Green and
Sustainable
Chemistry

Introduction to GSC

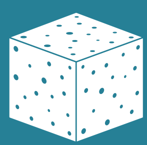
No.8

Received the Minister of Economy, Trade and Industry Award of the 8th GSC Awards (2008)

Development and Commercialization of a New Manufacturing Process for Propylene Oxide Utilizing Cumene Recycling

Sumitomo Chemical Co., Ltd.

Sumitomo Chemical Co., Ltd. developed a new manufacturing process for propylene oxide, which is used as a raw material for polyurethane and other materials.
The new process enables high yields of propylene oxide while reducing its environmental impact.



Outline of the GSC Awards and award-winning company

The GSC Awards are bestowed upon individuals and organizations for their contribution toward the advancement of Green and Sustainable Chemistry (GSC), and several awards are conferred each year. Innovations that contribute toward the development of sustainable industrial technology are awarded the Minister of Economy, Trade and Industry Award; those that contribute toward the development and promotion of science are awarded the Minister of Education, Culture, Sports, Science and Technology Award; those that contribute toward the overall reduction of environmental impact are awarded the Minister of the Environment Award; while small and medium-sized businesses that contribute toward the development of industrial technology are awarded the Small Business Award (established in 2015; renamed to Venture Company Award, Small and Medium-sized Company Award in 2018 and Venture, Small and Medium sized Company Award in 2022). Additionally, innovations that exhibit high potential for future development are awarded the Incentive Award.

Sumitomo Chemical Co., Ltd. is a chemical company founded in 1913 (headquartered in Chuo-ku, Tokyo, Japan). The company manufactures and sells a wide range of chemical products, including synthetic resins, synthetic fiber raw materials, inorganic materials, battery component materials, photofunctional films, semiconductor materials, agricultural chemicals, and feed additives. Sumitomo Chemical maintains a high global market share in raw materials for household and horticultural pesticide.

Objective of the textbook series

Global issues, in areas such as resources and energy, global warming, water and food have increasingly become major and complicated concerns. Innovations for achieving both environmental conservation and economic development are needed in order to resolve these issues and realize the sustainable development of society, and expectations for GSC continue to rise. In this textbook series, technologies and products that have received the GSC Awards given to great achievements contributing to the progress of GSC are explained, so that everyone can understand “what is GSC?” and take responsibility for realizing a sustainable society.

*Please refer to The Statement 2015 at the end of the textbook.

What is GSC?

Acronym for Green and Sustainable Chemistry

Definition of GSC

Chemical sciences and technologies which are benign to both human health and the environment, and support the development of a sustainable society

Guidelines of GSC activities

- The chemistry community has been addressing future-oriented research and education, and development towards environmentally-benign systems, processes and products for the sustainable development of society.

- Specifically, in response to the Rio Declaration at the Earth Summit in 1992, the chemistry community has been working in a unified manner linking academia, industry and government to start up Green and Sustainable Chemistry and engage in its activities, in order to advance the pursuance of coexistence with the global environment, the satisfaction of society’s needs, and economic rationality. These goals should be pursued with consideration for the environment, safety and health across the life cycles of chemical products, their design, selection of raw materials, processing, use, recycling and final disposal.

- Long-term global issues, in areas such as resources and energy, global warming, water and food, and demographics have increasingly become major and complicated concerns in the present century. Therefore, expectations are growing for innovations, based on the chemical sciences, as driving forces to solve such issues and to achieve the sustainable development of society with enhanced quality of life and well-being.

- The chemistry community will live up to these expectations by strongly advancing Green and Sustainable Chemistry through global partnership and collaboration and by bridging the boundaries that separate industries, academia, governments, consumers and nations.

Examples of GSC

- The general classification is expressed in terms of a combination of the intended social contribution and the means to achieve this goal. With regard to the objectives, the efforts to achieve them have extended in stages from social challenges to difficult long-term challenges, beginning with manufacturing or utilization, and common/basic categories have also been established -

Minimization of resource consumption and maximization of the efficiency of reaction processes for production with reduced environmental impact

1. Chemical technologies and products that lead to reduction in by-product formation and avoid the use of hazardous substances

2. Separation, purification and recycling technologies that reduce the generation and emission of greenhouse gases like CO_2 or toxic/hazardous substances, thus lowering environmental impact

3. Chemical technologies and products that reduce the generation and emission to the environment of greenhouse gases like CO_2 or toxic/hazardous substances

