Green and Sustainable Chemistry

Introduction to GSC

No.7

Received the Minister of Economy, Trade and Industry Award of the 18th GSC Awards (2018)

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.

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.

Kao Corporation is a chemical manufacturer founded in 1887 (headquartered in Chuo-ku, Tokyo). The company manufactures household and industrial detergents, toiletry products, cosmetics, and food products. It is the leading manufacturer of toiletry products and detergents and the second-largest manufacturer (including subsidiaries) of cosmetics in Japan.

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)

Lower VOC (volatile organic compound) emissions and environmental impact Development of Water-based Inkjet Ink for Food Package

Kao Corporation

The Minister of Economy, Trade and Industry Award at the 18th GSC Awards (FY2018) was awarded to Kao Corporation's "Development of Water-based Inkjet Ink for Food Package". Traditionally, gravure printing is used to print on flexible packaging films. However, this method is unsuitable for high-mix, small-volume printing, and the oil-based ink used contains problematic volatile organic compounds (VOC). Kao Corporation developed a water-based inkjet pigment ink that enables high-resolution printing on flexible packaging films, thereby reducing environmental impact.

1 The Path to Technology Development

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

The plastic packaging materials used for food products and daily commodities are printed with brightly colored product names and images. These packages are made of polyethylene or polypropylene films (flexible packaging films), and over 90% of them are printed using gravure printing.

Gravure printing is a form of indented plate printing. The image is engraved onto a metal roller. Ink is then applied to the recessed areas, and when the roller is pressed against the surface of the film, the ink is transferred to the film to create the characters and patterns (Column ①). The color density can be controlled by adjusting the indentation depth, thereby making detailed printing possible. However, specially prepared rollers are required for each printed image; therefore, gravure printing is only profitable when used for high-volume printing of the same image and is thus unsuitable for low-volume printing. Hence, the companies that use gravure printing should either reduce their small-volume orders or print excess volume and retain it as inventory, which leads to increased waste.

Oil-based inks that dry quickly and produce high-quality images are used for printing on flexible packaging films. These oil-based inks contain pigments, resins, organic solvents, and other additives that emit large volumes of VOCs into the atmosphere, necessitating good ventilation in the workplace. VOCs is a collective term used for organic compounds that evaporate easily, such as toluene and xylene, and more than 200 VOCs have been identified thus far. These VOCs are transformed into air pollutants called photochemical oxidants by the action of UV rays. High concentrations of photochemical oxidants cause photochemical smog, which negatively impacts the human body, causing eye irritation and headaches as well as physiological damage to agricultural crops. Legal regulation of VOCs began in 2004 with the promulgation of the Revised Air Pollution Control Act. This law requires printers that use oil-based inks to implement measures against VOCs.

Kao Corporation proposed inkjet printing using water-based ink to print only the required volume of the packaging film. Inkjet printing is widely used in household inkjet printers. In this printing method, a minute volume of ink is sprayed directly onto the paper, and the image is formed by controlling the volume and density of the ink. The images were printed based on digital signals sent from a computer. This precludes the creation of special printing plates, thus making it suitable for high-mix, low-volume printing (Column ②).

*1
In dye ink, the colorant evenly dissolves in the solvent.

*2
In pigment ink, the colorant is dispersed in the solvent but does not dissolve.

Dye ink*1 and pigment ink*2 were used in inkjet printing; however, Kao Corporation selected the water-based pigment ink. This was because they already possessed the related know-how, and water-based ink emits lower VOCs.

For existing water-based pigment inks, the ink is absorbed into the paper to a certain extent and dries, resulting in stable colors and images. However, the ink cannot be absorbed by film materials, and the drying time is long, resulting in the running and mixing of the ink. Hence, a good ink setting and clear images cannot be achieved via this method (Fig. 1).

