CHEMWATCH

Bulletin Board

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MAY. 16, 2025

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ASIA PACIFIC

Chemicals added to the Inventory 5 years after issue of assessment certificate - 28 April 2025

2025-04-28

The following industrial chemicals have been added to the Australian Inventory of Industrial Chemicals (Inventory) in accordance with section 82 of the Industrial Chemicals Act 2019 because 5 years have passed since the assessment certificates for the industrial chemicals were issued.

A list of chemicals added to the Inventory 5 years after issue of assessment certificate

CAS Number	161074-93-7
Chemical Name	D-Glucopyranose, oligomeric, 2-ethylhexyl glycosides
Molecular Formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	17/04/2025
CAS Number	1857296-89-9
Chemical Name	1-Tetradecene, homopolymer, hydrogenated
Molecular Formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	28/04/2025

Read More

AICIS, 28-04-25

https://www.industrialchemicals.gov.au/news-and-notices/chemicals-added-inventory-5-years-after-issue-assessment-certificate-28-april-2025

Summary of Workers' Compensation Scheme Developments in Australia and New Zealand

2025-05-09

The Summary of Workers' Compensation Scheme Developments in Australia and New Zealand 2024 has been published.

Workers' compensation schemes in Australia continue to evolve to meet emerging trends in relation to the changing nature of work. This report provides an overview of recent developments to workers' compensation schemes between 1 January 2024 and 31 December 2024, including any significant changes to:

- administration and scheme delivery
- policy developments, and
- legislative amendments.

Developed in collaboration with Australian and New Zealand workers' compensation authorities, the report complements the Comparison of Workers' Compensation Arrangements in Australia and New Zealand 2023 report released last year.

The full report is available to view on the Safe Work Australia website

Read More

Safe Work Australia, 09-05-25

https://www.safeworkaustralia.gov.au/doc/summary-workers-compensation-scheme-developments-australia-and-new-zealand-2024

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

2025-05-09

What importers, manufacturers and suppliers must now be doing to comply with the Labelling, Safety Data Sheet and Packaging notices.

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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 ended on 30 April 2025.

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.

Read More

EPA NZ, 09-05-25

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/

PFAS remediation at Lake Munmorah enters phase one

2025-05-09

The NSW Environment Protection Authority (EPA) has approved a Voluntary Management Proposal (VMP) for the former Lake Munmorah Power Station, kicking off the first phase of a complex remediation process to remove PFAS and petroleum.

Part of the Central Coast site was declared significantly contaminated in April 2024 due to per- and polyfluoroalkyl substances (PFAS) and petroleum hydrocarbon pollution, stemming from the historical operation

of the coal-fired power station and past use of fire-fighting foams containing PFAS at the site.

NSW EPA Executive Director of Operations Jason Gordon said the recently approved Voluntary Management Proposal (VMP) is a critical first step in ensuring the former coal-fired power station site is remediated effectively.

"This is a complicated remediation project, and we must allow enough time to get it right," Gordon said.

"Under the VMP, the site's current owner will work with environmental consultants to gather detailed information about the contaminants, including how they move through soil and water.

"Taking the time to thoroughly assess the onsite contamination will ensure the remediation approach selected is suitable and fit-for-purpose to achieve the best long-term outcomes for the community and surrounding environment."

Following completion of the first Voluntary Management Proposal, site owner Generator Property Management Pty Ltd (GPM) will submit a second VMP (Phase 2) outlining the implementation of the remediation approach.

Read More

Waste Management Review, 09-05-25

https://wastemanagementreview.com.au/pfas-remediation-at-lake-munmorah-enters-phase-one/

AMERICA

~ Trump executive order aims to reshore US drug production

2025-05-08

President Donald J. Trump has signed an executive order that seeks to do what past presidents, including Trump himself in his previous administration, did not succeed in doing: increasing US production of drugs and pharmaceutical ingredients.

The order, signed May 5, intends to lower regulatory barriers for companies looking to expand or set up new drug manufacturing facilities in the US. It directs the Food and Drug Administration and the Environmental Protection Agency to take steps to reduce the time it takes

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to approve new US plants for active pharmaceutical ingredients, key starting materials, and raw materials.

The order refers to industry estimates that building new manufacturing capacity for pharmaceuticals and critical inputs may take as long as 5–10 years, which it calls "unacceptable from a national security standpoint."

The order directs the FDA and EPA to eliminate "duplicative or unnecessary requirements." It also mandates that the FDA streamline facility inspection routines and work with "domestic manufacturers to provide support before facilities start functioning."

At the same time, it instructs the FDA to ramp up inspections of foreign plants that supply ingredients and raw materials to the US. These facilities are inspected less frequently than those in the US, the order says.

Read More

c&en, 08-05-25

https://cen.acs.org/policy/regulation/Trump-executive-order-aims-reshore/103/web/2025/05?sc=230901_cenrssfeed_eng_latestnewsrss_cen

EPA Announces Major Actions on PFAS and the TSCA New Chemical Program

2025-05-07

The U.S. Environmental Protection Agency (EPA) has published a much anticipated roadmap for how Administrator Lee Zeldin plans to address per- and polyfluorinated substances (PFAS) in the coming months. The announcement signals important changes ahead. EPA also issued critical guidance to help companies understand how to provide new information required for premanufacture notifications (PMNs) under the Toxic Substances Control Act (TSCA) until the agency is able to update the Central Data Exchange (CDX) reporting platform. In addition, the Office of Chemical Safety and Pollution Prevention (OCSPP), which administers TSCA and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), is poised to gain more resources as part of the Administrator's plan for reorganizing EPA.

Plans to Address PFAS and Provide Relief from TSCA Section 8(a)(7) PFAS Reporting

Read More

JD Supra, 07-05-25

https://www.jdsupra.com/legalnews/epa-announces-major-actions-on-pfas-and-2247679/

Navigating the Legal Soup: A New "Short-Form" Recipe for Prop 65 Warnings on Food and Beverages

2025-05-07

Until this year, food companies—often the target of Proposition 65 enforcement actions—have been limited to specific "full-length" language for Prop 65 warnings, without explicit guidance regarding whether short-form warnings could be used as a safe harbor warning for food products and non-alcoholic beverages. Prior to the implementation of amended regulations this year, Prop 65 regulations required the following full-length warnings for food products containing a listed carcinogen or reproductive toxicant:

WARNING: Consuming this product can expose you to chemicals including [name of one or more chemicals], which is [are] known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov/food.

WARNING: Consuming this product can expose you to chemicals including [name of one or more chemicals], which is [are] known to the State of California to cause birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov/food.

Read More

JD Supra, 07-05-25

https://www.jdsupra.com/legalnews/navigating-the-legal-soup-a-new-short-2599392/

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EUROPE

PFAS breakthrough: 'forever chemical' banned under global treaty

2025-05-08

International negotiations in Geneva have led to a major breakthrough: the addition of a new "forever chemical" to the Stockholm Convention's blacklist. It marks another crucial step in the global effort to regulate what many now call the "poison of the century".

Though largely overlooked by the wider public, this decision represents a significant advance in the fight against persistent organic pollutants (POPs) – highly toxic substances that linger in the environment and accumulate in living organisms.

Between April 28 and May 9, delegates from across the globe gathered in Geneva for the Conferences of the Parties to the Basel, Rotterdam and Stockholm ConventionsExternal link (BRS, see infobox below). There, member states agreed to ban the production and use of long-chain perfluorocarboxylic acids (PFCAs), a group of pollutants within the broader family of PFAS chemicals.

PFAS – short for per- and polyfluoroalkyl substances, pronounced "pee-fass" – are valued for their water-resistant and non-stick properties. As a result, they have become omnipresent in modern life. These synthetic compounds are found in everything from non-stick pans and pesticides to food packaging, cosmetics, technical clothing, tyres, ski wax, electric car batteries, and firefighting foams. Alarmingly, traces of PFAS are now being detected in mineral water, breast milk, and even human blood.

Read More

swissinfo, 08-05-25

https://www.swissinfo.ch/eng/international-geneva/geneva-breakthrough-forever-chemical-banned-under-global-treaty/89279639

The EU has banned BPAs: here's what you need to know about this common, toxic compound

2025-05-01

The European Union has banned the use of bisphenol A (BPA). This came into effect with Regulation 2024/3190 in late 2024, but it took over 20

years of scientific study to cut out this silent toxin. BPA slowly enters our bodies at low concentrations, meaning its health effects are not usually discovered until they are serious.

Bisphenol A, or BPA, is an organic compound consisting of two phenolic rings (hence 'bi' and 'phenol') joined at the centre to a symmetrical propane molecule. It is mainly used in epoxy (a type of polymer), as well as certain other plastics and some polycarbonates.

Its job is to harden plastic material, prevent bacteria from contaminating food, and prevent cans from rusting. However, its uncontrolled and excessive use in packaging has placed it on a long list of compounds that have gone from champions of progress to case studies in environmental harm.

Read More

The Conversation, 01-05-25

https://theconversation.com/the-eu-has-banned-bpas-heres-what-you-need-to-know-about-this-common-toxic-compound-255241

INTERNATIONAL

Call for contractors: WHO initiatives to evaluate PFAS (Phase 2)

2025-05-07

The World Health Organization (WHO) is seeking expressions of interest from institutions to contribute to the second phase of WHO initiatives to evaluate per- and polyfluoroalkyl substances (PFAS).

Expressions of interest are welcome for systematic evidence collection and evaluation for key health effect categories for prioritized ingested PFAS identified through a landscape review conducted in the first phase of WHO initiatives to evaluate PFAS. Expressions of interest are welcome to specify which health effect categories, since there are multiple (e.g., Metabolic, Reproductive, Endocrine, Hepatic, Cardiovascular and circulatory, Developmental, Nervous and neurobehavioral, Immune, Cancer Renal and urinary, etc), recognizing that these categories are not mutually exclusive and may overlap.

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Expressions of interest are also welcome to provide methodological guidance to ensure that the evidence collection and evaluation activities align with best practices.

Read More

WHO, 07-05-25

https://www.who.int/news-room/articles-detail/request-for-expressions-of-interest--who-initiatives-to-evaluate-pfas-(phase-2)

REACH Update

MAY. 16, 2025

Screening report published for tetraethyllead

2025-05-05

We have published a screening report to assess whether the use of tetraethyllead in articles should be restricted in accordance with REACH Article 69(2).

In ECHA's view, there is no current need to prepare a restriction dossier under Annex XV.

Read More

ECHA, 05-05-25

https://echa.europa.eu/documents/10162/17233/rest_screening_axiv_entry_55_report_en.pdf/

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Janet's Corner

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Stem Cell Parental Advice

2025-05-16

https://swfhealthandwellness.com/activate-your-stem-cells/

Bis(2-chloroethyl)

2025-05-16

USES [2,3]

Phenanthrene is used to make dyes, plastics and pesticides, explosives and drugs. In addition, it has been used to make bile acids, cholesterol and steroids. Phenanthrene can be used as a feed stock of carbon black. It is a raw material of phenanthrenequinone, which -is widely used in the synthesis of dyes, agrochemical and preservatives.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

- Bis(2-chloroethyl) ether is primarily used as a chemical intermediate for the manufacture of pesticides.
- A small amount of bis(2-chloroethyl) ether is used as a solvent.
- In the past, bis(2-chloroethyl) ether was used as a solvent for fats, waxes, greases, and esters.
- It has also been used as a constituent of paints and varnishes, as a cleaning fluid for textiles, and in the purification of oils and gasoline.

