CHEMWATCH

Bulletin Board

Contents

APR. 11, 2025

(click on page numbers for links)

REGULATORY UPDATE

ASIA PACIFIC

AMERICA

EUROPE

REACH UPDATE

JANET'S CORNER

HAZARD ALERT

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Contents

GOSSIP

CURIOSITIES

TECHNICAL NOTES

Regulatory Update

ASIA PACIFIC

PFAS: The next asbestos?

2025-03-21

In some of the Earth's most remote and inaccessible regions, there are traces of humankind.

There's plastic in the Mariana Trench. Mount Everest looks like a garbage dump. And the Arctic Ocean is full of "forever chemicals" known as PFAS.

Per- and polyfluoroalkyl substances—PFAS—are a group of thousands of synthetic chemicals.

They came into vogue in the 1950s and started appearing everywhere. One common example is perfluorooctanoic acid (PFOA), which was used to produce Teflon.

Martyn Kirk is an epidemiologist at the Australian National University. He was the principal investigator of the PFAS Health Study, which ran between 2016 and 2021.

"They were used as anti-stick coatings, anti-stain coatings, cosmetics, pharmaceuticals, fast food, packaging—all sorts of things," says Martyn.

Read More

Phys.org, 21-03-25

https://phys.org/news/2025-03-pfas-asbestos.html

Transitional period in Labelling, Safety Data Sheet and Packaging Notices ends on 30 April 2025

2025-04-03

Find out what importers, manufacturers and suppliers must do to comply with the Labelling, Safety Data Sheet and Packaging notices.

In April 2021, we updated the three notices that set out rules for:

- Labelling
- safety data sheets (SDSs)
- packaging

These updates included a four-year transitional period to give manufacturers, importers and suppliers time to meet new requirements (the changes don't impose new requirements on end-users). The transitional period ends on 30 April 2025.

This guidance explains how to ensure you're complying with these notices when the transitional period ends. The guidance supports but doesn't replace the notices. You must refer to the notices to be sure you are complying.

Notices updated for the move to GHS 7

In April 2021, the EPA updated the classification system for hazardous substances in New Zealand to one based on the 7th edition of the Globally Harmonised System of classification and labelling of hazardous substances (GHS) (2017).

To reflect the new classification system, we updated the Labelling, Safety Data Sheet and Packaging Notices. We also made other changes.

This update ensures New Zealand is consistent with international standards, improving safety through clear communication about chemical hazards.

Learn more about the move to GHS 7

What this means for you

From 30 April 2025, importers, manufacturers and suppliers must meet the requirements of the notices that were updated in 2021.

Importers and manufacturers

From 30 April 2025, you must ensure that all hazardous substances you are responsible for meet the requirements of these notices:

- Hazardous Substances (Labelling Notice) 2017 – EPA Consolidation 30 April 2021
- Hazardous Substances (Safety Data Sheets Notice) 2017 – EPA Consolidation 30 April 2021
- Hazardous Substances (Packaging Notice) 2017 – EPA Consolidation 30 April 2021

Suppliers

From 30 April 2025, you must make sure that the label, packaging and SDS for all hazardous substances you supply are compliant with these notices. If you are in any doubt, you should check with your own supplier.

You must also ensure that you comply with the requirements of other EPA notices, in particular clause 13 of the Hazardous Substances (Hazardous Property Controls) Notice. For further information on this, check our guidance: Hazardous chemicals you can only supply to workplaces

Read More

EPA NZ, 03-04-25

https://www.epa.govt.nz/hazardous-substances/safety-data-sheets-labelling-and-packaging/transitional-period-in-labelling-safety-data-sheet-and-packaging-notices-ends-on-30-april-2025/

Application to introduce Rhapsody, a new fungicide

2025-04-03

We welcome your views on an application to import or manufacture a new fungicide, Rhapsody.

It is used on apples and pears to control powdery mildew and blackspot, and on grapes to control Botrytis.

The application

UPL New Zealand Limited has applied for approval to introduce a new fungicide, Rhapsody, a suspension concentrate containing the active ingredient ipflufenoquin at 218 g/L.

Ipflufenoquin is a new active ingredient to Aotearoa New Zealand. It has been approved in various overseas jurisdictions, including Australia, Canada, Japan, and the United States of America. It is pending approval in Europe.

If approved, Rhapsody could only be used by professionals in commercial settings and applied onto crops using ground-based methods.

The EPA carried out a quantitative human health and environmental risk assessment. The results are outlined in the draft science memorandum.

This public consultation enables people and industry to provide us with more information about this substance, and any potential risks and benefits.

Read More

EPA NZ, 03-04-25

https://www.epa.govt.nz/public-consultations/open-consultations/application-to-introduce-a-new-fungicide-rhapsody/

EPA Announces Changes to Pesticide Data Submission Process to Increase Efficiency and Reduce Burden

2025-04-03

The U.S. Environmental Protection Agency (EPA)is announcing improvements to simplify the process for companies submitting data to the agency as part of a pesticide registration package.This improvement will also make the agency's processing of this information more efficient. Streamlining this process, while partnering with industry to safeguard human health and the environment, reduces burden for both companies and EPA, supporting Administrator Zeldin's Pillar Threeof Powering the Great American Comeback initiative to advance permitting reform, cooperative federalism, and cross-agency partnership.

Companies are required tosubmita document called a "data matrix" form when their pesticide registration packages contain cited data from outside sources.Currently, companies must submit two versions of the data matrix form (in either paper or electronic format): one for internal agency use and one with reference dataredactedfor public use. However, in the interest of reducing burden, and since no information on the form is Confidential Business Information, the agency determined that there is no need for a redacted version and is now only asking for one unredacted version of the form to be used for both internal and public use.Additionally, EPA will no longer accept paper submissions of this form and will only accept this information via a web-based portal.

Further detailed instructions for how to complete and submit the revised forms will be available in the updated Pesticide Registration Manual.

Read More

US EPA, 03-04-25

https://www.epa.gov/pesticide-registration/prn-2025-1-revised-procedures-citing-data-support-pesticide-registrations

Rules for using clopyralid products

2025-04-03

Compost rules

All clopyralid products have the same rules around compost:

- Users of clopyralid products must ensure that green waste from vegetation treated with clopyralid is not used in compost (or in similar ways such as for mulch, fertiliser or mushroom substrate).
- Users of clopyralid products must also ensure that this green waste is not sent to a composting facility.
- Retailers must only sell clopyralid products to a workplace to ensure only those with training and knowledge use these products.
- The labels on clopyralid products all have the same statements to tell people how to avoid compost contamination. Importers and manufacturers have until 12 March 2026 to update their labels.

Label statements

Your product label must meet the requirements laid out in the Consolidated Hazardous Substances (Labelling) Notice 2017.

Read More

EPA NZ, 03-04-25

https://www.epa.govt.nz/hazardous-substances/rules-notices-and-how-to-comply/specific-substance-guidance/clopyralid/#rules

Changes to three internationally restricted chemicals now in effect

2025-04-03

Three new chemicals were recently added to the Stockholm Convention. The Stockholm Convention is an international treaty to eliminate or restrict the production and use of persistent organic pollutants – highly toxic chemicals that do not readily degrade. Because New Zealand signed this convention, we must restrict the chemicals here. The three chemicals are:

Methoxychlor – a legacy pesticide not used in New Zealand.

Dechlorane Plus – a flame retardant used in adhesives and sealants, mainly in motor vehicle cable and wire coatings.

UV-328 – a UV inhibitor used to protect surfaces like paints against discolouration from sunlight.

The chemicals and products containing them have now been banned with some time-limited specific exemptions provided for Dechlorane Plus and UV-328. The HSNO Act has been amendedto implement the restrictions.

Read More

EPA NZ, 03-04-25

https://www.epa.govt.nz/public-consultations/decided/proposal-to-restrict-three-new-stockholm-convention-chemicals/

AMERICA

EPA kicks chemical regulations down the road

2025-04-02

Workers in chemical plants, along with communities near such facilities, will have to wait longer for regulations that aim to reduce cancer and other health risks associated with widely used solvents like trichloroethylene, perchloroethylene, and carbon tetrachloride, and common building block chemicals like formaldehyde and 1,3-butadiene.

While attention has focused on President Donald J. Trump's moves to gut the federal workforce and slash funding that doesn't align with his priorities, the US Environmental Protection Agency has been quietly delaying restrictions on many hazardous substances, from asbestos to air pollutants. Environmental groups fear the delays are a first step toward weakening or even eliminating the restrictions.

Read More

c&en, 02-04-25

https://cen.acs.org/policy/chemical-regulation/EPA-kicks-chemical-regulations-down/103/i9

EPA Announces Changes to Pesticide Data Submission Process to Increase Efficiency and Reduce Burden

2025-04-03

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the agency as part of a pesticide registration package.This improvement will also make the agency's processing of this information more efficient. Streamlining this process, while partnering with industry to safeguard human health and the environment, reduces burden for both companies and EPA, supporting Administrator Zeldin's Pillar Threeof Powering the Great American Comeback initiative to advance permitting reform, cooperative federalism, and cross-agency partnership.

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Read More

US EPA, 03-04-25

https://www.epa.gov/pesticide-registration/prn-2025-1-revised-procedures-citing-data-support-pesticide-registrations

Review of New Source Performance Standards for Stationary Combustion Turbines and Stationary Gas Turbines; Reopening of Comment Period

2025-03-25

SUMMARY:

On December 13, 2024, the U.S. Environmental Protection Agency (EPA) proposed amendments to the new source performance standards (NSPS) for new, modified, and reconstructed stationary combustion turbines and stationary gas turbines. The EPA is reopening the public comment period for this proposed rule to allow additional time for stakeholders to review and comment on the proposal. The initial 90-day public comment period, which ended March 13, 2025, is being reopened for an additional 21 days, from March 25, 2025 to April 15, 2025.

DATES:

The comment period for the proposed rule published on December 13, 2024, at 89 FR 101306, is reopened. Comments must be received on or before April 15, 2025.

Read More

US Federal Register, 25-03-25

https://www.federalregister.gov/documents/2025/03/25/2025-04990/review-of-new-source-performance-standards-for-stationary-combustion-turbines-and-stationary-gas

EUROPE

Regulatory fees for British chemicals sector slashed

2025-04-01

New legislation to cut UK REACH costs for chemical businesses comes into force as part of Government’s Plan for Change

New legislation coming into force today (Tuesday 1 April) will slash regulatory burdens on the chemicals industry – saving businesses £40 million over the next six years.

The move as part of the Government’s Plan for Change means nearly all current fees and charges for chemical businesses are going down. Changes are expected to lead to a total reduction of costs by £40 million for businesses across the next six years – from 2025/26 to 2030/31.

Included in the changes is a new standard registration fee of £2,222, which will mean a significant reduction to the cost of registration for 92% of firms. Alongside this, the continuation of the small and medium enterprise discounts and a reduction in legal identity changes will ensure the chemicals industry is fairly regulated and remains competitive.

This will relieve the UK’s chemicals industry of unnecessary cost burdens, create conditions for them to invest in new infrastructure and delivering growth for the sector.

Environment Minister Emma Hardy said:

The UK chemicals sector is world-leading but has faced a range of challenges in recent years, including high regulatory costs.

As part of Plan for Change, we’re reducing UK REACH fees by £40 million over the next six years, helping businesses continue to deliver growth in this vital sector.