4. Catalysts and reaction processes that realize the saving of energy and resource and improvement in product yields

Risk reduction of chemical substances beneficial to safe and secure living environment

5. Chemical technologies, products and systems that reduce waste generation

6. Chemical technologies, products and systems that inhibit the generation and emission of hazardous substances and pollutants

Challenges to solve energy, resource, food and water issues

7. Chemical technologies, products and systems to utilize low-grade heat sources, non-conventional resources, and other similar alternatives

8. Chemical technologies, products and systems whereby un-utilized energy and resources can be converted into available energy, transported and stored

9. Chemical technologies, products and systems which decrease the dependence on exhaustible resources such as fossil fuels and scarce minerals and promote the shift to renewable energy and resources, including their storage

10. Chemical technologies, products and systems that contribute to the Three R's: Reduce, Reuse and Recycle

11. Chemical technologies, products and systems that promote the efficiency of production and supply of food, and utilization of water resources

Pioneering challenges to long-term issues aiming to realize a safe, secure and sustainable society with enhanced quality of life

12. Chemical technologies, new products and new operational systems that contribute to the introduction of new social systems, for instance based on ICT, and aimed at solving social issues such as energy and resource consumption, food and water security, disaster prevention and infrastructure improvements, transportation and logistics, medical and health care, education and welfare, and other mega-trends of society

13. Chemical technologies, new products and new operational systems that contribute to the improvement of social and individual comfort whilst reducing and preferably inhibiting environmental impact

Systematization, dissemination, enlightenment and education of GSC including its metrics to be established

14. Systematization of GSC practices and concepts

15. Dissemination, enlightenment and education of GSC practices and concepts

16. Establishment and dissemination of GSC metrics

(Definition from JACI GSCN Council
https://www.jaci.or.jp/english/gscn/page_01.html)

High yield and energy saving Development and Commercialization of a New Manufacturing Process for Propylene Oxide Utilizing Cumene Recycling

Sumitomo Chemical Co., Ltd.

The Minister of Economy, Trade and Industry Award at the 8th GSC Awards (FY2008) was awarded to Sumitomo Chemical Co., Ltd.'s "Development and Commercialization of a New Manufacturing Process for Propylene Oxide Utilizing Cumene Recycling." In traditional manufacturing processes for propylene oxide, there are two issues: 1. the production of substantial quantities of chloride compounds as by-products, which have a significant environmental impact; 2. the production of the co-products affects the market price of propylene oxide, diminishing the competitiveness of the manufacturing process. In contrast, Sumitomo Chemical's innovative technology enables the production of propylene oxide with high yield and without any by-products, while also demanding less energy.

1 The Path to Technology Development

~ What were the intentions that started development toward realizing the sustainable progress of society?

The chemical products used in everyday life are manufactured from raw materials through various chemical reactions (Column ①). Propylene oxide (PO)*1 is an important raw material for numerous chemical products such as polyurethane, which is used to make sponges and car seat cushions (Fig. 1). Global production of PO exceeds 10 million tons per year, and its demand has been steadily increasing.

Until the 1990s, commercialized PO manufacturing processes included the "chlorine method" and the "organic peroxide method" (Column ②). Even though the chlorine method affords only PO without co-products, a large volume of wastewater containing calcium chloride is discharged, causing a higher environmental impact. On the other hand, the organic peroxide method generates more than twice the volume of the co-products as the target PO. In this scenario, the market prices of the co-products significantly affect the competitiveness of this manufacturing process.

Prior to the development of this new process, Sumitomo Chemical had manufactured PO using the organic peroxide method through a joint venture. The demand for PO was strong, and transactions were steady. However, when the demand for co-produced styrene and its market price deteriorated, the PO business was also affected. Additionally, the adoption of the Kyoto Protocol in 1997 led to increased societal interest in the environmental impact of manufacturing processes. Hence, in 1998, Sumitomo Chemical started to develop a sustainable, rationally designed PO-only manufacturing process with low environmental impact. Another company was developing a PO manufacturing process based on the same concept, using hydrogen peroxide (H_2O_2). This hydrogen peroxide method is a clean PO-only manufacturing process, with water as the only by-product.

To respond to the thriving PO market, Sumitomo Chemical launched a project in 2003 to start PO production at a new plant. The development of a new industrial manufacturing process usually requires a long time, but this project was requested an exceptionally short timeframe.

