CHEMWATCH

Bulletin Board

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ASIA PACIFIC

Safe Work Australia has published a new model Code of Practice for managing risks of respirable crystalline silica in the workplace to help protect workers from silica.

2025-08-29

Breathing in respirable crystalline silica (silica dust) can cause serious health conditions like silicosis and lung cancer. Silica dust is generated when processing material containing silica, for example cutting, sanding or polishing. All silica-related diseases are preventable by eliminating or minimising exposure to silica dust.

The model Code of Practice gives employers practical information on how to comply with the WHS Regulations to manage risks of silica dust.

View the model Code of Practice: Managing risks of respirable crystalline silica in the workplace.

More information about silica is available on Safe Work Australia's website

Read More

Safe Work Australia, 29-08-25

https://www.safeworkaustralia.gov.au/doc/model-code-practice-managing-risks-respirable-crystalline-silica-workplace

Download the latest list of chemicals on the Inventory

2025-008-29

We took a snapshot of all the chemicals on the Inventory on 25 August 2025 and published it as a downloadable spreadsheet in an Excel format (.xlsx).

We frequently update the Inventory and usually publish a downloadable version twice a year.

If you are looking for the most up-to-date information, use our Inventory search to find chemicals and check any regulatory obligations associated with importing or manufacturing those chemicals.

The downloadable inventory does not contain links to assessments (statements or reports). You can search for these on our website.

Read More

AICIS, 29-08-25

https://services.industrialchemicals.gov.au/search-inventory/

Chemical added to the Inventory following issue of assessment certificate - 25 August 2025

2025-08-29

The following industrial chemical has been added to the Australian Inventory of Industrial Chemicals (Inventory) in accordance with section 83 of the Industrial Chemicals Act 2019.

Chemical added to the inventory following issue of assessment certificate

AICIS Approved Chemical Name (AACN)	**Ethanaminium, 2-[3-(dioxoheteromonocycle) propoxy]-*N,N,N*-trimethyl-, monopolyisobutylene derivs., Me oxalates**
Defined scope of Assessment	The polymer has been assessed: as imported into Australia at up to 65 tonnes/year as imported in formulations containing the assessed polymer at up to 18% concentration for end use as a component of fuel additives at up to 150 ppm concentration
Listing date	21/08/2025

Read More

AICIS, 29-08-25

https://www.industrialchemicals.gov.au/news-and-notices/chemical-added-inventory-following-issue-assessment-certificate-25-august-2025

AMERICA

New Data Shows Chemical Releases Decline While American Economy Thrives

2025-08-21

Today, U.S. Environmental Protection Agency (EPA) released its Toxics Release Inventory (TRI) National Analysis for reporting year 2023, which shows that toxic chemical releases have decreased as the chemical industry's contribution to the national Gross Domestic Product (GDP) has increased. This demonstrates that industry can simultaneously protect the environment and grow the nation's economy.

"With this analysis, EPA is showing how American industry continues to improve its environmental performance while growing the economy," said Nancy Beck, Principal Deputy Assistant Administrator for EPA's Office of Chemical Safety and Pollution Prevention.

Highlights from the 2023 TRI National Analysis include:

- Between 2014 and 2023, environmental releases of TRI-listed chemicals fell 21%, including a 32% decrease in air releases. During this 10-year period, releases from manufacturing facilities decreased by 15% while the manufacturing sector's contribution to the U.S. GDP increased by 13%.
- A feature profile on automotive manufacturing which shows that, from 2014 to 2023, this sector's value to the economy increased by 34% while chemical releases decreased by 14%.
- In 2023, facilities managed 90% of their TRI chemical waste through preferred practices such as recycling, energy recovery and treatment.
- From 1998 to 2023, companies managing TRI chemicals, which include lead, mercury, dioxins, and per-and-polyfluoralkyl substances (PFAS) chemicals, have decreased releases by 54% while the national GPD has increased by 74%.
- For reporting year 2023, nine PFAS were added to the reporting requirements for a total of 189 PFAS tracked by the TRI program. During 2023, 61 facilities managed 1.6 million pounds of PFAS as waste and decreased chemical releases by 16%.