Routes of Exposure

Bis(2-chloroethyl) ether can affect the body if it is inhaled, comes in contact with the eyes or skin, or swallowed. It may enter the body through the skin.

HEALTH EFFECTS [4]

Acute Health Effects

- Acute inhalation exposure to bis(2-chloroethyl) ether in humans results in extreme irritation of the respiratory tract and skin.
- Animal studies have reported respiratory effects such as irritation of the nose and eyes; congestion, oedema, and haemorrhage of the lung; congestion of the brain, liver, and kidneys; and central nervous system (CNS) effects from inhalation exposure to bis(2-chloroethyl) ether.
- Acute animal tests in rats and mice have shown bis(2-chloroethyl) ether to have high acute toxicity from inhalation and oral exposure and extreme acute toxicity from dermal exposure.

Bis(2-chloroethyl) ether (also known as bis dichloroethyl ether), molecular formula C4H8Cl2O, is a colourless, nonflammable liquid with a strong unpleasant odour. It dissolves easily in water, and some of it will slowly evaporate to the air. It does not occur naturally. [1,2]

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Carcinogenicity

- No information is available on the carcinogenic effects of bis(2-chloroethyl) ether in humans.
- Animal studies have reported an increased incidence of liver tumours in mice exposed to bis(2-chloroethyl) ether via oral exposure.
- EPA has classified bis(2-chloroethyl) ether as a Group B2, probable human carcinogen.

Other Effects

- No information is available on the developmental or reproductive effects of bis(2-chloroethyl) ether in humans.
- In one animal study, no effects were observed on the reproductive tissues of the animals, but no tests on reproductive function were performed.

SAFETY

First Aid Measures [5]

- **General advice:** Consult a physician. Show this safety data sheet to the doctor in attendance.
- **If inhaled:** If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
- **In case of skin contact:** Wash off with soap and plenty of water. Consult a physician.
- **In case of eye contact:** Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.
- **If swallowed:** Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

Workplace Controls & Practices [4]

- Handle in accordance with good industrial hygiene and safety practice.
- Wash hands before breaks and at the end of workday.

Personal Protective Equipment [5]

The following personal protective equipment is recommended when handling bis(2-chloroethyl) ether:

- Eye/face protection: Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).
- Skin protection: Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands. The selected protective gloves have to satisfy the specifications of EU Directive 89/686/EEC and the standard EN 374 derived from it.
- Body Protection: Impervious clothing. The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.
- Respiratory protection: For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator. For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

REGULATION

United States

OSHA: The Occupational Safety & Health Administration has set the following Permissible Exposure Limit (PEL) for bis92-chloroethyl) ether:

- General Industry: 15 ppm, 90 mg/m3 Ceiling (Skin)
- Construction Industry: 15 ppm, 90 mg/m3 Ceiling (Skin)

ACGIH: The American Conference of Governmental Industrial Hygienists has set a Threshold Limit Value (TLV) for bis92-chloroethyl) ether of 5 ppm, 29 mg/m3 TWA; 10 ppm, 58 mg/m3 STEL (Skin); Appendix A4 (Not Classifiable as a Human Carcinogen)

NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for bis92-chloroethyl) ether of 5 ppm TWA (Skin), 10 ppm STEL (Skin), Potential Carcinogen

REFERENCES

1. http://en.wikipedia.org/wiki/Bis%28chloroethyl%29_ether

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2. http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=816&tid=159
3. http://www.epa.gov/ttnatw01/hlthef/chl-ethe.html
4. http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+502
5. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=AU&language=en&productNumber=B38503&brand=ALDRICH&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Faldrich%2Fb38503%3Flang%3Den
6. https://www.osha.gov/dts/chemicalsampling/data/CH_233700.html

Detergent additives found to generate glyphosate in treated wastewater

2025-05-14

Certain detergent additives known as aminopolyphosphonates can be transformed into glyphosate and other problematic substances when wastewater is treated.

A research team led by Professor Stefan Haderlein of the Geo- and Environmental Center at the University of Tübingen has made this fundamental finding.

To achieve this, the team carried out comprehensive experiments in the laboratory which also included conditions found in wastewater. The finding solidifies the suspicion that detergent additives are a significant source of the consistently high levels of glyphosate in European waters. It was previously assumed glyphosate was released into the environment almost exclusively during its use as an herbicide.

The study has been published in Nature Communications.

Glyphosate is considered the most widely used active ingredient in herbicides worldwide. It prevents growth by inhibiting the formation of vital component proteins in plants and many microorganisms. When it leaches from the soil, glyphosate can get into ground and surface waters as well as the environment.

It is still unclear how severely this damages all sorts of life forms. Ecologists are warning of incalculable consequences. Glyphosate is only slightly toxic to the human body, but a carcinogenic effect has been the subject of discussion.

In the EU, the use of glyphosate in agriculture, above all, has been criticized. "We noticed even in areas and times when hardly any glyphosate input could be expected from agriculture, the concentrations in the water did not decrease accordingly," report Stefan Haderlein and his colleague Carolin Huhn of the Institute of Physical and Theoretical Chemistry of the University of Tübingen.

They suspected this could be related to precursor substances such as aminopolyphosphonates coming from wastewater.

Aminopolyphosphonates are used in detergents as complexing agents to soften water and improve cleaning. From the standpoint of water ecology, Haderlein questions whether they are an improvement on their predecessors, which also degrade poorly.

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"After all, phosphates are also released from aminopolyphosphonates, which deplete oxygen in bodies of water because they promote algal growth," he says. As an environmental mineralogist, Haderlein is interested in chemical reactions that take place on the surfaces of minerals.

He explains, "We knew from an earlier project that polyphosphonates can react with and adsorb at manganese minerals."

Manganese as a reaction driver

The current study's laboratory experiments showed manganese compounds, very commonly found in soil sediments, but also wastewater and sewage sludge, are the key to a multi-stage transformation of aminopolyphosphonates, of which glyphosate is a by-product.

The researcher reports, "In the lab we varied conditions, such as oxygen concentration and pH values, for example, and used wastewater in which many different substances could influence the reactions with manganese.

"Yet from DTPMP—the most important representative of the aminopolyphosphonates—we always got glyphosate, already with tiny amounts of dissolved manganese as long as oxygen was also present. And with mineral manganese, even in the absence of oxygen."

Haderlein also questions previous laboratory results for the microbial decomposition of aminopolyphosphonates. He notes, "Manganese is mostly present in the nutrient media for the microorganisms." As a result, what was supposedly observed as a biological breakdown of aminopolyphosphonates could be a purely chemical process, he continues.

"Now, we've produced the proof that certain aminopolyphosphonates which are used in detergents yield glyphosate in the presence of manganese. This is an important step. Next, we must test which role this glyphosate source plays in terms of quantity," says Haderlein.

He goes on, "To do that, we need still better understanding of how environmental conditions in water and wastewater systems influence the quantity of glyphosate produced during the reaction of DTPMP and manganese."

"With their research, Professor Haderlein, Professor Huhn and their colleagues have uncovered very exciting relationships that are attracting a great deal of attention from the interested public. The results are to help to

better protect our environment," says Professor Dr. Dr. h.c. (Dōshisha) Karla Pollmann, President of the University of Tübingen.

Phys Org, 14 May 2025

https://phys.org

Uncovering compounds that tame the heat of chili peppers

2025-05-14

When biting into a chili pepper, you expect a fiery sensation on your tongue. This spiciness is detected because of capsaicinoid compounds. But for some peppers, despite high levels of capsaicinoids, the heat is mysteriously dull. Now, researchers reporting in ACS' Journal of Agricultural and Food Chemistry have identified three compounds that lessen peppers' pungency. These results challenge the reliability of the century-old Scoville scale, which traditionally bases its rating on two capsaicinoids.

"The discovery of natural dietary compounds that reduce pungency presents promising opportunities for both the food and pharmaceutical industries," says Devin Peterson, the corresponding author of the study.

Capsaicinoids are a group of compounds that produce the strong spicy sensation or pungency that comes with consuming chili peppers. The combined amount of capsaicin and dihydrocapsaicin in a pepper is used to calculate its heat intensity rating on the Scoville scale, ranging from zero Scoville Heat Units (SHU) for bell peppers to millions of SHU for the hottest peppers. However, some of these fruits have less heat than would be expected from their Scoville rating, which suggests that something else in the pepper influences that spicy sensation. So, Peterson, Joel Borcherding and Edisson Tello wanted to investigate multiple chili pepper varieties for potential spiciness suppressors.

Initially, they collected dry, powdered samples from 10 types of peppers, including Chile de árbol, serrano, African bird's eye, Fatalii and Scotch bonnet. The amount of capsaicin and dihydrocapsaicin in each was determined by liquid chromatography mass spectrometry. Then a trained panel of taste testers evaluated the intensity of the powders in tomato juice. Each mixture had 800 SHU (a level meant to be spicy but tolerable). Despite the same amount of capsaicin and dihydrocapsaicin in each tasting sample, the 10 peppers' perceived heat intensities ranged

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significantly, suggesting other chemical constituents in the peppers impacted the sensation.

After additional chemical composition analyses on the pepper powders and performing complex statistical analysis, the researchers identified five compounds that could be modulating pepper spiciness. Another set of panelists assessed whether these compounds, alone or in combination, changed the pungency of capsaicin and dihydrocapsaicin. Three of the five compounds (capsianoside I, roseoside and gingerglycolipid A) reduced the heat intensity, though they didn't have an additive effect when combined. In addition, none of the spiciness suppressors had a noticeable flavor in water.

"These advancements could enable the customization of desirable spicy flavor profiles or lead to the creation of a household ingredient designed to tone down excessive heat in dishes -- the anti-spice," says Peterson. "Additionally, they hold significant medical potential in the design of (non-opioid) analgesic agents for pain management."

Science Daily, 14 May 2025

https://sciencedaily.com

Computational chemistry unlocked: A record-breaking dataset to train AI models has launched

2025-05-15

Open Molecules 2025, an unprecedented dataset of molecular simulations, has been released to the scientific community, paving the way for the development of machine learning tools that can accurately model chemical reactions of real-world complexity for the first time.

This vast resource, produced by a collaboration co-led by Meta and the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), could transform research for materials science, biology, and energy technologies.

"I think it's going to revolutionize how people do atomistic simulations for chemistry, and to be able to say that with confidence is just so cool," said project co-lead Samuel Blau, a chemist and research scientist at Berkeley Lab. His colleagues on the team hail from six universities, two companies, and two national labs.

"We were super excited to work with the community to build this dataset and see where it will take us in creating new AI models," said Larry Zitnick, research director of Meta's Fundamental AI Research (FAIR) lab.

Open Molecules 2025, or OMol25, is a collection of more than 100 million 3D molecular snapshots whose properties have been calculated with density functional theory (DFT).

DFT is an incredibly powerful tool for modeling precise details of atomic interactions, allowing scientists to predict the force on each atom and the energy of the system, which in turn dictate the molecular motion and chemical reactions that determine larger-scale properties, such as how the electrolyte reacts in a battery or how a drug binds to a receptor to prevent disease.

