Industrial Applications of Green Chemistry to Prevent Environmental Pollution and to Sustain the Earth

(A Review)

by

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Abstract

Chemistry brought about medical revolution till about the middle of 20th century in which drugs and antibiotics were discovered. The worlds food supply also increased enormously due to thediscovery of hybrid varieties, improved methods of farming,better seeds,use of insecticides, herbicides and fertilizers. The quality of life on earth became much better due to the discovery of dyes, plastics, cosmetics and other materials. Soon the ill effects of chemistry also became pronounced in the form of soil, air and water pollution. The use of toxic reagents and reactants made situation worse. The pollution level became so high that there came an utmost need for green chemistry. Maximum pollution is caused by chemical industries. Therefore, attempts should be made to design synthesis for the manufacturing process in such a way so that toxic waste are minimised and carcinogenic reactants are not usedas solvents. Use of bio based chemicals should be increased.

Keywords: green chemistry, hazardous waste, environmental pollution etc.

Introduction

Green chemistry has now been around for two decades, and it has been making a real difference in our world. The well-known companies and organizations that have embraced the discipline include Nike, BASF, Hewlett-Packard, the National Aeronautics & Space Administration, Eastman Chemical, United Soybean Board, Pfizer, the Environmental Protection Agency, Bayer MaterialScience, Codexis, Johnson & Johnson, Amgen, DuPont, and World Wildlife Fund. The global market for green chemistry is predicted to grow exponentially in the coming years, to $98.5 billion by 2020. The young discipline has produced thousands of scientific papers. Research networks in more than 30 countries on every settled continent have been formed along with at least four new international scientific journals. Green chemistry has been credited for decreasing the amount of chemical waste released to the air, water, and land. It has also spawned new areas of research including green solvents, bio-based transformations and materials, alternative energy science, molecular self-assembly, next-generation catalyst design, and molecular design for reduced hazard. Some industry reports predict green chemistry as the future of all chemistry.

12 Principals of green chemistry

- **Prevention** – It is better to prevent rather than cleaning later on.
- **Atom Economy** – Synthetic Methods should be designed to maximize the incorporation of all material used in the process into the final products.
- **Less hazardous Chemical Synthesis** – where ever possible synthesis method should be designed to use and generate substances that possess little or no toxicity to human health and environment.
- **Design Safer Chemicals** – Chemical product should be designed to effecttheir desired function while minimising their toxicity.
- **Safer Solvents and Auxiliaries** – the use of auxiliary substances (eg solvents,separation agents etc) should be made unnecessary wherever possible and innocuous when used.
- **Design for energy efficiency**–energy requirement of chemical process should be recognised for their environment and economic impacts and should be minimised. If possible, synthetic methods should be conducted at ambient temperature and pressure.
- **Use of renewable raw material** – A raw material should be renewable rather than depleting wherever technically and economically practicable.
- **Reduce derivatives** – Unnecessary derivatization (use of blocking groups, protective /deprotective, temperature modification of physical/chemical process) should be minimized or avoided if possible because such steps require additional reagents and can generate waste.
- **Catalysis** – Catalytic reagent (as selective as possible) are superior to stoichiometric reagents.

- **Design for degradation** –Chemical product should be designed so that at the end of their function they break down into innocuous degradation products and donot persist in the environment.
- **Real time analysis for pollution prevention -** Analytical methodologies need to be further developed to allow for real time, improve monitoring and control prior to the formation of hazardous substance.
- **Inherently safer chemistry for accident prevention**- Substances and the form of a substances used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosions and fires.

INDUSTRIAL APPLICATIONSOF GREEN CHEMISTRY

The wide range of applications of green chemistry includes uses in the pharmaceutical industry, as well as new approaches that reduce or eliminate the use of solvents, or render them safer and more efficient. Green chemistry has also inspired a growing number of ways to synthesize traditionally petroleum-based chemicals from biological materials instead, often plant matter or waste. Green chemistry also plays a key role in alternative energy science, and the production of new ways to make solar cells, fuel cells, and batteries for storing energy. When self-assembling molecules use bio-based plant materials, it is considered green chemistry. Because a primary goal of green chemistry is to minimize or eliminate waste in the manufacture of chemicals and allied products, it has inspired the creation of many green "next generation" catalysts. Another important development in green chemistry is the trend toward redesigning chemical products to reduce their hazard.