UK REACH is the regulatory regime that applies to many chemical substances that are manufactured or imported into the Great Britain. It exists to provide a high level of protection of human health and the environment when chemicals are used.

To ensure UK REACH is enforced effectively, chemical businesses pay fees to recover the cost of the services provided. The new charges will ensure businesses pay for what they get.

The Government is committed to protecting human health and the environment from the risks posed by chemicals. This includes reshaping the UK REACH Work Programme in future years to ensure it delivers the Government’s ambitions, while also setting out a clear direction of travel to support businesses and the chemicals industry, taking account of UK REACH’s relationship with regulation in the EU.

Read More

Gov.uk, 01-04-25

https://www.gov.uk/government/news/regulatory-fees-for-british-chemicals-sector-slashed

CEFIC calls for EU action on chemicals rescue plan

2025-04-01

“For us, it is way past 12 o’clock,” said CEFIC president Ilham Kadri, urging EU leaders to act on the association’s-point rescue plan to prevent further shutdowns and loss of investments. Kadri, who is also CEO of Syenqo, was speaking at the High-Level Strategic Dialogue on the Chemical Industry Package with the European Commission.

EU industry is facing “declining demand, soaring energy prices and growing regulatory burdens” as highlighted in the broader Antwerp Declaration. Without immediate, targeted action, she argued, more production sites will shut down, investments will move elsewhere and Europe will fall further behind global competitors.

"Today, companies are halting investments in Europe while our global competitors race ahead," Kadri said. "Without urgent action, we risk losing an entire industrial base. This is not just about chemicals; it's about Europe's economic and strategic future."

CEFIC has laid out ten "urgent actions" that must be included in a comprehensive Chemical Industry Package. These, it says, "must go beyond PFAS and REACH and ensure that Europe's chemicals industry receives the urgent and tailored support it needs to restore its base in Europe":

1. A plan to secure EU value chains of chemicals used in the European defence industries, making chemicals a full part of the Readiness 2030 ambition
2. Direct, immediate measures to lower energy costs, including reinstating organic chemicals in the EU's indirect cost compensation list and ensuring hydrogen is a viable low-carbon energy fuel, as well as the Affordable Energy Action Plan
3. A clear policy of urgency on trade protection, fast-tracking anti-dumping measures and securing a strong EU response to tariff disputes and Russian sanctions

Read More

Speciality Chemicals Magazine, 01-04-25

https://www.specchemonline.com/node/10103

Chemical Recycling Still Faces Regulatory Challenges in the EU

2025-04-03

Chemical recycling of plastic is at a turning point in Europe, with several large projects poised to start but still facing regulatory and market challenges. As highlighted in the study recently published by consultants E-cube, regulations are playing a driving role in the sector's development.

Regulation (EU) 2025/40 of December 19, 2024, on packaging and packaging waste, the "PPWR", sets ambitious requirements regarding recyclability and recycled content in plastic packaging. However, several key provisions of the PPWR still need to be clarified in upcoming implementing decrees, particularly concerning the "mirror clause", which intends to allow non-EU recycled material on the EU market, provided such material is recycled in a facility abiding by environmental standards mirroring those applicable in the EU.

Sourcing of waste material will also be an issue in light of the growing demand and increasing prices for plastic waste in territories where waste collection and management are heavily regulated, and sometimes subject to stringent public tender procedures. Ongoing regulatory uncertainty makes negotiating long-term contracts necessary to secure sourcing especially difficult.

Read More

JD Supra, 03-04-25

https://www.jdsupra.com/legalnews/chemical-recycling-still-faces-6770446/

European Commission restricts PAHs in clay targets

2025-04-02

On 1 April 2025, the Commission adopted an EU-wide restriction on polycyclic aromatic hydrocarbons(PAHs) in clay targets for shooting. Each year, it is estimated that at least 270 tonnes of these toxic, persistent and bioaccumulative substances are released into the environment from clay target shooting. The new restriction is expected to reduce these emissions by 99 %.

In addition to environmental benefits, the restriction will also reduce the exposure for workers and the public handling or shooting clay targets, lowering the associated cancer risk. It will start applying from 22 April 2026.

PAHs are found in binders, such as petroleum pitch, which are used to produce clay targets.

The restriction proposal was prepared by ECHA in October 2021. Our scientific committees for Risk Assessment and Socio-Economic Analysis supported the proposal in their 2022 opinions.

Read More

ECHA, 02-04-25

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32025R0660&qid=1743584247665

European Commission publishes guide on microplastics restriction – ECHA to develop it further

2025-04-02

The Commission has released an Explanatory Guide to help stakeholders implement the REACH microplastics restriction (entry 78 of Annex XVII).

The guide, prepared in collaboration with ECHA and EU countries, explains what the restriction is about, answers stakeholders' questions and features decision trees and examples of borderline cases.

The Commission has also asked ECHA to take over the further development of the guide when needs for clarification emerge from the practical implementation of the restriction. We will also publish its future versions.

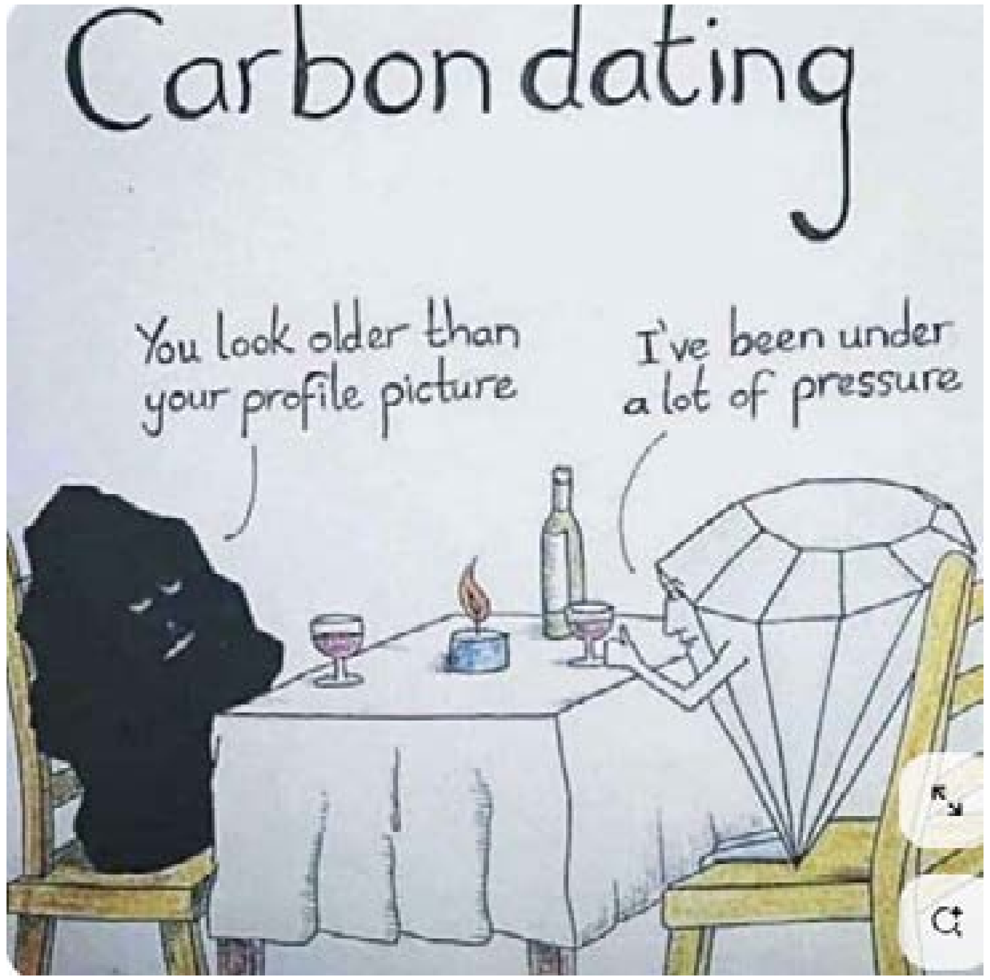
Read More

ECHA, 02-04-25

https://single-market-economy.ec.europa.eu/sectors/chemicals/reach/restrictions/commission-regulation-eu-20232055-restriction-microplastics-intentionally-added-products_en

Carbon Dating

2025-04-11



https://au.pinterest.com/pin/16677461115268556/

Diacetyl

2025-04-11

USES [2,3]

Diacetyl is primarily used an artificial food additive found in flours, chocolate, cooking oils, candy, chips, frosting and more. Most notably, it is responsible for the butter aroma and taste in microwave popcorn.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

Primary opportunities for exposure to diacetyl exist in occupational settings, where workers in flavouring companies' facilities inhale vapours during food and beverage production processes. Part of the problem is that the FDA evaluates such flavouring chemicals as generally recognised as safe (GRAS) to be eaten, because they are food additives, but most of these substances have not been specifically tested for respiratory toxicity via inhalation.

Workers who make, use, or work near flavouring chemicals containing diacetyl may be at risk. Settings where these exposures may occur include:

- Flavouring plants
- Microwave popcorn plants
- Commercial and retail bakeries
- Snack food and candy plants
- Dairy products and packaged vegetable oil plants (e.g., margarine, cooking oil)
- Other flavoured food production plants

Routes of Exposure

Diacetyl can be absorbed into the body by inhalation and by ingestion.

HEALTH EFFECTS [4]

Acute Health Effects

Exposure to diacetyl causes the following acute health effects:

- Contact can irritate eyes. Eye contact with vapours can cause chemical burns, which require medical treatment to heal.

Diacetyl, also called butanedione or butane-2,3-dione) is an organic compound with the chemical formula $(CH_3CO)_2$. It is a volatile, yellow/green liquid with an intensely buttery flavour. [1] It contributes to beer and wine and has a slick or slippery texture at low levels and a butterscotch flavour at higher levels. It is a natural by-product from the conversion of glucose to ethanol by yeast during fermentation in beer, and it is also found naturally in low concentrations in coffee, vinegar, dairy, honey, and fruits. [2] Diacetyl has been used as a marker of exposure to flavouring vapours in investigations evaluating lung

- Contact with the skin can cause irritation. It can result in a rash with dryness, redness, flaking, and cracking of the skin.
- Breathing diacetyl can irritate the nose and throat causing coughing and wheezing.
- High exposure to diacetyl may cause headache, drowsiness, lack of coordination and seizures.

Carcinogenicity

Diacetyl has not been tested for its ability to cause cancer.

Other Effects

Diacetyl has not been tested for its ability to effect reproduction.

SAFETY

First Aid Measures [5]

- **Inhalation:** If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
- **Skin Contact:** In case of contact, immediately wash skin with soap and copious amounts of water.
- **Eye Contact:** In case of contact, immediately flush eyes with copious amounts of water for at least 15 minutes.
- **Ingestion:** If swallowed, wash out mouth with water provided person is conscious. Call a physician.

Workplace Controls & Practices [4]

Engineering Controls

- Safety shower and eye bath.
- Use non-sparking tools.
- Mechanical exhaust required.

General Hygiene Measures

- Remove and wash contaminated clothing promptly.
- Wash thoroughly after handling.

Personal Protective Equipment [5]

The following personal protective equipment is recommended when handling diacetyl:

- **Respiratory Protection:** Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU). Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator.
- **Hand Protection:** Compatible chemical-resistant gloves.
- **Eye Protection:** Chemical safety goggles.

