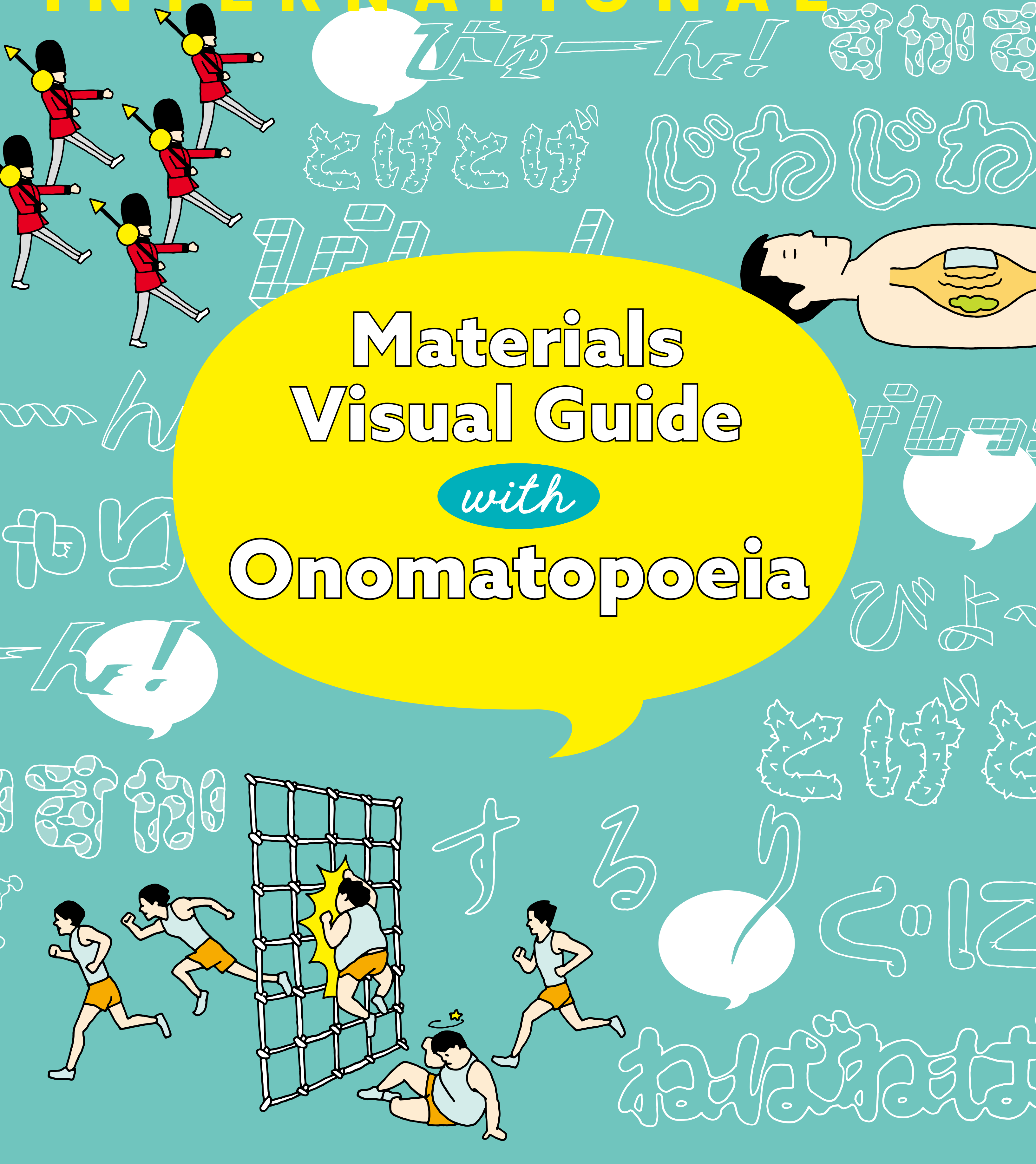
NIMS NOW INTERNATIONAL

NATIONAL INSTITUTE FOR MATERIALS SCIENCE
2020
No. 4



Materials Visual Guide *with* Onomatopoeia

Materials Visual Guide *with* Onomatopoeia

A broad array of onomatopoeia is commonly used in the Japanese language, adding a vibrant liveliness to both speech and formal writing.

The following examples illustrate ways in which Japanese people may employ onomatopoeia in various situations.

Some magicians create the illusion that they can bend a steel spoon effortlessly, as if it is made of rubber. The Japanese onomatopoeic word "gu-nya-ri" can be used to describe this.

When you are impressed by the appearance of someone dressed in a perfect suit, you may describe the perfection using the word "bi-shi".

If you are gradually influenced by a beautiful song, you may describe this experience using the expression "jiwa-jiwa".

The use of onomatopoeia stimulates our imaginations.

It is also an effective tool for communicating the essential nature of materials.

Onomatopoeic words can be used to vividly and graphically characterize materials according to shape, texture and function.