GREENER PHARMACEUTICALS

Pharmaceutical companies are also selecting less hazardous reagents, reducing reaction steps, and developing better catalysts.

Viagra, known generically as sildenafil citrate, is a blockbuster drug that has long been a "poster child" for the green credentials of its manufacturer, Pfizer. When gearing up for commercial production of Viagra, Pfizer's chemists designed a new reaction strategy that radically reduced the amount of solvent required, cut out the reagents tin chloride (an environmental pollutant) and hydrogen peroxide (a fire and transportation hazard), and produced just a quarter of the waste of the original process. Pfizer has also improved the process to make its well-known Lipitor (atorvastatin), a drug for reducing blood cholesterol, so that it uses an enzyme that catalysis chemical reactions in water, minimizing the need for potentially polluting organic solvents.Other well-known drugs have been recognized by the EPA's green chemistry awards for waste-reducing improvements to how they are manufactured. The chemical company BASF now makes its annual output of the painkiller ibuprofen—some 2 billion tablets— in a three-step rather than a six-step process. Of the atoms used in the synthesis, which are mostly derived from hydrocarbons, 77% make it into the final product compared with 40% before.Another leading drug for treating high cholesterol, Zocor (simvastatin), traditionally used a multistep method involving large amounts of hazardous reagents that produced a large amount of toxic waste. A new method for synthesizing the drug uses an engineered enzyme and a low-cost feedstock that was optimized by Codexis, a bio catalysis company. Additionally, Codexis worked with Merck to develop a greener route for synthesizing sitagliptin, the active ingredient in Januvia, a treatment for type 2 diabetes. This collaboration led to an enzymatic process that reduces waste, improves yield and safety, and eliminates the need for a metal catalyst.Another notable drug that now requires less waste to produce is the chemotherapy drug paclitaxel (marketed as Taxol). It was originally made by extracting chemicals from yew tree bark, a process that used a lot of solvent in addition to killing the tree. The drug is now made by growing tree cells in a fermentation vat.

GREEN SOLVENTS

The fifth principle of green chemistry holds that the use of auxiliary substances such as solvents "should be made unnecessary wherever possible and innocuous when used." Solvents are a key priority when greening chemistry, because they are used in high volumes and are typically volatile organic compounds (VOCs), leading to high risk for large amounts of waste, air pollution, and other health concerns. Finding safer, more efficient alternatives or removing solvents altogether is one of the most effective ways to impact the safety and efficiency of a process or product. Between 1996 and 2014, Presidential Green Chemistry Awards have recognized approaches that reduce the use of conventional solvents, including alternative, greener solvents, and processes that use carbon dioxide or water or avoid the use of solvents completely.A recent example of a green solvent that is now in commercial use is in fabric dyeing. Traditional dyeing also requires a lot of water—about 7 gallons to dye a T-shirt—and isenergy intensive because the dyed material must be dried. Dutch start-up firm DyeCoo Textile Systems recently invented an industrial-scale, water-free dyeing process and equipment that uses supercritical carbon dioxide, which functions like a liquid when under pressure and at slightly elevated temperature.In recent years, manufacturers of laundry detergents, spray cleaners, and other cleaning products for home and industry have been adding greener solvents to improve their performance, for both environmental and human health reasons. Procter & Gamble and DuPont have announced plans to use cellulosic ethanol derived from corncobs and stalks in TideColdwater Clean. The cellulosic ethanol produced by a plant that DuPont is building in Iowa will replace ethanol derived from corn kernels. Blending this cellulosic ethanol into Tide Coldwater will repurpose more than 7,000 tons of agricultural waste a year, the partners say, and in the process will save the amount of energy.DuPont also sells another bio-based chemical, 1,3-propanediol, as a solvent, stabilizer, and enzyme carrier. Propanediol is found in environmentally friendly method brand cleaning products, including a spray cleaner and a concentrated laundry detergent.

Another green cleaning solvent is butyl 3-hydroxybutyrate, trade-named Omnia, which was developed by Eastman Chemical. Eastman created the new solvent by methodically going through a database of some 3,000 molecules with potential as cleaning solvents and whittling it down to one through a combination of computer simulations and wet-lab testing.