REGULATION

United States

Exposure Limit	Limit Values	HE Codes	Health Factors & Target Organs
OSHA Permissible Exposure Limit (PEL) - General Industry	Not established		
OSHA PEL - Construction Industry	Not established		
OSHA PEL - Shipyard Employment	Not established		
National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL)	Not established		

Exposure Limit	Limit Values	HE Codes	Health Factors & Target Organs
American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) (2012)	0.01 ppm (0.04 mg/m3) TWA 0.02 ppm (0.07 mg/m3) STEL A4	HE10	Lung damage (bronchiolitis obliterans-like illness)
CAL/OSHA PEL	Not established		

References

1. https://en.wikipedia.org/wiki/Diacetyl
2. http://www.toxipedia.org/display/toxipedia/Diacetyl
3. https://www.osha.gov/SLTC/flavoringlung/diacetyl.html
4. http://pubchem.ncbi.nlm.nih.gov/compound/2_3-butanedione#section=Non-Human-Toxicity-Excerpts
5. https://ohsonline.com/articles/2011/11/10/niosh-releases-new-fact-sheet-on-diacetyl-exposure.aspx
6. http://nj.gov/health/eoh/rtkweb/documents/fs/0274.pdf
7. https://www.osha.gov/SLTC/flavoringlung/health.html
8. http://www.cdph.ca.gov/programs/hesis/Documents/diacetyl.pdf
9. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=AU&language=en&productNumber=D3634&brand=SIGMA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Fsigma%2Fd3634%3Flang%3Den
10. https://www.osha.gov/dts/chemicalsampling/data/CH_231710.html

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Carbon-Negative Building Material Made From Seawater and CO2

2025-03-21

The material can hold up to half its weight in trapped CO2 and replace sand in concrete.

Researchers have successfully developed a new carbon-negative material using seawater, electricity and carbon dioxide (CO2).

The material – a mineral precipitate formed during a modified seawater splitting process – can store half its weight in trapped CO2 and can be used as a replacement for sand in the production of concrete, or in certain plasters and paints.

The research, published in the journal Advanced Sustainable Systems, also found that altering the applied voltage, current and CO2 injection rate during the precipitation process can tailor the properties of such minerals.

From trash to treasure

Seawater splitting is a process commonly used in green hydrogen production. Using a cathode and anode powered by a source of renewable electricity, the seawater is electrolyzed and splits to produce hydrogen gas at the cathode and oxygen or chlorine gas at the cathode.

During this electrochemical process, mineral deposits of calcium carbonate ($CaCO_3$) and magnesium hydroxide ($Mg(OH)_2$) also slowly build up at the cathode – especially when there is a high amount of dissolved CO2 present in the water. These deposits have generally been dismissed as an energy-intensive byproduct by those who produce green hydrogen. However, some believe that these minerals could have untapped potential for carbon sequestration.

"Traditionally, mineral precipitates similar to those analyzed in this work are considered an unwanted byproduct of green hydrogen production. This is because they typically increase the electrical resistance of the process, leading to higher energy consumption," lead study author Dr. Alessandro F. Rotta Loria, told Technology Networks.

"As a part of our work, we have devised controllable ways to synthesize these minerals and engineer their deposition onto cathodic interfaces or directly in solution," he explained. "This capability enables us to tailor the properties of the precipitated minerals to suit desired engineering applications."

Storing carbon with sea minerals

To produce their materials, the researchers inserted electrodes into a large reactor filled with seawater and applied an electric current while bubbling CO2 gas through the water. Molluscs form their shells by a similar process, using their metabolic energy to convert dissolved ions into calcium carbonate; the researchers use electrical energy as a replacement and increased the mineralization with the injection of extra CO2.

This extra CO2 becomes effectively "trapped" as it interacts with the ions present in seawater – the formation of CaCO3 acts directly as a carbon sink, while the Mg(OH)2 produced can also sequester some carbon through additional interactions.

By varying different experimental factors – including the applied voltage and current, the flow rate and duration of CO2 injection and the recirculation of seawater in the reactor – the researchers were also able to vary the composition and properties of the carbon-sinking minerals produced. Depending on these factors, the minerals can be made to be more flaky and porous or denser and harder.

"These factors collectively influence the precipitation process in a highly complex manner, as it strongly depends on local pH, ionic availability and type, temperature and other variables," Rotta Loria explained. "Through our work, we have developed an understanding of how to simultaneously control all these variables to achieve mineral precipitations with desired properties while also optimizing the energy input required to obtain the intended outcomes."

Depending on these factors and the resultant ratio of minerals produced, the deposited material can trap approximately half its weight in CO2.

Towards more sustainable construction

The researchers believe that this material, in addition to simply acting as a carbon sink, could also be used as a component in construction materials without compromising on their strength.

"The precipitated minerals can be utilized in the production of various cements, such as magnesium-based cements, as well as plasters and paints," Rotta Loria said. "Additionally, these minerals can be cultivated as large-scale aggregates for use in concrete manufacturing."

Producing enough cement to meet demand while also reducing emissions in line with a "Net Zero by 2050" target has already been identified as a particular challenge by the International Energy Agency, with current emissions figures remaining stubbornly high despite the required 4% annual reduction needed to meet that goal. Using carbon-negative materials in the production of cement and concrete could help to improve the footprint of this industry.

To be useful in such an application, it is critical that the production method for such carbon-negative materials is highly scalable. This is something that this new method delivers, Rotta Loria believes.

"The developed process utilizes highly modular components that can be integrated into scalable reactors for large-scale deployment, featuring real-time monitoring and product quality control. As a result, this approach holds significant scalability potential. The project team is actively progressing in this direction," Rotta Loria said.

"On the scientific side, several questions remain regarding the mineralization process, the answers to which could further enhance its control. On the engineering side, multiple steps are required to industrialize the technology," Rotta Loria said. "However, the knowledge we have developed uniquely positions us to effectively tackle these challenges."

Technology Networks, 21 March 2025

https://technologynetworks.com

Serendipitous discovery could lead to more efficient catalysts

2025-04-09

Preparing catalysts by sending hot, steamy car exhaust over them could improve their efficiency and reduce the amount of rare and expensive metals required in vehicle catalytic converters and many other emission control and industrial processes.

Reporting in the journal, Nature, an international team of researchers found that the hot car exhaust containing nitrogen oxides and carbon monoxide caused a previously unknown reaction that, used proactively, can significantly improve catalytic activity. Catalysts are substances that increase the rate of chemical reactions.

The researchers found that hot exhaust encouraged ceria particles, one of the components of the catalyst materials, to form two-dimensional, nano-sized clusters. These clusters, densely covering the surface, create many sites where chemical reactions can happen, increasing the efficiency of the process. The method also creates a large number of loosely bound oxygen ions associated with cerium atoms, which can move easily and further improve many, common catalytic reactions that require either adding or taking away oxygen.

"They act like an oxygen sponge, and once the oxygen is easily activated, it's very useful for many reactions requiring oxygen, like oxidation of hydrocarbons and carbon monoxide," said Yong Wang, one of the study's corresponding authors and Regents Professor in Washington State University's Gene and Linda Voiland School of Chemical Engineering and Bioengineering. "This offers better design of a catalyst for multiple reactions."

Serendipitously discovered, the new treatment method was found to improve catalytic activity by about ten times.

"Luck was a factor in this. Sometimes, we just stumble into a great science discovery. At the same time, this is one which is of practical interest," said Wang, who also holds a joint appointment with Pacific Northwest National Laboratory.

Researchers are continually trying to improve catalytic converters and other emission control technologies. Over their lifetime, these technologies for removing pollutants from the exhaust streams of cars or power plants become less effective. Manufacturers have to include extra amounts of rare and expensive metals, such as rhodium, platinum, or palladium, in the converter to compensate for the catalyst's degradation and to meet required emission standards.

One mystery that has befuddled industry for many years is that while nano-sized metal materials in catalytic converters are known to "sinter," or glob together into larger particles and become ineffective over time when exposed to very hot and harsh conditions of the exhaust steam, the catalytic converters somehow still hold up better than expected.

"If you look at the ceria particle size growth, you would expect at least a hundred times reduction in activity, and that's not the case," said Konstantin Khivantsev, a staff scientist and chemical engineer at Pacific Northwest National Laboratory (PNNL) and a corresponding author. "There is a process that was not discovered or recognized, but it contributed to improved dispersion and catalytic activity."

The researchers, including from WSU, PNNL, University of New Mexico, University of Sofia, Bulgaria, and Purdue University, decided to artificially age a catalyst to study it. However, instead of using just water, which is a typical component of aging tests, they decided to run very hot car exhaust over the catalyst for several hours. They observed that the catalyst's performance improved rather than degraded.

"So, this is part of the fun of doing research because intuition told us that the catalyst would de-activate, and the results were the complete opposite," said Abhaya Datye, Distinguished Regents Professor Emeritus at the University of New Mexico and a corresponding author. "We then asked ourselves whether this was real, and repeated the experiment several times. The next step was to figure out the science."

They discovered that catalytic converters do not degrade as quickly as expected because the hot car exhaust, unbeknownst to the researchers in the field, had actually been aiding the reactions occasionally in short bursts when the car exhaust was at especially high temperatures. In terms of practical impact, the researchers now want to use the treatment process on purpose -- pre-activating the catalyst and purposely forming the reactive state at the beginning of the catalyst's life.

The new treatment technique could allow for the reduction of the amount of precious metals, such as rhodium, required in the catalyst, offering significant cost savings. Catalytic converters in a car usually contain about $800 worth of rhodium.

"In the spent catalysts, atomically thin patches of ceria that formed during the dispersion of ceria nanoparticles, are in in contact with precious metals, such as rhodium and platinum," said János Szanyi, a corresponding author and staff scientist at PNNL. "This allows the catalysts to survive harsh temperature conditions of vehicle exhaust and still maintain their activity."

The researchers have been testing their catalyst treatment at the lab scale. They're also working with industry partners to test them in vehicles under real operating conditions. The work relied on fundamental science that was supported by the U.S. Department of Energy's Office of Science, Basic Energy Sciences, Catalysis Science program. The research at PNNL was supported by the U.S. Department of Energy's Energy Efficiency and Renewable Energy Vehicle Technologies Office.

Science Daily, 9 April 2025

https://sciencedaily.com

Iron Without Fire: How Electricity Could Replace the Blast Furnace

2025-04-09

Ironmaking could be on the edge of a major upgrade. Scientists have developed a cleaner, electrochemical method to extract iron that could one day rival traditional blast furnaces in cost while slashing pollution.

Rethinking Ironmaking with Electrochemistry

Iron and its alloys, like steel and cast iron, are essential to modern infrastructure and manufacturing, and global demand for these materials continues to rise. Traditionally, iron is extracted from ore using blast furnaces, a process that consumes large amounts of energy and produces significant air pollution.

Now, researchers reporting today (April 9) in ACS Energy Letters have developed a cleaner alternative. By using electrochemistry to extract iron from a synthetic iron ore, their method could one day compete with blast furnaces in both efficiency and cost.

"Identifying oxides which can be converted to iron metal at low temperatures is an important step in developing fully electrified processes for steelmaking," says Paul Kempler, the study's corresponding author.

Breaking Down the Electrochemical Process

In this electrochemical approach, electricity is passed through a liquid containing iron-rich materials, isolating the metal without the need for extreme heat. This method could substantially reduce emissions, including greenhouse gases, sulfur dioxide, and particulate matter, and improve energy efficiency. In earlier work, Kempler's team demonstrated that solid iron(III) oxide particles could be reduced to pure iron in a sodium hydroxide solution at relatively low temperatures (176-194°F, or 80-90°C). However, natural iron ores, often dense, irregular, and filled with impurities, proved challenging for this method.

