Eco-Friendly Product Development

* Image shown is only an illustration

Carbon Neutrality through Sustainable Raw Materials

Ecolocel is a flexible polyurethane foam made from at least 50% plant-based raw materials.

This product offers two main advantages.

(1) Carbon neutrality that reduces dioxide (CO_2) emissions

Carbon neutrality here refers to the approach of producing zero net CO_2 emissions through the use of plant-based raw materials, balancing out the CO_2 emitted when products are manufactured and discarded with the CO_2 absorbed in the growth process of the plants resulting in no increases to CO_2 released in the air over the life cycle as a whole. We developed *Ecolocel* based on this approach.

(2) Reducing dependence on fossil resources

We have chosen a method that keeps the earth's limited fossil resources form being exhausted and has no impact of food problems due to the use of non-food plant-based raw materials.

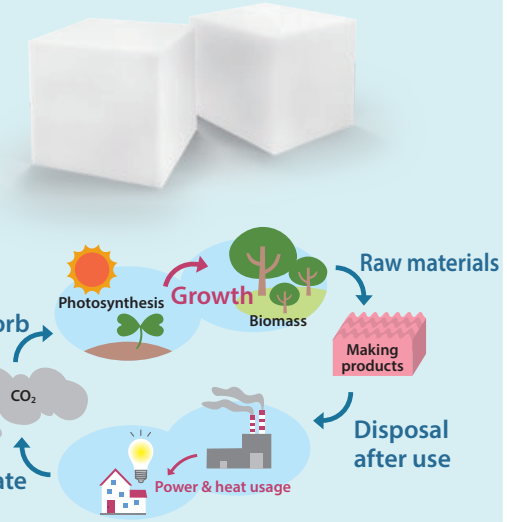

Illustration of the carbon cycle when using plant-based raw materials

Pursuing carbon neutrality

Due to the adoption of the SDGs (Sustainable Development Goals), sustainable development is being seen as increasingly important. Companies are now expected to develop products made of sustainable raw materials instead of conventional petroleum-based materials. We selected raw materials from among plants not used for food in order to proceed with development based on the approach of carbon neutrality using plant-based materials while also helping to achieve SDGs goal number 2 "Zero Hunger." To also contribute toward achieving SDGs goal number 13 "Climate Action" we started development on materials with 50% or higher content of biomass (made from at least 50% plant-based raw materials), which has less impact on the environment.

Successful transition to mass production through trial & error

Raising the biomass content destabilizes foaming and the deterioration of physical properties is inevitable, so biomass levels of 30% had previously been the highest. Developing foam with a biomass level of at least 50% was therefore an extremely daunting research theme.

We first began experiments with a laboratory scale. While the foam did take shape, its strength was weak and its properties were unstable, so we went through repeated trial and error. We reselected the plant-based raw materials and the properties finally stabilized after that, so we proceeded to try mass production-based foaming. However, this was not the same as the laboratory scale. Since it involves continuous production, we encountered a variety of problems. Enlisting the help of the Manufacturing Section in addition to the Technology Section, we further improved the composition and optimized the production conditions, and at long last we were able to reach the stage of mass production.

Aiming for applications in the consumer products market

This foam is currently in use for making kitchen sponges, but we will be adding features such as high impact resilience, low resilience, and high hardness and deploying it for other usage applications such as mattresses in the future.

* Image shown is only an illustration
(pillows, mattresses, kitchen sponges)

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Eco-Friendly Product Development

* Image shown is only an illustration

Further advancements in eco-friendly technology

With heightening interest in global environmental issues such as the SDGs, carbon neutrality, and marine plastic waste, we believe companies—particularly manufacturers of resin products such as INOAC—have an inherent responsibility to take action toward environmental conservation.

Our main product at INOAC is polyurethane foam. Since it is foam material, much of its production is volume-based, and it is a resin that strongly needs to be recycled.

However, while some polyurethane foam waste is reused as materials and thermally recycled to be used as recycled materials and heat sources, some is also discarded without any efficient use. For that reason, we are working to boost its recycling rate by developing chemical recycling technologies to recycle the foam as raw materials.