Elevance Renewable Sciences, Inc., a small company that converts vegetable oils into specialty chemicals with olefin metathesis technology invented by Nobel laureate Robert H. Grubbs, has been involved with the production of two green solvents last year as a replacement for solvents such as n-methylpyrrolidone and methylene chloride in adhesive removers and paint strippers. The surfactant also can be used in household and industrial cleaners in place of glycol ethers.Elevance has also formulated a heavy-duty degreasing solvent aimed at manufacturing, food processing, and transportation maintenance customers, called Elevance Clean 1200. It is meant to appeal to companies looking for ingredients that are considered low vapour pressure by California and have a low enough vapour pressure or enough carbon atoms to be exempt from EPA’s VOC designation. Clean 1200 is being marketed as a replacement for aromatic hydrocarbons and d-limonene, a citrus-derived VOC.

A team at the University of Wisconsin at Madison recently described a promising biobased green solvent. They used mineral acid catalysts as a solvent in the conversion of hemicellulose and cellulose biomass into high value platform chemicals and transportation fuels. The use of lignin-derived alkylphenols as solvents in this process (carried out in a biphasic reactor) minimized side-reactions in the aqueous phase and enabled recycling of the mineral acid catalysts.

For analytical chemists, a new way to avoid solvents such as acetonitrile in high-performance liquid chromatography (HPLC) may be to replace them with distilled alcohols, such as rum or vodka, combined with household products.New work by a team of scientists from Merck Research Laboratories suggests that this combination can serve as low-cost and sustainable alternative eluents for HPLC, and in many cases produce excellent analytical results.Other green solvents seeing increasing use are water, supercritical carbon dioxide, and ionic liquids.Reversed phase HPLC-UV analysis of several pharmaceutical and foodrelevant compound mixtures using conventional HPLC instrumentation with different spirit alcohol-based mobile phases.

BIO-BASED TRANSFORMATIONS AND MATERIALS

Green chemistry has played a key role in the development of a growing number of alternative ways to synthesize chemicals traditionally made from petroleum or other non-renewable resources. Advances in genetics, biotechnology, process chemistry, and engineering are leading to a new manufacturing concept for converting renewable biomass to valuable fuels and products, generally known as the bio refinery concept.

Between 1996 and 2014, 34 Presidential Green Chemistry Award-winning technologies involved using a renewable resource in place of a petroleum-based or depleting resource. The winning technologies have involved a wide array of biological materials, including algae, bacteria and other microorganisms, biomass, cellulose, oils from crops and other plants, sugars, starch, and yeast. These technologies have been developed by some well-known companies, including Archer Daniels Midland, Cargill, DuPont, Eastman Chemical, Dow, Procter and Gamble, Sherwin-Williams, as well as academic researchers and smaller companies.

DuPont's Sorona polymer, which earned a Presidential Green Chemistry award in 2003, is an example of a bio-based process that is now commercially available. DuPont developed the process, which uses a genetically engineered microorganism and renewable cornstarch instead of petroleum to make cost-competitive textiles.The Sorona polymer can be used in apparel, carpeting, and packaging. This bio-based method uses less energy, reduces emissions, and employs renewable resources compared to traditional petrochemical processes.

Using a process developed by Genomatica that earned the EPA's 2011 Presidential Green Chemistry Challenge Award for "Greener Synthetic Pathways," BASF is commercially producing renewable 1,4-butanediol (1,4-BDO). This bio-based material is used to produce BASF's Ecoflex compostable polyester film, which is in turn used together with cassava starch and calcium carbonate to create fully biodegradable Ecovio bags. These bags, which are certified by the Biodegradable Products Institute, disintegrate into water, CO_2, and biomass in industrial composting systems.

Some recent innovations in producing bio-based chemicals have been the result of coupling chemical and biological processes.In a recent study, a team of academic researchers demonstrated that a variety of high-value products can be produced from a previously unexplored platform chemical—triacetic acid lactone, which is a 2-pyrone compound.The pyrone was synthesized from glucose by a genetically modified Escherichia coli and a yeast species, Saccharomyces cerevisiae. The researchers were able to produce 2,4-pentanedione (also known as acetylacetone), which has several commercial applications, including in metal extraction, in metal plating, and as a fuel additive. They also converted it to dienoic acid, which is usually produced from petrochemical sources and can be useful as a food and feed additive due to its ability to inhibit the growth of various mold and bacteria. Two other compounds the team reported producing are hexenoic acid, which can be used as a flavoring agent, and γ-caprolactone, a fragrance and cosmetics ingredient.