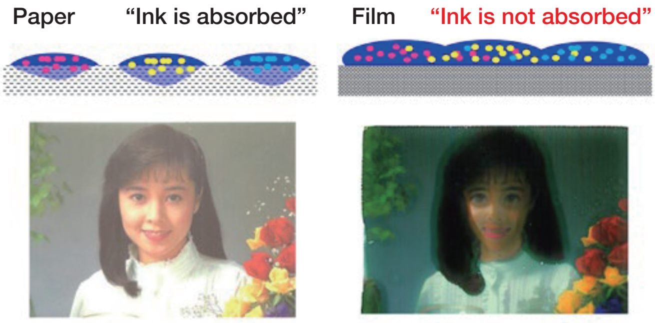


Fig. 1: Images printed on paper (left) and film (right) using inkjet printing with an existing water-based pigment ink.

Column 1

Printing methods

Printing involves reproducing images and characters on paper and other materials by creating a printing plate and applying ink to it. Depending on the printing plate, printmaking is classified into three printing methods: relief, intaglio, and lithographic printing.

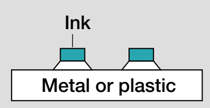
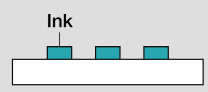
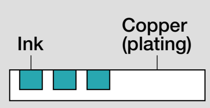
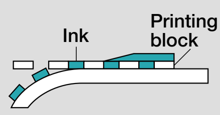
In relief printing, ink is applied to the raised surface of a printing plate and transferred to paper or other material. It is the oldest printing method derived from letterpress printing, which was discovered by German inventor Gutenberg in the late 15th century.

In intaglio printing, ink is applied to the recessed areas of the printing plate and then transferred. Gravure printing is an example of intaglio printing.

Lithographic printing does not use an engraved printing plate but uses the immiscibility of water and oil. This process is also called offset printing and is the most common technique for commercial printing.

Stencil printing is a relatively new printing technology. The printing plate is a screen made of fabric or other materials with areas that allow ink to pass through and areas that block the ink. Silk-screen printing and micrography are types of stencil printing. In addition, inkjet printing has become increasingly prevalent in recent years. In this technique, ink is sprayed directly onto the paper, avoiding the use of printing plates.

Each printing method has its own strengths and weaknesses, and the best method is selected based on a given application.

Type	Relief printing	Lithographic printing	Intaglio printing	Stencil printing
Printing method	Letterpress printing, flexographic printing	Offset printing	Gravure printing	Screen printing
Printing technology	Ink is applied to the raised area and then transferred to paper or other material	Using a hydrophobic image area and a hydrophilic non-image area, water and hydrophobic ink are successively applied to the printing plate without engraving it and then transferred to the printed material	Ink is applied to the recessed area and then transferred to the printed material	Using a screen with small holes that allows ink to pass in the image area while blocking the ink in the non-image area, ink is pressed through the screen in the image area and transferred to the printed material
Features	Inexpensive	Clear	Suited to high volume printing Can satisfy a wide range of needs	Small volume printing is possible Can print anything
Ink thickness	8 microns	4 microns	25 microns	30 microns
Main uses	Newspapers, business cards, cardboard boxes, etc.	Newspapers, posters, calendars, advertisement inserts, etc.	Plastic film, flexible packaging materials, photo albums, construction materials, etc.	Stickers, instrument panels, printed circuits, keyboards, etc.
				

Printing methods
Based on https://sp-jp.fujifilm.com/future-clip/reading_keywords/vol17.html

Column 2

What is inkjet printing?

In inkjet printing, ink is sprayed onto a printed object using tiny nozzles. Unlike offset printing, inkjet printing does not require a printing plate, and ink sprays are controlled through the digital signals of the characters and images sent from a computer. In addition, a full spectrum of colors can be achieved by adjusting the amount of ink sprayed and dot density.

Ink spraying can be performed using the piezoelectric sensor method, in which the spray is initiated through the pressure applied by a piezoelectric sensor, or the thermal method, in which the spray is initiated through the generation of air bubbles by heat. Because ink is applied directly to paper or other printed materials in this method, objects that do not have a flat surface can be printed even with low volumes of ink.