This NIMS NOW issue describes some of the fascinating materials NIMS has developed in a reader-friendly way using onomatopoeia as a guide.

ne ba ne ba

ねばねば

=gooey

01

Functional Organic Liquids

This gooey liquid has a unique characteristic: it glows blue in the dark when irradiated with UV-light.

Most electrically and optically functional materials are solids. Despite this general trend, Dr. Takashi Nakanishi has chosen "neba-neba"(gooey) liquids with these functions. Because liquids are entirely homogeneous in composition, the characteristics they exhibit maintain in any condition. In addition, they can be used for a variety of purposes by adjusting their viscosity. For example, they can be manually shaped—like clay—into different forms, and fabricated into soft devices by impregnating fabrics with them. With creativity, their uses are potentially unlimited.

Photo-storing goo

This gooey liquid contains anthracene, a blue light emitting pigment molecule. Anthracene molecules are individually wrapped in soft alkyl chains, preventing them from reacting with each other and protecting them from oxidation, allowing them to continuously glow. This gooey liquid can also be made to emit different colors of light (i.e., yellow, green and red) by changing the pigment molecules they contain.

Charge-storing goo

A so-called liquid electret material can semi-permanently retain an electric charge after a voltage is applied. This material may be used to develop stretchable, standalone sensors and elastic power generation devices by impregnating textile electrodes made of silver-coated fiber with it.

02

Wound Dressing Material for Post-Operative Cancer Recovery

After cancer cells are surgically removed, the resulting wounds must be closed. Coating materials serve this purpose. They need to be non-inflammatory and also have to be able to firmly adhere to wounds while retaining the ability to stretch and shorten as the body moves. Materials with "neba-neba"(gooey) textures are therefore ideal candidates for coating materials. Commercially available wound dressing sheets do not fully satisfy these requirements.

To address this issue, Drs. Akihiro Nishiguchi and Tetsushi Taguchi have developed a very gooey material using porcine-derived gelatin. It is approximately 10 times more strongly adhesive than commercially available products, is non-inflammatory and is able to be eventually integrated into the body. Because this material is particulate in form rather than a sheet, it can be easily delivered to target sites in the body using an endoscope. The use of this gooey material may potentially accelerate the healing of cancer surgery wounds by eliminating the need for surgical sectioning to access them.

Newly developed coating material being tested for its adhesiveness

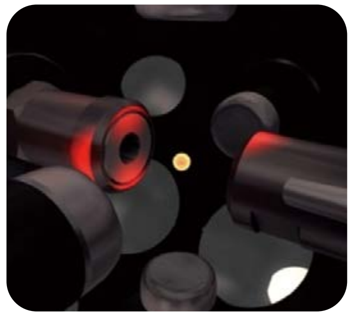
03

Glass

Gooey materials may seem completely irrelevant to very hard glass materials. However, some argue that glass is a liquid, not a solid: in fact an extremely viscous "neba-neba"(gooey) material. While supporters of this theory contend that glass objects several hundred years old show evidence of slow deformation, the debate over the nature of glass continues.

A coordinated glass-related research project is currently ongoing at a number of locations, including one beyond Earth: the International Space Station's Japanese Experiment Module Kibo. The Kibo research team is analyzing the structures of selected materials under very low gravity conditions using the module's equipment. Dr. Shinji Kohara from NIMS is the project leader.

The team is specifically studying erbium oxide (Er_2O_3), a non-glass material when cooled to a solid state. One of this project's objectives is to better understand the nature of glass by paradoxically studying this non-glass material to determine the mechanisms preventing it from becoming a glass. The atomic arrangement and the electronic state of Er_2O_3 were successfully determined in 2020 based on the combined results of terrestrial and extraterrestrial experiments.



Interior of an electrostatic levitation furnace, an analytical instrument installed on Kibo. A liquid material sample (the spherical object at the center) is floating in mid-air due to near micro gravity conditions.

gooey
readily permeable
porous
slow propagation
perfecting alignments
spiny
collapsible