To overcome this, Kempler teamed up with researchers Anastasiia Konovalova and Andrew Goldman to explore which types of iron ore-like materials might better support the scalability of this cleaner process.

Tweaking Iron Oxide for Better Results

First, the researchers prepared high surface area iron oxide particles with internal holes and connective cavities to investigate how the nanoscale morphology of the particles impacted the electrochemical reaction. Then, they converted some of these into micrometer-wide iron oxide particles to mimic the morphology of natural ores. These particles contained only a few trace impurities, such as carbon and barium. The team designed a specialized cathode to pull iron metal from a sodium hydroxide solution containing the iron oxide particles as current passed through it.

In experiments, dense iron oxides were reduced, or converted into elemental iron, most selectively at a current density of 50 milliamperes per square centimeter, similar to rapidly charging lithium-ion batteries. Conversely, loose particles with higher porosity, and thus higher surface area, facilitated more efficient electrochemical iron production, as compared to those made to resemble the less porous natural iron ore hematite.

Efficiency, Cost, and the Road Ahead

The researchers evaluated the potential cost of their electrochemical ironmaking method. At the current density used in the experiments, they estimated that iron could be produced at less than $600 per metric ton ($0.60 per kilogram), which is comparable to traditional ironmaking.

The study showed that much higher current densities, up to 600 milliamperes per square centimeter, similar to those used in industrial electrolysis cells, could be achieved when using particles with nanoscale porosity. Further advances in electrochemical cell design and techniques to make iron oxide feedstocks more porous will be required before the technology sees commercial adoption.

Sci Tech Daily, 9 April 2025

https://scitechdaily.com

Mercury Found Atop Rocky Mountains

2025-04-02

As storms carry snow to the Rocky Mountains, they bring mercury and other contaminants from mines in the region.

Mountain snowpacks accumulate snow throughout the winter, building up stores of water that will supply communities across the American West throughout the long dry season. Now, a new study shows that as storms carry snow to the Rocky Mountains, they are also bringing mercury and other contaminants from mines in the region. The research helps scientists understand how contaminants are spread by atmospheric circulation and has implications for snowpack preservation and illuminating the lasting environmental impact of mining activities.

The study, published in the May issue of the journal Environmental Pollution, examined contamination levels for Mercury, Zinc, Cadmium and Antimony from nearly 50 sites in the Rocky Mountains. DRI's Monica Arienzo, Associate Research Professor of Hydrology, led the research, along with colleagues from the U.S. Geological Survey (USGS), the University of Nevada, Reno, and Portland State University. They found higher levels of metal contaminants in the northern Rockies and identified mines in the Pacific Northwest, Idaho, and Montana as the likely source by following winter storms back in time. It is one of the first studies to look at metal contamination across the greater Rocky Mountains.

"Metal pollution in the Rockies is relatively understudied," Arienzo said. "Other studies have focused on certain parts, so the fact that we have this transect from Montana to New Mexico makes this study unique."

Although contamination levels were found to be within guidelines set by the EPA for both drinking water and aquatic life, dust can accelerate snowmelt by decreasing the reflectivity of the snowpack. The data can also provide critical information about how environmental contaminants and dust are distributed by the atmosphere.

The study combined a number of data sets to capture a comprehensive understanding of the amount of metal contamination making its way to the region. First, snow samples were collected from 48 sites throughout the Rocky Mountains during the spring of 2018. The researchers then measured metal concentrations in each sample, including metals like calcium that come from natural dust rather than human activities. By comparing the amounts of purely dust-sourced metals to those that result from both dust and industrial activities like mining, the scientists determined how much metal contamination stemmed from human activities.

To strengthen their findings, they then examined data from the National Atmospheric Deposition Program that measured mercury and calcium in precipitation from 2009 through 2018. Again, the scientists saw higher amounts of metal contamination in the northern Rockies, across Montana, Idaho, and Northern Wyoming.

"I was surprised by the amount of agreement we saw between all these different data sets we brought together," Arienzo said. "The snow samples showed us that contamination is higher in the northern Rockies, and that was really interesting. Looking at mercury contamination over time helped us say that 2018 is not just a fluke. When you start to see these trends that are consistent between different records, it makes you feel more confident that something's really happening here."

To determine the likely source of the contaminants, Arienzo and her colleagues tracked the winter's storms back through time. For the northern Rockies, many of the storms had moved in from the Pacific Northwest region, whereas in the southern stretch of the mountains, storms came from across the Mojave Desert.

By referencing a USGS dataset that tracks mining and smelting locations, the scientists identified active sites near the northern Rockies. An examination of EPA Superfund locations uncovered historical sites that could also be sources of contamination.

"Our idea is that the dust from current and historical mining sites gets carried up into the mountains and deposited across our study sites," Arienzo said. "This study shows the importance of continued scientific monitoring efforts, like the long-term USGS datasets we used here, as well as mitigation of current and historical mining sites."

The research is part of a larger study, supported by the National Science Foundation (NSF), using tree rings to examine historical mercury contamination. Arienzo and her team will compare the mercury record found in tree rings to that found in the snowpack to better understand how mercury is deposited and spread throughout the environment.

Technology Networks, 2 April 2025

https://technologynetworks.com

New plastic dissolves in the ocean overnight, leaving no microplastics

2025-03-27

Plastics are durable and strong, which is great while they're being used but frustrating when they end up in the environment. Scientists at RIKEN in Japan have developed a new type of plastic that's just as stable in everyday use but dissolves quickly in saltwater, leaving behind safe compounds.

The benefit of plastics is that they're made with strong covalent bonds that hold their molecules together, meaning they take a lot of energy to break. This is why they're so sturdy, long-lasting and perfect for everything from packaging to toys.

But those same strong bonds become a problem after the useful life of a plastic product is over. That cup you used once and threw away will sit in landfill for decades, even centuries, before it fully breaks down. And when it does, it forms microplastic pieces that are turning up in all corners of the natural world, including our own bodies, where they wreak havoc on our health in ways we're only just beginning to understand.

RIKEN researchers have now developed a new type of plastic that can work just as well as the regular stuff when it's needed, and break down readily into safe compounds when it's not. It's made of what are known as supramolecular polymers, which have reversible bonds that function like sticky notes that can be attached, removed and reattached, according to the team.

The team wanted to make a specific type of supramolecular polymer that would be strong enough for the usual uses of plastic, but could also be made to break down quickly when required, under mild conditions and leaving only non-toxic compounds.

After screening a range of molecules, the researchers identified a particular combination that seemed to have the right properties – sodium hexametaphosphate, which is a common food additive, and monomers based on guanidinium ions, which are used in fertilizers. When these two compounds are mixed together in water, they form a viscous material that can be dried to form plastics.

A reaction between the two ingredients forms "salt bridges" between the molecules that make the material strong and flexible, like conventional plastic. However, when they're soaked in saltwater, the electrolytes unlock those bonds, and the material dissolves.

In practice, the team found that the material was just as strong as normal plastic during use, and was non-flammable, colorless and transparent. Immersed in saltwater though, the plastic completely dissolved in about eight and a half hours.

There's one major hurdle with any degradable plastic material of course: what if it comes into contact with the catalyst for its destruction before you want it to? A plastic cup is no good if certain liquids can dissolve it, after all.

In this case, the team found that applying hydrophobic coatings prevented any early breaking down of the material. When you eventually want to dispose of it, a simple scratch on the surface was enough to let the saltwater back in, allowing the material to dissolve just as quickly as the non-coated sheets.

While some biodegradable plastics can still leave behind harmful microplastics, this material breaks down into nitrogen and phosphorus, which are useful nutrients for plants and microbes. That said, too much of these can be disruptive to the environment as well, so the team suggests the best process might be to do the bulk of the recycling in specialized plants, where the resulting elements can be retrieved for future use.

But if some of it does end up in the ocean, it will be far less harmful, and possibly even beneficial, compared to current plastic waste.

A paper describing the research was published in the journal Science.

New Atlas, 27 March 2025

https://newatlas.com

Stronger coffee with fewer coffee beans

2025-04-08

Tens of billions of kilograms of coffee are consumed around the world each year. However, due to its very specific agricultural needs, coffee can be difficult to cultivate, and ongoing climate change threatens its growth.

To efficiently meet the high demand for coffee grounds, researchers from the University of Pennsylvania worked to optimize their use in pour-over coffee.

They presented their suggestions in Physics of Fluids, by AIP Publishing.

“What we recommend is making the pour height as high as possible, while still maintaining a laminar flow, where the jet doesn’t break up when it impacts the coffee grinds,” said author Ernest Park.

In particular, the group found the thick water jets typical of standard gooseneck kettles are ideal for achieving this necessary height and laminar flow.

Strong -- but focused -- water jets create an avalanche in the coffee grounds.

Displaced grounds recirculate as the water digs deeper into the coffee bed, allowing for better mixing between the water and the grounds, and thus, results in a stronger coffee with fewer beans.

If the water jet is too thin, it cannot adequately create this interaction to achieve a desirable strength and sensory experience.

“If you have a thin jet, then it tends to break up into droplets,” said author Margot Young.

“That’s what you want to avoid in these pour-overs, because that means the jet cannot mix the coffee grounds effectively.”

The dark color of coffee beans -- and of coffee itself -- makes it hard to demystify.

Along with creating pour-over drinks with actual coffee grounds, the scientists supplemented their study with laser-illuminated transparent particles in a glass funnel to help thoroughly visualize the mixing dynamics and understand how the liquid jet affects the grains.

Though the group does not plan further studies related to coffee, they say there are many other parameters left to explore, such as the impacts of the size of the coffee grounds on the interplay between the physics and chemistry of the brewing process.

When it comes to easy, accessible kitchen science, the researchers have some unorthodox advice: Do try this at home.

“We can really learn something from both the chemistry and physics point of view by looking at the kitchen,” said author Arnold Mathijssen. “It leads to new science where you didn’t expect it.”

Science Daily, 8 April 2025

https://sciencedaily.com

Ball-Milling Destroys PFAS While Recycling Valuable Fluorine

2025-03-31

The mechanochemical destruction of PFAS offers a simple, sustainable solution to a major environmental challenge.

Researchers at the University of Oxford and Colorado State University have developed a new method for destroying per- and polyfluoroalkyl substances (PFAS) that can break down even the toughest PFAS fluoroplastics.

The method, which aims to solve the problem of these extremely persistent “forever chemicals” building up in the environment, also preserves the fluorine content of these compounds, allowing them to be turned into useful, high-value fluorochemicals for future use.

Published in Nature, the researchers believe that this technique could be an important piece of the puzzle in creating a more sustainable, circular fluorine economy.

Improving PFAS remediation

PFAS-containing products were produced in large quantities throughout the latter half of the 20th century, as the extreme chemical stability of PFAS made these compounds a useful inclusion in firefighting foams, food packaging and non-stick cookware. Today, PFAS are widely recognized as an environmental hazard; their chemical stability means that they also resist natural breakdown processes, meaning that these compounds build up in the environment and can have a negative impact on livestock, agricultural products and potentially human health upon extended exposure.

To tackle this PFAS problem, researchers have created numerous ways to destroy these compounds. However, these aren’t without their drawbacks.