2 Toward Resolution of Issues

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

Rapid drying of the ink

To obtain clear images on the film surface, the ink must not mix or run. Therefore, the ink should dry quickly on the film surface. To overcome this issue, the composition of the ink was adjusted to hasten drying, and the ink concentration was increased. Consequently, the ink droplets were smaller, and the ink dried faster.

Even though a high concentration of the ink dried quickly and the image was clear, the ink droplets were small, the color density was insufficient, and the image quality was poor with the appearance of streaks. As mentioned previously, tiny ink droplets are sprayed through small nozzles in inkjet printing. If the ink dots sprayed onto the film are not evenly spread during printing, the image quality decreases.

Hence, the research team attempted to evenly spread the ink droplets while maintaining a small droplet size. In water-based pigment ink, the insoluble pigment is dispersed in water. Compared to the oil-based ink used in gravure printing, the pigment surface of water-based ink has a low affinity for the solvent, making it extremely difficult to disperse it. Pigments are particulates (secondary particles) composed of nanosized primary particles. Separating the particulates into primary particles improves the image quality. However, as the particles became smaller, the surface area increased, resulting in stronger intermolecular forces that induced particle agglomeration. This leads to unstable pigment dispersion and decreased image quality.

Dispersing the pigment particles in water

To disperse the pigment particles, the technology for laundry detergent, one of the main products manufactured by the Kao Corporation, was used. The surfactants in detergents adhere to oil and create an emulsion that disperses the oil in water. Surfactants contain both a hydrophilic portion with an affinity for water and a hydrophobic portion with an affinity for oil. The hydrophobic portion of the surfactant binds to the oil, forming a small sphere around it. The hydrophilic portion of the surfactant faces outward and disperses in the water (Fig. 2).

This technology was used to disperse nano-sized pigment particles in water. Similar to the surfactant, the polymer dispersant binds to the surface of the pigment (secondary particles). Upon application of energy, the pigment breaks down into nanosized primary particles. The hydrophilic end of the polymer dispersant then faces outward and disperses in the water.

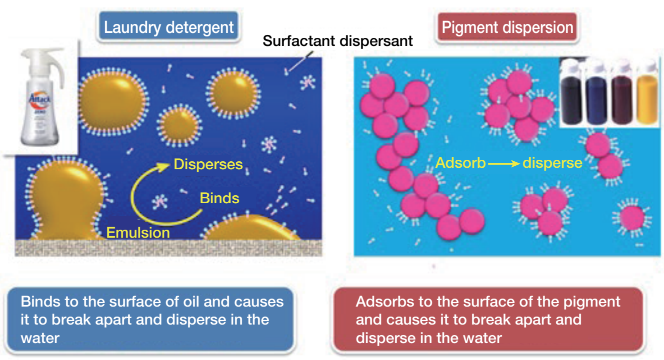


Fig. 2: Utilization of detergent technology to disperse pigments

Furthermore, the pigment particles should not agglomerate in water for uniform dispersion. Hence, the structure of polymer dispersants is altered to create mutual repulsion. This could be achieved by introducing a functional group with an electrical charge, as molecules with the same charge repel each other. In addition, steric repulsion between functional groups was used to ensure dispersion. The substituted polymer dispersant adsorbs to the surface of the pigment and encapsulates its particles. The outward-facing repulsion-inducing groups ensured that the pigment capsules were stably dispersed in water.

This technology, the newly developed polymer dispersant and dispersion process involving the encapsulation of the pigment in the polymer dispersant, was named "Nano-pigment dispersion technology."