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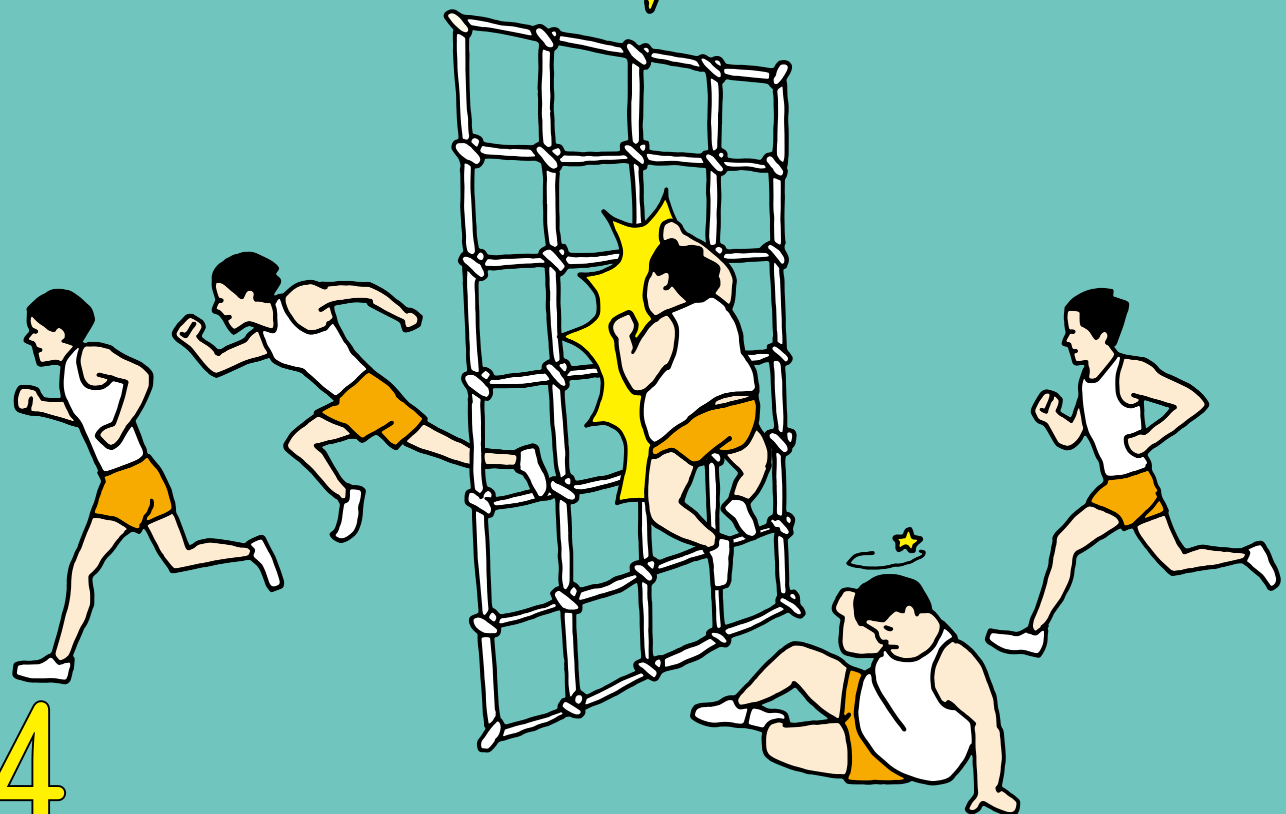
collapsible

su ru ri

するり = readily permeable



04

Oil Purification Filters

A filter material is used to remove unwanted impurities from fluids. It allows only desirable substances to pass through ("su-ru-ri") while blocking undesirable ones, depending on its pore size. Dr. Izumi Ichinose has been developing an oil purification filter made of carbon materials. It is designed to remove substances harmful to humans from crude petroleum.

To create this oil purification filter, a polymer is first coated onto the surface of a non-woven fabric. After pores approximately 20 nanometers in diameter are formed in the polymer, a carbon film with tiny pores (a few nanometers in diameter) is then vapor-deposited onto the polymer layer. The resulting filter is thin and tough and has extremely fine pores. Approximately human hand-sized versions of these filters were used experimentally to filter crude oil and were found to allow desirable molecules, such as gasoline and diesel fuel, to easily pass through while blocking the only slightly larger molecules of harmful substances. This filtration process was previously very difficult to accomplish. Because efficient filtration of large amounts of oil will require the use of filters with large surface areas, Ichinose is currently developing a system capable of uniformly coating the polymer onto large areas.

Disk shaped filters used for performance tests

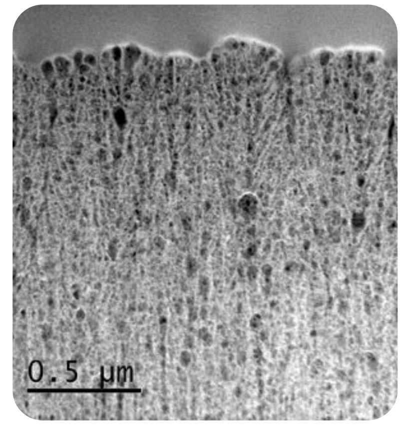
Large-scale polymer coating system being developed

05

Anode Material for All-solid-state Batteries

All-solid-state lithium batteries—batteries in which the flammable liquid electrolyte used in lithium ion batteries (LiBs) has been replaced with a non-flammable solid one—are safer than the conventional LiBs. Silicon (Si) is a promising candidate as an anode material for these batteries because of its theoretical capacity of ~4,200 mAh/g; approximately 11 times greater than conventional graphite. However, Si undergoes the huge change in volume during charge and discharge (~300%), causing it to crack and pulverize. This rapidly diminishes the anode's capacity.

