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## The ways the green chemistry is helping make the world a better place

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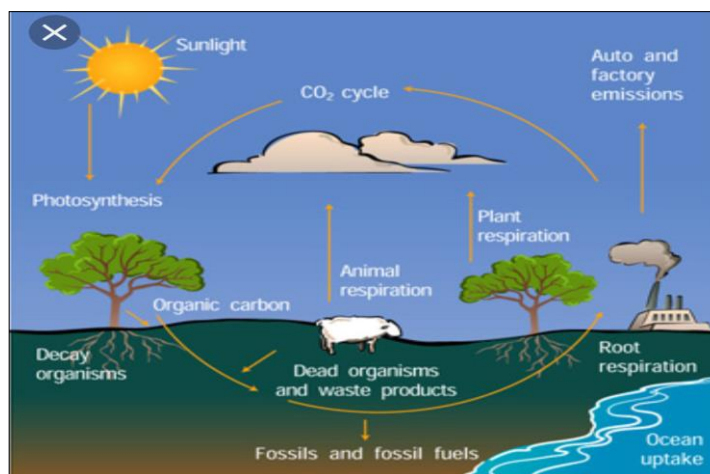
### Abstract

A grand challenge facing government, industry, and academia in the relationship of our technological society to the environment is reinventing the use of materials. To address this challenge, collaboration from an interdisciplinary group of stakeholders will be necessary. Traditionally, the approach to risk management of materials and chemicals has been through interventions intended to reduce exposure to materials that are hazardous to health and the environment. In 1990, the Pollution Prevention Act encouraged a new tact-elimination of hazards at the source. An emerging approach to this grand challenge seeks to embed the diverse set of environmental perspectives and interests in the everyday practice of the people most responsible for using and creating new materials—chemists. The approach, which has come to be known as Green Chemistry, intends to eliminate intrinsic hazard itself, rather than focusing on reducing risk by minimizing exposure.

**Keywords:** Green chemistry, pollution, environment, chemicals

### Introduction

Chemistry is the study of matter, and “green chemistry” – or what we in the business world might call molecular technology – will be a key component in closing the overall consumption loop. Green chemistry, or sustainable chemistry, involves creation the molecular level: devising chemical reactions that give rise to new products and processes that have the ability to meet sustainability goals, such as becoming more energy-efficient, and reducing the amount of waste or harmful matter found in the environment. Some major themes in green chemistry today include reducing our reliance on nonrenewable energy sources, reducing industrial carbon footprints, breaking down landfill waste, and taking advantage of abundant resources (waste) that nobody wants – like carbon dioxide (CO<sub>2</sub>), for example. Carbon dioxide (CO<sub>2</sub>) has a deserved reputation of being a damaging greenhouse gas that is pushing up the rate of global warming.



**Fig 1:** CO<sub>2</sub> Cycle

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Green chemistry has been pivotal in coming up with ways to use CO<sub>2</sub> as a resource instead of having it become a waste product stuck in our air. For instance, chemists found that when CO<sub>2</sub> molecules are kept in a transitive state, or what's known as transcritical CO<sub>2</sub>, the dynamic state in which CO<sub>2</sub> is at the point of converting from a liquid to a gas, it can be used as an industrial refrigerant to keep things cool. The application of transcritical CO<sub>2</sub> is clear. We have a lot of buildings that need to stay cold: Supermarkets, food processing facilities, warehouses, and even ice skating rinks. Thanks to transcritical CO<sub>2</sub>, a building's climate impact can be reduced by approximately 15% while also replacing Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HFCs) – greenhouse gases that are commonly used for refrigeration.

**Improving paint performance while cutting costs**

Green chemistry has reduced the carbon footprint for the Dow Chemical Company's paint production. Titanium dioxide (TiO<sub>2</sub>) is an important additive to paint, but is also expensive and energy-intensive to make. It acts as a base pigment in paint that covers the original color underneath the new coat of paint. Through research to find greener chemical reactions, Dow Chemical developed a polymer (EVOQUE<sup>tm</sup>) that improves the function of titanium dioxide by coating it and enabling it to be dispersed more evenly and thoroughly. As a result, the effectiveness of paint was actually improved while requiring less titanium dioxide to make. Not only was the product improved, but costs were cut because the paint now required less titanium dioxide to make. Moreover, a lifecycle assessment (LCA) of the production of paint showed that the reduction of titanium dioxide through the use of EVOQUE<sup>tm</sup> in outdoor house paint reduced the carbon footprint of the paint by 22% and consumed 30% less water. EVOQUE<sup>tm</sup> also reduced the amount of VOCs (volatile organic compounds) in the paint, which contributes to smog (also known as tropospheric