"Although numerous methods have been developed for PFAS destruction, many methods are focused on functionalized classes of PFAS such as PFOA (perfluorooctanoic acid, a widely used surfactant) and lack generality," Véronique Gouverneur FRS, professor of chemistry at the University of Oxford, told Technology Networks. "Incineration is a broadly accessible method, but the breakdown of PFAS compounds requires very high temperatures."

In the new Nature paper, a research team led by Gouverneur presents a new way to break down many types of PFAS which doesn't just obliterate these compounds – it can also save and recycle their fluorine content, effectively transforming troublesome PFAS into a new source for high-value fluorochemicals.

Their discovery of this new, simple PFAS destruction method came about while performing a separate set of experiments, during an investigation of different alkali metal fluoride-free (HF-free) synthesis techniques for producing fluorochemicals.

"While performing a study on the HF-free mechanical activation of fluorspar (CaF2), we found that the milling of fluorspar with potassium phosphate in a Teflon (PTFE)-sealed jar released more fluoride than anticipated, a result not seen when using rubber sealing ring," Gouverneur recalled. "This experiment suggested that fluoride was released from PTFE and provided the inspiration to try mechanical activation for the destruction of PTFE and other PFAS classes."

Mechanochemistry is simple, reduces solvent use

Ball-milling is a common griding technique that uses ball bearings in a rotating vessel to blend or grind materials down into very fine powders. However, chemists have also discovered that these kinds of mechanical forces can be used to drive chemical transformations – this is known as mechanochemistry.

Gouverneur's team found that ball-milling PFAS in the presence of potassium phosphate salts broke down the PFAS into smaller fluoride salts. The researchers then demonstrated that this recovered fluoride can be transformed into common fluorinating reagents that are used in industrial reactions. The method also allows for the phosphate salts to be recovered and reused, which the researchers note is an advantage due to the scarcity of phosphorous.

"The new method has been successfully applied to a broad range of PFAS classes including polymeric PFAS (e.g. PTFE, PVDF, PFA), short-chain PFAS (e.g. PFOA, PFOS and fluorotelomers, as well as the electronics coolant liquid FC-70. The method also allows recovery of fluorine for re-use, as demonstrated with the generation of essential fluorochemicals," Gouverneur said. "This was demonstrated with the synthesis of fluorochemicals used as common precursors for the preparation of pharmaceuticals, agrochemicals and battery electrolyte."

Gouverneur also highlights the rapidly depleting reserves of fluorspar – a fluorine-containing mineral that is used as a raw material in the production of steel, life-saving medicines, battery components and other fluorine products – as an important reason for developing methods that can enhance fluorine recovery.

"[…] the production of fluorochemicals from waste PFAS reduces the amount of fluorochemicals that need to be produced from mined fluorspar, a mineral today classified as critical in many countries worldwide," Gouverneur said.

"Performing chemistry using mechanical conditions gives access to new reactivity with no need for solvents," she added. "The method is also operationally simple."

The researchers hope that this method could mark the start of a shift away from thinking of PFAS as being "forever chemicals", with the team now aiming to demonstrate the technique's scalability.

"One aim is to translate the technology from a laboratory scale to an industrial scale. More broadly, our goal is to render fluorine chemistry safe and circular for the benefit of humanity," Gouverneur said.

Technology Networks, 31 March 2025

https://technologynetworks.com

Transparent paper-based material can hold boiling water and degrade in deep ocean in under a year

2025-04-10

A team of biomaterial engineers, environmental resource specialists and industrial design researchers affiliated with a host of institutions across Japan has developed a biodegradable material that is clear and can hold boiling water—and it degrades in less than a year after settling on the ocean floor. Their work is published in the journal Science Advances.

Prior research has shown that millions of tons of plastics are piling up in the environment, including on the ocean floor. Because of this, scientists have been looking for better, biodegradable replacements. In this new effort, the research team has developed a paper-based, clear, biodegradable material that can stand up to liquids for several hours, even those that have been heated, allowing them to replace plastic cups, straws, and other everyday objects.

The research team made the material by starting with a standard cellulose hydrogel. After drying, the material was treated with an aqueous lithium bromide solution which forced the cellulose to solidify into desired shapes. The researchers note that end-products could be as thin as plastic cup walls, or as thick as desired. They describe the material as tPB, a transparent 3D material made solely of cellulose.

Testing of the material showed it worked as well as standard drinking straws, with no signs of the collapse seen in paper straws that are used for very long. They also noted that cups made using the material leaked just a little bit after three hours—adding a plant-based resin coating stopped them from leaking at all.

The research team also tested the biodegradability of the material in a marine environment. They made several sheets of the material and placed some in shallow water, and others in very deep places. Prior research has shown that due to the cold temperatures at great depths, materials take longer to degrade. They found their new material degraded completely in less than 12 months in the deepest parts of the ocean.

The final test involved how well the material could be recycled. The research team found it could be done easily enough, but that it became less transparent after being melted and reformed.

Phys Org, 10 April 2025

https://phys.org

New Polymer Discovery Challenges Conventional Wisdom

2025-04-06

The UMass Amherst-led team is challenging the common belief that perfect fillers are the best choice for creating thermally conductive polymers.

In the pursuit of developing next-generation materials for modern devices, materials that are lightweight, flexible, and highly efficient at dissipating heat, a research team led by the University of Massachusetts Amherst has uncovered a surprising insight: imperfection has its upsides.

Published in Science Advances, the study combines experimental and theoretical work to show that polymers enhanced with thermally conductive fillers containing defects performed 160% better than those with flawless fillers. This unexpected result challenges the conventional belief that defects weaken material performance. Instead, it opens a new path for designing polymer composites with exceptionally high thermal conductivity.

The study was led by UMass Amherst with collaborators from Massachusetts Institute of Technology, North Carolina State University, Stanford University, Oak Ridge National Laboratory, Argonne National Laboratory, and Rice University.

The Challenge of Heat Management in Polymers

Polymers have revolutionized modern devices with their unmatched lightness, electrical insulation, flexibility, and ease of processing – qualities metals and ceramics simply can't rival. Polymers are embedded in every corner of our tech landscape, from high-speed microchips and LEDs to smartphones and soft robotics. However, common polymers are thermal insulators with low thermal conductivity, which can lead to overheating issues. Their inherent insulating properties trap heat, spawning dangerous hot spots that sap performance and accelerate wear, heightening the risk of catastrophic failures and even fires.

For years, scientists have attempted to enhance the thermal conductivity of polymers by incorporating highly thermally conductive fillers such as metals, ceramics, or carbon-based materials. The logic is straightforward: blending in thermally conductive fillers should improve overall performance.

However, in practice, it is not this simple. Consider a polymer blended with diamonds.

Given a diamond's exceptional thermal conductivity of about 2,000 watts per meter per kelvin ($W\ m^{-1}\ K^{-1}$), a polymer that is composed of 40% diamond filler might theoretically achieve conductivity of around 800 $W\ m^{-1}\ K^{-1}$. Yet, practical results have fallen short due to challenges like filler clumping, defects, high contact resistance between polymers and fillers, and low thermal conductivity of polymer matrices, which undermine heat transfer.

"Understanding thermal transport mechanisms in polymeric materials has been a long-standing challenge, partly due to the complicated polymer structures, ubiquitous defects, and disorders," says Yanfei Xu, UMass Amherst assistant professor of mechanical and industrial engineering and corresponding author of the paper.

Testing the Role of Defects

For their study, aimed at laying the foundation for understanding thermal transport in polymeric materials and controlling heat transfer across heterogeneous interfaces, the team created two polymer composites of polyvinyl alcohol (PVA) – one incorporating perfect graphite fillers and the other using defective graphite oxide fillers, each at a low 5% volume fraction.

As expected, the perfect fillers on their own were more thermally conductive than imperfect ones.

"We measured perfect fillers (graphite) on their own have high thermal conductivity of roughly 292.55 $W\ m^{-1}\ K^{-1}$ compared to only 66.29 $W\ m^{-1}\ K^{-1}$ for defective ones (graphite oxide) on their own – a nearly fivefold difference," says Yijie Zhou, the lead author and a mechanical engineering graduate student at UMass Amherst.

However, surprisingly, when these fillers are added into polymers, polymers made with graphite oxide fillers containing defects performed 160% better than those with perfect graphite fillers.

The team used a combination of experiments and models – thermal transport measurements, neutron scattering, quantum mechanical modeling, and molecular dynamics simulations – to study how defects influence thermal transport in polymer composites.

They found that defective fillers facilitate more efficient heat transfer because their uneven surfaces don't allow the polymer chains to pack together as tightly as the perfectly smooth fillers do. This unexpected effect, known as enhanced vibrational couplings between the polymers and defective fillers at the polymer/filler interfaces, boosts thermal conductivity and reduces resistance, making the material more efficient at transferring heat.

"Defects, at times, act as bridges, enhancing the coupling across the interface and enabling better heat flow," says Jun Liu, associate professor in the Department of Mechanical and Aerospace Engineering at North Carolina State University. "Indeed, imperfection can sometimes lead to better outcomes."

Xu believes these results, both experimental and theoretical, lay the groundwork for engineering new polymeric materials with ultrahigh thermal conductivity. These advances present new opportunities for devices – from high-performance microchips to next-generation soft robotics – to operate cooler and more efficiently through improved heat dissipation.

Sci Tech Daily, 6 April 2025

https://scitechdaily.com

Understanding the precursor to detonation: Probing high-pressure deflagration with laser ignition experiments

2025-04-10

Suddenly, there's a flash of intense light and heat, followed by a rapidly expanding fireball. Combustion of high explosives is everywhere in popular culture, and it's also critical for ensuring the safety and reliability of the U.S. stockpile.

While detonations often get all the credit for combustion, deflagrations—their subsonic, less famous precursors—are also fundamental to understanding the safety and sensitivity of high explosives.

In a new study, researchers at Lawrence Livermore National Laboratory (LLNL) have conducted laser ignition experiments in a diamond anvil cell and employed large-scale quantum molecular dynamics (QMD) simulations to investigate the products of deflagration at high pressures. The results could improve models of deflagration and high explosives overall. The work is published in the journal Combustion and Flame.

"A deflagration will generally precede a detonation, so understanding deflagration chemistry is important for understanding the necessary processes that are required for a detonation," said LLNL scientist and first author Brad Steele.

These experiments and models aim to determine the products (resulting materials) of a deflagration. The composition of deflagration products, especially the solids, influences the amount of energy and pressure released in the reaction and whether it transitions to a detonation.

Typically, deflagration is studied at relatively low pressures. But by using laser ignition in a diamond anvil cell, the team was able to acquire data at high pressures that are comparable to the detonation pressure of high explosive LLM-105.

“The experimental approach is a modernized version of the technique first developed at LLNL in the 1990s,” said co-author and project principal investigator Jonathan Crowhurst. “It allows us to probe burn dynamics and chemistry in microscopic samples of high explosives at very high pressures.”

At these high pressures, the deflagration products of the experiment were transparent. However, the team’s experiment only detected molecular nitrogen, which did not account for the additional elements thought to be present, like carbon, hydrogen and oxygen. To better understand this, they looked to simulations.

The researchers used large-scale QMD simulations to investigate the pressure dependence of the product chemistry. They found reaction mechanisms that produce extended disordered clusters containing nitrogen and the additional elements.

“The condensed-phase chemistry of energetic materials has typically been simulated using potentials that do not model reaction kinetics accurately. Here we get qualitative agreement with experiment by more accurately modeling reaction kinetics with QMD,” said Steele. “The main drawback is that the method is extremely computationally expensive, so it requires the high-performance computing power available here at LLNL.”

