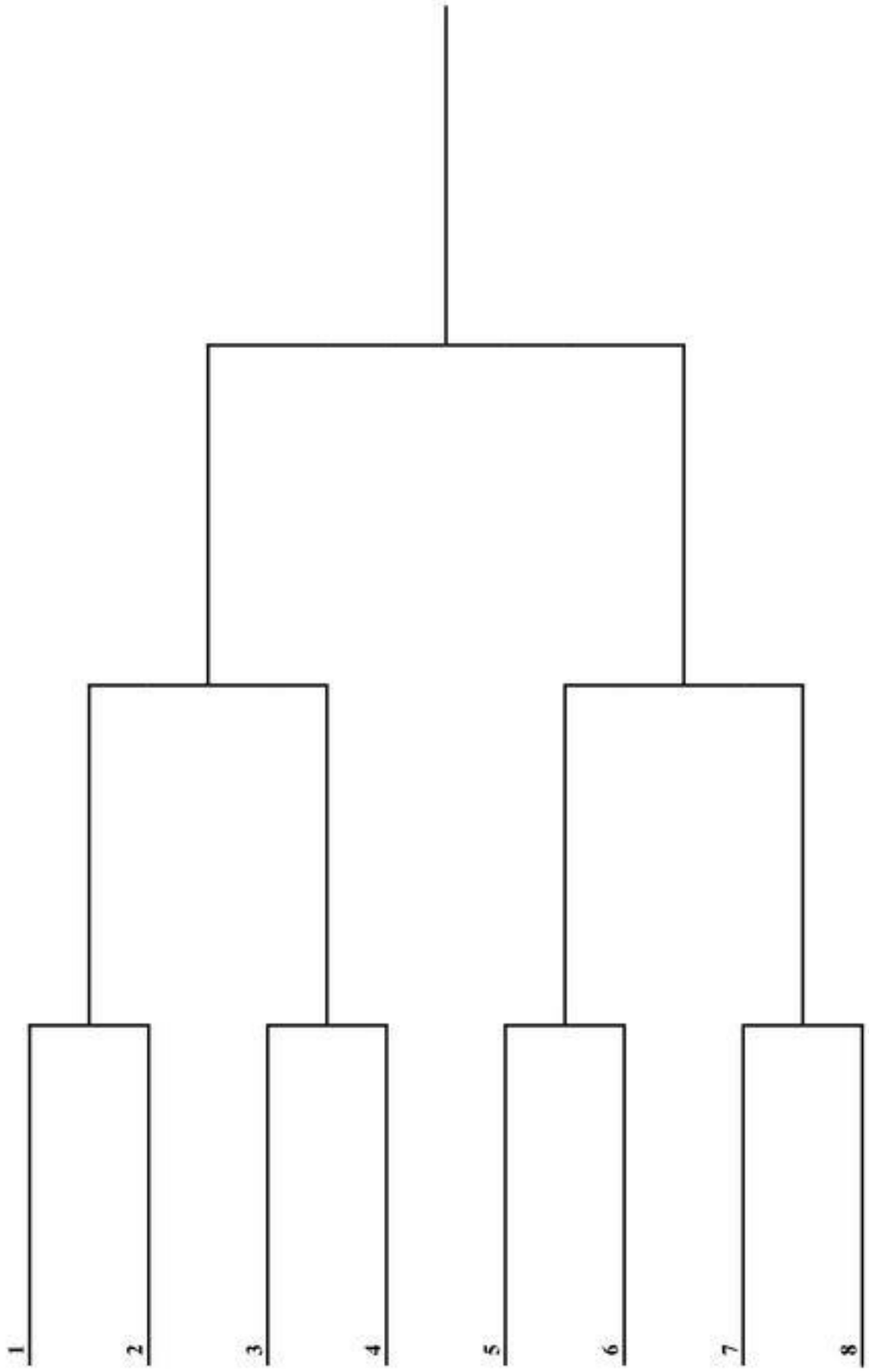
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Suggested Debate Topics and Team Platforms