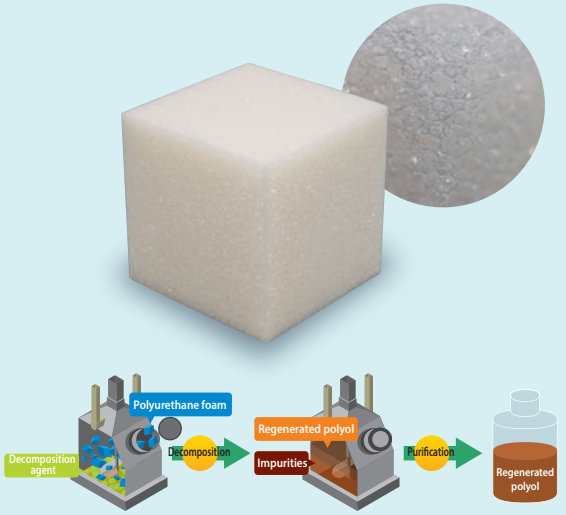

Illustration of the polyurethane foam chemical recycling process

Big obstacle in breaking chemical bonds

Polyurethane is a resin with thermosetting properties, making it different from thermoplastic resins such as polypropylene and polyethylene terephthalate in that it can neither remelt nor reshape when heat is applied. It cannot be reused as raw material if its chemical bonds are not broken. Since it is difficult to break polyurethane bonds once they are formed, chemical recycling of polyurethane resin presents a formidable challenge and has not advanced very far in practical application.

This time, we attempted to lower the technical difficulty and establish a basic technology by targeting in-house polyurethane foam waste with precise material composition.

Establishing chemical recycling technology

We selected compounds that promote the decomposition of polyurethane foam and studied methods to purify the degraded material. Doing so, we were able to establish a basic technology at the laboratory level and verify that the foam could be regenerated as raw materials.

For regeneration into polyurethane foam, we have verified that the same performance as existing products can be achieved even when around 20% of the raw material is replaced with recycled material, so reuse appears viable.

The challenge now is to scale up toward mass production. We are currently implementing this at a pilot plant on the way to scale-up and are selecting the equipment needed for each process. After installing the equipment we plan to review the reaction conditions and equipment conditions, and test out mass production.

We also intend to work on improvements to yield and energy efficiency to establish this as an energy-saving, clean chemical recycling technology that contributes even more toward environmental conservation.

Balancing environmental conservation with comfortable lifestyles

Ultimately, we want to expand the scope of or recycling beyond polyurethane foam waste generated in production processes to also include used products as well.

We will continue striving to develop eco-friendly technologies that can balance environmental conservation with comfortable lifestyles.

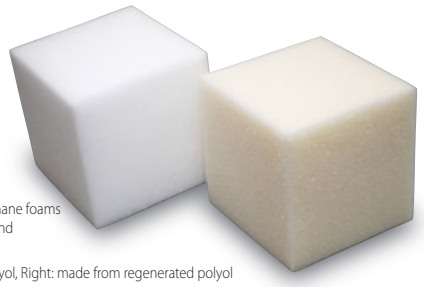

Photo comparing polyurethane foams made from normal polyol and regenerated polyol

Left: made from normal polyol, Right: made from regenerated polyol

Developers

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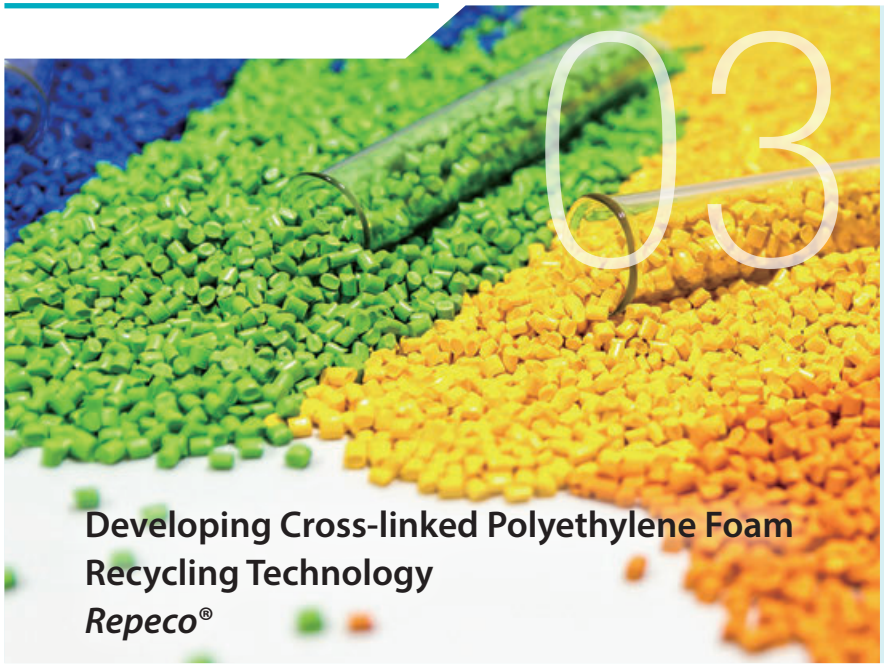
Eco-Friendly Product Development



03

Developing Cross-linked Polyethylene Foam Recycling Technology *Repeco*®

* Image shown is only an illustration

Efforts to significantly reduce waste

This technology recycles cross-linked polyethylene foam (PE-LITE®) material cutoffs produced by INOAC. It has established a cyclical system to re-employ material cutoffs that used to be discarded, to use them as raw materials. Thanks to this recycling technology, nearly all material cutoffs can now be recycled into the original product they were produced for, PE-LITE®. We expect this to significantly reduce waste and improve usage efficiency.