The ability to simulate large systems with DFT-level accuracy would help scientists rapidly design new energy storage technologies, new medicines, and beyond. But DFT calculations demand a lot of computing power, and their appetite increases dramatically as the molecules involved get bigger, making it impossible to model scientifically relevant molecular systems and reactions of real-world complexity, even with the largest computational resources.

Recent advances in machine learning offer a way to overcome these limitations. Machine Learned Interatomic Potentials (MLIPs) trained on DFT data can provide predictions of the same caliber 10,000 times faster, unlocking the ability to simulate the large atomic systems that have always been out of reach, while running on standard computing systems.

However, the usefulness of an MLIP depends on the amount, quality, and breadth of the data that it has been trained on. Enter OMol25—the most chemically diverse molecular dataset for training MLIPs ever built.

Building a new resource

Creating OMol25 required an exceptional amount of computing power and DFT expertise. The FAIR team used Meta's massive global network of computing resources to run the millions of DFT simulations, taking advantage of the periods of spare bandwidth when a part of the world was asleep instead of browsing Instagram and Facebook.

Past molecular datasets were limited to simulations with 20-30 total atoms on average and only a handful of well-behaved elements.

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The configurations in OMol25 are 10 times larger and substantially more complex, with up to 350 atoms from across most of the periodic table including heavy elements and metals, which are challenging to simulate accurately. The datapoints capture a huge range of interactions and internal molecular dynamics involving both organic and inorganic molecules.

"OMol25 cost six billion CPU hours, over 10 times more than any previous dataset. To put that computational demand in perspective, it would take you over 50 years to run these calculations with 1,000 typical laptops," said Blau.

A leap forward in AI models

Scientists around the world can now begin training their own MLIPs on OMol25. They can also use the FAIR lab's open-access universal model, also released today. The universal model was trained on OMol25 and FAIR lab's other open-source datasets—which they have been releasing since 2020—and is designed to work "out of the box" for many applications.

However, the universal model and any other MLIPs trained with the dataset are expected to improve over time, as researchers learn how to best leverage the vast amount of data at their fingertips.

To measure and track model performance, the collaboration has provided evaluations, which are sets of challenges that analyze how well a model can accurately complete useful tasks. The team strove to develop exceptionally thorough evaluations to give fellow researchers more confidence in the capabilities of MLIPs trained on the dataset.

"Once you get to chemistry like atomic bonds breaking and reforming and molecules with variable charges and spins, researchers are going to be rightfully skeptical of any ML tool," said Blau, who also played a large role in this component of the project.

Evaluations also drive innovation through friendly competition, as the results are ranked publicly. Potential users can see which ones run smoothly and developers can see how their model stacks up against others.

"Better benchmarks and evaluations have been essential for progress and advancing many fields of ML," added OMol25 team member Aditi Krishnapriyan, a faculty scientist in Berkeley Lab's Applied Mathematics and Computational Research Division, and assistant professor of Chemical and Biomolecular Engineering and Electrical Engineering and Computer

Sciences at UC Berkeley. Krishnapriyan assisted in the evaluations and developing a subset of the chemical simulations.

"Trust is especially critical here because scientists need to rely on these models to produce physically sound results that translate to and can be used for scientific research," said Krishnapriyan.

By the community, for the community

OMol25 was created by scientists to fill an unmet need for their community, and the ethos of collaboration is woven throughout all aspects of the project.

To curate the content in OMol25, the team started with past datasets made by others, as these represent molecular configurations and reactions that are important to researchers in different chemistry specialties. Then they performed more sophisticated simulations on these snapshots using their advanced DFT capabilities.

Next, they looked to see what major types of chemistry had not been captured previously, and tried to fill the gap.

Three-quarters of the dataset is composed of this new content, divided into three major focus areas: biomolecules, electrolytes, and metal complexes (molecules arranged around a central metal ion). There is still a need for snapshots involving polymers—large molecules made of repeating units called monomers.

This will be addressed by the upcoming Open Polymer data, a complementary project that also includes collaborators from Lawrence Livermore National Laboratory.

The OMol25 team itself was brought together by the branching connections of the STEM community that span academia and industry. Blau and co-leader Brandon Wood, a research scientist in FAIR, met while working in the lab of Kristin Persson, a Berkeley Lab and UC Berkeley researcher who leads the Materials Project. Wood, Blau, and Larry Zitnick, the FAIR chemistry research director, joined forces on the OMol25 project in Fall 2023.

Together, they recruited scientists they admired from UC Berkeley, Carnegie Mellon, New York University, Princeton University, Stanford University, the University of Cambridge, Los Alamos National Laboratory, and Genentech.

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"This open dataset is the result of a fantastic team effort, and we can't wait to see how the community leverages it to explore new directions in AI modeling," said Wood.

"It was really exciting to come together to push forward the capabilities available to humanity," added Blau.

Phys Org, 15 May 2025

https://phys.org

New Nanoparticle Could Enhance Precision in Cancer Ultrasound Treatment

2025-05-15

Researchers have created a new kind of nanoparticle that could make ultrasound-based cancer treatments more effective and safer, while also helping prevent tumors from coming back.

The study, published in the journal Nano Letters, explores a way to make high-intensity focused ultrasound less harmful to healthy tissues.

Oregon Health & Science University was the first hospital in Oregon to offer prostate cancer treatment using a robotic-assisted high-intensity focused ultrasound device. Researchers in the OHSU Knight Cancer Institute's Cancer Early Detection Advanced Research Center, or CEDAR, wanted to improve a category of focused ultrasound known as mechanical tumor ablation.

This technique uses energy to destroy solid tumors without surgery. However, using focused ultrasound to treat solid tumors has two major challenges: it usually needs a lot of energy, which can create heat and harm healthy tissue, and even if the tumor is broken up, some cancer cells might survive and allow the cancer to come back.

"In this study, we developed a tiny particle – about a thousand times smaller than the width of a sheet of paper – that helps treat cancer more effectively," said Michael Henderson, BA, the study's co-lead author.

"These nanoparticles are engineered with small bubbles on their surface. When targeted with focused ultrasound, the bubbles pop and release energy that helps destroy tumors more precisely," he said. "The particles are also coated with a special molecule called a peptide, which helps them stick to tumors and enter cancer cells more easily."

To make the therapy even more powerful, the scientists also attached a potent chemotherapy drug to the peptide on the nanoparticle's surface. Li Xiang, PhD, a postdoctoral scholar with CEDAR and the study's other co-lead author, describes this method as a "one-two punch."

"The ultrasound physically destroys the tumor, and the drug helps eliminate any leftover cancer cells that might cause the tumor to return," she said.

In preclinical models of human melanoma, this combination led to deeper tumor destruction and more effective drug delivery than either treatment alone.

"Our nanoparticles reduce the energy needed for ultrasound treatment by up to 100-fold," Henderson said. "This allows us to use short ultrasound pulses to disrupt tumors mechanically, without overheating surrounding tissue."

When tested in mice with human melanoma tumors, the combined treatment – ultrasound plus the drug-loaded nanoparticles – led to significantly better outcomes than either treatment alone. In some cases, tumors completely disappeared and improved overall survival for more than 60 days with no major side effects observed.

The new platform could eventually be used for other treatments, including infections or cardiovascular disease, where a mix of mechanical and drug therapy could be helpful.

"What began in 2018 as research into nanoparticle-assisted tumor ablation has evolved into a multifunctional platform enabled by simple mixing – we're now excited to bring this into immunotherapy," said Adem Yildirim, PhD, the study's senior author and assistant professor of oncological sciences in the OHSU School of Medicine and the OHSU Knight Cancer Institute. "By combining focused ultrasound with smart drug delivery, we're seeing a promising new way to fight cancer more effectively and reduce the chance of it coming back."

Henderson said future combined treatments, in this case ultrasound and immunotherapy, could help go beyond what each therapy does on its own.

Deep background at OHSU

Henderson is early in his career, but he has an unusually deep background at OHSU.

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Henderson was born at OHSU Hospital in 1998 and raised by an OHSU-trained physician. He is now a PhD student in biomedical engineering and a CEDAR member.

There were a few pitstops along the way for a bachelor's degree at Carroll College in Montana and a stint under the tutelage of Gaurav Sahay, PhD, in the OHSU/Oregon State University College of Pharmacy, but now he's back "home" at OHSU once again.

Henderson aspires to be a physician-scientist who can translate his research to the bedside for patients and currently is working under the guidance of Stuart Ibsen, PhD, and Yildirim, at OHSU. His work focuses on developing methods to improve the effectiveness of immunotherapies and enrich liquid biopsy using noninvasive responsive nanomaterials and protein blockers.

The new publication represents an important early milestone.

"While this work is still in the early stages, it lays the foundation for a new kind of nanoparticle-based therapy that could improve how we approach hard-to-treat tumors," he said.

Technology Networks, 15 May 2025

https://technologynetworks.com

Self-assembly of a large metal-peptide capsid nanostructure through geometric control

2025-05-09

A significant advancement in molecular engineering has produced a large, hollow spherical shell nanostructure through the self-assembly of peptides and metal ions, report researchers from Japan. This dodecahedral link structure, measuring 6.3 nanometers in diameter, was achieved by combining geometric principles derived from knot theory and graph theory with peptide engineering. The resulting structure demonstrates remarkable stability while featuring a large inner cavity suitable for encapsulating macromolecules, opening pathways for producing complex artificial virus capsids.

Controlling the topology and structure of entangled molecular strands is a key challenge in molecular engineering, particularly when attempting to create large nanostructures that mimic biological systems. Examples found in nature, such as virus capsids and cargo proteins, demonstrate the remarkable potential of such architectures. However, methods for

constructing large hollow nanostructures with precise geometric control have remained elusive -- until now.

In a recent study, a research team led by Associate Professor Tomohisa Sawada from Institute of Science Tokyo, Japan, has successfully constructed a molecular spherical shell structure with the geometric topology of a regular dodecahedron. This groundbreaking work, which was published online in the journal Chemon May 01, 2025, describes how the researchers created this large structure, bearing an outer diameter of 6.3 nanometers, through the entanglement of peptides with metal ions.

"The synthesis of this highly complex structure was based on geometric considerations and predictions, leading to the proposal of a new concept: the geometric control of chemical structures," explains Sawada. The team's approach combined two distinct mathematical frameworks, namely knot theory and graph theory, to predict and then achieve the self-assembly of an unprecedented dodecahedral link with an entanglement of 60 crossings, composed of 60 metal ions and 60 peptide ligands (or M60L60).

The researchers had previously created smaller structures with tetrahedral and cubic links. However, a more complex dodecahedral link emerged after they introduced further modifications to the peptide sequence during attempts to functionalize M24L24, a smaller cubic link. X-ray crystallographic analysis revealed that the resulting M60L60 metal-peptide shell contains an inner cavity of approximately 4.0 nanometers (approximately 34,000 $Å^3$), which is large enough to encapsulate macromolecules such as proteins or nanomaterials.

Beyond its impressive structural complexity, the M60L60 shell exhibited remarkable stability against heat, dilution, and oxidative conditions, which the researchers attributed to its unique entangled network structure. Interestingly, the team also demonstrated that the capsid's surface could be modified with various functional groups while maintaining its structural integrity, opening pathways for customization based on specific needs.