*1
It is also referred to as propylene oxide, propene oxide, methyloxirane, and 1,2-epoxypropane. It is a colorless, transparent liquid used as a raw material for various chemical products.

Propylene oxide (PO) Polyurethane (R is a PO polymer derivative)

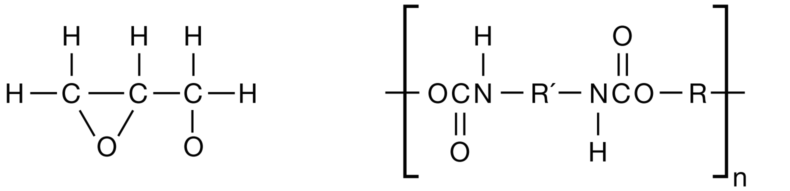


Fig. 1: The structure of propylene oxide (left) and polyurethane synthesized from PO (right)

2 Toward Resolution of Issues

~ What types of technological challenges did the developers face and how did they resolve them?

Hastening the development of the new process

The development of a new manufacturing process for a chemical product is conducted in phases, from the laboratory level to bench plants, pilot plants, demonstration plants, and actual production plants, while passing along the results obtained in each phase. Even reactions that occur satisfactorily in the laboratory are not guaranteed to perform well in large-scale facilities, such as production plants. Therefore, the scale of production is gradually increased to overcome any issues that occur in each phase and evaluate the process from multiple perspectives.

To develop the new PO manufacturing process in an exceptionally short timeframe, technology development and basic manufacturing facility design for each step of the process were conducted in parallel from the laboratory level to the completion of the production plant. This approach is known as “concurrent engineering,” and if successful, it can greatly reduce the development timeline. From the beginning of the development process, laboratory researchers worked together with plant engineers, which required a deeper mutual understanding and cooperation than typical development projects. One of the project members stated, “It was the first time for us to attempt concurrent engineering. It was the quite challenging work.” The efforts succeeded. The typical 10-year development period was achieved in just four years.

Using cumene

The Sumitomo Chemical research team used cumene hydroperoxide (CMHP) as a novel approach instead of isobutane and ethylbenzene that are used in the organic peroxide method. Using CMHP, it is possible to produce only PO without generating co-products, such as styrene and tert-butyl alcohol.

The process involves ① oxidation, in which cumene is oxidized with air to produce CMHP; ② epoxidation*2, in which PO and cumyl alcohol are obtained from CMHP and propylene; and ③ hydrogenation, in which cumyl alcohol is hydrogenated to produce cumene. A notable feature of this method is cumene recycling, where cumene serves as a reaction mediator and an oxygen carrier (Fig. 2).

*2 Epoxidation involves the addition of an oxygen atom between double-bonded carbon atoms (C=C) to form a 3-member epoxide ring (epoxy compound).

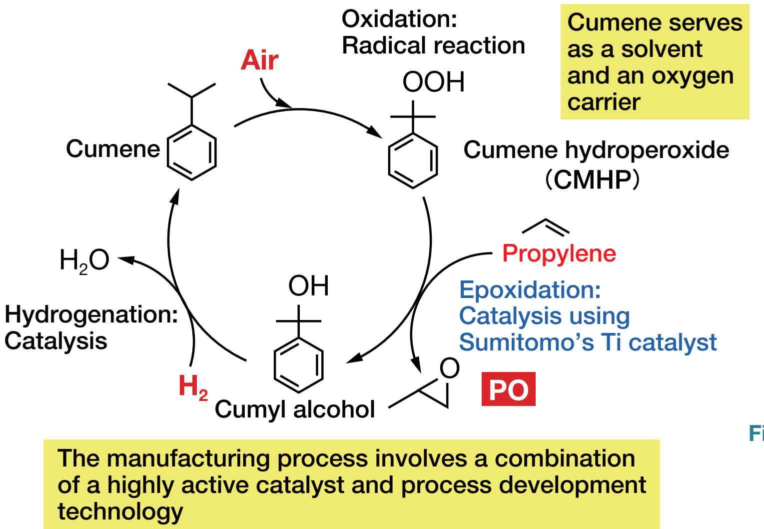


Fig. 2: PO manufacturing process utilizing cumene recycling (Cumene method)

The concept of using CMHP to manufacture PO had existed for many years; however, a catalyst that facilitates efficient epoxidation did not exist, and thus, had to be developed.