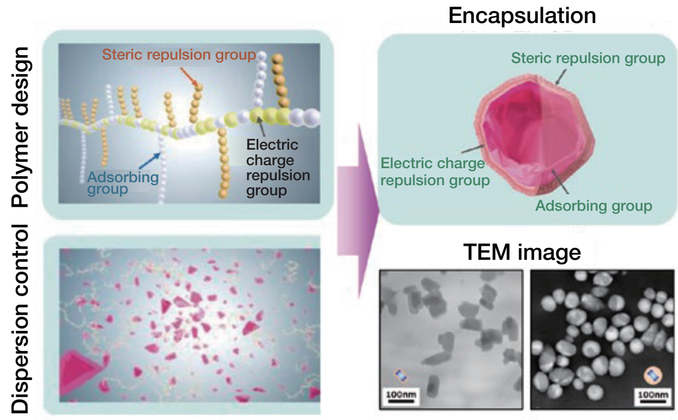


Fig. 3: Nano-pigment dispersion technology

Successful encapsulation was achieved using a combination of polymer design and dispersion control technologies, where the polymer dispersant is bound around the entire surface of the pigment, resulting in the nanosized dispersion of the pigment particles in water.

The application of this nano pigment dispersion technology for printing on plastic film is shown in Fig. 4. The ink dots spread much further than those of the existing ink. In addition, without the nano-pigment dispersion technology, pigment particles were collected at the edge of the dot, resulting in ring-shaped coloring. Hence, even coloring was achieved using the novel nano-pigment dispersion technology.

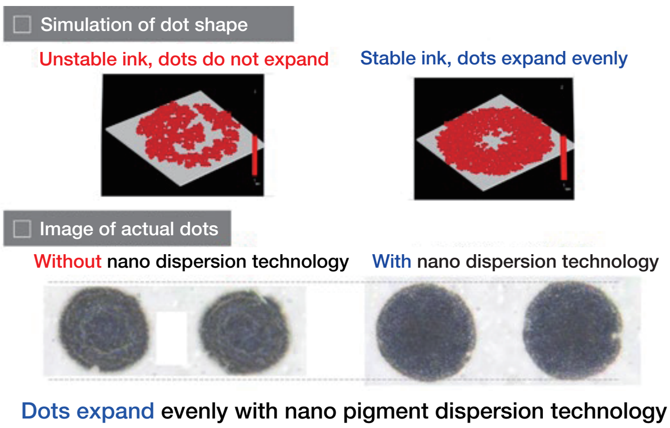


Fig. 4: Uniform dot expansion with nano-pigment dispersion technology (right)

Controlling the physical properties of the ink

Another factor that influences ink-dot mixing is the difference in the surface tension of the ink. During the printing process, each color is printed individually, leading to a short time lag until the next color is printed. This staggered ink spraying leads to differences in the surface tension of the ink. When ink dots with different surface tensions are located next to each other, the dot with the lower surface tension attempts to cover the dot with a higher surface tension*3, resulting in the mixing of the ink dots.

However, this novel ink manufacturing process involves the dispersion of pigment in water, followed by an adjustment in the final ink composition. The addition of surfactants increases the permeability and drying speed of the ink and controls the surface tension of adjacent dots. Therefore, the ink composition, including the type and amount of polymer dispersant, influences and controls the physical properties of the ink, thus preventing the mixing of adjacent dots (Fig. 5).

*3
When a drop of liquid is placed onto the surface of a solid object, it is said to have "good wetting" if it spreads out and "poor wetting" if it remains in small three-dimensional dot form. Liquids with good wetting have high affinity with the surface, whereas liquids with poor wetting have low affinity with the surface.

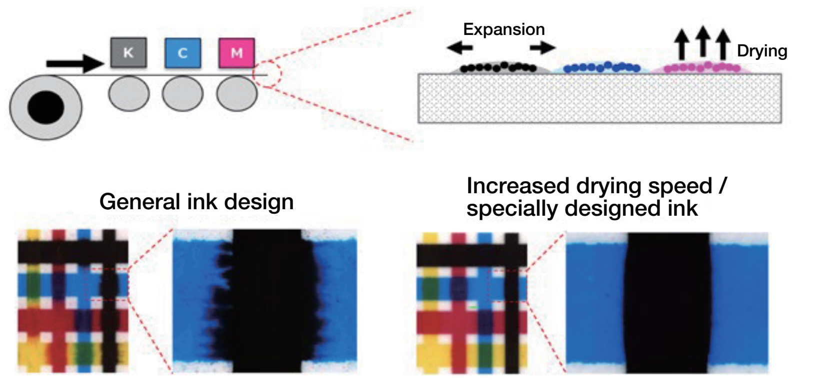


Fig. 5: Prevention of ink mixing by controlling the physical properties of the ink

3 Contribution to Society

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

The nanosized dispersion of the pigment particles and the precise control of the physical properties of the ink enabled the development of a water-based pigment ink for inkjet printing that fulfilled the objectives of GSC.