Dr. Narumi Ohta has conceived of a possible solution to this issue: giving the Si anode a "su-ka-suka"(porous) structure. He envisaged an Si structure comprised of homogeneously-distributed fine pores and ultrathin walls that could relieve deformation-induced stress efficiently and thus avoid mechanical damage. He examined the performance of the anode in all-solid-state batteries and found it to demonstrate highly-stable cycling performance. The anode maintained a high capacity of over 2,960 mAh/g during 100 charge-discharge cycles. A nanoporous Si structure has therefore been proven to be highly beneficial for enhancing the cycling stability of high-capacity Si anodes in all-solid-state batteries.



Porous Si film with pores ranging from 10 to 50 nm in size
The Si walls separating the pores are extremely thin, enabling them to efficiently relieve the stress induced by the change in the volume of the anode material.

すかすか = porous

su ka su ka

06

Aerogels

Aerogel is a fluffy material as light as cotton. More than 90% of its volume is made up of air. It is a highly "suka-suka"(porous) material with numerous nanoscale pores, enabling it to retain a large volume of air—a poor thermal conductor. The insulation performance of aerogel is approximately three times that of typical glasswool insulation materials. The production of aerogel, however, was previously cumbersome because it required special equipment to dry the initial gel under high pressure.

Dr. Rudder Wu applied a new technique to produce aerogel under ambient pressure without damaging its porous structure during the drying process. He also used rice hulls as an alternative ingredient to produce environmentally friendly, low-cost aerogel with high thermal insulation performance.

Silicon dioxide (also known as silica)—the main component of the aerogel Dr. Wu has developed—can also be obtained by heating rice hulls and subjecting them to a simple extraction process.

A cubic object with its surface coated with the thermal insulation coating.

The aerogel can be processed into a thermal insulation coating by dispersing fine aerogel particles in a solvent.

gooey
readily permeable
porous
slow propagation
perfecting alignments
spiny
collapsible

ji wa ji wa

じわじわ

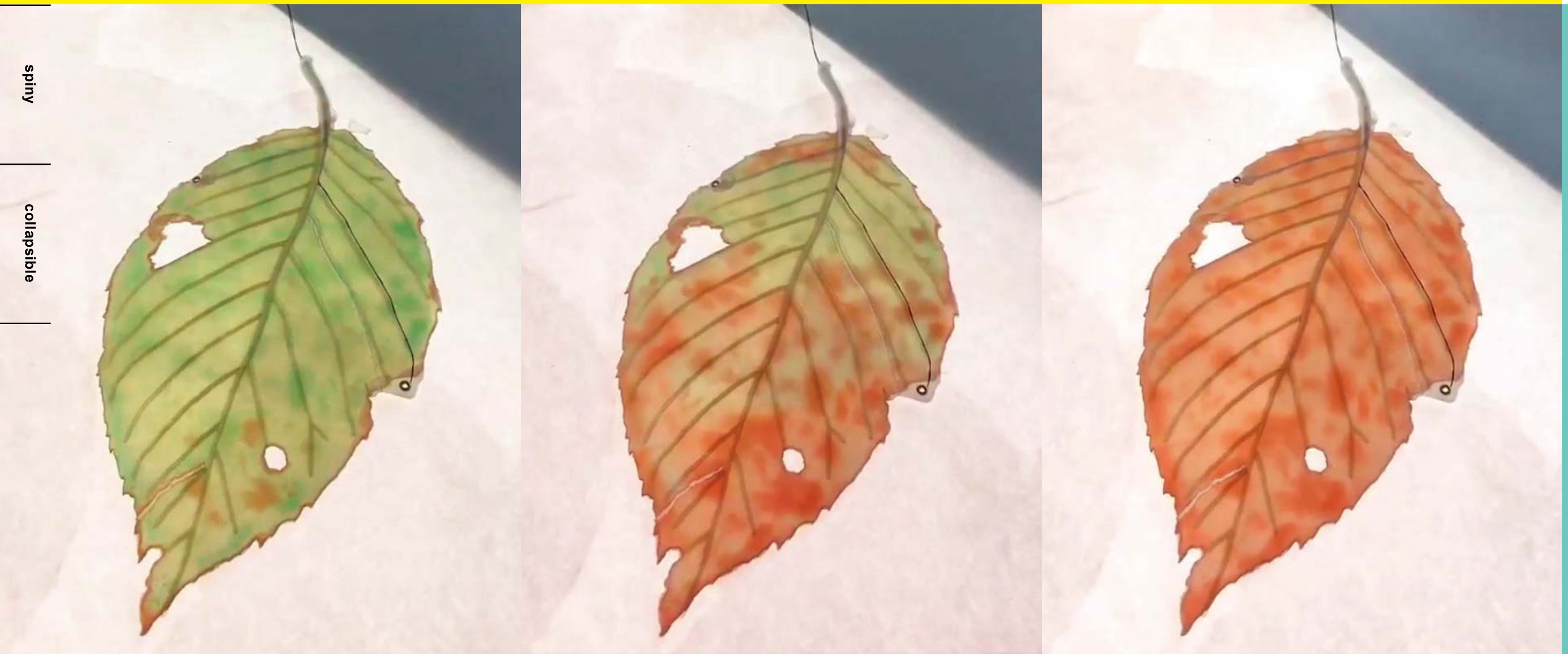
= slow propagation

07

Electrochromic Displays

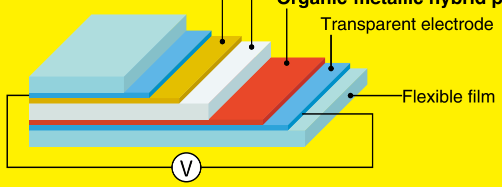
What appears to be a leaf changing color from green to red is in fact a leaf-shaped display device designed by Dr. Masayoshi Higuchi. This device is made of a polymer capable of changing color when electric current passes through it.