Development of a highly active catalyst for epoxidation

Titanosilicate (TS-1: a zeolite containing a titanium framework) is a well-known epoxidation catalyst and exhibits high catalytic activity in the presence of hydrogen peroxide as the oxidizing agent. However, TS-1 exhibited almost no activity when using CMHP.

TS-1 has micropores with a regular size of 1 nm*3 that could fit reactants and serve as active sites for the reaction. The larger the surface area inside the pores, the more space available for the reaction to occur. However, the micropores in TS-1 were too small for CMHP.

Therefore, a larger pore size is required to accommodate CMHP in the cumene-based PO manufacturing process. In this context, mesoporous materials*4 such as silicon dioxide (silica) with larger uniform pores than those in TS-1 were explored. Titanium, which is the active site for epoxidation, was introduced into the silica matrix. Moreover, the number of mesopores was increased to improve reaction efficiency. Notably, titanium was introduced in a highly dispersed state to increase the epoxidation activity, and the catalyst affinity for propylene was increased by making its surface hydrophobic. This silicon oxide catalyst containing titanium "Sumitomo Ti catalyst" was developed by various studies. It exhibited high epoxidation activity when CMHP was used (Fig. 3).

Even though mesoporous catalysts had been widely reported in the literature, this is the first instance of the industrial application of a mesoporous catalyst. The company also focused on manufacturing the catalyst with high efficiency and low cost.

*3
1nm (nanometer) is 1/1,000,000,000 of 1 meter.

*4
Meso is a prefix that means "intermediate." In this context, the pore size is larger than that of titanium silicate and smaller than those of the other catalysts.

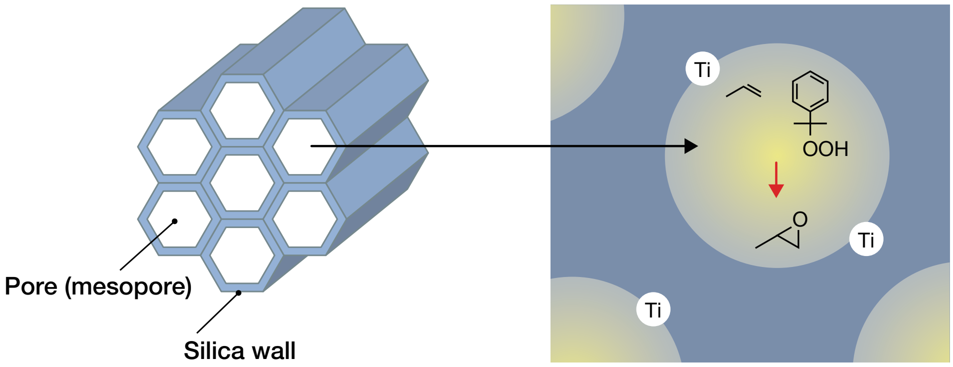


Fig. 3: Mesoporous structure (left) and Sumitomo Ti catalyst with mesoporous structure (right)
A mesoporous structure refers to a configuration featuring uniformly sized pores with diameters ranging from 2 to 50 nm. The reaction occurs in the pores of the catalyst; therefore, a mesoporous structure is advantageous for reactions involving large molecules.

Development of the new process

Increasing production efficiency and reducing environmental impact were the main objectives of the development of this novel PO manufacturing process. As previously stated, the PO manufacturing process involves three steps: oxidation, epoxidation, and hydrogenation. Concurrent engineering was performed, and the reaction conditions were optimized to increase the reaction rate and yield for high-efficiency PO manufacturing. The heat generated during each step is recovered and used effectively in the other steps. In addition, cumene functions as both a solvent and a reaction mediator, eliminating the need for another solvent. This simplifies the process and reduces energy consumption. Furthermore, cumene is recovered in the hydrogenation step for reuse.

Achieving high yield and energy efficiency

This process enables high yields of PO and requires less energy than other processes. Typically, in manufacturing, tradeoffs exist between increasing yield and reducing energy consumption. For example, although lowering the reaction temperature leads to an increased yield, recovering heat becomes difficult, resulting in energy loss. The use of cumene and the development of high-performance catalysts are key factors; however, they alone are not responsible for the high yield and energy savings. Other factors, such as the optimized reaction vessel and reaction conditions, also contributed to the high yield and energy savings.