Read More

US EPA, 21-08-25

https://www.epa.gov/newsreleases/new-data-shows-chemical-releases-decline-while-american-economy-thrives

EPA Announces Public Hearings and Extends Comment Period for Multiple Air Regulations

2025-08-21

What: On August 15, 2025, the U.S. Environmental Protection Agency (EPA) announced it would hold public hearings on and extend the comment deadlines for three different Clean Air Act proposed regulations.

Why: The three rules covered by EPA's announcement cover oil, natural gas, integrated iron and steel manufacturing, and coke ovens.

- EPA has extended the comment deadline for the interim final rule "Extension of Deadlines in Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review Final Rule" until October 2, 2025. A virtual public hearing will be held on September 2, 2025.
- EPA has extended the comment deadline for the interim final rule "National Emission Standards for Hazardous Air Pollutants for Integrated Iron and Steel Manufacturing Facilities Technology Review" until October 3, 2025. A virtual public hearing will be held on September 3, 2025.
- EPA has extended the comment deadline for the interim final rule "National Emission Standards for Hazardous Air Pollutants for Coke Ovens: Pushing, Quenching, and Battery Stacks, and Coke Oven Batteries; Residual Risk and Technology Review, and Periodic Technology Review" until October 6, 2025. A virtual public hearing will be held on September 4, 2025.

Read More

US SBA, 21-08-25

https://advocacy.sba.gov/2025/08/18/epa-announces-public-hearings-and-extends-comment-period-for-multiple-air-regulations/

EPA Grants 63 Small Refinery Exemptions

2025-08-27

The Environmental Protection Agency (EPA) has completed its long-delayed adjudication of 175 petitions for small refinery exemptions (SREs) under the Renewable Fuel Standard (RFS), covering compliance years 2016 through 2024. The August 22 decision provides long-awaited clarity to refiners, renewable fuel producers, and credit markets after years of litigation and shifting interpretations of disproportionate economic hardship.

EPA granted 63 petitions in full, 77 in part, denied 28, and found 7 ineligible, affecting roughly 5.34 billion Renewable Identification Numbers (RINs) across nearly a decade of compliance years.

“Returning previously retired RINs is the least disruptive and most equitable way to implement exemptions for past compliance years,” said Aaron Szabo, EPA Assistant Administrator for Air and Radiation, in the August 2025 Federal Register notice.

What the Decision Covers:
Petitions reviewed: 175 from 38 refineries nationwide.

- Compliance years: 2016–2024 (EPA has not yet ruled on 2025 petitions).
- **Outcome:** 63 full exemptions, 77 partial (50%), 28 denials, 7 ineligible.
- Credits affected: Approximately 5.34 billion RINs; about 1.39 billion remain usable because of the two-year RIN credit life.

The agency emphasized that billions of credits are involved, but the impact on current and future compliance years will be limited. EPA anticipates little effect on 2024 and beyond because most of the affected RINs have already expired.

Read More

Environmental Energy Leader, 27-08-25

https://www.environmentenergyleader.com/stories/epa-grants-63-small-refinery-exemptions,89132

EUROPE

EU economy greenhouse gas emissions: +3.4% in Q1 2025

2025-08-14

The EU economy greenhouse gas emissions were estimated at 900 million tonnes of CO2-equivalents (CO2-eq) in the first quarter of 2025, a 3.4% increase compared with the same quarter of 2024 (871 million tonnes of CO2-eq). At the same time, the EU’s gross domestic product (GDP) increased by 1.2% in the first quarter of 2025, compared with the same quarter of 2024.

This information comes from data on quarterly estimates of greenhouse gas emissions by economic activity published by Eurostat today. Quarterly estimates of greenhouse gas emissions complement quarterly socio-economic data, such as GDP or employment. This article presents the key findings from the more detailed Statistics Explained article on quarterly greenhouse gas emissions.

Greenhouse gas emissions decreased in 7 EU countries

In the first quarter of 2025, compared with the same quarter of 2024, increases in greenhouse gas emissions were estimated for 20 EU countries, while decreases were estimated for the remaining 7 countries.