LUNAJET®, a water-based pigment ink for inkjet printing that enabled printing on flexible packaging films, was launched on the market in 2016. This water-based ink prints clear characters and images on flexible packaging films. Unlike gravure printing that requires specially prepared plates, which require time and money, inkjet printing with this water-based ink is suitable for high-mix, small-volume printing (Fig. 6). This method precludes large inventories and the consequent waste.

Fig. 6: Products that use water-based pigment ink for inkjet printing.
Small product lots can be printed and personalized based on customer requests.

The lower VOC emissions from printing is revolutionary progress. The flammable oil-based inks used for gravure printing must be handled with care as dangerous goods and require ventilation and explosion-proof equipment. Similar measures are not required for water-based inks, leading to an improved work environment. In addition, inkjet printing with water-based ink reduces VOC emissions by 75% compared with gravure printing with oil-based ink, thus precluding the use of VOC treatment (Table 1).

		Gravure printing with oil-based ink	LUNAJET®
Environment	VOC	100	24
	SO_x	100	64
	CO_2	100	61
Safety	Fire Service Act	Dangerous goods	Not dangerous goods

Table 1: Results of the environmental assessment
When comparing VOC and CO_2 emissions between inkjet printing with water-based ink and gravure printing with oil-based ink at a printing length of 2,000 meters, a remarkable difference was noticed.

Kao Corporation conducted a lifecycle assessment (LCA) to evaluate the environmental impact and burden throughout the product lifecycle, from the procurement of raw materials, design, and manufacturing to transportation, use, and disposal. Efforts were made to use environmentally friendly products and technology. The environmental assessment of low-volume inkjet printing with water-based ink revealed a significantly reduced environmental impact, CO_2 emissions, and VOC emissions compared to those from gravure printing with oil-based ink.

The newly developed water-based ink for inkjet printing has received significant attention. In addition to the GSC award, it received the Innovation Award at the 2017 National Commendation for Invention. It has been adopted for printing snack packages and is a highly regarded original Kao product.

Nevertheless, gravure printing remains the leading technique in flexible packaging film printing. The development team will continue working to improve this new technology and promote its widespread use.

Column 3

Pigment colors

The ink required for printing is composed of a colorant, a medium, and additives. Pigments are solid colorants that do not dissolve in water or oil and can be used to color an object by surface application or mixing. Dyes are colorants that dissolve in water or oil.

We can see colors when looking at a light source or an object lit by light. Differences in color are due to differences in the wavelength of light and the light that reaches the object. The wavelengths that are reflected by the object without being absorbed determine the color of the object. When pigments interact with light, they absorb different wavelengths, and the remaining wavelengths are reflected. This reflected light is perceived as a color.