Another example is the process used by Auckland, New Zealand-based LanzaTech to convert carbon monoxide-containing gases to ethanol and other chemicals via microbial fermentation. Because steel mills produce CO_2-rich gas streams, LanzaTech recently constructed a 100,000-gallon-per-year ethanol production demonstration plant in Shanghai at Baosteel, China's largest steel producer. LanzaTech's microbes can also produce 2,3-butanediol, which can be converted to other compounds such as 1,3-butadiene, a monomer used to make synthetic rubber. U.S.-based Coskata is another company produces syngas, a mixture of mainly CO and hydrogen, via thermochemical gasification of biomass or other solids or via catalytic reforming of natural gas. Selective microbial fermentation of syngas yields low-molecular-weight alcohols. Coskata operates a plant that can produce tens of thousands of gallons of ethanol per year from wood chips.Solazyme is a biotech company that engineers microalgae to produce much higher amounts of oil than the 5-10% oil content in wild algae. The company won a Presidential Green Chemistry Challenge Award in 2014. Its products include the commercial production of algal oils that are engineered to be chemically similar to palm oil products, such as the C_{10} and C_{12} fatty acids found in palm kernel oil. The company's oils are found in products such as a laundry detergent.

ALTERNATIVE ENERGY SCIENCE

Solar Photovoltaics According to a recent analysis, solar photovoltaic technology is "one of the few renewable, low-carbon resources with both the scalability and the technological maturity to meet ever-growing global demand for electricity." The use of solar photovoltaics has been growing at an average of 43% per year since 2000. In recent years, clean energy experts have been very excited about the emergence of two new chemistry-driven solar technologies, perovskite solar cells and quantum dots. Perovskite solar cells compare well to most older photovoltaic technologies because they offer good power outputs from low-cost materials that are relatively simple to process into working devices. Scientists use the term loosely today to refer to a large class of materials that, like $CaTiO_3$, exhibit ABX_3 stoichiometry and adopt the perovskite crystal structure. The perovskites that are getting so much attention in the photovoltaics world these days are organometaltrihalides, the most commonly studied of which is $CH_3NH_3PbI_3$. (CH_3NH_3 is the A group in ABX_3.) The main reason for the excitement is the recent steep rate of improvement in Perovskite solar-cell performance.

In just a few years, the conversion efficiency of perovskite cells leaped from just a few percent in a forerunner version to more than 20% in 2015. This is a milestone that took other solar cells decades to reach. Most of the advances were reported in 2012 and 2013. The fast-paced improvement, which hasn't shown signs of slowing, coupled with inexpensive materials and preparation methods, prompts some experts to declare that perovskite solar cells are poised "to break the prevailing paradigm" by combining low cost and excellent performance.

Some of the key features of perovskite solar cells involved treating a film of TiO_2 with a solution containing CH_3NH_3I and PbI_2. The researchers triggered a self-assembly process that coated the oxide with a layer of $CH_3NH_3PbI_3$ nanocrystals, one of the perovskite materials at the centre of current research efforts. The group fashioned solar cells by sandwiching the perovskite-coated oxide films together with an organic electrolyte solution between conducting glass electrodes. They found that the triiodide cell readily generated electric current with a conversion efficiency of 3.8%. Two years later, a South Korean team reported using a similar cell with optimized parameters to achieve a conversion efficiency of 6.5%. From there, a team discovered the improvements possible when using a polyaromatic ring compound in the spirobifluorene family known as spiro-OMeTAD to achieve 9.7% efficiency. Replacing TiO2 with alumina (Al2O3) resulted in an unexpected 10.9% conversion efficiency.

In quick succession throughout 2013, a series of research papers appeared on a number of journal websites, each describing a slightly different perovskite solar-cell design, and each reporting efficiency improvements. The National Renewable Energy Laboratory, which is regarded internationally as the official verifier of solar-cell performance, has been confirming the performance of each improved version. In March 2015, researchers from the U.K. published information about a new low-temperature method for making perovskite solar cells so they can be used in high-efficiency, colourful, see-through photovoltaic films that could be laminated on windows or plastered on walls.