Topic	Opinion A	Opinion B
Wind Energy vs. Solar Energy from a green chemistry perspective	Wind energy is a better resource.	Solar energy is a better resource.
A $2 million grant can be used to either prevent hazardous waste from entering the environment or to decrease worker exposure to hazardous chemicals.	It should be used to prevent environmental impact.	It should be used to increase occupational safety.
A company can either reduce the amount of packaging material or reduce the amount of waste generated during the product manufacturing process.	The amount of material used to produce packing should be minimized.	The waste generated during the manufacturing process should be minimized.
A $2 million grant can be used to either clean up existing superfund sites or prevent new ones from forming.	It should be used to clean up existing sites.	It would be better spent on preventing future superfund sites from forming.
Isocyanides are used to create the standard of living most Americans are used to. They are found in paint, furniture and a variety of building materials and plastics. Industry representatives argue that they are harmless because they don't leach out of finished materials, like seat cushions. Other research has found them to pose a serious health risk.	Use of isocyanides should be banned – their costs are greater than their benefits.	The modern standard of living depends on isocyanides – their benefits are greater than their costs.
A process can be designed to produce no waste or to produce byproducts that are completely recoverable/recyclable.	It is better to produce no waste.	It is better to recover/recycle products.
Crops can be protected from pests through genetic modification or application of pesticides.	Genetically modified crops should not be used to prevent damage from pests: pesticides are a good alternative.	Pesticides should not be used to prevent damage from pests: genetically modified crops are a good alternative.

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Green Chemistry versus Sustainability

Remember, this debate is focused on green *chemistry,* which it is important to distinguish from sustainability and environmental friendliness. Topics should relate primarily to green chemistry. So what's the difference?

Initiatives such as recycling, using less paper, and cleaning up litter are examples of general sustainability projects which are focused on the need to slow global warming, reduce carbon dioxide emissions, etc. Many of which have been popularized and there's a good level or awareness surrounding them. It's easy to get these kinds of activities confused with green chemistry because, in certain respects, they overlap significantly. It is essential, however, to make a distinction between the two.

The manufacture of goods – everything from cars to paint to pesticides – involves chemical processes. "Green Chemistry" was developed as a way to re-think past and current processes many of which posed significant risk to human health and safety for the environment. Green Chemistry takes into consideration the effects of a chemical through its entire "life", from the time it is extracted from the earth to what happens after it is disposed of as waste. This includes the risks involved in its transportation, effects when it enters wastewater, and potential harm caused to those who are working with it. Green chemistry is also a way in which businesses can reduce their expenses by spending less money on waste treatment and using fewer chemicals in general. Some green chemists consider there to be twelve guiding principles for greener chemistry while others feel the scope is much broader. A few key ideas in green chemistry are to prevent waste instead of treating or cleaning it, use as few materials as possible, make and use non-toxic substances, reduce energy use, take advantage of renewable materials, and design things to be harmless even when they reach the end of their useful life.

Although a goal of green chemistry is to create more sustainable practices it's a specific area of the sustainability movement. For example, recycling plastic is a great sustainability practice. However, a green chemist might consider designing plastic that is more biodegradable, that doesn't require non-renewable petroleum or contain potentially harmful chemicals like BPA, or discover how to improve the efficiency of the recycling process itself. Another example of a sustainability project would be "going electronic" for a newsletter to reduce paper. A green chemist might consider how to reduce the environmental impact of the paper production process such as eliminating the use of bleach as a whitener or how to re-use chemicals that become waste during the paper production process.

Where are the Best Places for Teams to Find Credible Information?

Debaters will need background information to support their arguments. Here are some sources you might suggest.

As with any subject there is bias among resources in chemistry. It's important for teams to reference reliable sources in order to build the audience's confidence in their knowledge and credibility.

Suggest that teams:

- Keep an open mind when searching for answers.
- Consider opposing viewpoints:
  - What evidence are claims based on?
  - What organization has sponsored the research?
- Draw conclusions only after a review of a variety of credible sources.

The best places to find information are **peer-reviewed scientific journals**. The university or college library almost certainly provides free access to these articles. Email or visit your librarian if unsure of how to get access (either online or in print). Google Scholar is also a good place to search for the subject of interest using keywords.

There are a growing number of green chemistry **textbooks and lab manuals** that may provide relevant examples. Again, your university or departmental library may have copies of these. Otherwise, you can always kindly request that the library order reference copies for chemistry students. A list of these textbooks can be found on the ACS Green Chemistry Institute website, here.

More and more **websites and databases** with information about green chemistry are popping up on the internet. For example, the Greener Education Materials for Chemists (GEMs) database provides a collection of green chemistry resources. The Nexus Blog from the Green Chemistry Institute is another source of articles and information on emerging science. The Washington State Department of Ecology has also put together a list of various online green chemistry resources.

A member of faculty in the chemistry department might be interested in green chemistry. Ask the chapter's advisor and inquire about current research at your university.

If a team is feeling unsure about what green chemistry is, how it applies to them, or why it's worth participating in a debate, here are a few resources which cover the basic concepts:

The ACS Green Chemistry Institute
Beyond Benign
The Berkeley Center for Green Chemistry
Green Chemistry Initiative at the University of Toronto

Submitting Your Green Student Chapter Activity

Once your ACS student chapter has completed a green activity it's time to fill out the student report with details about what's been done. Feel free to send along photographs or a mention of your work in the university or college news.