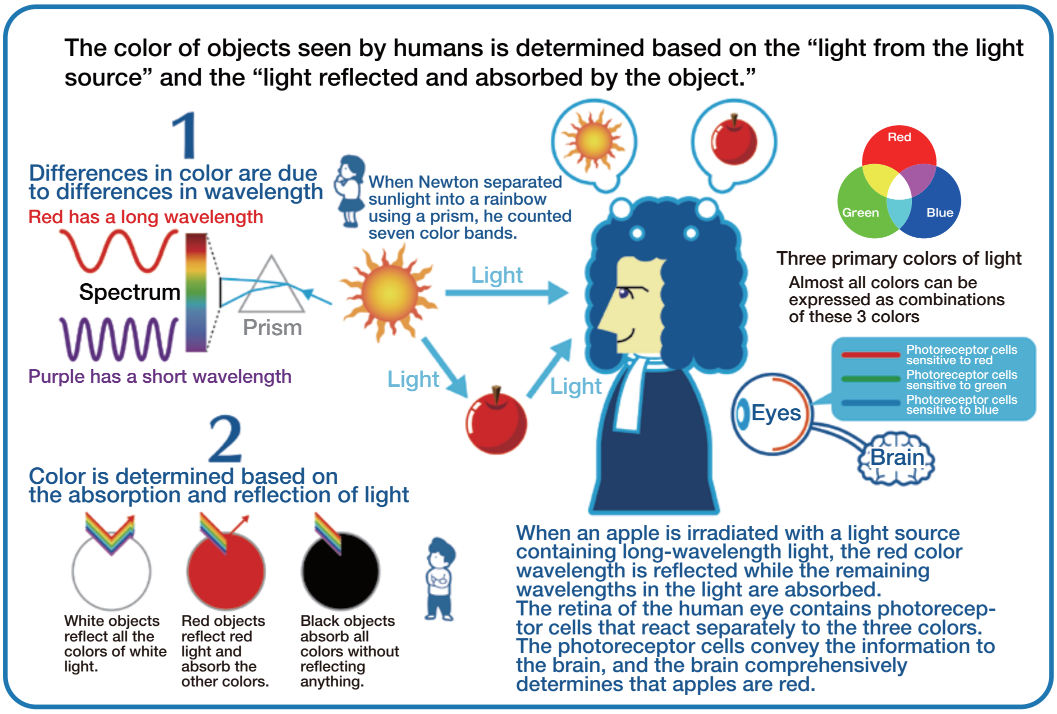


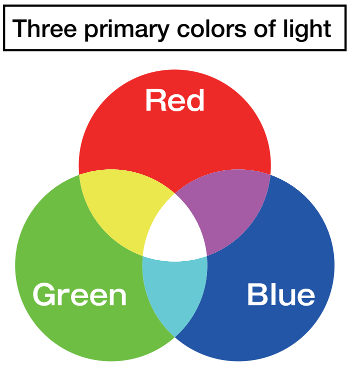
Fig. Color as perceived by humans

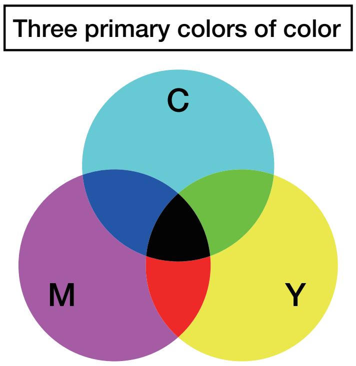
Column 4

Color of ink and color of light

Sunlight contains light of various colors. Red (R), green (G), and blue (B) are the three primary colors of light (RGB). Mixing primary colors in different ratios creates almost any color, and mixing them in even ratios gives white. TV screens and computer monitors create images using RGB combinations.

However, the three subtractive primary colors of ink were yellow (Y), magenta (M), and cyan (C). When the ink is irradiated with light, part of the light is absorbed, whereas the remaining light is reflected or permeated. Hence, the color of ink is the color of the light that is reflected or permeated. The three primary ink colors are complementary to the color of the absorbed light. Therefore, when all three colors are mixed, the red, green, and blue colors of light are absorbed, resulting in no reflection and a black color.





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 The term "universal design", coined by Dr. Ronald Mace, is defined as the concept of designing products and environments that can be used by all people. Within this concept, conveying information through color is termed as color universal design. Summarize the three principles of universal color design.

Q4 The vaper concentrations of organic solvents in the workplace are regulated in Japan. For example, the permissible concentration of acetone, a major organic solvent, is 200 ppm. Calculate the amount of acetone (in units of weight) required to reach the maximum permissible concentration based on a workspace with a floor area of 50 m^2 and a height of 3 m. Assume that the molecular weight of acetone is 58, it evaporates as an ideal gas, and the room temperature is 25 °C. In addition, calculate the permissible concentration of toluene and perform the same calculations using identical assumptions.

Q5 Explain the relationship between this technology and the SDGs.

Q6 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

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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

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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.

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