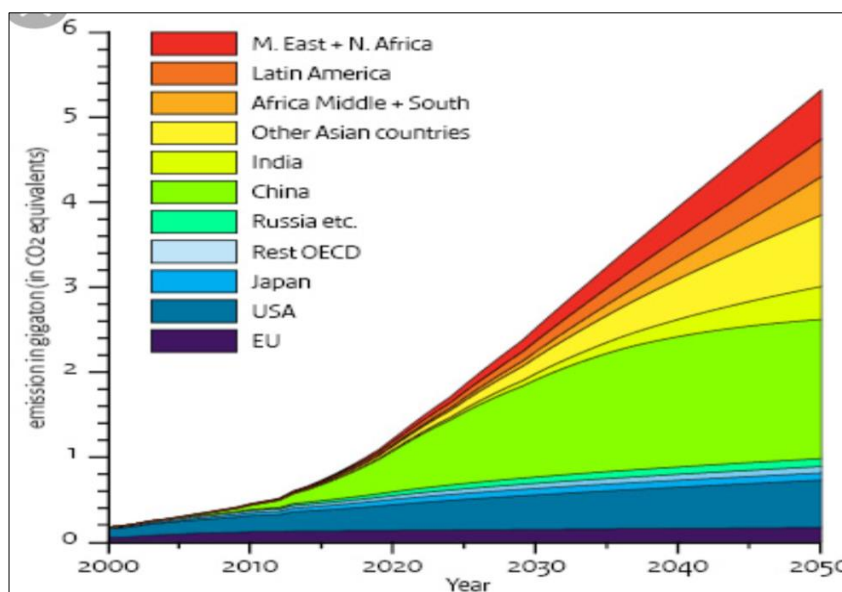
ozone). This is green chemistry in action. The paint in below diagram observed.



**Fig 2:** Paint pollution reduced by Green chemistry

**Producing fuel and useful chemicals out of waste gas**

Many industrial processes typically create gas byproducts that cannot be utilized. Though gas fermentation processes – in which microorganisms convert a combination of gases into fuels – do exist, most gas byproducts don't have the right combination of molecules required for gas fermentation. Dihydrogen (H<sub>2</sub>), which is normally necessary, is particularly hard to come by in industrial gas byproducts. To address this gap, Illinois-based Lanza Tech Inc. developed proprietary microbes that can convert the gas byproducts into fuels without dihydrogen (H<sub>2</sub>). This breakthrough process makes it possible to utilize gas fermentation in more settings and more industries, and the economic benefits of being able to produce fuels out of existing gas byproducts are clear. Moreover, third-party LCA analysis showed that fuels made through Lanza Tech's process creates 70% less greenhouse gases than traditional fossil fuels, in addition to a reduction in particulate matter and other molecular byproducts that contribute to smog.



**Fig 3:** Global Emission of

Total HFC Emissions without control Measures that I observed in above diagram. Replacing CFCs with naturally occurring or CO<sub>2</sub> byproducts in polystyrene foam sheets – then licensing the technology:- Polystyrene foam will be

familiar to anyone who has picked up an egg carton. Polystyrene foam is also used for meat and poultry trays and fast food containers. As it turns out, CFCs, a greenhouse gas that negatively affect the ozone and air quality, were

required to make polystyrene – that is, until the Dow Chemical Company developed a process to use CO<sub>2</sub> instead of CFCs. CO<sub>2</sub> is common industrial byproduct and is abundant and readily available. This green chemistry process keeps 3.5 million pounds of CFCs out of the atmosphere and only uses existing CO<sub>2</sub>, so that it helps reduce global levels of CO<sub>2</sub>. The DOW Chemical Company patented the technology and licenses it commercially, creating a new income stream for itself as well as preserving air quality for all.

#### **In the future: Tackling the plastic problem**

Today, plastic takes anywhere from 500 to 1,000 years to degrade, and anywhere from four to twelve million metric

tons of additional plastic end up in our oceans every year. The end game can't be far. Polyethylene is one of these plastics, known sometimes as PET or no.1 plastic and is ubiquitously used for making plastic water bottles, paper bags, clam shell packaging, and other containers, thanks to its light weight and sturdiness. But the downside to those3 desirable qualities in modern living is that PET is hard to degrade because of its highly stable molecular structure and resilience against moisture (it was designed to be able to store liquids, after all). Fortunately, researchers in Japan however have discovered a microbe that can break down PET and also identified enzymes to stimulate the microbes to break down PET even faster.



**Fig 4:** Plastic collection recycling by Green chemistry

Meanwhile, the outstanding researchers hope to provide a means for manufacturers to move away from petroleum-based production processes to make plastic. Today, many plastics are petroleum-based. Professor Matthew Kanan and his lab researchers recently created a novel way to make plastic out of carbon dioxide and plant byproducts, such as agricultural waste or otherwise unusable plant material, like fibers left over from carrot juicing.

#### **Conclusion**

Going forward, green chemistry will be an important foundation for the circular economy, since a no-waste use of natural resources is one of its overarching goals. For the non-science person, green chemistry may be highly technical but it can also be highly rewarding, for those who are willing to invest in it.

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