A member of the development project said, "Each step is intricately interrelated. So, it was difficult to optimize the overall manufacturing process and understand the behavior of the trace compounds formed in each reaction. Even though the process was understood theoretically, that alone did not make it easy to increase the competitive strengths of the process." Concurrent engineering played a major role in optimizing the manufacturing process in such a short time period.

3 Contribution to Society

~ What is the contribution of this novel technology to society?

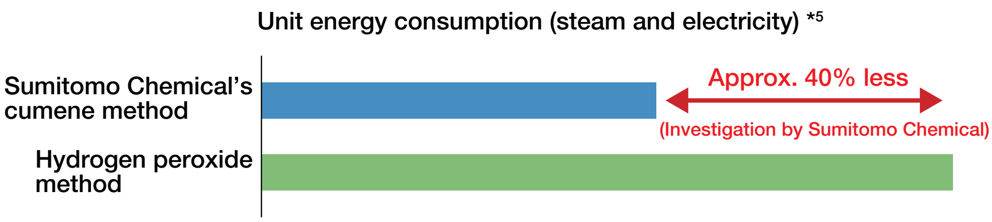
This new PO-only manufacturing process "Cumene method" developed by Sumitomo Chemical is characterized by cumene recycling and efficient PO generation. In addition to solving the problems inherent in the existing chlorine and organic peroxide methods, Sumitomo Chemical's new method reduces energy consumption and environmental impact. For example, the hydrogen peroxide method, developed around the same time, requires a large amount of energy to recover the solvent methanol. In contrast, this Cumene method that uses cumene also as a solvent, requires less energy to recover and recycle the solvent due to cumene's lower latent heat of vaporization. In addition, energy consumption is further reduced through extremely high yields at each step of the process and efforts to recover the heat generated during the reactions. The estimated energy consumption of the cumene-based method is approximately 40% lower than that of the hydrogen peroxide method (Fig. 4).

Moreover, efforts for energy saving contribute to reducing the emissions of carbon dioxide, a recognized contributor to global warming. The reuse of resources and reduced energy requirements of this technology make it a practical example of Green and Sustainable Chemistry (GSC).

The production of PO at a new plant in Chiba began in 2003, as originally planned, and the plant has been operating steadily. Since then, the manufacturing department and the research laboratory have continued to work together to improve this process.

This technology has received considerable attention overseas, and three technology license agreements have been made, resulting in the establishment of plants in Saudi Arabia in 2009, South Korea in 2015, and Thailand in 2020. If more license agreements are made, the global market share of the process is expected to exceed 10%. Expanding the use of this technology should contribute to reducing the global environmental impact. Sumitomo Chemical aims to improve continuously the catalyst and processes for PO manufacturing and expand its technology worldwide.

*5 Energy consumed to produce a set volume of product.



*The energy required to manufacture hydrogen peroxide is also considered for the hydrogen peroxide method.

Fig. 4: Comparison of the energy consumption.

Column 1

Chemical industry

The chemical industry uses natural resources such as coal, oil, ores, air, and water as raw materials to manufacture various chemical products, such as synthetic rubber and plastic, through chemical reactions. Consumers rarely come into direct contact with chemical products, unlike with clothing and food. However, chemical products are used as raw materials to manufacture everyday products. Thus, the chemical industry is an unsung hero.

Chemical plants produce numerous desired products from reactants through numerous chemical reactions. Therefore, practical processes with high reaction yields and efficiency are crucial. In this context, reaction conditions, such as the reaction temperature, pressure, and reactant concentrations, should be optimized. Catalysts are also used in numerous reactions. A small amount of catalyst can accelerate specific chemical reactions without undergoing the reaction itself. Therefore, identifying the appropriate catalyst for each chemical reaction in a manufacturing process is important.

Many by-products are generated during these chemical reactions, which are typically discharged in large volumes, resulting in environmental contamination and pollution. However, in light of GSC, which aims to efficiently use resources and reduce waste to the extent possible, the treatment and management of waste materials have become an important part of plant operations in recent years.

Column 2

Propylene oxide (PO) manufacturing process

The chlorine method (chlorohydrin method) and the organic peroxide method (organic hydroperoxide method) are traditional PO manufacturing processes. Epoxidation of propylene is the main reaction in PO synthesis, but it is a complex industrial manufacturing process.