See this webpage for information on deadlines, submission requirements, and the report form.

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Appendix A

Everyday Examples of Green Chemistry [2]

If you're interested in learning more about how green chemistry affects you, below are some interesting examples of green chemistry in real-world applications.

- *Have you ever had you clothes dry-cleaned?* [3]
    - Dry Cleaning: dry-cleaning processes have conventionally used the chemical perchloroethylene (perc). Several organizations have stated that perc is a hazardous substance to human health. The International Agency for Research on Cancer (IARC) concluded that perc is a "probable human carcinogen" meaning it is likely to cause cancer in addition to its short term effects like dermatitis. Workers in a dry-cleaning facility can be exposed to perc in a number of ways from cleaning the machine to simply loading clothing.[4] In addition, perc is categorized as a hazardous air pollutant by the U.S. EPA's Clean Air Act and it may contaminate groundwater when it is disposed.[5]
    - *Applying green chemistry to this situation has resulted in a markedly improved process using liquid carbon dioxide – a substance that is essentially non-toxic and is equally effective at removing grease and dirt from fabric. This simple innovation of replacing a hazardous chemical for a benign one is a perfect example of green chemistry at work in everyday life.*
- *Do you own something involving a computer chip?*
    - Have you ever considered what goes into making a smartphone, computer, or television work? As technology progresses so does our consumption of endangered elements: the 44 critical materials which will soon face supply limitations. These limitations can stem from factors such as geographic concentration, political motivations, regulatory laws, or consumer demand. Some green chemists are researching more abundant alternatives, more efficient syntheses where alternatives are not found, diversifying the supply and better recycling and recovery programs for these scarce materials. A smartphone, for example, usually contains over 80 elements, many of which are considered "endangered," for everything from the touch screen (dysprosium, europium, etc.) to the color display (yttrium, terbium, and more). To manufacture computer chips, many chemicals, large amounts of water, and energy are required. In a study conducted in 2003, the industrial estimate of chemicals and fossil fuels required to make a computer chip was a 630:1 ratio! That means it takes 630 times the weight of the chip in source materials just to make one chip! Compare that to the 2:1 ratio for the manufacture of an automobile. This is an example of very poor atom economy. Scientists at the Los Alamos National Laboratory have developed a process that uses supercritical carbon dioxide in

[2] http://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry/examples.html
[3] Ryan, M. (ed.), Tinnesand, M. (ed.) (2002) *Introduction to Green Chemistry*, American Chemical Society: U.S.A. pp.23-29
[4] https://www.osha.gov/dsg/guidance/perc.html
[5] http://yosemite.epa.gov/opa/admpress.nsf/0/e99fd55271ce029f852579a000624956

one of the steps of chip preparation, and it significantly reduces the quantities of chemicals, energy, and water needed to produce chips. Richard Wool, director of the Affordable Composites from Renewable Sources (ACRES) program at the University of Delaware, found a way to use chicken feathers to make computer chips! The protein, keratin, in the feathers was used to make a fiber form that is both light and tough enough to withstand mechanical and thermal stresses. The result is feather-based printed circuit board that actually works at twice the speed of traditional circuit boards. Although this technology is still in the works for commercial purposes, the research has led to other uses of feathers as source material, including for biofuel.

- *Who owns clothes? By the looks of it, all of you!*
    - Micro-organisms are everywhere, even in our clothes. They cause odors, wearing, and color changes to fabrics in textiles. To reduce the number and effects of micro-organisms on our clothes, antimicrobial textiles have been developed. Unfortunately, some of these synthetic agents have toxic effects on humans. For example, silver antimicrobial agents have caused dermatitis, some synthetic dyes have been found to cause cancer, and still others like zinc pyrithione are mildly neurotoxic. Not only are these compounds harmful to humans, they are often not biodegradable and the waste created by their manufacture is difficult to treat and sometimes become ineffective over time. *Green chemistry approaches have created benign antimicrobial textile solutions. These include materials called biopolymers that are made from a huge variety of renewable materials found in nature such as chitosan from crustaceans and fungi, cyclodextrin from starch, and alginate from brown sea weeds. Antimicrobial agents made from these ingredients are less harmful to the environment, have lower toxicity, are renewable, and still highly functional.* [6]
- *Have you ever eaten food?*
    - Many people are surprised to learn that even what they eat is a product of chemical design. Decaffeination and the production of flavors are just two examples of food-industry processes that green chemistry principles have been applied to with success. Decaffeination of coffee beans using dichloromethane, a suspected carcinogen, was the accepted process for about 70 years. However, greener methods have been developed and applied on an industrial scale. The Swiss water process and the use of supercritical CO_2 are both the result of green chemical innovation. The Swiss water process uses water, green bean extract and a difference of caffeine concentrations. No harmful solvents are used and very little waste is produced as the water is easily recycled. Decaffeination by supercritical CO_2 is also a safer and more environmentally friendly method because it is a very low-waste process using a relatively non-toxic substance; the carbon dioxide is recycled throughout the process and the caffeine solution produced is sold to other manufacturers.[7]
    - Consider everything vanilla-flavored you've ever eaten or vanilla-scented candles, soaps, and more that you've used. The production of synthetic vanillin, the main flavor