The most remarkable feature of this device is its ability to change color in stages("jiwa-jiwa"), exhibiting color blending effects. Unlike liquid crystal displays, which consist of perfectly aligned rows of pixels, the electrochromic polymer contains scattered color-changing ions, enabling the device to replicate gradual, autumn leaf-like color changes. In addition, because both the polymer and the electrodes of which this display is composed are flexible materials, it can be cut into different shapes and holes can even be cut out of it. This unique display device is attracting a great deal of interest for its artistic applications.



This display slowly changes color when a small electric current passes through it. The course of the color change can be reversed by inverting the direction of the electric current.
When the display is switched off while a color change is in progress, it will keep to display the coloration as of the moment it is shut down. This device was developed jointly by NIMS, Tama Art University and Waseda University.

Display structure



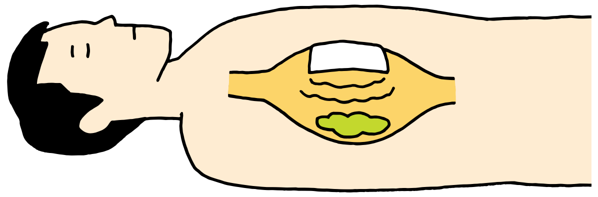
08

Nanofiber Mesh

Drugs and heat are both effective in treating cancer. Slow, continuous("ji-wa-jiwa") administration of anticancer drugs in combination with the regular, gentle("jiwa-jiwa") application of heat at a constant temperature is known to effectively destroy cancer cells without causing adverse side effects.

Dr. Mitsuhiro Ebara is developing an adhesive dressing impregnated with an anti-cancer drug to achieve this combined treatment. It works through a simple procedure. The dressing is first surgically attached directly to a target site in the body. An external magnetic field is then applied to the location of the dressing whenever treatment needs to be administered. The activated dressing generates heat, slowly and gently warming the cancer cells while at the same time slowly releasing anticancer drugs.

The key to this medical technology is the use of a special type of thread made of a smart polymer. The thread contains nanoparticles which react to an external magnetic field, generating heat. The heated thread subsequently shrinks, triggering the release of anti-cancer drugs while heating the cancer cells.



09

Gas Releasing Patches

Hydrogen sulfide (H_2S) gas—a source of the sulfuric odor emitted by natural hot springs—is effective in treating dermatitis and high blood pressure. However, inhalation of a large amount of this gas at once can be hazardous. Therefore, H_2S can be either medicinal or poisonous depending on slight differences in dosage. Safe medicinal use of H_2S requires techniques that can "jiwa-jiwa"(slowly) deliver low concentrations of the gas to target sites in a patient.

The gas releasing patch Drs. Shinsuke Ishihara and Nobuo Iyi have developed has proven effective in slowly releasing this gas at an adequate concentration. This patch stores a precursor of H_2S in a clay component. When the patch is taken out from a sealed bag, the clay material reacts with air, releasing H_2S gas. The patch is easy to apply and highly portable, like a disposable hand warmer. Ishihara and Iyi are currently working with medical organizations to further develop this patch into a practical product. Practical use of this clay material capable of slowly releasing H_2S may promote more widespread medicinal use of gases in the near future.

For more details about this research,
see p. 10 in the NIMS NOW International vol. 18 no. 3 "Versatile CLAY" issue.

Clay powder (right) and gas releasing patches (left) developed by Ishihara and Iyi.
Clay material can be designed to adjust the concentration and amount of gas to be released.

gooey | readily permeable | porous | slow propagation | perfecting alignments | spiny | collapsible

gooey
readily permeable
porous
slow propagation
perfecting alignments
spiny
collapsible

10

Magnetic Refrigeration Cycle System

An electron has spin—corresponding to an intrinsic rotational motion. Although electrons in a material normally spin in random directions, the directions in which they spin align perfectly("bi-shi") when a magnet is placed in close proximity.

The change of the alignment of spin directions in a material influences its temperature. A certain amount of energy is required for electrons to spin. Electron spin directions are brought into complete alignment as a magnet is moved into close proximity with them. When this happens, the spin energy of the electrons in a material is restricted to the direction of the alignment, causing the redundant spin energy to be released from the material as heat. By contrast, when electron spin directions randomize due to the removal of the magnet, they gather the spin energy to begin random spin, causing the materials to absorb heat.