These features make M60L60 a promising platform for various applications, including drug delivery systems and molecular transportation. "Considering the diversity and modifiability of peptide structures, our method is overwhelmingly advantageous compared to DNA origami technology in terms of functionalizing structures," highlights Sawada. "Moreover, since our approach involves theoretical prediction and trial-and-error experiments, sometimes astonishing structures far beyond our expectations are obtained -- this is the essence of chemistry."

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Overall, this research represents a significant step forward in understanding how to construct artificial virus capsid-like structures. "Our findings significantly expand the foundation of peptide engineering and are anticipated to have immense effects across various fields, including molecular self-assembly, materials chemistry, and mathematical theories," concludes Sawada. The researchers are now aiming for even more ambitious structures, envisioning M180L180 and M240L240 assemblies with 180 and 240 crossings, respectively, as their next challenges.

Science Daily, 9 May 2025

https://sciencedaily.com

Natural molecule reverses age- and dementia-related cognitive decline

2025-05-14

In a new study, researchers identified a molecule produced by a particular type of brain cell that reversed the cognitive decline seen in both healthy aging and dementia. It provides a deeper understanding of the aging process and a potential target for future treatments.

Aging causes a decline in cognition, as does dementia, including Alzheimer's disease (although the former is a natural process, the latter is pathological). For years, scientists have been investigating ways of reversing that decline, and there have been some promising discoveries.

In a new study, a collaboration between the Federal University of Rio de Janeiro (UFRJ) and the University of São Paulo (USP) in Brazil, researchers examined the impact of hevin, a molecule secreted by star-shaped brain cells called astrocytes, on cognitive decline in older mice with and without dementia.

"Hevin is a well-known molecule involved in neural plasticity," said the study's co-corresponding author, Flávia Alcantara Gomes, PhD, head of the Cellular Neurobiology Laboratory in the Institute of Biomedical Sciences at UFRJ. "It's naturally secreted by cells in the central nervous system that support the functioning of neurons and are known as astrocytes. We found that the overproduction of hevin is capable of reversing cognitive deficits in aged animals by improving the quality of synapses in these rodents."

Astrocytes are large cells that actively support and protect nerve cells (neurons), including the connections, or synapses, between them. They are involved in the formation, function, and elimination of synapses, the

regulation of brain chemistry, and even influence synaptic plasticity, the brain's ability to adapt and change over time. Astrocytes secrete hevin, a type of protein that helps regulate how synapses form and function by influencing how neurons interact with one another.

The researchers started by examining public health data and found that hevin levels were decreased in the brains of people with Alzheimer's disease compared to healthy people of the same age. Moving on to mice, they found that hevin was also decreased in mouse models of Alzheimer's disease. This led the researchers to consider whether manipulating the levels of hevin in astrocytes would affect the signs and symptoms of Alzheimer's disease.

After causing the overproduction of hevin in some mice and not in others, the researchers found that boosting hevin levels prevented cognitive decline in both the Alzheimer's mouse models and the healthy middle-aged mice. Interestingly, though, the researchers observed that elevated hevin levels didn't have any effect on beta-amyloid plaques, the buildup of which is a hallmark of Alzheimer's disease.

"To our surprise, although the cognitive deficit was reversed in Alzheimer's model animals, there was no change in the content of the plaques," said lead and co-corresponding author Felipe Cabral-Miranda, PhD, a scientist at UFRJ's Institute of Biomedical Sciences. "This highlights the complexity of the disease in terms of having a multifactorial mechanism. This is illustrated by older people who have plaque formation but show no symptoms of the disease.

"Although there's still no consensus among researchers, I work with the hypothesis that the formation of beta-amyloid plaques isn't the cause of Alzheimer's. And the results of the study, by finding proof of concept for a molecule that can reverse cognitive decline without affecting beta-amyloid plaques, support the hypothesis that these, although involved in the mechanisms of the pathology, aren't enough to cause Alzheimer's."

There is still a long way to go from these initial animal studies to a treatment for humans. But the study's findings are certainly promising.

"Of course, in the future it'll be possible to develop drugs that have the same effect as hevin," Gomes said. "For now, the fundamental benefit of this work is a deeper understanding of the cellular and molecular mechanisms of Alzheimer's disease and the aging process. The originality lies in understanding the role of the astrocyte in this process. We've taken the focus away from neurons, shedding light on the role of astrocytes,

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which we've shown could also be a target for new treatment strategies for Alzheimer's disease and cognitive impairment."

The study was published in the journal Aging Cell.

New Atlas, 14 May 2025

https://newatlas.com

First planar annulene compounds with metal centres synthesised

2025-05-13

Scientists have synthesised a new class of organometallic molecules – metal-centred planar annulene frameworks. These new compounds hold promise as building blocks in materials science, potentially finding use in electronics, catalysis and photonics.

Annulenes are monocyclic hydrocarbons with the general formula CnHn or CnHn+1 when n is an even or odd number, respectively. The best known example is benzene. They can form coordinates with various metals to form metal complexes where the metal sits above or below the plane of the flat annulene anions – ferrocene is an example of an out-of-plane annulene complex with an iron atom sandwiched between two cyclopentadienyl rings. The synthesis of three metal-centred [15]planar annulene complexes is a first for the field. Incorporating a metal within the plane has been synthetically challenging due to issues such as ring flexibility and restrictions on annulenes' cavity size.

A team of researchers from China and the US overcame these obstacles through targeted molecular design to create a 15-carbon annulene – five fused rings bonded to osmium at the centre. The osmium forms a sigma bond with the carbon atoms and sits within the ring. The team employed a novel method of building the annulene framework around the metal centre, rather than inserting the metal into the system. Their four-step synthesis started with a precursor containing a reactive osmium–carbon triple bond and then involved assembling carbon–carbon bonds around the metal atom via cycloaddition reactions.

This route resulted in the synthesis of three in-plane metallo-annulenes and then converting the symmetrical, parent molecule to the corresponding chlorinated, iodinated and nitrated derivatives. Characterisation revealed that the structures exhibited characteristics similar to expanded porphyrins – highly conjugated planar molecules with

a hollow centre where a metal atom can sit – but without heteroatoms. The osmium complex displayed high stability and functionality.

The work redefines metalla-aromaticity by bridging classic annulene chemistry and porphyrin coordination chemistry adding to fundamental bonding theory. Since the researchers' strategy worked with osmium, they now plan to adapt it to other transition metals to create a diverse family of planar metal–carbon aromatic systems.

Chemistry World, 13 May 2025

https://chemistryworld.com

New Research Challenges 160-Year-Old Long-Standing Origin of Life Theory

2025-05-11

A discovery by scientists at Scripps Research and the Georgia Institute of Technology could shed light on the evolution of life on Earth and pave the way for more efficient biofuel production.

Early Earth was a volatile and inhospitable place, marked by extreme temperatures, widespread volcanic activity, and a thin, primitive atmosphere. Yet somehow, the basic molecular components of life, such as sugars, amino acids, and nucleotides, emerged from this chaos. One long-standing theory among chemists holds that ribose, a sugar that forms the structural backbone of RNA, arose spontaneously through a chemical process. However, new research challenges this idea.

In a study published in Chem, scientists from Scripps Research and the Georgia Institute of Technology question the validity of the "formose reaction" hypothesis. This hypothesis proposes that simple formaldehyde molecules reacted under early Earth conditions to form ribose. But the new findings reveal a key limitation: under controlled experimental conditions, the formose reaction does not yield linear sugars like ribose. Instead, it predominantly produces branched sugar structures, which are incompatible with the formation of RNA.

These results not only reshape our understanding of how life's essential molecules may have originated, but also offer insights that could influence synthetic biology and biofuel production strategies.

"The concept of the formose reaction as a prebiotic source of ribose needs serious reconsideration," says corresponding author Ramanarayanan Krishnamurthy, professor of chemistry at Scripps Research. "Other models

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and options should be explored if we want to understand how these sugar molecules arose on early Earth."

The formose reaction was serendipitously discovered in 1861 and has been a leading hypothesis for prebiotic sugar formation ever since. During the reaction, formaldehyde molecules spontaneously and repeatedly react with each other to create larger molecules: first two formaldehydes react to create a two-carbon molecule, which then reacts with another formaldehyde to create a three-carbon molecule, and so on and so on, until all the formaldehyde has been used up.

The reaction is slow to begin but then accelerates uncontrollably. As more and more complex sugars are made, the reaction mixture turns from colorless, to yellow, to brown, to black. "It's almost like caramelization," says Krishnamurthy.

Exploring Controlled Conditions

"The problem is it's a very messy reaction, and if ribose is formed at all, it's a minuscule part and only one among hundreds and thousands of compounds that will be formed," says Krishnamurthy. "We wanted to understand why this reaction is so complex, and whether it can be controlled."

Usually, the formose reaction is conducted at high temperatures and in a very basic environment (at a high pH of 12 or 13). In this case, the researchers decided to test the reaction under milder conditions: at room temperature and at a pH of around 8, which they say is likely to be closer to the conditions present on prebiotic early Earth. To monitor the abundance and types of sugars produced, they used a high-powered analytical technique known as nuclear magnetic resonance (NMR) spectroscopy and labeled the starting molecules. The mixture was monitored over several days.

They showed that the reaction is possible even under mild conditions, but that the results are just as complex and uncontrollable as usual.

"The reactivity of formaldehyde doesn't allow you to stop at a particular stage," says Krishnamurthy. "Even with very mild reaction conditions it goes on until all of the formaldehyde is consumed, which means it's very difficult to control or stop the reaction in order to form intermediate sugars."

Implications for the Origin of Life and Industry

The NMR data revealed that all of the larger sugars produced had branched structures. Since almost all of the sugars that are used as molecular building blocks in living organisms are linear and unbranched, this suggests that the formose reaction cannot explain the origins of biotic sugars.

"Our results cast doubt on the formose reaction as the basis for the formation of linear sugars," says co-senior author Charles Liotta, Regents' Professor Emeritus of the Georgia Institute of Technology.

Though the study's mild reaction conditions failed to create the linear sugars necessary to explain the origins of RNA, the methods could be useful for the biofuel industry, where branched sugars are a desirable commodity.

"Our work might be helpful for biofuel production, since we found that with milder conditions, we can more cleanly produce branched sugars that can be used for green fuel," says Krishnamurthy.

This isn't necessarily the end for origins of life research on the formose reaction, but the researchers hope to spur different lines of thinking.

"Our goal was to point out all the problems that you will face if you are thinking about the formose reaction in the context of the prebiotic sugar synthesis, but we aren't saying this is the endpoint; our results might inspire somebody to come up with a better way to somehow overcome these issues," says Krishnamurthy. "We encourage the community to think differently and search for alternative solutions to explain how sugar molecules arose on early Earth."

Sci Tech Daily, 11 May 2025

https://scitechdaily.com

Durable catalyst boosts efficiency of high-temperature CO_2 conversion

2025-05-14

We've all heard that carbon dioxide (CO2) emissions need urgent solutions, but what if we could turn this greenhouse gas into useful chemicals or fuels? Electrochemical CO2 conversion—the process of transforming carbon dioxide into valuable products—is a promising path toward greener energy and reducing emissions. The catch? Existing methods

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either don't last long or consume too much energy, limiting their real-world use.