Global environmental problems have reached critical stages in recent years, and carbon neutrality has emerged as a rallying cry. As an INOAC initiative, we are now using the material cutoffs recycled through this technology as part of the raw materials used when producing PE-LITE®. This has reduced the usage of new material, ultimately reducing CO_2 emissions and contributing toward carbon neutrality.

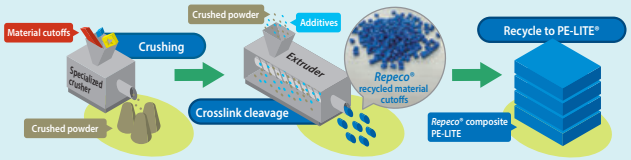


Illustration of the PE-LITE® recycling process

New products created from material cutoffs

The production characteristics of PE-LITE® products inevitably result in large volume of material cutoffs. We have long conceptualized the idea of recycling of these cutoffs for reuse as raw materials, but there were just too many challenges to overcome.

In studies on crushing equipment for a different development process, we tried processing PE-LITE® material cutoffs and found a possible solution to the high bulk specific gravity which had previously been the biggest roadblock to recycling the cutoffs. From there, we began to study crosslink cleavage processes. After around one year in development we established the technology, and recycled cutoff material *Repeco*® was finally complete.

Repeco®: the journey to completion

There were two main challenges.

The first challenge was crushing the foam. When simply crushing the foam it would be lighter with a bulk specific gravity of 0.075g/ml, and it was difficult to subsequently input into the machines used for breaking crosslink since it was in a soft and fluffy state. To overcome this, we worked together with a crushing machine manufacturer to develop a special new crushing process which resulted in bulk specific gravity at least three times heavier. We were then able to input the crushed foam into the machines for the next process.

The second challenge was breaking cross-link of polyethylene. Extruders are used for this, and aspects such as the specifications, screw structures, barrel structures, and operating conditions of the extruders are extremely important. First for the extruder specifications, we could not simply use extruders made by any company. The specifications of extruders differ by company. There were differences in crosslink cleavage capability in the extruders made by each manufacturer. Through the process of creating prototypes we were able to identify the important parameters, from which we were able to determine that an extruder made by one particular company would be advantageous. That brought us to the point of installing the mass production machinery. Next for the screw and barrel structures and operating conditions, we created prototypes with dozens of different patterns and found the optimal pattern.

Having resolved these and other issues, we were able to establish the new recycling technology.

The final waste reduction

We are currently preparing the production lines for *Repeco*®. First we aim to create a circular economy contained within a single plant for polyethylene foam. We are considering initiatives after that to reduce final waste volume by rolling this out to our other locations, and ultimately collecting and reusing material cutoffs generated by clients. In our development work, we are constantly thinking about what would be good not only for INOAC but for society as a whole.

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Eco-Friendly Product Development

* Image shown is only an illustration

Usage cycles to reduce our environmental footprint

Conventionally, carbon fiber reinforced plastic (CFRP) materials are high-performance high-priced composite materials that combine resins with carbon fibers made from petroleum and coal. Here, we reused high-value carbon fibers extracted from discarded CFRP products (regenerated CFs) and combined them with thermoplastic resin to develop recycled carbon fiber reinforced thermoplastics (CFRTP). Since these high-performance resin materials offer the superior lightweight, high-strength properties of carbon fibers and can be processed and molded like normal plastics, they have great potential for use in a wide variety of products.