[6] Shahid-ul-Islam, Shahid, M., Mohammad, F. Green chemistry approaches to develop antimicrobial textiles based on sustainable biopolymers – a review. *Ind. Eng. Chem. Res.* 2013, 52, 5245-5260.
[7] Jimenez-Gonzalez, C., Constable, D. J. C. (2011) *Green Chemistry and Engineering: A Practical Design Approach.* Hoboken, New Jersey: John Wiley & Sons, Inc.

component of natural vanilla extract, has undergone several changes through industry attempts to improve efficiency, reduce waste, and increase the quality as demand grows at a faster rate than vanilla bean production. In the 1930's, use ligninsulfonates (organic material from wood pulp production) became the conventional starting material for vanillin production but were eventually replaced by a petrochemical starting material due to the large amounts of waste created through the wood-production by-product process[8]. New research has found that vanillin molecules can be collected and purified using ionic solvents which are often greener than the solvents they replace (less volatile) and can be derived from renewable resources unlike petrochemicals[9]. Although this synthesis is still in development the pathway towards greener production is being paved.

- *Have you ever used plastic?*
    - Several companies have been working to develop plastics that are made from renewable, biodegradable sources.
    - NatureWorks of Minnetonka, Minnesota, makes food containers from a polymer called polylactic acid branded as Ingeo. The scientists at NatureWorks discovered a method where microorganisms convert cornstarch into a resin that is just as strong as the rigid petroleum-based plastic currently used for containers such as water bottles and yogurt pots. The company is working toward sourcing the raw material from agricultural waste.
    - BASF developed a compostable polyester film that called "Ecoflex®." They are making and marketing fully biodegradable bags, "Ecovio®,"made of this film along with cassava starch and calcium carbonate. Certified by the Biodegradable Products Institute, the bags completely disintegrate into water, CO_2, and biomass in industrial composting systems. The bags are tear-resistant, puncture-resistant, waterproof, printable and elastic. Using these bags in the place of conventional plastic bags, kitchen and yard waste will quickly degrade in municipal composting systems.
- *Have you ever taken a medication?*
    - Merck and Codexis developed a second-generation green synthesis of sitagliptin, the active ingredient in Januvia™, a treatment for type 2 diabetes. This collaboration lead to an enzymatic process that reduces waste, improves yield and safety, and eliminates the need for a metal catalyst. Early research suggests that the new biocatalysts will be useful in manufacturing other drugs as well.
    - Originally sold under the brand name Zocor®, the drug, Simvastatin, is a leading prescription for treating high cholesterol. The traditional multistep method to make this medication used large amounts of hazardous reagents and produced a large amount of toxic waste in the process. Professor Yi Tang, of the University of California, created a synthesis using an engineered enzyme and a low-cost feedstock. Codexis, a biocatalysis company, optimized both the enzyme and the chemical process. The result greatly reduces hazard and waste, is cost-effective, and meets the needs of customers.

[8] Calvo-Flores, F.G., Dobado, J.A. Lignin as a renewable raw material, *Chem Sus Chem.*, 2010, 3, 1227-1235. http://onlinelibrary.wiley.com/enhanced/doi/10.1002/cssc.201000157/
[9] http://www.sciencedirect.com/science/article/pii/S1383586610002789

- *Have you ever painted something?*
    - Oil-based "alkyd" paints give off large amounts of volatile organic compounds (VOCs). These volatile compounds evaporate from the paint as it dries and cures and many have one or more environmental impacts.
    - Procter & Gamble and Cook Composites and Polymers created a mixture of soya oil and sugar that replaces fossil-fuel-derived paint resins and solvents, cutting hazardous volatiles by 50 percent. Chempol® MPS paint formulations use these biobased Sefose® oils to replace petroleum-based solvents and create paint that is safer to use and produces less toxic waste.
    - Sherwin-Williams developed water-based acrylic alkyd paints with low VOCs that can be made from recycled soda bottle plastic (PET), acrylics, and soybean oil. These paints combine the performance benefits of alkyds and low VOC content of acrylics. In 2010, Sherwin-Williams manufactured enough of these new paints to eliminate over 800,000 pounds, or 362,874 kilograms of VOCs.

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