The magnetic refrigeration cycle system being developed by Dr. Takenori Numazawa and colleague achieves cooling using the temperature fluctuations induced when electron spin states alternate between completely uniform and random. The group's ultimate goal is to achieve liquefaction of hydrogen—a leading candidate for next-generation energy—by generating cryogenic temperatures. The fully efficient controll of electrons is crucial in this technology.

For more details about this research, see the NIMS NOW vol. 19 no. 4 "Revolutionary H_2 Liquefaction" issue.

11

Single Crystal

The orientations of crystals within most solid metals and ceramics vary. However, a special technique can be used to create a single-crystal material with an entirely continuous and unbroken crystal lattice.

Single crystals often exhibit enhanced characteristics in a specific direction of crystal. Some materials with a specific type of "bi-shi"(perfectly aligned) crystal lattice can exhibit desirable physical properties, such as increased electrical conductivity and increased optical transparency.

The fundamental approaches to create materials with perfectly aligned crystal lattices—thereby improving their performance—are eliminating impurities and improving the orderliness of their atomic arrangements. Drs. Kiyoshi Shimamura and García Víllora have been leading NIMS' efforts to create the ultimate single crystals.

The TSLAG single crystal Drs. Shimamura and García Víllora developed has been used to control light in laser machinery. It alters the direction of optical polarization, thereby protecting the light source from damage caused by reflected light.

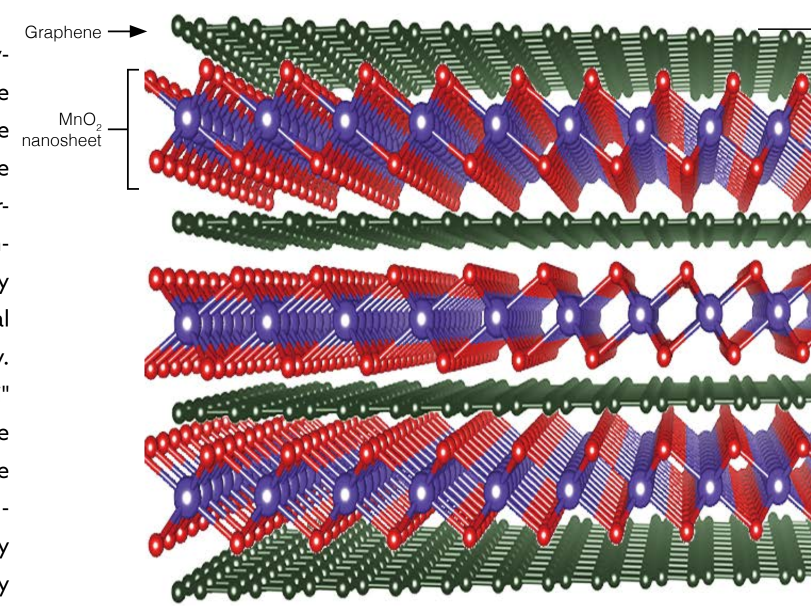
Photo:Nacása & Partners

12

Nanosheet

A nanosheet only one to several atoms in thickness is the thinnest layer that is possible to produce. Manganese oxide (MnO_2) nanosheets are promising battery materials. Their use as a lithium ion battery anode may offer approximately triple the anode capacity of current anode materials. In addition, MnO_2 nanosheets have significantly larger surface areas, allowing chemical reactions to occur more readily, potentially increasing battery charge/discharge rates. However, these very thin materials had been found to be susceptible to intensive chemical reactions which cause them to clump together and deteriorate rapidly.