Quantum Dots are nanocrystals of semiconductor materials that emit a bright glow of a pure colour when they're excited by light or an applied voltage. Many alternative-energy experts are excited about quantum dot-based solar cells because they have a theoretical conversion of 45%. This is possible because when a single photon is absorbed by a quantum dot, it produces more than one bound electron-hole pair, or exciton, thereby doubling normal conversion efficiency numbers seen in single-junction silicon cells. To date, no one has yet to come close to achieving that kind of efficiency, but the rates have been improving. For example, in 2014, research teams reported that quantum-dot solar cells using ternary CuInS2 achieved a record of 7.04% (with certified efficiency of 6.66%).

Also in 2014, researchers at the Massachusetts Institute of Technology (MIT) produced a quantum-dot solar cell that changes light to electricity with 9% conversion efficiency. The MIT team says that the technology can be produced using an inexpensive production method that promises to keep manufacturing costs down. And recently, a new class of organometal halide perovskite-based semiconductors has emerged as a viable candidate for quantum-dot solar cells. These cells can use methylammonium lead iodide chloride (CH3NH3PbI2Cl) perovskite. Other quantum-dot solar cells use cadmium, prompting some observers to question whether it is correct to call applications of the technology that use such metals "clean" or "green."

Fuel Cells In the last decade, the cost of fuel cells has dropped, vehicle range has gone up, and engineers have perfected their ability to perform in frigid weather and operate under other challenging conditions. The first fuel-cell cars became available in the U.S. this year, but research by chemists and materials scientists continues to improve the technology the cells use to produce electricity by converting hydrogen and oxygen into water.

For example, over time, normal fuel-cell operation corrodes and oxidizes the carbon materials typically used as catalyst supports, leading to catalyst degradation and poor device performance. Metal nitrides have been studied as replacement supports, but they don't always tolerate the acidic conditions required for some fuels. A Cornell University team recently reported that a titanium chromium nitride material appears to overcome those problems. The researchers used palladium-silver nanoparticles supported on a highly porous Ti0.5Cr0.5N network, and they found it serves as an active and stable catalyst system in acidic and alkaline media across the typical range of fuel-cell voltages. Tests showed the material to be more active and durable than standard carbon materials.

Other important research relates to how to store the hydrogen fuel that fuel cells require. A research team from Boston College recently created an H2 storage molecule that does not decompose even at extreme temperatures of up to 150 °C. The researchers synthesized a new compound, a bis-BN cyclohexane, which may prove appropriate for applications such as backup generators that would store energy long-term in the event of a natural disaster.

NEXT-GENERATION CATALYST DESIGN

Twenty Presidential Green Chemistry Challenge Awards have recognized green catalysts. A recent example is the technologies developed by Elevance, which uses a Nobel-prizewinning catalysis approach to produce high-performing, green specialty chemicals at advantageous costs. The catalyst technology breaks down natural oils and recombines the fragments into novel, high-performance green chemicals. These chemicals combine the benefits of both petrochemicals and bio-based chemicals. The technology consumes significantly less energy and reduces greenhouse gas emissions by 50% compared to petrochemical technologies. Elevance is producing specialty chemicals for many uses, including in personal care products, cleaning products, lubricants, and in candle waxes. Some of these chemicals are commercially available.

One of Dow Chemical's awards is for a green catalyst that reduces the environmental footprint associated with producing propylene oxide, one of the biggest volume industrial chemicals in the world.The Hydrogen Peroxide to Propylene Oxide (HPPO) process, which was developed jointly with BASF, serves as a chemical building block for a vast array of products including detergents, polyurethanes, de-icers, food additives, and personal care items. The new process reduces the production of wastewater by as much as 70–80 percent and the use of energy by 35 percent over traditional technologies.

Another recently developed catalyst promises to be a less expensive and more efficient catalyst for cleansing diesel engine exhaust. Developed by a team of scientists from the U.S., China, and South Korea, the catalyst uses Mn-mullite(Sm, Gd)Mn2O5—manganesemullite materials containing either samarium or gadolinium to convert the toxic diesel engine-exhaust product nitric oxide to the more benign nitrous oxide.

A new catalyst developed by pharmaceutical companies Merck and Codexis for the green synthesis of sitagliptin, the active ingredient in the type 2 diabetes treatment Januvia™ may also be useful in the manufacturing of other drugs. For example, a recent clinical trial showed that it may help patients with acute coronary syndrome.