Low-temperature CO2 conversion, for instance, typically lasts less than 100 hours and reaches efficiencies below 35%. The process can be more practical at higher temperatures—between 600 and 1,000°C—but current catalysts often wear out quickly or require costly precious metals. The technology needs an efficient, stable, and cost-effective solution that can turn CO2 into useful products like carbon monoxide, a key ingredient in many industrial processes.

Now, a team led by Professor Xile Hu at EPFL has crafted a new type of catalyst that promises to make this high-temperature conversion more practical and cost-effective. The catalyst could accelerate the transition towards cleaner industries by converting CO2 into usable chemicals and fuels. The work is published in the journal Nature.

The researchers developed an innovative catalyst made from a cobalt-nickel (Co-Ni) alloy encapsulated within a ceramic material called Sm2O3-doped CeO2 (SDC). The encapsulation prevents the metal from agglomerating (clumping together), a common problem that reduces catalyst effectiveness.

Impressively, their catalyst operates at 90% energy efficiency, 100% product selectivity, and sustains its performance over an unprecedented 2,000 hours, far surpassing existing technologies.

To create the catalyst, first-author and EPFL postdoc Wenchao Ma used a sol-gel method, a process that mixes metal salts with organic molecules to form tiny metal clusters encased by ceramic shells.

They tested different combinations of metals, discovering that a balanced mix of cobalt and nickel delivered the best performance. Unlike traditional catalysts, which quickly degrade under intense heat, the encapsulated alloy remained stable, maintaining its efficiency even after thousands of hours of continuous operation.

The results were remarkable. The new catalyst maintained an energy efficiency of 90% at 800°C while converting CO2 into carbon monoxide—a valuable chemical used in industrial processes—with 100% selectivity. In simpler terms, nearly all the electricity used in the reaction directly contributed to producing the desired chemical, without wasteful side reactions.

The breakthrough brings us closer to practical, cost-effective carbon recycling. Instead of releasing CO2 into the atmosphere, industries could reuse it, transforming waste gas into valuable products. This technology could help industries reduce their environmental footprint, saving both energy and money in the process.

The EPFL team's catalyst remained stable at industrially relevant conditions for more than 2,000 hours, a milestone that dramatically reduces operating costs. Compared to existing technologies, their approach could cut overall costs by 60% to 80%, according to the researchers' preliminary estimate.

The catalyst is a significant step towards cleaner industries. By turning CO2 into valuable products efficiently, we can envision a future where industries recycle carbon emissions as routinely as we recycle paper and plastic today. The EPFL team has filed an international patent application for the catalyst.

Phys Org, 14 May 2025

https://phys.org

Watch: New structures shrink instead of stretching when pulled

2025-05-15

Researchers in the Netherlands have created mechanical structures that strangely shrink – or more precisely, snap inward – instead of stretching outward when pulled.

It sounds impossible, but it's really down to novel design ideas from the team at Dutch physics research institute AMOLF that combine geometry and mechanics to demonstrate this unexpected behavior, with the potential to overcome undesirable instabilities.

"This new kind of behavior – that we coin 'countersnapping' – has never been seen in experiments before," said Bas Overvelde, principal investigator of the Soft Robotic Matter Group. "This could transform how we design everything from medical robotic devices to earthquake-resistant buildings."

You can see the mechanism in action in the clip below.

Pretty nifty, right? This countersnapping behavior, documented in the journal PNAS last month, is materialized through the design and assembly of specific mechanical structures that leverage geometric nonlinearities.

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The core principle is to create a system that exhibits a self-intersecting force–displacement relation, where a sudden contraction occurs under increasing tension, or a sudden increase in tensile force happens under increasing extension.

By combining three different types of nonlinear building blocks – each of which exhibits specific force-extension behaviors – in a network arrangement, the team was able to create a countersnapping system. In the example above, the pieces are 3D printed.

Together, these countersnapping elements unlock a bunch of interesting mechanical properties:

- Unidirectional stick–slip motion: Unlike regular snapping which causes movement in opposite directions under cyclic loading, countersnapping enables movement in the same direction, allowing for incremental motion that consistently moves in one direction.
- Switchable stiffness: The structure can switch between different levels of stiffness at a specific point where it has the same extension and applied force. This means you can change how resistant it is to deformation without altering its current size or the load it's carrying.
- Passive resonance avoidance: Because the stiffness can be switched without changing the equilibrium state, countersnapping can be used to automatically change the natural vibration frequency of a system. This can help protect the system from excessive vibrations at certain frequencies.
- Sequential stiffness switching: When multiple countersnapping elements are connected side-by-side (in parallel), their stiffness can be changed one after the other.
- Instantaneous collective switching: When multiple countersnapping elements are connected end-to-end (in series), they can switch their state all at once, like an avalanche.

The researchers believe that countersnapping could be useful in protective gear and prosthetics that can go from flexible to stiff for support (similar to motorcycle safety equipment), and vibration dampening applications in buildings and planes. They could also enable soft medical robots make their way through the body safely by moving forward without slipping backward.

New Atlas, 15 May 2025

https://newatlas.com

Versatile fungi-based living material is tear-resistant and can even be safely eaten

2025-05-13

Sustainably produced, biodegradable materials are an important focus of modern materials science. However, when working with natural materials such as cellulose, lignin or chitin, researchers face a trade-off. Although these substances are biodegradable in their pure form, they are often not ideal when it comes to performance. Chemical processing steps can be used to make them stronger, more resistant or more supple—but in doing so, their sustainability is often compromised.

Empa researchers from the Cellulose and Wood Materials laboratory have now developed a bio-based material that cleverly avoids this compromise. Not only is it completely biodegradable, it is also tear-resistant and has versatile functional properties. All this takes place with minimal processing steps and without chemicals—you can even eat it. Its secret: It's alive.

The study is published in the journal Advanced Materials.

Optimized by nature

As the basis for their novel material, the researchers used the mycelium of the split-gill mushroom, a widespread edible fungus that grows on dead wood. Mycelia are root-like filamentous fungal structures that are already being actively researched as potential sources of materials. Normally, the mycelial fibers—known as hyphae—are cleaned, and chemically processed if necessary, which brings about the above-mentioned trade-off between performance and sustainability.

The Empa researchers chose a different approach. Instead of treating the mycelium, they use it as a whole. As it grows, the fungus not only forms hyphae, but also a so-called extracellular matrix: a network of various fiber-like macromolecules, proteins and other biological substances that the living cells secrete.

"The fungus uses this extracellular matrix to give itself structure and other functional properties. Why shouldn't we do the same?" explains Empa researcher Ashutosh Sinha.

"Nature has already developed an optimized system," adds Gustav Nyström, head of the Cellulose and Wood Materials lab.

With a bit of additional optimization, the researchers gave nature a helping hand. From the enormous genetic diversity of the split-gill, they

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selected a strain that produces particularly high levels of two specific macromolecules: the long-chain polysaccharide schizophyllan and the soap-like protein hydrophobin.

Due to their structure, hydrophobins collect at interfaces between polar and apolar liquids, for example, water and oil. Schizophyllan is a nanofiber: less than a nanometer thick, but more than a thousand times as long. Together, these two biomolecules give the living mycelium material properties that make it suitable for a wide range of applications.

A living emulsifier

The researchers demonstrated the versatility of their material in the laboratory. In their study, they showcased two possible applications for the living material: a plastic-like film and an emulsion. Emulsions are mixtures of two or more liquids that normally do not mix. All you have to do to see an example is open the fridge: Milk, salad dressing or mayonnaise are all emulsions. Various cosmetics, paints and varnishes also take the form of emulsions.

One challenge is to stabilize such mixtures so that they do not separate into individual liquids over time. This is where the living mycelium shows its strengths: Both the schizophyllan fibers and the hydrophobins act as emulsifiers, and the fungus keeps releasing more of these molecules.

"This is probably the only type of emulsion that becomes more stable over time," says Sinha. Both the fungal filaments themselves and their extracellular molecules are completely non-toxic, biologically compatible and edible—the split-gill mushroom is routinely eaten in many parts of the world. "Its use as an emulsifier in the cosmetics and food industry is therefore particularly interesting," says Nyström.

From compost bags to batteries

The living fungal network is also suitable for classic material applications. In a second experiment, the researchers manufactured the mycelium into thin films. The extracellular matrix with its long schizophyllan fibers gives the material very good tensile strength, which can be further enhanced by targeted alignment of the fungal and polysaccharide fibers within it.

"We combine the proven methods for processing fiber-based materials with the emerging field of living materials," explains Nyström.

Sinha adds, "Our mycelium is a living fiber composite, so to speak."

The researchers can control the fungal material's properties by changing the conditions under which the fungus grows. It would also be conceivable to use other fungal strains or species that produce other functional macromolecules.

Working with living materials also presents certain challenges.

"Biodegradable materials always react to their environment," says Nyström. "We want to find applications where this interaction is not a hindrance but maybe even an advantage."

However, its biodegradability is only part of the story for the mycelium. It is also a biodegrader: The split-gill mushrooms can actively decompose wood and other plant materials.

Sinha sees another potential application here: "Instead of compostable plastic bags, it could be used to make bags that compost the organic waste themselves," says the researcher.

There are also promising applications for mycelium in the field of sustainable electronics. For example, fungal material shows a reversible reaction to moisture and could be used to produce biodegradable moisture sensors. Another application that Nyström's team is currently working on combines the living material with two other research projects from the Cellulose and Wood Materials laboratory: the fungal biobattery and the paper battery.

"We want to produce a compact, biodegradable battery whose electrodes consist of a living 'fungal paper,'" says Sinha.

Phys Org, 13 May 2025

https://phys.org

Scientists Find Common Household Plastics Linked to Heart Disease

2025-05-09

A growing body of research suggests that plastics (such as the takeout container kind) and chemicals used to create them, called phthalates, increase heart disease risk by causing inflammation and metabolic dysfunction. A new study adds more data to the pile with global estimations of phthalate-related cardiovascular deaths that occurred over one year, and the numbers are jarring.

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Below, experts break down what the research means, exactly, how concerned you should be about your personal plastic use, and how to protect your heart health in general.

What did the study find?

Researchers found that, in 2018 alone, an estimated 356,238 deaths, globally, could be attributed to exposure to di-2-ethylhexylphthalate (DEHP), a specific phthalate used to make plastics more flexible and durable. That number represented approximately 13.5% of all cardiovascular-related deaths of people between the ages of 55 and 64 that year.

The study noted geographic disparities among potential plastic-related deaths: Regions with booming plastic industries saw a dramatic impact. For example, South Asia and the Middle East experienced the highest percentage of cardiovascular-related deaths attributable to DEHP exposure at nearly 17%. Those areas, combined with East Asia and the Pacific, hosted the largest percentage of global DEHP-attributed deaths at around 73%. Altogether, researchers estimated that DEHP exposure collectively shortened life by roughly 10.4 million years worldwide.

To arrive at all of those numbers, scientists took data from a past large U.S.-based study that measured DEHP and other phthalate levels of participants' urine and compared it to global mortality rates and environmental data from the Institute for Health Metrics and Evaluation, a research group that collects medical information worldwide to identify trends in public health.

"These are only broad associations and do not definitively implicate DEHP," notes Sanjay Rajagopalan, M.D., the director of Case Western Reserve University's Cardiovascular Research Institute. "It could also mean that there are other chemicals that could drive this risk."