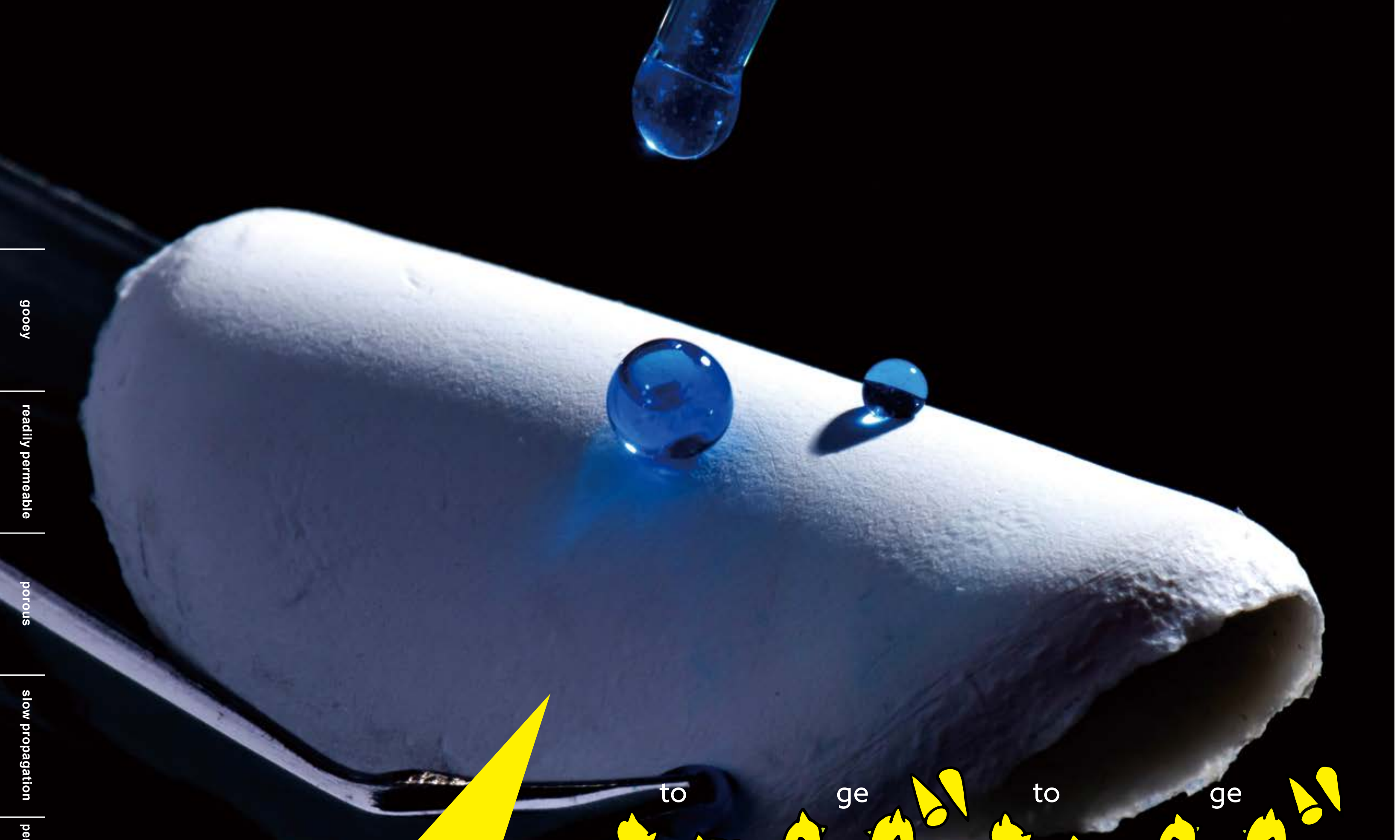
Drs. Takayoshi Sasaki and Renzhi Ma resolved this issue by "bi-shi" (neatly) and alternately stacking MnO_2 nanosheets and graphene nanosheets. The sandwiching of MnO_2 nanosheets between graphene nanosheets prevents these layers from clumping together. The composite material was integrated into a battery and experimentally subjected to 5,000 charge/discharge cycles, confirming that the very high performance remained virtually unchanged.



The two types of nanosheets can be neatly stacked simply by placing them in a solution and stirring gently. They alternately stack by themselves, almost like magic. The trick is to modify the graphene nanosheets with positive charge in advance before placing them into the solution of negatively charged MnO_2 nanosheets.

For more details about this research, see p. 12 in the NIMS NOW International vol. 16 no. 6 "Controlling nanoscale order" issue.

gooey
readily permeable
porous
slow propagation
perfecting alignments
spiny
collapsible



to ge to ge
とげとげ
= spiny

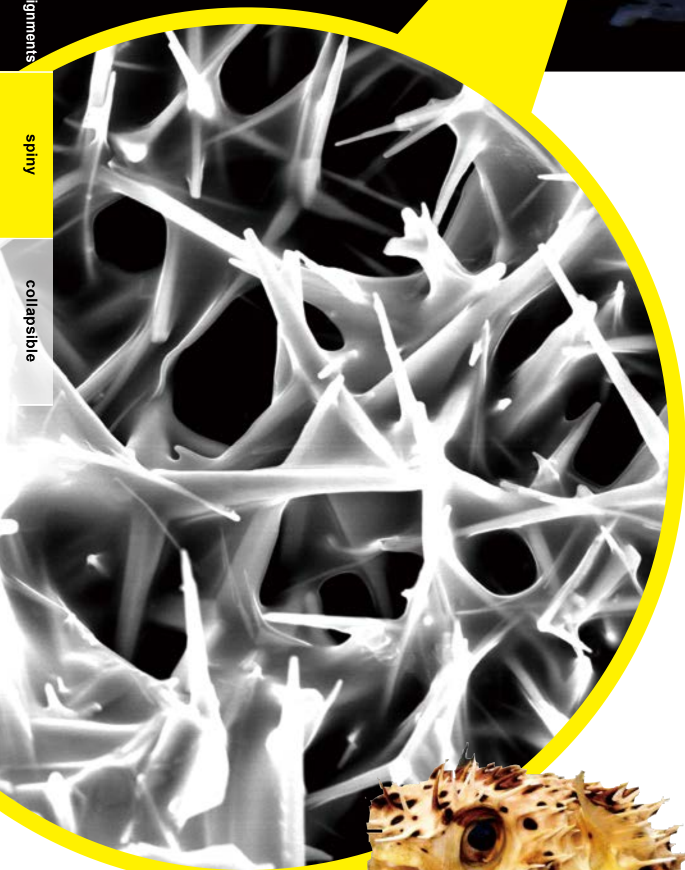
13

Water-Repellent Material

Super hydrophobic materials are able to resist water penetration due to their microscopically uneven surfaces. Water repellency can be imparted to materials by spraying hydrophobic microparticles onto them, making their surfaces microscopically uneven. However, these materials can lose their water repellency when their uneven surface structures rub off or are mechanically damaged.