6 countries (Bulgaria, Czechia, Cyprus, Poland, Hungary and Greece) were estimated to have increased their emissions by more than 5%.

The largest reductions in greenhouse gases were estimated for Malta (-6.2%), Finland (-4.4%) and Denmark (-4.3%). Out of the 7 EU countries that registered decreases in greenhouse gas emissions, 3 also recorded a decline in their GDP (Estonia, Latvia and Luxembourg). The other 4 EU countries (Denmark, Finland, Malta and Sweden) were estimated to have decreased emissions while growing their GDP.

Read More

Eurostat, 14-08-25

https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250814-1

Public consultation opens on restricting PFAS in firefighting foams

2025-08-18

Six-month consultation seeks views on UK REACH technical dossier and proposed restrictions.

The Health and Safety Executive (HSE), in its role as the Agency for UK REACH, today opened a six-month public consultation to gather stakeholder views on per- and polyfluoroalkyl substances (PFAS) in firefighting foams.

The opening of the UK REACH consultation links to the publication of the Annex 15 restriction report, which presents HSE's scientific analysis and evidence base for potential restrictions on PFAS use in firefighting foams in Great Britain.

The consultation provides an opportunity for those who use foams from industry, and other stakeholders, such as trade associations, to comment on the proposals before the opinions are made and sent to the Defra Secretary of State, and the Scottish and Welsh Governments for a decision on whether to bring a restriction into law.

Read More

UK HSE, 18-08-25

https://press.hse.gov.uk/2025/08/18/public-consultation-opens-on-restricting-pfas-in-firefighting-foams/

Chemical companies lobbying MPs not to ban Pfas

2025-08-28

Chemical firms are lobbying MPs not to ban "forever chemicals" in the same way as proposed in the EU, using arguments disputed by scientists and described as "big tobacco playbook" tactics, it can be revealed.

Pfas, short for per- and polyfluoroalkyl substances and commonly known as forever chemicals owing to their persistence in the environment, are a family of about 10,000 chemicals, some of which have been linked to a wide range of serious illnesses, including certain cancers. They are used across a range of industries, from cosmetics to firefighting.

In May, MPs on the environmental audit committee (EAC) launched an inquiry into Pfas, with a call for evidence on the uses and risks of the substances, and options for how to regulate them.

What are PFAS, how toxic are they and how do you become exposed?

Read more

Exclusive analysis by the Ends Report and the Guardian of the responses submitted to the parliamentary committee has revealed major chemical producers, from UK-based companies to large US corporations, urging parliamentarians that any incoming UK Pfas regulation should be more limited than that currently proposed in the EU, which targets the whole family of chemicals.

Specifically, many of the responses from chemicals firms analysed by the Ends Report call for a commonly used type of Pfas called fluoropolymers – used across a broad range of industries including domestic cookware production, such as non-stick frying pans, and pharmaceuticals – to be spared the same kind of regulation as other types of forever chemicals, on the basis that they are not as harmful.

Read More

The Guardian, 28-08-25

https://www.theguardian.com/environment/2025/aug/28/chemical-companies-lobbying-mps-not-to-ban-pfas-forever-chemicals

INTERNATIONAL

UNEP and ICAO launch $82.5 Million project to eliminate harmful firefighting foams in African airports

2025-08-19

The UN Environment Programme (UNEP) and the International Civil Aviation Organization (ICAO) have jointly launched the Fortifying Infrastructure for Responsible Extinguishment (FIRE) project, which aims to phase out the use of toxic fluorinated firefighting foams and replace them with safer alternatives at major airports in Egypt, Ethiopia, Kenya, Nigeria, and South Africa.

FIRE – a $82.5 million initiative with a $10 million grant from the Global Environment Facility (GEF) and $72.5 million in co-financing from partners – will phase out firefighting foams containing PFAS (per- and polyfluoroalkyl substances), hazardous "forever chemicals" linked to serious environmental and health risks.