The chlorine method (Fig. 5) is the first PO manufacturing process to be commercialized. Propylene chlorohydrin is produced by reacting propylene with chlorine and water. Then, propylene chlorohydrin is reacted with a base, such as calcium hydroxide, to form PO. The process not only uses toxic chlorine but also produces a large volume of salt, such as calcium chloride, as a by-product; therefore, a post-process treatment is required.

In the organic peroxide method (Fig. 6), hydroperoxide of ethylbenzene and isobutane react with propylene to produce PO along with styrene (via α-methylbenzyl alcohol) or tert-butanol, respectively.

Another manufacturing method involves the use of hydrogen peroxide synthesized from hydrogen and oxygen (Fig. 7). Similar to the new method developed by Sumitomo Chemical, this method does not produce any by-products; however, recovering the solvent methanol requires a significant amount of energy.

Fig. 5: Chlorine method

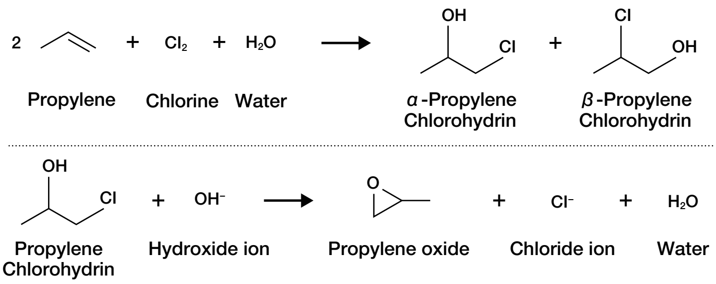


Fig. 6: Organic peroxide method

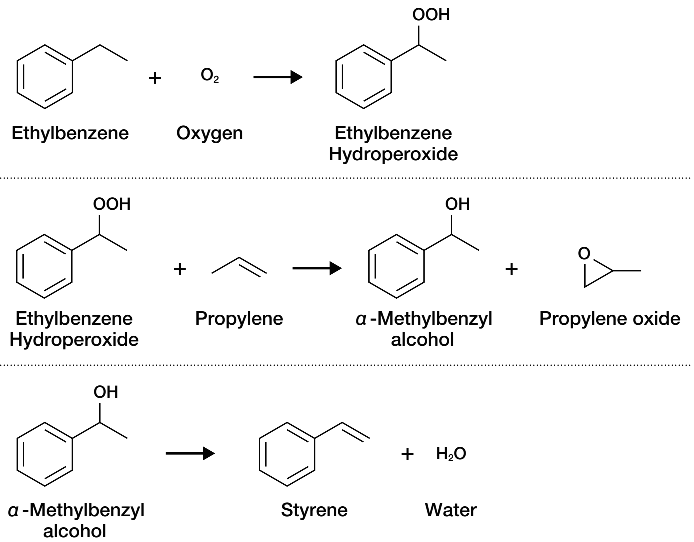
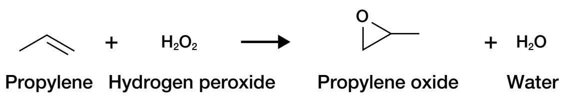


Fig. 7: Hydrogen peroxide method



Questions

For deeper understanding

Through this case study, discuss the following questions from the viewpoint of GSC (Green and Sustainable Chemistry).

Q1 Discuss which of the GSC cases best applies to the technologies and products of this teaching material, along with the reasons.

Q2 Implementation in society is vital for any technology to meet the goals of GSC. This involves the simultaneous fulfillment of coexistence with the global environment, the satisfaction of society's needs, and economic rationality. In the examples of technologies and products in this teaching material, summarize what measures have been taken to meet not only environmental and social satisfaction but also economic rationality.

Q3 Several methods have been proposed for assessing how “green” a particular chemical synthesis is. The following assessment method was used to compare propylene oxide synthesis using the chlorine, organic peroxide, cumene, and hydrogen peroxide methods discussed in this teaching material.
Using the following evaluation methods, compare the propylene oxide synthesis using the chlorine, organic peroxide, cumene, and hydrogen peroxide.
Atom efficiency (atom economy)
Atom efficiency (%) = [molecular weight of the synthesized target compound] / [total molecular weight of the reactants included in the process] × 100
Environmental factor
Environmental factor = [Weight of waste materials (kg)] / [Weight of target product (kg)]

Q4 Explain the relationship between this technology and the SDGs.