In both the experiments and models, the authors found evidence of pressure reduction during deflagration. The predicted presence of nitrogen and oxygen in the disordered clusters is consistent with a delay in the formation of gaseous products, a result that could prevent a deflagration from transitioning into full detonation.

Future work will focus on confirming these findings, applying the techniques to other energetic materials, and incorporating both into

Scientists Develop Non-Toxic Water-Repellent Alternative to PFAS

2025-04-09

A team of international scientists has invented a substitute for synthetic chemicals, called PFAS (perfluoroalkyl substances), which are widely used in everyday products despite being hazardous to health and the environment.

Until now, it was believed fluorine – the element in such products which forms a highly effective barrier between substances like air and water, making them water repellent – could not easily be replaced because of its unique properties.

But scientists, from the University of Bristol in the UK, Hirosaki University, Japan, and Université Côte d’Azur, France have discovered that the unique ‘bulky’ attribute of fluorine, which makes it especially good at filling space, can actually be replicated in a different, non-toxic form.

Co-lead author Professor Julian Eastoe, from the University of Bristol School of Chemistry, said: “From fire-fighting foam to furniture, food packaging and cookware, to make-up and toilet tissue, PFAS products are everywhere. Despite the risks to human health, and the fact they don’t degrade, perfluoroalkyl substances persist in the environment, finding an alternative with comparable properties has proven elusive. But after many years of intensive research, we’ve made a great breakthrough.”

The results of their discovery are published in a study, which unpacks the chemical structure of PFAS and pinpoints the characteristic ‘bulkiness’ they sought to replicate in a safer form. It also demonstrates how non-fluorinated components, containing only non-toxic carbon and hydrogen, could be equally effective replacements.

Prof Eastoe said: “Through extensive experimentation, it turns out these ‘bulky’ fragments feature in other common chemical systems like fats and fuels. So we took those principles and created modified chemicals, which have these positive attributes and are also much safer.

“Using our specialised laboratories for chemical synthesis, we substituted the fluorine in PFAS with certain groups containing only carbon and hydrogen. The whole process has taken about 10 years and the implications are very significant not least because PFAS is used in so many different products and situations.”

The researchers now plan on using these principles discovered in the lab to design commercially viable versions of PFAS substitutes.

Co-author Professor Frédéric Guittard, from the Université Côte d'Azur, Nice said: "These new results are of great interest for industrial and academic researchers. We are now working with companies in France and China to bring these ideas to market."

Technology Networks, 9 April 2025

https://technologynetworks.com

How Much Magnesium You Should Take in a Day, with an Expert Doctor's Detailed Wisdom

2024-04-16

Magnesium is "the relaxation mineral," but—no surprise—many Americans aren't getting enough. A doctor reveals the daily magnesium requirement, the best magnesium supplements, and natural ways to increase magnesium intake.

With nearly half of Americans falling short of their daily magnesium needs, it's no surprise that magnesium supplements have been trending. In fact, the global magnesium supplements market was projected to value at $107 million in 2024 and anticipated to climb to $130 million by 2031. That's a greater-than 20% jump over just a few years.

So, what's the cause of this widespread magnesium shortfall? According to experts like Mark Hyman, MD, a leader in functional medicine, there are multiple reasons we're not getting the recommended amounts of magnesium:

- Our meals are more processed and less nutrient-dense than ever before.
- The soil where our food grows is increasingly stripped of magnesium.
- Our consumption of coffee, alcohol, and sugar—all of which can diminish magnesium levels—is on the rise.

So, by the time you see your doctor for muscle cramps or spasms, poor sleep, unexplained weight problems, urinary issues or another symptom of low magnesium, it's likely you'll discuss much magnesium should you take per day, and the best ways to get more magnesium.

Keep reading for clinical recommendations on magnesium intake.

What is magnesium?

Magnesium is a mineral involved in at least 300 enzyme reactions within the human body—and according to some studies, up to 600. This means magnesium is fundamental for muscle and nerve function, regulating blood sugar and blood pressure, and producing protein, bone, and DNA.

Given its central role in so many physiological functions, it's clear why a magnesium deficiency can lead to symptoms such as fatigue, muscle cramps, mental issues, irregular heart rhythms, and increased stress.

Here's how much magnesium you should take per day

The recommended dietary allowances for magnesium are specific to age, gender, and physiological conditions, says the National Institutes of Health:

- Men between 19 and 30 years old should consume 400 milligrams of magnesium
- Men 31 years and older should consume 420 milligrams of magnesium
- Women between 19 and 30 years old should consume 310 milligrams of magnesium
- Women 31 years and older should consume 320 milligrams of magnesium
- For pregnant individuals over age 18, an increased daily requirement of 350-360 milligrams is recommended.

The National Institutes of Health has set the upper limit of magnesium that you should take in supplement form at 350 milligrams. (Dr. Hyman suggests a daily supplemental magnesium intake of 300 milligrams.) However, consult your healthcare provider to determine the optimal amount for your unique needs, as some individuals may benefit from higher doses.

When selecting magnesium supplements, magnesium glycinate is often recommended for its ability to cross the blood-brain barrier, which can be beneficial for reducing anxiety and improving sleep quality.

If constipation is a concern, magnesium citrate may offer relief, though be cautious because excessive amounts could lead to diarrhea.

Magnesium L-threonate has also been shown to benefit brain health in a 2022 study.

Magnesium carbonate, oxide, or gluconate are forms that research suggests are less efficiently absorbed by the body.

How to get more magnesium

Magnesium supplements can work, but experts suggest adding magnesium-rich foods to your diet is the best way to increase magnesium intake:

- Dark leafy greens (spinach, kale)
- Nuts and seeds (pumpkin seeds, almonds, chia seeds)
- Whole grains (brown rice, quinoa)
- Legumes (black beans, chickpeas)
- Avocado
- Dark chocolate

Additionally, an Epsom salt bath is a relaxing way to absorb magnesium through the skin.

Is it OK to take magnesium every day?

It is generally safe to take magnesium every day, provided you stick within the dosage guidelines recommended by your healthcare provider. Consistent, moderate intake supports your body without leading to adverse side effects.

Is it better to take magnesium in the morning or at night?

Taking magnesium at night may benefit those looking to improve their sleep quality, as it supports muscle relaxation and has been linked to a calming effect on the nervous system. However, if you are taking magnesium to support energy production or exercise recovery, the morning may be a more suitable time—just make sure you are taking it at the same time every day.

Who shouldn't take magnesium?

People suffering from kidney disease, heart disease, intestinal disorders, diabetes, or those on specific medications such as bisphosphonates, antibiotics, diuretics, and proton pump inhibitors—which can impact magnesium levels—should seek medical advice before beginning any magnesium supplementation.

Magnesium risks

While magnesium is beneficial, excessive intake can lead to several risks, including:

- Diarrhea and abdominal cramping
- Nausea and vomiting
- Interference with certain medications, such as antibiotics and blood pressure medications
- In severe cases, irregular heartbeat and cardiac arrest.

To minimize risks, always follow the recommended dietary allowance and guidelines set by your healthcare provider if you have concerns about your magnesium intake.

The Healthy, 16 April 2024

https://thehealthy.com

Shingles Vaccine Reduces Dementia Risk by 20%, Study Shows

2025-04-07

Vaccination to prevent shingles also reduces the risk of developing dementia in later life, according to a research paper published recently in Nature. This conclusion is based on the analysis of data collected in connection with the introduction of a shingles immunization program launched in Wales in 2013. Economists with their special expertise in statistical analyses have made a significant contribution to the corresponding study. "We were able to apply our capabilities in statistics to medical data, thus forging a bridge between these two fields," said Dr. Markus Eyting of Johannes Gutenberg University Mainz (JGU), lead author of the study. Together with co-lead author Dr. Min Xie, a postdoctoral researcher at the Heidelberg Institute of Global Health, he demonstrated that the shingles vaccination was associated with a 20 percent reduction in the probability of a new dementia diagnosis over a period of seven years. As noted in the article, "A natural experiment on the effect of herpes zoster vaccination on dementia," this could raise various new possibilities for dementia prevention.

Electronic health records for Wales supply basis for statistical analysis

Dr. Min Xie identified the groundwork of what would represent a "natural experiment" created by the introduction of a herpes zoster vaccination program in Wales about two years ago. In the program, the eligibility to receive the vaccine was determined by an individual's exact date of birth. Those born before 2 September 1933 were automatically ineligible for life, while those born on or after 2 September 1933 were entitled to receive the vaccine. "We can speak of a natural experiment in this context because this setting gives us the opportunity to compare individuals who had just turned 80 with those who had not quite reached 80 years of age," Eyting explained. Because the individuals in the study cohort were only a few weeks apart in age, the researchers could assume that vaccination was the only factor that set the groups apart. "We then looked at the risk of developing dementia over the next seven years," Eyting continued.

One of the main goals of the analysis was to identify a potential causal effect rather than just a correlation. In other words, the researchers were looking for a causal relationship between the shingles vaccine and the risk of developing dementia, not just a random connection between the two factors. In economics, threshold values and target dates – in this case, the individuals' birthdays – are often employed to test for causal effects using regression discontinuity designs. "This method is widely used in economics but has not yet been adequately recognized as a tool for clinical research," Eyting added. In his view, regression discontinuity analyses offer many opportunities for evaluating the effectiveness of public health measures.

Technology networks, 7 April 2025

https://technologynetworks.com

Sodium-iron battery startup to challenge Li-ion for extended storage

2025-03-31

We've long relied on lithium-ion batteries for long-term energy storage, but they can be expensive to produce and maintain over the years. California-based startup Inlyte wants to offer a scalable alternative with its sodium-iron battery tech, and it'll soon manufacture cells to showcase its benefits.

The idea behind sodium-iron batteries has been around for decades. Beta Research, an outfit in the UK, pioneered this technology back in the 1970s for use in electric vehicles, but it didn't take off – and lithium-ion took the lead instead. Several years later, Stanford graduate Antonio Baclig chose to run with sodium metal halide battery designs in his effort to create

a utility-grade energy storage solution, and launched his own firm to commercialize it.

Inlyte looked at Beta Research's work developing this tech and acquired the latter's team and facilities. In 2023, the startup raised US$8 million in seed funding to pursue its ambitions. Now, it's inked a deal with Horien Salt Battery Solutions to scale up production of sodium-iron batteries at a facility in the US, and bring these long-duration storage batteries to market.

The big draw of sodium-iron batteries is in the name: they're made of two highly abundant materials, which means they could cost as little as $35 per kWh when manufactured at scale. That's a fraction of what you'd pay for lithium-ion batteries, which are around $139 per kWh.

Sodium-iron batteries are also durable, can operate and be safely shipped in any climate, pose low fire risks, and promise between 6-24 hours of energy storage. In comparison, lithium-ion storage batteries generally offer about 4 hours of storage duration.

Inlyte has also demonstrated its cells managing over 700 cycles with no loss in energy capacity, and claims a battery life of at least 7,000 cycles, or 20 years. That could give lithium-ion-based storage options like Tesla's Megapack a run for their money.

By partnering with Horien, Inlyte hopes to throw open the doors to its first US-based battery factory by 2027. The company has already been testing its tech at a pilot plant in the UK; manufacturing in the US with Horien's expertise could accelerate its ambition to commercialize its cells and sign up customers in the near future.