What is DEHP in?

DEHP and other phthalates are used to make various products like food containers, medical equipment, and household items, says Dr. Rajagopalan. He adds that DEHP is also found in vinyl flooring, shower curtains, children's toys, and food processing and storage materials like cling wrap.

How phthalates may impact heart health and mortality

It has been shown that phthalates can infiltrate the arteries of humans and contribute to heart disease, Dr. Rajagopalan says. Marianela Areces, M.D., medical director and cardiologist at Pritikin Longevity Center adds that all phthalates, and especially DEHP, "are environmental endocrine-disrupting chemicals," meaning that they may interfere with hormone function and raise risk for conditions like obesity and diabetes, both of which are also risk factors for heart disease.

The core detriment here is believed to be that phthalates are inflammatory, which may inhibit bodily processes and make oxidative stress and cell damage more likely. Phthalates have also been linked to high blood pressure, high cholesterol, and cardiovascular arrhythmias, Dr. Areces adds.

Should I be concerned about plastic exposure?

In short, experts say, yes. However, there's only so much we can do because phthalates are, unfortunately, ubiquitous at this point. You can reduce exposure, though, with "conscious effort and lifestyle changes," says Dr. Areces. Those might include:

- **Avoid plastic products:** Opt for glass, stainless steel, or silicone alternatives for food storage and household items.
- **Check labels:** Look for products labeled "phthalate-free," especially in personal care items, toys, and food packaging.
- **Limit processed foods:** Phthalates can leach into food from packaging, says Dr. Areces. Choose fresh, whole foods and avoid heavily processed or packaged items.
- **Avoid heating plastics:** "Do not microwave food in plastic containers, as heat can increase the release of phthalates into food," says Dr. Areces.
- **Improve ventilation:** Phthalates can be present in indoor air and dust. Regularly ventilate your home and clean with a vacuum equipped with a HEPA filter.
- **Advocate for regulation:** "Support policies and initiatives aimed at reducing phthalate use in consumer products and improving waste management," Dr. Areces recommends.

In addition to being aware of your plastic use, Drs. Areces and Rajagopalan say you can protect your heart health by making generally healthy lifestyle choices like eating a balanced diet, exercising regularly, avoiding tobacco and alcohol use, prioritizing sleep and mental health, and getting regular check-ups.

Prevention, 9 May 2025

https://prevention.com

Turning lead into gold (for a split second)

2025-05-12

Several centuries ago, a branch of alchemy called chrysopoeia is said to have explored the possibilities of transforming widely available base metals into precious metals. Early practitioners never managed to pull it off, but it appears that in studying the conditions that emerged just after the Big Bang using the Large Hadron Collider (LHC), scientists have turned lead into gold – for just fractions of a second.

Before you get too excited and start looking into investing in the LHC as a new asset class, it wasn't a whole lot of gold. In fact, it was "trillions of times less than would be required to make a piece of jewelry." But you can still marvel at the fact that one element transformed into another with distinctly different properties, through a new mechanism.

Before we dive into the how, let's recap where it took place. The LHC is the world's largest and most powerful particle accelerator: a circular tunnel where scientists smash tiny particles together at incredible speeds. The tunnel is 17 miles (27 km) in circumference, and is located in Geneva, Switzerland.

This facility is used to test theoretical predictions in particle physics, get a better sense of how the forces in our universe work, and understand the Big Bang.

The LHC goes through "runs," or operational periods when the collider is actively accelerating and colliding particles for scientific experiments. Run 1 (2010-2013) culminated in the discovery of the Higgs boson particle.

Run 2 took place between 2015 and 2018, and was crucial in refining our understanding of the Standard Model of particle physics, as well as probing the properties of the Higgs boson with greater detail.

Now within the LHC complex, you've got ALICE, short for A Large Ion Collider Experiment. It refers to a specific detector and research program at the facility, and is focused on the physics of strongly interacting matter.

The idea is to study the conditions thought to have existed immediately after the Big Bang by measuring the properties of what's called quark-gluon plasma.

When you have high-energy collisions between lead nuclei at the LHC that travel at almost the speed of light, it creates this quark–gluon plasma, a hot and dense state of matter that is believed to have filled the universe right after the Big Bang took place. There's also a strong electromagnetic field emanating from lead nuclei.

It turns out that high-speed lead nuclei, the frequent near-miss interactions between them, and their electromagnetic field are a recipe for gold. "... the very high speed at which lead nuclei travel in the LHC (corresponding to 99.999993% of the speed of light) causes the electromagnetic field lines to be squashed into a thin pancake, transverse to the direction of motion, producing a short-lived pulse of photons," explained the folks at CERN (European Organization for Nuclear Research), which runs the LHC.

"Often, this triggers a process called electromagnetic dissociation, whereby a photon interacting with a nucleus can excite oscillations of its internal structure, resulting in the ejection of small numbers of neutrons and protons. To create gold (a nucleus containing 79 protons), three protons must be removed from a lead nucleus in the LHC beams. The ALICE team used the detector's zero degree calorimeters (ZDC) to count the number of photon–nucleus interactions that resulted in the emission of zero, one, two and three protons accompanied by at least one neutron, which are associated with the production of lead, thallium, mercury and gold, respectively."

As such, gold nuclei emerged from the collision and hit the LHC beam pipe, where they immediately fragmented into single protons, neutrons and other particles. So effectively, lead transmutated into gold in the experimental setup through near-miss collisions, for the briefest of moments.

This is the first time gold production has been measured at the LHC, and the results appeared in Physical Review Journals last week. Sure, it might only have been 29 picograms of gold, but it still technically counts as alchemy. Our ancestors may indeed have been onto something all those hundreds of years ago after all.

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Source: CERN

New Atlas, 12 May 2025

https://newatlas.com

Charged droplets don't splash when they hit a solid surface

2025-05-09

Applying an electrical charge to liquid droplets reduces the splash when those droplets hit a solid surface. In some cases, charge can even prevent splashing altogether. The researchers behind the finding suggest that the phenomenon could be used to control impact dynamics during inkjet printing, and in the application of pesticides or surface coatings.

Droplets can acquire charge in various settings. For example, charge is generated in the raindrops that make up thunderstorm clouds. And in the laboratory, the simple act of squeezing a droplet from a plastic pipette induces a small charge in the substance.

To study how charge influences the splashing behaviour of droplets, a team led by Zuankai Wang from the Hong Kong Polytechnic University in China used high-speed cameras to observe ethanol drops hitting a glass slide. The ethanol was dispensed from a syringe needle connected to a high-voltage power supply, below which was a grounded copper ring that drops fell through. The electric field created between the syringe and the ring induced a lasting charge in the droplets that remained as they hit the glass slide.

As a droplet hits a horizontal surface, a thin layer of liquid called a 'lamella' forms and expands outwards across the surface. Various forces acting on the lamella then cause this layer to lift off the surface, at which point it breaks up and creates a splash.

Now, Wang's team has shown that for droplets with higher charge, the lamella doesn't expand to the same extent and has a stronger attraction to the surface. This means that the liquid doesn't lift as far off the surface, resulting in a smaller splash. For droplets with a sufficient charge, splashing can be suppressed completely.

The researchers also performed the experiments with slides made from a range of materials, noting that the effect varies depending on the dielectric constant of the surface. For highly conducting materials

splashing is not suppressed at all, as the droplet loses its charge as soon as it touches the surface.

Chemistry World, 9 May 2025

https://chemistryworld.com

Biodegradable Microplastic Remodels Gut Metabolism

2025-05-12

Microplastics from polylactic acid, a medical biodegradable material approved by the FDA, can alter metabolism in the gut.

Microplastic pollution is a severe ecological and environmental issue faced globally and is also one of the important risk factors affecting human health. Polylactic acid (PLA), as a medical biodegradable material approved by the FDA, is an important material to replace petroleum-based plastics,

Although PLA has achieved large-scale application in food packaging, its brittle characteristics make it more likely to generate microplastic particles. These particles can efficiently invade the gut through the food chain and trigger unknown biotransformation processes at the microbiota-host interface. Therefore, elucidating precisely the transformation map of PLA microplastics within the living body is crucial for assessing their safety.

In a study published in PNAS, a research team led by Prof. CHEN Chunying from the National Center for Nanoscience and Technology (NCNST) of the Chinese Academy of Sciences revealed the complete biological fate of PLA microplastics (PLA-MPs) in the gut of mice, particularly focusing on their microbial fermentation into endogenous metabolites and their involvement in the carbon cycle.

Researchers focused on the in vivo transformation of PLA-MPs. Through spatial functional analysis, they found that the colonic microbiota is the core functional unit for the degradation of PLA-MPs. The specific esterase FrsA secreted by the colonic microbiota could precisely recognize and cleave the ester bonds of PLA through its α/β-hydrolase fold domain, thereby achieving efficient degradation of PLA-MPs.

Besides, researchers found that further integration of the microbiota-protein interaction network with single-strain functional validation confirmed that Helicobacter muridarum and Barnesiella intestinihominis dominate the degradation process of PLA-MPs in the gut, providing key targets for the targeted regulation of plastic biotransformation.

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Moreover, researchers innovatively combined stable isotope 13C labeling with metabolic flux tracing. This approach overcame the challenge of distinguishing signals from endogenous metabolites and exogenous particulate derivatives. For the first time, it was shown that PLA-MPs can enter the double "carbon cycle" of gut microbiota and gut epithelium as a carbon source.

This process integrated into the host-microbiota co-metabolic network via two pathways. Microbially, 13C-PLA-MPs are metabolized through lactate and aspartate into the purine pathway, driving uric acid synthesis. In the gut epithelium, 13C-PLA-MPs support the synthesis of amino acids and nucleotide precursors via the succinate hub. Ultimately, their entry into the gut carbon cycle trigger metabolic reprogramming, reducing short-chain fatty acid production, disrupting energy homeostasis, and reallocating carbon flux. This led to suppressed host feeding behavior and significant weight loss.

"This work comprehensively maps the dynamic biotransformation pathways of biodegradable microplastics within mice. It is of great significance for assessing the biosafety of degradable plastics, and provides important data support for understanding the impact of degradable plastics on human physiological processes," said Prof. CHEN Chunying.

Technology Network, 12 May 2025

https://technologynetworks.com

Carbon dioxide is key to making a precise polymer safely

2025-05-13

Watch a Cornell ice hockey game at Lynah Rink and you'll spend three periods looking at—or rather, through—a methacrylate, a type of polymer used widely in paints, adhesives and glass substitutes. But making this material for applications more nuanced than blocking hockey pucks—for instance in drug delivery mechanisms—requires a highly controlled process called anionic polymerization, which has been difficult and even dangerous to pull off.

Now, Cornell chemists have developed a user-friendly, scalable anionic polymerization process for methacrylate that's precisely controlled and mediated by carbon dioxide (CO_2). Useful for developing advanced applications of methacrylate, the process is already benefiting researchers

such as engineers working to develop metal-free batteries and has potential future applications in biomedical settings.

"Making anionic polymerizations more accessible and safer will allow the scientific community to use these powerful methods to make next-generation materials," said Brett Fors, the Frank and Robert Laughlin Professor of Physical Chemistry in the Department of Chemistry and Chemical Biology in the College of Arts and Sciences (A&S).