The super hydrophobic material which was developed by Dr. Masanobu Naito is capable of maintaining water repellency despite being rubbed or even sliced. The secret to this remarkable capability lies in the dense microscopic "toge-toge"(spines) integrated into the material.

Naito developed this material by modeling it on the skin of the porcupinefish. By close observation, the hard spines covering a porcupinefish resemble the concrete tetrapods used for coastal protection in Japan with the exception of their sharp, needle-like projections. Naito created a large number of porcupinefish spine-like structures, added them to a soft silicone and kneaded them together. The material he developed is able to maintain water repellency even when its surface is damaged because microscopic spines are densely distributed throughout the material.



The densely distributed spines resemble porcupinefish spines in shape.

gu nya ri
ぐにゃり
= collapsible, like a flattened soda can

14

Magnesium Alloy with High Energy Absorbability

Magnesium (Mg) alloys—among the lightest conventional metals—have the potential to serve as superb lightweight automotive materials. However, they crack easily when subjected to great force. To resolve this problem, Dr. Hidetoshi Somekawa has developed a new Mg alloy. When this alloy, shaped into a tubular form, is compressed from above, it collapses into a flattened mass without forming cracks("gu-nya-ri") or sharp edges as shown in the photo, exhibiting excellent impact absorption properties.

Somekawa achieved this by adding a trace amount of manganese (Mn) to an Mg material and allowing Mn to be distributed at grain boundaries. The resulting Mg alloy is able to withstand more than three times the compressive force that commercially available Mg alloy products can stand up to before cracking. Somekawa is currently working to improve this Mg alloy so it can withstand higher speed impacts.

The upper portions of commercially available Mg alloy products crack easily when compressed from the top.

gooey | readily permeable | porous | slow propagation | perfecting alignments | spiny | collapsible

Researcher's LIST

ne ba ne ba

ねばねば =gooey

01

Functional Organic Liquids

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02

Wound Dressing Material for Post-Operative Cancer Recovery

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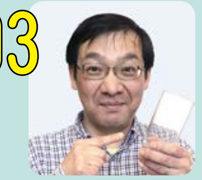
03



Glass

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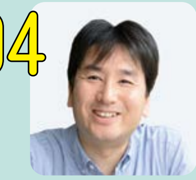
su ru ri

するり =readily permeable

04



Oil Purification Filters

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su ka su ka

すかすか =porous

05

Anode Material for All-solid-state Batteries

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06

Aerogels

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ji wa ji wa

じわじわ =slow propagation

07

Electrochromic Displays

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Nanofiber Mesh

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09

Gas Releasing Patches

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bi shi

ビシッ! =perfecting alignments

10

Magnetic Refrigeration Cycle System

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Single Crystal

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Nanosheet

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to ge to ge

とげとげ =spiny

13

Water-Repellent Material

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gu nya ri

ぐにゃり =collapsible, like a flattened soda can

14

Magnesium Alloy with High Energy Absorbability

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Research Center for Structural Materials

Do you want to know more about materials science?

"To the Scientists of the Future" video clips

"To the Scientists of the Future" is a YouTube video clip series created jointly by NIMS and EUPHRATES Ltd. (a group specializing in creative work, including NHK's educational TV programs). We have an English subtitle option to these clips.
This scientific video series has been popular in Japan with a cumulative view count exceeding 7 million. These clips demonstrate the various intriguing scientific phenomena and unique materials NIMS has developed using fascinating images that are also entertaining and beautiful.

List of "To the Scientists of the Future" video clips

Sialon phosphor

Invisible glass

Super hydrophobic material

How to display English subtitles

On the YouTube website, type "nims euphrates" in the search box. Select the video clip entitled "NIMS × EUPHRATES 未来の科学者たちへ." Click the "Settings" icon in the lower right corner of the screen and select "Subtitles", and click "English" (only Japanese audio is available).

*More video clips with English subtitles will be released as they become available.

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NIMS NOW International 2020. Vol.18 No.4

National Institute for Materials Science

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photo by Michihito Ishikawa (p4,p6,p7<bottom>,p9,p12<top>,p13)
Illustration by Jo Okada (vision track)
editorial design by Barbazio Inc.

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R70
Percentage of Waste Paper pulp 70%

VEGETABLE OIL INK