“The FIRE project shows how sector-focused action can drive the elimination of hazardous chemicals across value chains,” said Anil Sookdeo, Senior Chemicals Specialist, Global Environment Facility (GEF). “The GEF is proud to support this effort, which we hope will inspire both participating countries and the wider aviation sector to transition to PFAS-free firefighting foams.”

“FIRE is an important initiative that empowers countries to eliminate one of the most harmful groups of pollutants found in firefighting foam supply chains,” said Sheila Aggarwal-Khan, Director of UNEP’s Industry and Economy Division. “It supports a practical transition to safer, accessible, and affordable alternatives, showing that environmental and health protection can go hand in hand with business and operational viability.”

Read More

UNEP, 19-08-25

https://www.unep.org/news-and-stories/press-release/unep-and-icao-launch-825-million-project-eliminate-harmful

When Europe’s electronics become Africa’s waste: a Nigerian take on producer responsibility

2025-08-25

The European Union is recognised for its strong environmental policies, yet much of its waste is dumped abroad. Aliyu Umar Sadiq explores what happens when used electronics are exported from the EU to Nigeria.

Aliyu Umar Sadiq is a Visiting Researcher at the European Environmental Bureau (EEB), and a Co-Founder of Ecocykle Development Foundation, a Nigerian NGO.

The export of second-hand products from the EU to Africa can benefit receiving countries, providing wider access to affordable goods. But when the fees that producers pay to finance waste treatment – the so-called Extended Producer Responsibility (EPR) fees – remain in Europe, African countries are left to handle the waste management of imported products without the necessary support.

This places an unfair, heavy burden on emerging African economies, as shown by a study on the implications of second-hand electronics and vehicles exports from Europe to Ghana and Nigeria, published by the EEB.

Read More

EEB, 25-08-25

https://meta.eeb.org/2025/08/26/when-europes-electronics-become-africas-waste-a-nigerian-take-on-producer-responsibility

ECHA update on the per- and polyfluoroalkyl substances (PFAS) restriction process

2025-08-27

The European Chemicals Agency’s (ECHA) scientific committees for Risk Assessment (RAC) and for Socio-Economic Analysis (SEAC) have been evaluating the proposal to restrict PFAS in the EU/EEA since March 20231. This restriction proposal covers more than 10 000 substances and many sectors of application. Following its submission to ECHA, the subsequent six-month consultation has resulted in more than 5 600 responses from all stakeholder groups (Industry, NGOs, institutions, academia, national authorities, agencies, civil society actors, citizens etc.).

The Committees’ evaluation is being carried out in batches, focusing on the 14 different sectors2 analysed in the originally submitted restriction proposal, as well as PFAS manufacturing and horizontal issues. In parallel, the national authorities of Denmark, Germany, the Netherlands, Norway and Sweden, who prepared the proposal (the Dossier Submitter), have progressively updated their initial report to address the significant number of responses received during the consultation, sector by sector. This updated report, called the Background Document, forms the basis for the Committees’ opinions.

Read More

ECHA, 27-08-25

https://echa.europa.eu/documents/10162/111425157/echa_update_pfas_en.pdf/6775e241-204e-af0a-a2d0-4c16ba2c138d?t=1756287349062

Who Am I?

2025-09-05

I am element number 14. I am a metalloid, meaning I have properties of both metals and nonmetals. You’ll find me everywhere in modern technology, forming the basis of computer chips and solar cells due to my unique semiconducting abilities. I’m the second most abundant element in Earth’s crust, often found in sand and quartz. I have a relatively high melting point and a grayish, lustrous appearance.

(Send in your answers and get a surprise Chemwatch merch from us for free)

I am element number 14.

Dimethylacetamide

2025-09-05

It is a colourless (to yellow), water miscible, oily, polar, hygroscopic liquid with a faint, specific amine-like odour. DMAc is miscible with most other organic solvents including alcohols, ethers, esters ketones, chlorinated and aromatic compounds, although it is poorly soluble in saturated aliphatic hydrocarbons. It has a good thermal and chemical stability. [1,2]

USES [2,3]

Dimethylacetamide is used for many organic reactions and industrial applications. It can be a reactor solvent or plasticiser for cosmetic and pharmaceuticals, an extraction agent for gases and oils. It can be applied as a solvent for the manufacture of films, acrylic fibres, X-ray contrast media, polyimide resins, polysulfones and cellophane.