Fors is corresponding author of "Controlled Anionic Polymerization Mediated by Carbon Dioxide," which is published in Nature Chemistry. The first author is doctoral student Paige Jacky, M.S. '23. Alexa Easley, Klarman Postdoctoral Fellow in chemistry and chemical biology (A&S) is a co-author.

Anionic polymerization is a powerful way to make materials with well-defined molecular structures, in which precise control allows scientists to understand how the material's structure and properties are related, Easley said.

"For specialty applications, like drug delivery, if you're submitting to the Food and Drug Administration a plan with an exact polymer, you need to have a very known structure, which Plexiglas does not have," Easley said. "Glass substitute is great for what it's doing, like protecting us at sports events, but it couldn't be used for these biomedical applications, where there's more need for structural control."

Existing anionic polymerization methods are hard to do—and often dangerous, requiring toxic metals, chemicals that are explosive or spontaneously flammable in air, or other compounds that contaminate the final material. Some of these methods require very low temperatures and are sensitive to moisture and air.

In contrast, the Cornell team's method, called CO2-mediated reversible deactivation anionic polymerization (CMAP), is simple, requiring one container. It uses an atmosphere of carbon dioxide plus an initiator, and it works through easy-to-achieve heating rather than deep cold. It yields well-defined materials. The simple synthesis of the initiator and "one-pot" nature of the process makes anionic polymerization an accessible tool that can be used outside specialized chemistry labs.

The keys to the method are carbon dioxide and heat, Jacky said. Inspired by recent research on reversible initiators—chemicals used to both start and stop a reaction—she turned to carbon dioxide: it's relatively

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abundant, cheap and nontoxic in this context. Typically, carbon dioxide is considered a terminating agent in anionic polymerizations, but she discovered that "the process is reversible if you apply heat."

Carbon dioxide starts and stops the reaction rapidly. It also protects and stabilizes the enolate, a key component that is very reactive.

The researchers tested the method using a setup Easley had developed during her Klarman Fellow research to monitor molecules for carbon dioxide capture.

Work still needs to be done to scale the CMAP method for industry, but the researchers believe this work will inspire future similar reversible deactivation strategies for other anionically polymerizable vinyl monomers. They also hope the method makes anionic polymerization of methacrylate materials more approachable to the broader scientific community.

It's already in use by some researchers, including Easley. As a graduate student in engineering at Texas A&M University, Easley tried to make a polymer for a metal-free battery, but the only available method—using pyrophoric initiators—was not working.

"I tried multiple ways to do it and never could get it," she said. But now, using CMAP, "we made it."

Phys Org, 13 May 2025

https://phys.org

New Materials and Design Revolutionize Battery Science for Faster Charging and Longer Cycle Life

2025-05-13

Rechargeable batteries have become an indispensable part of modern technological advancements, powering an extensive array of devices from portable smartphones and laptops to electric vehicles (EVs) and renewable energy systems. Their evolution has been a catalyst for the development of many technologies that have shaped the world we live in today. From the smartphone revolution to the rise of EVs, rechargeable batteries have played a pivotal role in powering the innovations that define contemporary life. However, as technology advances at an unprecedented rate, so does the demand for more efficient, reliable and faster-charging batteries.

Consumers today expect their devices to not only provide more power but also charge faster and last longer. With devices becoming more power-hungry, this shift in consumer expectations has intensified the need for breakthroughs in energy storage solutions. This appetite for faster charging, longer battery life and improved performance has led to an explosion of research and development in battery science. The result is an increasing focus on the development of novel materials, improved battery designs and innovative battery chemistries to meet these demands.

While conventional lithium-ion (Li-ion) batteries have long been the go-to solution for portable energy storage, their limitations have become more pronounced. This includes slow charging times, limited cycle life and degradation issues. These challenges become particularly evident in high-power applications such as EVs and portable electronics.

Addressing these limitations has become a central goal for researchers and scientists worldwide, driving the search for new battery materials, improved chemistry and innovative structural designs that promise to transform battery technology in the coming years.

Emerging materials enhance charging efficiency and cycle life

As the demand for batteries that charge faster and last longer intensifies, researchers have been exploring a variety of emerging materials that can significantly enhance battery performance. Among these materials, silicon-based anodes have garnered considerable attention for their ability to revolutionize Li-ion batteries.

Traditionally, graphite has been used as the anode material in Li-ion batteries. While graphite offers reasonable energy density and stability, it has limitations, particularly in terms of the amount of lithium it can store.5

Silicon, on the other hand, has the potential to store up to 10 times more lithium ions than graphite, dramatically increasing the energy density of batteries.6 This increased capacity translates to longer-lasting power and greater energy storage, which could significantly extend the operating time of portable devices and EVs.

However, silicon's expansion and contraction during the charging and discharging process presents a notable challenge.7 This action causes the material's structural integrity to degrade over time, resulting in cracking and a reduction in battery performance.8 To address this issue, researchers are exploring ways to stabilize silicon by using advanced materials like

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graphene or by introducing nanoscale design concepts to silicon-based anodes to control its expansion and prevent degradation.

Another significant development in battery materials is the use of solid-state electrolytes. Traditional Li-ion batteries rely on liquid electrolytes which, while effective, have a few drawbacks. Liquid electrolytes are flammable, prone to leakage and can contribute to overheating or combustion in the event of a battery failure.11 Solid-state electrolytes – typically made from ceramic or glass-like materials – present a much safer alternative. These materials offer enhanced thermal stability and greater ionic conductivity, enabling faster ion flow and reducing the risk of dangerous failures. Solid-state electrolytes can also improve the energy efficiency of batteries by minimizing energy loss during charging and discharging processes.

A new solid-state electrolyte, called N2116, was recently discovered by a research collaboration between Microsoft and the Pacific Northwest National Laboratory (PNNL) using artificial intelligence (AI) and supercomputing methods. This material could potentially reduce lithium use in batteries by up to 70%, addressing concerns over lithium shortages and environmental impact.

By leveraging AI, researchers screened 32 million possible inorganic materials in under a week, a process that would have taken decades through traditional methods. The development of a working battery prototype took less than nine months.

"Computational methods struggle with predicting two critical factors: scalable synthesis processes and emergent properties like interphase layer evolution. These limitations create costly trial-and-error cycles during material development," said Dr. Vijay Murugesan, a scientist in the Physical Sciences Division and group leader for the materials science group at Pacific Northwest National Laboratory.

"The solution lies in building AI-ready experimental datasets that capture material synthesis pathways and operando material behavior. This integrated AI-guided experimental approach would enable AI models to predict not just basic properties but also manufacturable materials with desired performance under real-world conditions, dramatically reducing development timelines," Murugesan said.

"The future breakthrough will be AI-powered battery digital twins that accurately model long-term performance and safety across diverse operational conditions," Murugesan continued. "In coordination with

rigorous experimental validation at a facility such as Pacific Northwest National Laboratory's Grid Storage Launchpad, this approach could accelerate materials development to meet fast charging requirements. Through autonomous science approaches, we'll detect early performance signatures and engineer resilient structures, enabling reliable decade-long performance predictions without decade-long testing. This will revolutionize how quickly we can deploy new battery technologies at scale."

The lithium supply chain is crucial for rechargeable batteries, but it is facing rising demand and potential shortages. Lithium mining is environmentally damaging, requiring significant water and energy.14 Solid-state batteries (SSBs) that minimize the consumption of lithium, like those using N2116, offer a safer and more sustainable alternative with the added potential for higher energy density and better longevity.

The development of solid-state batteries is poised to make a significant impact on a wide range of applications, from consumer electronics to electric vehicles. By replacing liquid electrolytes with solid alternatives, these batteries promise to provide higher energy densities, faster charging times and longer cycle lives.

Innovative structural designs accelerate charging and enhance longevity

While advancements in battery materials are driving much of the progress in battery performance, structural innovations are also playing a critical role in improving charging times and extending battery longevity. AI-driven approaches further accelerate this progress by predicting material properties, optimizing battery architectures and designing materials with tailored characteristics, reducing reliance on trial-and-error experimentation.15

One of the most promising structural advancements is the development of three-dimensional (3D) electrode architectures. Traditional lithium-ion batteries use flat-layered electrodes, which limit the surface area available for ion exchange. This restriction slows down the rate at which ions can flow through the battery, ultimately reducing charging speeds.

3D electrode designs, however, utilize porous and microstructured materials to expand the surface area available for ion exchange. This increased surface area allows ions to move more quickly and efficiently, accelerating the charging process. By enhancing ion mobility, 3D

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electrodes can dramatically reduce charging times and improve the overall performance of batteries.

Another area of significant innovation is the optimization of cathodes – the electrode responsible for releasing and storing energy during battery cycles. Traditional cathodes, while functional, often suffer from performance degradation over time, leading to a reduction in battery capacity and lifespan. Researchers are now exploring ways to improve cathode performance by carefully controlling the material composition and structure.

Layered cathodes made from a combination of nickel, cobalt and manganese have been designed to maximize energy capacity and ensure long-term stability.18 This innovation not only promises longer-lasting batteries for electric vehicles, but also demonstrates the potential for structural design to extend the lifespan of batteries in a variety of applications.

Advances in nanomaterials are also playing a key role in battery development, enabling the creation of novel electrode coatings and separators.19 These coatings help improve the efficiency and stability of batteries and protect their electrodes from degradation.

Additionally, nanotechnology is being used to develop battery separators with nanoscale modifications that can enhance thermal stability and prevent short circuits. These innovations are crucial in reducing material wear and improving the overall durability of batteries, allowing them to maintain peak performance over extended periods.

Transitioning to next-generation battery technologies

While Li-ion technology has long dominated energy storage, its limitations have driven the search for superior alternatives. SSBs and sodium-ion (Na-ion) batteries are two promising next-generation technologies addressing these challenges. By replacing flammable liquid electrolytes with solid alternatives, SSBs offer enhanced safety, higher energy density and faster charging times, making them ideal for use in EVs. Meanwhile, Na-ion batteries, though slightly heavier than their Li-ion counterparts, are well-suited for large-scale energy storage due to sodium's relative abundance and lower cost. Recognizing this potential, the prominent Chinese battery manufacturer CATL has already begun the mass production of Na-ion batteries.

"For fast charging, the key innovation is the science behind solvation architecture in liquid electrolytes, ion transport through the solid electrolyte interphase (SEI) and cathode electrolyte interphase (CEI), as well as the tortuosity and porosity of electrode engineering," said Professor Ying Shirley Meng, the Liew Family Professor in Molecular Engineering at the Pritzker School of Molecular Engineering. She also serves as the chief scientist of the Argonne Collaborative Center for Energy Storage Science (ACCESS) at Argonne National Laboratory and director of the Energy Storage Research Alliance (ESRA), a research initiative driving advancements in next-generation battery technologies.

"For the long cycle life of batteries, it is important to realize that there are no thermodynamic limits to cycle life. If we can suppress all parasitic reactions in a cell, we can enable batteries to last for decades. This can be done and will be done," Meng added. "As for whether sodium-ion or solid-state batteries will succeed, my view is that we need one or two scalable TWh (terawatt-hour) battery chemistries. I am cautiously optimistic that both will be very successful, though the timing might be different."