Q5 Evaluate this technology in accordance with the GSC 4-axes method.
(Refer to “Introduction to GSC” No. 4 https://www.jaci.or.jp/english/gscn/GSCgs/e04/gsc_e04.php).

Literature

Helpful materials

1) *Industrial Organic Chemistry, 5th Edition,* K. Weissermel and H.-J. Arpe, Tokyo Kagaku Dojin, 2004.
2) *“Chapter 6: Making Useful Substances” In Environment and Chemistry - Introduction to Green Chemistry, 3rd Edition* (in Japanese), ed. K. Ogino, S. Takeuchi, and H. Tsuge, Tokyo Kagaku Dojin, 2018.
3) *Chemical Processes Engineering* (in Japanese), K. Onogi, T. Tagawa, N. Kobayashi, and S. Nii, Shokabo, 2007.
4) *Introductory Chemical Engineering for Engineers* (in Japanese), K. Saito and H. Muso (illustrations), Kodansha, 2012.
5) *Learning Chemical Engineering Through Actual Case Studies – Approaches to Solving Issues* (in Japanese), ed. The Society of Chemical Engineers, Japan Textbook Committee, Maruzen Publishing, 2022.

The previously published issue of the “Introduction to GSC” series and the special edition "Introduction to SDGs" can be viewed from the following URL or QR code.
https://www.jaci.or.jp/english/gscn/page_05.html

The Statement 2015

We, the participants of the 7th International GSC Conference Tokyo（GSC-7）and 4th JACI/GSC Symposium make the following declaration to promote "Green and Sustainable Chemistry（GSC）" as a key initiative in the ongoing efforts to achieve global sustainable development.

The global chemistry community has been addressing future-oriented research, innovation, education, and development towards environmentally-benign systems, processes, and products for the sustainable development of society.

In response to the Rio Declaration at the Earth Summit in 1992 and subsequent global Declarations, the global chemistry community has been working on challenges in a unified manner linking academia, industry, and government with a common focus to advance the adoption and uptake of Green and Sustainable Chemistry. The outcomes include the pursuance of co-existence with the global environment, the satisfaction of society's needs, and economic rationality. These goals should be pursued with consideration for improved quality, performance, and job creation as well as health, safety, the environment across the life cycles of chemical products, their design, selection of raw materials, processing, use, recycling, and final disposal towards a Circular Economy.

Long-term global issues, in areas such as food and water security of supply, energy generation and consumption, resource efficiency, emerging markets, and technological advances and responsible industrial practices have increasingly become major and complicated societal concerns requiring serious attention and innovative solutions within a tight timeline. Therefore, expectations are growing for innovations, based on the chemical sciences and technologies, as driving forces to solve such issues and to achieve the sustainable development of society with enhanced quality of life and well-being.

These significant global issues will best be addressed through promotion of the interdisciplinary understanding of Green and Sustainable Chemistry throughout the discussion of " Toward New Developments in GSC. "

The global chemistry community will advance Green and Sustainable Chemistry through global partnership and collaboration and by bridging the boundaries that traditionally separate disciplines, academia, industries, consumers, governments, and nations.

July 8, 2015
Kyohei Takahashi
on behalf of Organizing Committee
Milton Hearn AM, David Constable,
Sir Martyn Poliakoff, Masahiko Matsukata
on behalf of International Advisory Board
of 7th International GSC Conference Tokyo（GSC-7）, Japan July 5-8, 2015

JACI
GSCN Green & Sustainable Chemistry Network

JACI Textbook Introduction to GSC ~ Learning from the social practice cases that have received the GSC Awards, No.8
Issued March 2024 (Japanese version issued March 2023)
Planning/Editorial:Working Group for Teaching Materials, GSCN Dissemination and Enlightenment Group, Japan Association for Chemical Innovation
Issued by Japan Association for Chemical Innovation
Address: Sanbancho KS Bldg., 2F, 2, Sanbancho, Chiyoda-ku, Tokyo 102-0075, Japan
Phone: +81-3-6272-6880 FAX: +81-3-5211-5920
https://www.jaci.or.jp/english/
Acknowledgement : We would like to thank Editage (www.editage.jp) for English language editing.

GSC : Green and Sustainable Chemistry

Chemical sciences and technologies
which are benign to both human health and the environment,
and support the development of a sustainable society.