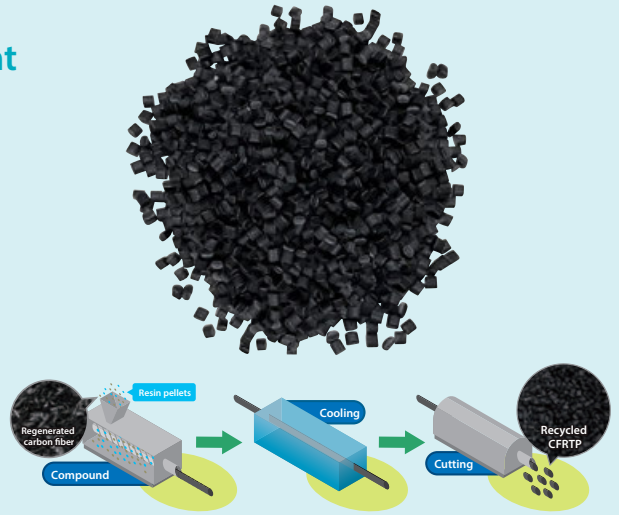

Illustration of the carbon fiber recycling process

Cyclical use of carbon fibers

Demand for CFRP has skyrocketed in recent years, and it has been used in airplanes, cars, industrial materials, and a broad range of other usage applications in place of metals such as iron and aluminum. Many CFRPs are made from resins with thermosetting properties which make them hard to reuse. Most of them are discarded as industrial waste, causing an increasingly heavy impact on the environment. At INOAC we manufacture and sell industrial CFRP products (RL-C), so we are grappling with the same waste problems. Carbon fibers are high-priced materials to start with, and large amounts of energy are also expended to manufacture them. Therefore, if carbon fibers could be used cyclically in-house, it could help to reduce CO_2 emissions.

With that in mind, we began looking into compounds combining thermoplastic resins with regenerated CFs obtained when thermal treatment is applied to CFRP waste.

Initial goals:

1. Easy processing and molding of products
2. Materials that cost less but have the same characteristic values through the use of virgin carbon fibers

Overcoming many challenges

There were three main challenges involved in development. The first challenge was the adhesion of the regenerated CFs. Since there is no functionality on the surface of regenerated CFs that have undergone high-temperature treatment, their adhesion to resin is not robust. To overcome that, we introduced compatibilizing agent with organic functionality and applied surface treatment to the regenerated CFs.

Second was the compounding process to combine regenerated CFs with resin. Since regenerated CFs have significant shape variations after processing, it was difficult to attain even dispersion. However, we studied methods of supplying the raw materials and set the conditions inside the extruder which enabled us to attain even dispersion.

Third was the evaluation method. Since this was a material that had not previously existed, we needed to establish analytical evaluations for making products from it, as well as quality control methods. To accomplish this, we analyzed the carbon fiber content and dispersion morphology in the material, and verified the form of its thermal degradation during mass material production.

Applications in various fields

Currently, we are looking into usage applications for which olefin resins can be deployed. In the future, we also plan to deploy this technology in engineering plastics and offer ways to utilize these material properties in many different fields.

Developers

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Syu Chin

CSR Activities Overseas

What is Relay For Life?

It was 1985 in Tacoma, Washington in the United States. One doctor walked and ran around a track continuously for 24 hours, raising money for donations to the American Cancer Society. This was how Relay For Life activities began. Its aim is to provide support by sharing the awareness that cancer patients face their disease 24 hours a day. Events representing this activity which generates hope and the will to live by walking and talking together currently takes place in about 30 countries worldwide, in roughly 4,500 locations and bringing in as much as 30 billion yen in donations per year.

Donating to the American Cancer Society for 18 consecutive years through Relay For Life activities

INOAC GROUP NORTH AMERICA, LLC. (IGNA)

How we joined Relay For Life

We joined Relay For Life and began donating to the American Cancer Society as IGNA in 2001.

IGNA HR Manager Renea McCauley was told in June 1999 that her mother had breast cancer. She was right by her mother's side until she recovered, through surgeries, radiation therapy, doctor examinations, and more. The following year, she participated in Relay For Life for the first time. She was impacted deeply to learn about the involvement and support from local communities for cancer survivors, those who are serving or have served as caregivers, and cancer victims who have lost their lives.

Local communities generate hope

After returning to work, she lobbied for IGNA to get involved in the activity, and the first volunteer team was launched at IGNA in Springfield in 2001.

Specifically, the team is active throughout the year selling homemade candies and snacks and holding events such as silent auctions and raffles (for charity) to raise money. The money they raise is first used to support local cancer patients and survivors (costs of doctor's visits, transportation, wigs, life expenses, etc.) and stays in the community. Funds remaining after that are allocated to support cancer treatment research activities by the American Cancer Society.

End suffering from cancer

Over the past few years, IGNA is one of the groups that has raised the most funds from the community. Relay For Life activities had to slow down due to the COVID-19 pandemic, and IGNA had been unable to organize events in the community for the past two years. However, all groups in the community (Washington County) have expressed that they are continuing to raise funds and support the American Cancer Society.

Many staff members at IGNA in Springfield who participate in Relay For Life activities have friends and family members who are battling cancer. We are tremendously proud to have continuously participated in activities such as these, raised funds, and supported cancer patients and cancer research as a team for 18 years running.

Human Resources
INOAC GROUP
NORTH AMERICA, LLC.
(IGNA)

Renea McCauley