An example of green catalysts with the potential to reduce the pharmaceutical industry's environmental impact is the powerful series of tetra-amido macrocyclic ligand (TAML) catalysts modelled on natural peroxidase enzymes developed by Terry Collins of Carnegie

Mellon University. Collins thinks that using the catalysts at a late stage in the sewage treatment process would allow them to break down a wide variety of chemical residues, including those from Lipitor, Prozac, Zoloft, the contraceptive pill, and more, before they enter the environment.

MOLECULAR DESIGN FOR REDUCED HAZARD

Dozens of Presidential Green Chemistry Awards recognize safer chemical products designed for use in a wide variety of industries. In 2014, the Solberg Company earned an award for its halogen-free RE-HEALING Foams for use in fighting fires. Traditionally, firefighting foams used fluorinated surfactants, persistent chemicals that have the potential for environmental impacts. The RE-HEALING firefighting foam concentrates use a blend of non-fluorinated surfactants and sugars, and they work well with far less environmental impact. Control, extinguishing time, and burnback resistance are paramount to the safety of firefighters everywhere, and the new foams have excellent performance in each. The foams also achieve full regulatory compliance with existing fire protection standards.

In 2013, Cargill, Inc. was honoured for its Envirotemp FR vegetable oil-based insulating fluid for high-voltage transformers. Until they were banned in the 1970s, polychlorinated biphenyls (PCBs) were used in the insulating fluid needed to prevent short circuiting and provide cooling for high-voltage electric transformers. After the PCB ban mineral oil became the primary replacement. Unfortunately, mineral oil is flammable and may be toxic to fish. Cargill's vegetable-oil-based transformer fluid is much less flammable, provides superior performance, is less toxic, and has a substantially lower carbon footprint. According to a life-cycle assessment, a transformer using FR3 fluid has a lower carbon footprint across the entire life-cycle of a transformer, with the largest reductions occurring in the raw materials, manufacturing, and transportation phases. The total carbon footprint of an electric transformer is about 55-times lower when using FR3 fluid compared to mineral oil. This is all in addition to high biodegradability and the fact that FR3fluids are based on a renewable resource. Furthermore, there have been no known explosions or fires in the hundreds of thousands of transformers filled with FR3 fluid since the product launched.

Faraday Technology, Inc. earned a Presidential Green Chemistry Award for a chrome plating technology that uses trivalent chromium, which is less toxic than hexavalent chromium, a

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known carcinogen. In 2012, Buckman International, Inc. earned a green chemistry award for enzymes that reduce the energy and wood fibre required to manufacture high-quality paper and paperboard. Traditionally, making strong paper required costly wood pulp, energyintensive treatment, or chemical additives. Buckman'sMaximyze enzymes can achieve the same goal by modifying the cellulose in wood to increase the number of "fibrils" that bind the wood fibres to each other, thus making paper with improved strength and quality—without additional chemicals or energy. Buckman's process also allows papermaking with less wood fibre and higher percentages of recycled paper, enabling a single plant to save $1 million per year.

Maximyze improves strength so the weight of the paper product can be reduced or some of the wood fibre can be replaced with a mineral filler such as calcium carbonate. Maximyzetreatment also uses less steam because the paper drains faster (increasing the production rate) and uses less electricity for refining. The treatment is less toxic than current alternatives and is safer to handle, manufacture, transport, and use than current chemical treatments used in paper production.

Conclusion

The expansion of Green Chemistry over the course of the past decade needs to increase at an accelerated pace if molecular science is to meet challenges of sustainability. It has been said that the revolution of one day becomes the new orthodoxy of the next Green Chemistry is applied and must involve the successful implementation of more environmentally friendly chemical processes and product design. Most importantly we need the relevant scientific, engineering, educational and other communities to work together for sustainable future through Green Chemistry. Green chemistry is here to stay, and the discipline is likely to have an even greater impact in the coming decades. The rapid rate of its acceptance as a scientific discipline and the ever-expanding rate of green chemistry's influence suggest that the vast majority of chemicals used in commerce may be benign by design within your lifetime. Furthermore, you may become a significant contributor to the positive changes that industrial green chemistry is creating and will continue to catalyse in our world.

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