Introduction to GSC

Learning from social practice cases that received the GSC Awards

Global issues, in areas such as resources and energy, global warming, water and food have increasingly become major and complicated concerns. Innovations for achieving both environmental conservation and economic development are needed in order to resolve these issues and realize the sustainable development of society, and expectations for GSC continue to rise. In this textbook series, technologies and products that have received the GSC Awards given to great achievements contributing to the progress of GSC are explained, so that everyone can understand “what is GSC?” and take responsibility for realizing a sustainable society.

Special Edition

“Introduction to SDGs” Sustainable Development Goals GSC plays a driving role in SDGs

Let's change the world towards a sustainable future!

The SDGs are global goals adopted by the United Nations, and it is essential to harmonize the three elements of economy, society, and the environment in order to achieve sustainable development. This way of thinking is shared with the GSC, which aims to achieve both environmental conservation and economic development for the sustainable development of society. As a special issue, this text aims to explain the SDGs from the perspective of the GSC and encourage everyone to think about and put them into practice.

No.1

New laundry proposal for pioneering a sustainable society

Kao Corporation

The "new laundry proposal for pioneering a sustainable society" of Kao Corporation, which received the Minister of Economy, Trade and Industry Award of the 12th GSC Awards (2012), is characterized by the introduction of Life Cycle Assessment (LCA) into the development of laundry detergents, and the proposal to reduce laundry-related environmental impacts together with consumers by using just one rinse cycle in laundry. How was this innovation generated that simultaneously satisfies environmental friendliness, social contribution and economic rationality?

No.2

Novel Non-phosgene Polycarbonate Production Process Using By-product CO_2 as Starting Material

Asahi Kasei Corporation

The great success of this technology is that unlike the conventional polycarbonate production process, it does not use toxic phosgene as a starting material. At the same time, the technology was revolutionary because it achieved saving of both resources and energy. More than 10 years have passed, and the technology has been widely commercialized all over the world. This worldwide use was highly regarded, and the process became the first technology by a Japanese company to receive the Heroes of Chemistry Award from the American Chemical Society in 2014. What kind of technology is involved in this world-renowned polycarbonate production process?

No.3

Development of Carbon Fiber Composite Materials for Lightweight Commercial Airplanes

Toray Industries, Inc.

TORAY's carbon fiber reinforced plastic developed through over 40 years of research and development has features of high toughness (material tenacity) in combination with light weight and flexibility. The high toughness carbon fiber reinforced plastic (high toughness CFRP) realizes weight reduction of airplanes which is effective in improving fuel consumption, and makes a substantial contribution to reducing environmental impact.

No.4

Development and Commercialization of High Performance Transparent Plastics Derived from Plant-Based Raw Material

Mitsubishi Chemical Corporation

"DURABIOTM", the transparent engineering plastic made from renewable resources developed by the company, not only contributes to the reduction of environmental impact, but also realizes performance exceeding that of conventional engineering plastics in terms of optical characteristics, weathering resistance, etc.

No.5

Development of High-Performance Reverse Osmosis Membrane Contribution to the solution of global water issues

Toray Industries, Inc.

This reverse osmosis membrane can be used in not only seawater but also river water, sewage wastewater, and various other water treatment systems, providing high quality water while saving energy.

No.6

Development of Low Environmental Load Battery for Idling-Stop System Vehicle with High Charge Acceptance and High Durability

Hitachi Chemical Co., Ltd.
(Currently Energywith Co., Ltd.)
Hitachi, Ltd.

Idling-stop systems heavily burden on the battery, causing existing batteries to rapidly degrade, with short battery lifetimes. This technology resolves this problem and contributes to the reduction in CO_2 emissions.

No.7

Development of Water-based Inkjet Ink for Food Package

Kao Corporation

Kao Corporation developed a “water-based inkjet ink” for printing on the plastic films used for packaging daily commodities and food.
The ink maintains a high image quality and has lower volatile organic compound emissions, thereby reducing its environmental impact.

No.8

Development and Commercialization of a New Manufacturing Process for Propylene Oxide Utilizing Cumene Recycling

Sumitomo Chemical Co., Ltd.

Sumitomo Chemical Co., Ltd. developed a new manufacturing process for propylene oxide, which is used as a raw material for polyurethane and other materials.
The new process enables high yields of propylene oxide while reducing its environmental impact.

You can read them in “PDF” and “HTML” that is easy to read on mobile phones.

Please take a look!

https://www.jaci.or.jp/english/gscn/GSCgs/spmenu/page_19_01_sp.php

JACI