Source: Inlyte via PR Newswire

New Atlas, 31 March 2025

https://newatlas.com

Scandium-doped TiO_2 boosts photocatalytic water splitting efficiency

2025-04-09

Photocatalytic water splitting is a clean energy technology that uses sunlight to split water into oxygen and hydrogen in order to produce green hydrogen—a clean fuel—without relying on fossil fuels. The process is driven by a photocatalyst.

While titanium dioxide (TiO2) has long been studied as a promising semiconductor for photocatalytic water splitting, its efficiency has been hindered by rapid charge recombination and insufficient charge separation.

Now, however, a research team led by Prof. Liu Gang from the Institute of Metal Research (IMR) of the Chinese Academy of Sciences (CAS) has achieved a breakthrough in photocatalytic water splitting by developing a scandium (Sc)-doped titanium dioxide (TiO2) semiconductor in the rutile crystal phase. The study is published in the Journal of the American Chemical Society.

The novel material demonstrated an apparent quantum yield (AQY) of 30.3%, which measures the percentage of photons that lead to useful water splitting, and a solar-to-hydrogen (STH) efficiency of 0.34%, which indicates the percent of solar energy converted into hydrogen energy. Both values set new benchmarks for TiO2-based photocatalytic overall water splitting under ambient (non-pressurized, non-heated) conditions.

To overcome the challenges associated with TiO2, the research team employed a dual-strategy approach. First, Sc3+ doping effectively eliminated detrimental Ti3+ defects, which are known for trapping charges and causing energy loss. The team then engineered a facet junction between the (101) and (110) crystal planes, generating a built-in electric field that drives electrons and holes to separate facets—facilitating water reduction and oxidation reactions.

“This dual approach not only minimizes defect-induced charge recombination but also mimics the efficient charge separation mechanism of p-n junctions in photovoltaic cells,” said Prof. Liu.

The findings underscore the significant commercial potential of Sc-doped TiO2, particularly given China’s abundant titanium and scandium resources. With an established industrial supply chain for titanium dioxide and advanced rare earth processing capabilities, this innovation could pave the way for scalable and cost-effective hydrogen production.

“Our design strategy—suppressing defects and leveraging crystal anisotropy—aligns perfectly with China’s resource strengths and industrial infrastructure,” said Prof. Liu. The team now aims to enhance light absorption and integrate the material into scalable solar-driven systems.

Phys Org, 9 April 2025

https://phys.org

Your skin is breathing: New wearable device can measure it

2025-04-09

Northwestern University researchers have developed the first wearable device for measuring gases emitted from and absorbed by the skin.

By analyzing these gases, the device offers an entirely new way to assess skin health, including monitoring wounds, detecting skin infections, tracking hydration levels, quantifying exposure to harmful environmental chemicals and more.

The new technology comprises a collection of sensors that precisely measure changes in temperature, water vapor, carbon dioxide (CO2) and volatile organic compounds (VOCs), which each give valuable insight into various skin conditions and overall health. These gases flow into a small chamber within the device that hovers above the skin without actually touching it. This no-contact design is particularly useful for gathering information about fragile skin without disturbing delicate tissues.

The study will be published on Wednesday (April 9) in the journal Nature. The paper demonstrates the device’s efficacy across small animals and humans.

“This device is a natural evolution of our lab’s wearable electronic devices that collect and analyze sweat,” said Northwestern’s John A. Rogers, who co-led the study. “In that case, we were analyzing sweat to learn about the wearer’s overall health. While useful, that method requires pharmacological stimulation of sweat glands or exposure to a hot, humid environment. We started thinking about what we could capture from the skin that is naturally occurring all the time. It turns out there are all kinds of things coming off the surface of the skin -- water vapor, carbon dioxide and volatile organic compounds -- that can be correlated to underlying physiological health.”

“This technology has the potential to transform clinical care, particularly for vulnerable populations, including newborn babies, the elderly, patients with diabetes and others with compromised skin,” said Northwestern’s Guillermo A. Ameer, who co-led the study. “The beauty of our device is that we found a completely novel way to assess the status of delicate skin without having to come in contact with wounds, ulcers or abrasions. This device is the first major step toward measuring changes in gases and correlating those changes with skin status.”

A bioelectronics pioneer, Rogers is the Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering and Neurological Surgery at Northwestern -- with appointments in Northwestern's McCormick School of Engineering and the Feinberg School of Medicine -- and the director of the Querrey Simpson Institute for Bioelectronics. Ameer is the Daniel Hale Williams Professor of Biomedical Engineering at McCormick, professor of surgery at Feinberg and founding director of the newly established Querrey Simpson Institute for Regenerative Engineering at Northwestern University (QSI RENU). Rogers and Ameer co-led the study with Yonggang Huang, the Jan and Marcia Achenbach Professor in Mechanical Engineering and professor of civil and environmental engineering.

Empowering patients at home

Called the skin barrier, the outermost layer of skin is the body's first line of defense from the external environment. It maintains hydration by preventing excessive water loss and acts as a barrier against irritants, bacteria and ultraviolet radiation. When the skin barrier is compromised, it can lead to increased water loss (known as transepidermal water loss or TEWL), skin sensitivity, and risk of infection and inflammatory conditions like eczema and psoriasis.

"The skin is critical for protecting us from the environment," said study co-author Dr. Amy Paller, the Walter J. Hamlin Professor of Dermatology and chair of the Department of Dermatology at Feinberg. "A major element of this protective function is the skin barrier, which is largely characterized by a formidable collection of tightly woven proteins and fats that keeps water in and irritants, toxins, microbes and allergens out."

By tracking changes in the emission of water vapor and gases from the skin, health care professionals can gain a glimpse into the integrity of their patients' skin barriers. While technologies to measure water vapor loss do exist, they are large, cumbersome machines that largely reside within hospital settings. The compact wearable device, on the other hand, is designed to help physicians monitor their patients remotely and to empower individuals to take control of their own skin health at home.

"The gold standard for measurement of skin barrier integrity is a large instrument with a probe that intermittently is touched to the skin to collect information about transepidermal water loss -- or the flux of water through skin," Paller said. "Having a device that can measure transepidermal water loss remotely, continuously or as programmed by the investigator -- and without perturbing a patient during sleep -- is a major advance."

How the device works

Measuring just two centimeters long and one-and-a-half centimeters wide, the device comprises a chamber, a collection of sensors, a programmable valve, an electronic circuit and a small rechargeable battery. Instead of touching the skin directly, the chamber hovers a few millimeters above it.

"Traditional wearable sensors rely on physical contact with the skin, limiting their use in sensitive situations, such as wound care or for individuals with fragile skin," Rogers said. "Our device overcomes this limitation by creating a small, enclosed chamber above the skin's surface."

An automatic valve opens and closes the entrance to this chamber -- a function that dynamically controls access between the enclosed chamber and the surrounding ambient air. When the valve is open, gases flow in or out of the chamber, enabling the device to establish a baseline measurement. Then, when the valve rapidly closes, it traps gases within the chamber. From there, the series of sensors measure changes in gas concentrations over time.

"If our device didn't incorporate a programmable valve and a time-dynamic measurement approach to quantify flux of species out of and into the skin in a real-time manner, then the system could be confounded by changes in the concentrations of these species that might naturally vary in the surrounding environment," Rogers said. "Specifically, if the valve were open all the time, the sensor would detect these sorts of changes -- not because of anything associated with the skin. On the other hand, if the valve were always closed, then it would perturb natural patterns of flux in a way that also could not account for environmental factors. For workers in potentially hazardous environments, it's helpful to know how much of those hazardous species are entering the body through the skin."

Ideal for wound care

Using Bluetooth, the device sends these data straight to a smartphone or tablet for real-time monitoring. These fast results can help health care workers make more informed -- and speedier -- decisions for wound management and for administering antibiotics.

Because increased water vapor, CO2 and VOCs are associated with bacterial growth and delayed healing, monitoring these factors can help caregivers detect infections earlier and with more confidence.

“Prescribing antibiotics for wounds can be a bit of a gamble,” said Ameer, who is an expert on regenerative engineering approaches to improve wound healing. “Sometimes it’s hard to tell if a wound is infected or not. By the time it’s obvious, it might be too late, and the patient can develop sepsis, which is incredibly dangerous. To avoid this, physicians prescribe a wide spectrum of antibiotics. That can lead to antibiotic resistance, which is a growing problem in health care. Being able to closely, continuously monitor a wound and prescribe an antibiotic at the earliest sign of infection is an obvious and important interest.”

While continuous monitoring is important for all types of wounds, it is particularly crucial for diabetic patients. Ameer previously has developed various strategies, including antioxidant gels and regenerative bandages, for treating diabetic ulcers. Just two years ago, Ameer teamed up with Rogers to create the first transient electronic bandage, which used electrical stimulation to accelerate wound healing. The new wearable provides yet another tool to help these vulnerable patients avoid risky side-effects.

“Diabetic ulcers are the number one non-traumatic cause of lower limb amputations worldwide,” said Ameer. “Sometimes it might appear that the wound is closing, but the skin barrier function is not quite restored. Our device can precisely measure emitted gases, which provides useful information about the skin barrier function.”

Assessing efficacy of bug repellants, lotions

The innovative new technology not only offers unprecedented insights into wound healing and skin health, it also might pave the way for advances in monitoring the efficacy of bug repellents, skin creams and systemic medications designed to improve skin health.

CO2 and VOCs are the very gases that attract mosquitos and other pests. So, measuring these emissions from the skin could help researchers understand and potentially mitigate mosquito attraction. The new device also could enable dermatologists and their patients to measure how fast lotions and creams penetrate the skin, which could provide insights into skin permeability and barrier function. These data also could help other researchers develop more effective transdermal drug delivery systems,

monitor the effects of systemically delivered drugs for skin diseases and evaluate the safety of cosmetics and personal care products.

Next, the Northwestern team plans to refine the device’s capabilities, including adding a sensor to track changes in pH levels and developing gas sensors with increased chemical selectivity for early detection of organ dysfunction and other diseases.

“This unusual wearable platform provides a new way to think about and understand skin health,” Rogers said. “This technology is not just about measuring gases and corresponding characteristics of the skin. It’s about predicting overall health, preventing infection and disease and creating a future where personalized care is driven by real-time, non-invasive, continuous health tracking through a new collection of parameters that complement those that can be captured with conventional wearables.”

Science Daily, 9 April 2025

https://sciencedaily.com

Rare disease drug can make human blood toxic to mosquitoes

2025-04-09

The blood of people taking a drug used in the treatment of rare metabolic disorders has been found to be deadly to the malaria mosquito vector Anopheles gambiae. The researchers say the discovery could be a tool to prevent transmission of the disease in malaria-endemic areas.

Nitisinone, a repurposed herbicide and competitive inhibitor of 4-hydroxyphenylpyruvate dioxygenase (HPPD), is used to treat rare human-inherited disorders affecting the body’s ability to break down the amino acid tyrosine. However, recent studies have identified that HPPD is essential for insects, such as mosquitoes, to digest their blood meals.

In the study, the researchers found that feeding human blood containing nitisinone to female Anopheles gambiae mosquitoes was toxic to both young and old mosquitoes, as well as insecticide-resistant Anopheles strains.

A pharmacokinetic–pharmacodynamic modelling comparison with ivermectin – an antiparasitic drug and the only human endectocide to be tested in clinical trials – showed nitisinone had improved efficacy against mosquitoes. Mosquitoes fed nitisinone died within 24 hours of blood-meal ingestion, whereas those fed ivermectin took up to four days to die.