The outlook for battery science

Rechargeable batteries have been instrumental in shaping modern technology, powering everything from smartphones to electric vehicles. However, the increasing demand for faster-charging, longer-lasting and safer energy storage solutions continues to drive significant advancements in battery science.

Innovations in materials, such as silicon-based anodes and solid-state electrolytes, along with structural improvements like 3D electrodes and optimized cathodes, are revolutionizing battery performance. Emerging alternatives, including SSBs and Na-ion batteries, hold immense promise in addressing the limitations of conventional Li-ion technology. As research continues to accelerate, the future of energy storage is poised for transformative breakthroughs, paving the way for more efficient, reliable and sustainable battery technologies.

Technology Networks, 13 May 2025

https://technologynetworks.com

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Sugar-coated nanotherapy dramatically improves neuron survival in Alzheimer's model

2025-05-14

In these devastating illnesses, proteins misfold and clump together around brain cells, which ultimately leads to cell death. The innovative new treatment effectively traps the proteins before they can aggregate into the toxic structures capable of penetrating neurons. The trapped proteins then harmlessly degrade in the body.

The "clean-up" strategy significantly boosted the survival of lab-grown human neurons under stress from disease-causing proteins.

Designated as an ACS Editor's Choice article, the study will be published on May 14 in the Journal of the American Chemical Society.

"Our study highlights the exciting potential of molecularly engineered nanomaterials to address the root causes of neurodegenerative diseases," said Northwestern's Samuel I. Stupp, the study's senior author. "In many of these diseases, proteins lose their functional folded structure and aggregate to make destructive fibers that enter neurons and are highly toxic to them.

"By trapping the misfolded proteins, our treatment inhibits the formation of those fibers at an early stage. Early stage, short amyloid fibers, which penetrate neurons, are believed to be the most toxic structures. With further work, we think this could significantly delay progression of the disease."

A pioneer in regenerative medicine, Stupp is the Board of Trustees Professor of Materials Science and Engineering, Chemistry, Medicine and Biomedical Engineering at Northwestern, where he has appointments in the McCormick School of Engineering, Weinberg College of Arts and Sciences and Feinberg School of Medicine. He also is the founding director of the Center for Regenerative Nanomedicine (CRN). Zijun Gao, a Ph.D. candidate in Stupp's laboratory, is the paper's first author.

The Stupp group led the development and characterization of the new therapeutic materials. Co-corresponding author Zaida Alvarez -- a researcher at the Institute for Bioengineering of Catalonia (IBEC) in Spain, former postdoctoral fellow in Stupp's laboratory and current visiting scholar at CRN -- led testing of the therapies in human neurons.

A sugar-coated solution

According to the World Health Organization, as many as 50 million people worldwide might have a neurodegenerative disorder. Most of these diseases are characterized by the accumulation of misfolded proteins in the brain, leading to the progressive loss of neurons. While current treatments offer limited relief, a dire need for new therapies remains.

To tackle this challenge, the researchers turned to a class of peptide amphiphiles, pioneered by the Stupp laboratory, that contain modified chains of amino acids. Peptide amphiphiles are already used in well-known pharmaceuticals including semaglutide, or Ozempic. In fact, the Northwestern investigators developed a similar molecule in 2012 that boosted insulin production.

"The advantage of peptide-based drugs is that they degrade into nutrients," Stupp said. "The molecules in this novel therapeutic concept break down into harmless lipids, amino acids and sugars. That means there are fewer adverse side effects."

Over the years, Stupp's research group has designed many peptide-based materials for different therapeutic purposes. To develop a peptide amphiphile to treat neurodegenerative diseases, his team added an extra ingredient: a natural sugar called trehalose.

"Trehalose is naturally occurring in plants, fungi and insects," Gao said. "It protects them from changing temperatures, especially dehydration and freezing. Others have discovered trehalose can protect many biological macromolecules, including proteins. So, we wanted to see if we could use it to stabilize misfolded proteins."

Instability is key

When added to water, the peptide amphiphiles self-assembled into nanofibers coated with trehalose. Surprisingly, the trehalose destabilized the nanofibers. Although it seems counterintuitive, this decreased stability exhibited a beneficial effect.

By themselves, the nanofibers are strong and well-ordered -- and resistant to rearranging their structure. That makes it more difficult for other molecules, like misfolded proteins, to integrate into the fibers. Less stable fibers, on the other hand, became more dynamic -- and more likely to find and interact with toxic proteins.

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"Unstable assemblies of molecules are very reactive," Stupp said. "They want to interact with and bond to other molecules. If the nanofibers were stable, they would happily ignore everything around them.

Searching for stability, the nanofibers bonded to amyloid-beta proteins, a key culprit implicated in Alzheimer's disease. But the nanofibers didn't just stop the amyloid-beta proteins from clumping together. The nanofibers fully incorporated the proteins into their own fibrous structures -- permanently trapping them into stable filaments.

"Then, it's no longer a peptide amphiphile fiber anymore," Stupp said. "But a new hybrid structure comprising both the peptide amphiphile and the amyloid-beta protein. That means the nasty amyloid-beta proteins, which would have formed amyloid fibers, are trapped. They can no longer penetrate the neurons and kill them. It's like a clean-up crew for misfolded proteins.

"This is a novel mechanism to tackle progression of neurodegenerative diseases, such as Alzheimer's, at an earlier stage. Current therapies rely on the production of antibodies for well-formed amyloid fibers."

Improving neuron survival

To assess the therapeutic potential of the new approach, the scientists conducted laboratory tests using human neurons derived from stem cells. The results showed the trehalose-coated nanofibers significantly improved the survival of both motor and cortical neurons when exposed to the toxic amyloid-beta protein.

Stupp says the novel approach of using unstable nanofibers to trap proteins offers a promising avenue for developing new and effective therapies for Alzheimer's, ALS and other neurodegenerative conditions. Much like cancer treatments combine multiple therapies -- like chemotherapy and surgery or hormone therapy and radiation -- Stupp said the nanotherapy might be most effective when combined with other treatments.

"Our therapy might work best when targeting diseases at an earlier stage -- before aggregated proteins enter cells," Stupp said. "But it's challenging to diagnose these diseases at early stages. So, it could be combined with therapies that target later-stage symptoms of the disease. Then, it could be a double whammy."

The study was supported by the Center for Regenerative Nanomedicine, the Chemistry of Life Processes Institute, the Spanish Ministry of Science,

the National Institute on Aging of the National Institutes of Health and the European Union's NextGenerationEU.

Science Daily, 14 May 2025

https://sciencedaily.com

Sponge-like pellets show promise for capturing carbon dioxide from industrial sources

2025-05-13

Capturing carbon dioxide (CO_2) from industrial processes is a necessary step to achieve net-zero greenhouse gas emissions and minimize the severe impacts of climate change. A new report from the University of Nottingham explains The study, published in the Chemical Engineering Journal, explored the use of novel sponge-like materials which can trap CO2, preventing it from entering the atmosphere from sources such as power plants.

These advanced materials are known as magnetic framework composites (MFCs), which combine two components: porous materials called metal-organic frameworks (MOFs) that trap CO_2, and magnetic nanoparticles, which allow the material to be heated efficiently using magnetic fields to release the captured gas for storage or further use.

Until now, the focus of research on these materials has been on their powder form, which isn't practical for real-world applications. To address this, the researchers in this study developed a method to shape the MFC powders into small, strong pellets using different polymer binders. They then tested how these different formulations affected the material's ability to absorb CO_2, its strength, and its heat transfer properties.

The results showed that some binders, such as polyvinyl alcohol (PVA), substantially increased the mechanical strength of the pellets, with just 4% binder resulting in a 107% increase in pellet strength. The inclusion of magnetic nanoparticles was also found to significantly improve how well the materials can transfer heat, which is important for making the CO_2 capture and release process more energy efficient.

This work is an important step toward making these materials suitable for large-scale CO_2 capture technologies, helping to reduce industrial carbon emissions and supporting climate change mitigation efforts.

"This exciting research brings us closer to developing scalable, energy-efficient carbon capture technologies. By improving the strength and

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thermal performance of these materials, we're opening up routes for their use in industrial applications, helping to prevent CO_2 emissions at source," says Dr. Luke Woodliffe, Research Fellow in Complex Hydrides that sponge-like pellets may hold the key to preventing CO_2 from entering the atmosphere, supporting future net zero ambitions.

sPhys Org, 13 May 2025

https://phys.org

The Breakthrough Tech Turning CO2-Rich Gas Into Chemical Gold

2025-05-11

Scientists developed a super-dry reforming process using SOECs and Rh-CeCO2 catalysts to efficiently convert CO2-rich methane into syngas with high conversion rates and nearly 100% selectivity.

Dry reforming of methane (DRM) is a well-established method for converting carbon dioxide (CO_2) and methane (CH_4) into synthesis gas (syngas), which is a valuable mixture of hydrogen (H_2) and carbon monoxide (CO). This process is typically conducted with a feed ratio of CO_2 to CH_4 close to one. However, future methane sources such as carbon dioxide-rich natural gas are expected to contain much higher levels of CO_2. These elevated concentrations often require costly separation processes in order to reach the desired methane content.

In a study published in Nature Chemistry, a research team led by Professors Guoxiong Wang, Jianping Xiao, and Xinhe Bao from the Dalian Institute of Chemical Physics at the Chinese Academy of Sciences introduced an innovative method for directly producing syngas. This process, referred to as super dry reforming of methane, operates with a CO_2 to CH_4 ratio equal to or greater than two. It enables direct conversion of CO_2-rich natural gas through high-temperature tandem electro-thermocatalysis using solid oxide electrolysis cells (SOECs).

These electrolysis cells function at high temperatures ranging from 600 to 850 degrees Celsius and are capable of converting carbon dioxide and water into carbon monoxide and hydrogen. Their advantages include high reaction rates, strong energy efficiency, and relatively low operating costs. As a result, they offer significant potential for carbon dioxide utilization, hydrogen production, and renewable energy storage.

Recognizing the compatibility of operating temperatures between SOECs and DRM, the researchers designed a process that combines DRM, the reverse water-gas shift reaction, and water electrolysis within the cathode of the electrolysis cell.

A Coupled Electrochemical System

In this setup, the in situ electrochemical reduction of H2O byproduct generates H2 and O2- ions. These O2- ions then migrate through the electrolyte and are electrochemically oxidized to O2 at the anode under an applied potential. This process drives the RWGS equilibrium forward, enhancing CO2 conversion and H2 selectivity beyond conventional thermodynamic limitations.

Moreover, researchers in situ exsolved Rh nanoparticles onto a CeO2-x support, creating high-density Ce3+-VO-Rhδ+ interfacial active sites. When operating at a CO2/CH4 ratio of 4, the system achieved CH4 conversion of 94.5% and CO2 conversion of 95.0%, with nearly 100% selectivity toward CO and H2. The apparent methane reducibility reached the theoretical maximum of 4.0.

Further investigation revealed that Rhδ+ sites are primarily responsible for CH4 dissociation, while the Ce3+-VO-Rhδ+ interface—rich in oxygen vacancies—promotes CO2 adsorption, activation, and the RWGS reaction. This same interface also catalyzed electrochemical H2O reduction, boosting both CO2 conversion and H2 selectivity.

"Our study may open a new avenue for the direct utilization of CO2-rich natural gas and industrial tail gases using renewable energy," said Prof. Wang.

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