The researchers predicted that mosquitocidal concentrations in human blood after three daily doses of nitisinone (1 mg/kg) or ivermectin (0.6 mg/kg) would last for 16 or 10 days, respectively. Although blood samples from individuals with a rare genetic metabolic disorder in the tyrosine degradation pathway, called alkaptonuria, who were taking a daily low dose of 2mg of nitisinone, were also lethal to mosquitoes.

The researchers highlighted limitations to their study, including the safety profiles for higher doses of nitisinone and a lack of safety data from healthy populations. However, they concluded that a single dose of the drug now warrants 'further investigation' as a complementary intervention to prevent the transmission of malaria.

Chemistry World, 9 April 2025

https://chemistryworld.com

Researchers show why water and heavy water behave similarly

2025-04-09

More than 70% of the Earth is covered with water—H2O. An almost negligible proportion of a few per million consists of "heavy water," in which the hydrogen atoms (H) are replaced by deuterium atoms (D). Deuterium has one more neutron in its nucleus than hydrogen and weighs about twice as much.One would therefore expect that heavy water, in which two atoms that are twice as heavy are bound to the oxygen atom, would differ significantly in its properties from normal water. In fact, however, the freezing temperatures of the two types of water differ by only 4°C.

Researchers at the Max Planck Institute for Polymer Research affiliated with Director Mischa Bonn have now been able to show for the first time that two special quantum mechanical effects—so-called nuclear quantum effects (NQE)—which compensate each other, are responsible for this.

Quantum mechanics dictates that atoms continue to move even at absolute zero, i.e., at -273°C: They "oscillate" or "tremble" slightly around a central position. This is referred to as "zero-point energy." The hydrogen atoms in normal water are, therefore, not at a defined, fixed distance from the oxygen atom but in a certain "cloud," which extends around an average distance. Because hydrogen is such a low-mass atom, these hydrogen clouds are large, NQEs are pronounced, and the vibration has a large amplitude.

If hydrogen is replaced by the heavier deuterium, the atoms vibrate less. The mean distance becomes smaller, meaning that the deuterium atom moves closer to the oxygen atom. As a result of this so-called intramolecular effect, the spatial expansion of a water molecule is reduced. Simultaneously, the distance to the next water molecule increases, which reduces the binding energy.

The binding energy is a measure of how easily two water molecules can be separated from each other—for example, during the transition from ice to liquid water.

At the same time, however, the deuterium atom can oscillate not only in the direction of the bond line to the oxygen atom, but also perpendicular to it. When exchanging hydrogen for deuterium, this so-called intermolecular effect counteracts the intramolecular effect: while one reduces the binding energy, the other increases the binding energy to a comparable extent.

The freezing temperatures differ only slightly because the two quantum mechanical effects have opposite effects on the binding energy and approximately compensate each other.

To measure these subtle effects, the researchers used a technique called heterodyne-detected sum-frequency generation (HD-SFG) spectroscopy. This method allowed them to study the uppermost water layer at an air-water interface, where water molecules exist with a "free" end that is not attached to other water molecules. By carefully analyzing the vibrational spectra of water with different proportions of hydrogen and deuterium, the scientists were able to deduce and quantify the individual inter- and intramolecular energy components.

The work, now published in the journal Science Advances, provides the first experimental evidence of the competition, and almost complete cancelation, between intramolecular and intermolecular quantum effects in water, which has long been predicted only theoretically. It highlights the importance of considering these quantum phenomena when trying to understand the behavior of water.

This has implications for fields ranging from climate research to biochemistry, where the properties of water play a crucial role.

Furthermore, the team's innovative approach opens up new avenues for studying quantum effects in other complex systems.

Phys Org, 9 April 2025

https://phys.org

These "Weird" Crystals Explode in Light

2025-04-10

Chemists are investigating the bizarre properties of certain materials that could be used to develop oxygen safety systems and support future space travel.

Chemistry students at the University of Cincinnati are studying lab-grown crystals that react in remarkable ways when exposed to light.

They bend. They twist. They bounce. And sometimes, they explode.

Professor Anna Gudmundsdottir leads the research on these photo-explosive crystals. Because the field is still relatively unexplored, her students are breaking new ground with each unexpected reaction they uncover.

"We're studying what makes crystals behave when exposed to light. We can make them jump, explode, or dance. They do all kinds of weird things," Gudmundsdottir said.

Light reveals molecular secrets

She received a $550,000 grant from the National Science Foundation to examine the properties of crystals that UC students "grow" in the chemistry lab. They react to light in different ways depending on the way the molecules are packed inside them.

"It fascinates me that the same molecules can create different crystals," UC doctoral student Fiona Wasson said.

When irradiated with light, some crystals bend at either end with the strength to lift objects hundreds of times their size. Others twist into a helix of more than 360 degrees. Others practically hop off the microscopic slide like a tiny jumping bean.

"I'm amazed by what the students have been able to do with these crystals," Gudmundsdottir said. "We don't yet understand a lot of it. We're the first ones to experiment with the gas release, so the discovery makes it a lot of fun for the students."

What causes this reaction?

Gudmundsdottir said the light prompts the crystals to expel atmospheric nitrogen trapped when the crystals form.

Documenting the explosive effect

For his undergraduate research fellowship, UC student Ben Miller spent a semester in a lab darkroom Gudmundsdottir built for the express purpose of documenting photo-explosive reactions in crystals. Students use adjustable red lights to focus the microscope's cameras on the tiny crystals before hitting them with a variety of LED lights.\

Miller learned that the crystals that bend from light can also be manipulated with mechanical force using tiny needles and tweezers. Experimenting with them was a lot of fun, he said.

"What's cool about it is it bends and when it snaps back, there's no damage to the surface or anything. That's pretty unique for crystals," he said. "I learned a lot. Sometimes I think, 'I know something about science that nobody else knows.' And that's very interesting."

Typically, the crystals UC students grow in the lab only put on a show once before their nitrogen escapes. But other crystals can perform their bending or twisting show again and again, raising the possibility of creating light-powered muscle fibers or sensor actuators, Gudmundsdottir said.

She sees even more potential for crystals that release oxygen when activated with light. These could be used to create a safer, lightweight oxygen system for airplanes that suffer a loss of cabin pressure at altitude, she said.

Or even some day for space exploration, Wasson said.

"There is lots of light in space," Wasson said. "It's exciting to study this. We're just in the first few years of exploring it."

Sci Tech Daily, 10 April 2025

https://scitechdaily.com

Metal-free alternative: Rethinking coupling methods for more sustainable organic synthesis

2025-04-09

Coupling reactions are among the most transformative tools in organic chemistry, enabling the formation of crucial chemical bonds in pharmaceuticals, agrochemicals, and advanced materials. Since their introduction, they have been one of the backbones of modern organic synthesis. However, these methods have long relied on environmentally taxing transition metal catalysts, such as palladium, which are often scarce, costly, and generate unwanted byproducts.

The limitations of conventional coupling methods have prompted researchers to seek alternative strategies that better align with the principles of green and sustainable chemistry (GSC). Such alternatives aim to minimize waste, reduce reliance on rare metals, and lower energy consumption, all while maintaining high efficiency and selectivity. Addressing these challenges is essential for the development of more sustainable industrial and pharmaceutical synthesis methods.

Now, a research team, led by Professor Toshifumi Dohi from the College of Pharmaceutical Sciences, Ritsumeikan University, and Professor Yasuyuki Kita, Visiting Senior Researcher at the Research Organization of Science and Technology, Ritsumeikan University, has provided a comprehensive overview of recent advancements in transition metal-free coupling methods. Their review article published in the journal Chemical Reviews on March 26, 2025, highlights emerging strategies that enable the activation of aryl-iodide bonds under environmentally benign conditions.

The review particularly emphasizes coupling via the hypervalent iodine strategy, a field in which the authors have been leading contributors for decades. Other members of the team included Dr. Elghareeb Elshahat Elboray, Dr. Kotaro Kikushima, and Dr. Koji Morimoto, all from Ritsumeikan University.

The hypervalent iodine approach leverages the unique properties of diaryliodonium salts, which serve as highly reactive intermediates in coupling reactions. By strategically manipulating the oxidation state of iodine atoms, researchers have been able to generate aryl cation-like species, radicals, and aryne precursors that facilitate selective bond formation. This transition metal-free approach reduces reliance on costly catalysts while also enhancing the atom economy of coupling processes.

“Our study presents hypervalency strategy, an innovative next-generation approach for coupling which better aligns with GSC requirements, intended for use in the synthesis of pharmaceuticals, related molecules, and functional organic compounds,” remarks Prof. Dohi.

One of the key advantages of hypervalent iodine-mediated coupling is its broad substrate scope, which allows for the efficient synthesis of diverse molecular architectures. The method also exhibits high functional group tolerance, making it particularly attractive for applications in medicinal chemistry. Additionally, researchers have devised various strategies to recycle the aryl iodide byproducts generated in these reactions, addressing previous concerns about waste and enhancing the overall atom efficiency.

Beyond hypervalent iodine strategies, the review also discusses alternative transition metal-free activation methods, including base-promoted aryl–iodide dissociation, photoinduced activation, electrochemical activation, and electrophotochemical activation. Each of these approaches offers unique benefits, such as reducing energy consumption, utilizing mild reaction conditions, or eliminating the need for certain hazardous reagents. By compiling and analyzing recent advances, the authors wish to guide and inspire further research in this area.

“We hope that this review will be of interest to researchers aiming to develop new methods of solving the problems associated with this field of chemistry,” says Prof. Kita.

With the growing need for greener and more efficient chemical synthesis methods, the strategies outlined in this review have the potential to reshape the future of organic chemistry. By reducing environmental impact and lowering production costs, these methods may play a critical role in the long-term development of pharmaceuticals and other fine chemicals. As the field continues to evolve, the present contributions will hopefully serve as a foundation for future breakthroughs in sustainable chemistry.

Phys Org, 9 April 2025

https://phys.org

CHEMWATCH

Bulletin Board

Technical Notes

APR. 11, 2025

(NOTE: OPEN YOUR WEB BROWSER AND CLICK ON HEADING TO LINK TO SECTION)

CHEMICAL EFFECTS

Fluorescence characteristics of dissolved organic matter (DOM) in bottled drinking water of different countries: A potential risk to public health

Identification of endocrine disrupting chemicals targeting NTD-related hub genes during pregnancy via in silico analysis

Prioritizing endocrine-disrupting chemicals targeting systemic lupus erythematosus genes via Mendelian randomization and colocalization analyses

ENVIRONMENTAL RESEARCH

Microplastic pollution: Critical analysis of global hotspots and their impact on health and ecosystems

Evaluating the environmental impact of leaking WW2 shipwrecks: A closer look at the VRAKA and AmuCad decision support tools

Risks of respiratory and circulatory system diseases induced by exposure to PM2.5 in high humidity and low solar radiation environments: disease types, genes, and functions

PHARMACEUTICAL/TOXICOLOGY

Impact of the Environmental Endocrine Disruptor 4-Octylphenol on Reproductive Function in Pubertal Male Mice

Plasma tRNA-derived small RNAs mediated the association between benzo[a]pyrene exposure with lung cancer risk among Chinese adults from a case-control study

OCCUPATIONAL

PFOS Exposure Impairs Porcine Oocyte Maturation and Embryo Development via Mitochondria-Dependent Ferroptosis

The impact of particulate matter exposure on global and domain-specific cognitive function: evidence from the Chinese Square Dancer Study