Dimethylacetamide (DMA or DMAc), also known as acetic acid-dimethylamide, N,N-dimethylacetamide or acetyldimethylamine, is an organic compound with the formula CH3C(O)N(CH3)2.[1]

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

Dimethylacetamide is used in industrial settings only. The possible routes of potential exposure for workers are inhalation, contact with the skin/eyes and ingestion. Dimethylacetamide may enter the body through the skin.

HEALTH EFFECTS [4]

Acute Health Effects

- Swallowing of the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis; serious consequences may result.
- When N,N-dimethylacetamide (DMAc) given to humans in daily doses (400 mg/kg for 3 days), depression, lethargy, confusion and disorientation ensued. In some patients there were visual and auditory hallucinations, perceptual distortions, delusions, emotional detachment and effective blunting, all reminiscent of the reactions induced by mescaline and by lysergic acid derivatives.
- Considered an unlikely route of entry in commercial/industrial environments.
- The liquid may produce gastrointestinal discomfort and may be harmful if swallowed.

Eye

- Evidence exists, or practical experience predicts, that the material may cause eye irritation in a substantial number of individuals.
- Prolonged eye contact may cause inflammation characterised by a temporary redness of the conjunctiva (similar to windburn).

Skin

- Skin contact with the material may be harmful; systemic effects may result following absorption.
- The material is not thought to be a skin irritant (as classified using animal models). Temporary discomfort, however, may result from prolonged dermal exposures.
- Open cuts, abraded or irritated skin should not be exposed to this material.
- Entry into the blood-stream through, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

Inhalation

- Inhalation of vapours or aerosols (mists, fumes), generated by the material during the course of normal handling, may be harmful.
- The material is not thought to produce respiratory irritation (as classified using animal models). Nevertheless inhalation of vapours, fumes or aerosols, especially for prolonged periods, may produce respiratory discomfort and occasionally, distress.
- Inhalation of N,N-dimethylacetamide (DMAc) may cause headache, nausea, vomiting, intolerance to alcohol, abdominal spasm and diarrhoea. Large doses can result in depression, lethargy, disorientation, and visual and auditory hallucinations.

Other Effects

Ample evidence exists, from results in experimentation, that developmental disorders are directly caused by human exposure to the material. Limited evidence suggests that repeated or long-term occupational exposure may produce cumulative health effects involving organs or biochemical systems. Repeated exposure of 20 to 25 ppm N,N-dimethylacetamide (DMAc) (due to appreciable skin absorption) has caused jaundice in workers; evidence of liver damage and hepatic dysfunction is clear. Workers exposed to DMAc for 2-10 years showed abnormal liver function. Chronic exposure can result in cumulative liver and kidney damage. (Repeated dermal application of the liquid to dogs caused severe fatty infiltration of the liver; repeated exposure of rats to the vapour resulted in focal necrosis of the liver.) Teratogenic effects from dermal application were reported in rats when DMAc was applied on gestation days 10 and 11 at a total does of 2400 mg/kg body weight. When DMAc was administered to rats by gavage at a dosage of 400 mg/kg/day on days 6 through 19 of gestation, malformations of the heart, major blood vessels and oral cavity were seen. Maternal toxicity and post-implantation loss were also seen at this dose. Some evidence exists that a demethylation metabolite, acetamide, is a rat liver carcinogen.

SAFETY

First Aid Measures [5]

- Ingestion: If swallowed do NOT induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain open airway and prevent aspiration. If spontaneous vomiting appears imminent or occurs, hold patient's head down, lower than their hips to help avoid possible aspiration of vomitus.
- Eye contact: Wash out immediately with fresh running water. Ensure complete irrigation of the eye by keeping eyelids apart and away from eye and moving the eyelids by occasionally lifting the upper and lower lids.
- Skin contact: Immediately remove all contaminated clothing, including footwear. Flush skin and hair with running water (and soap if available).
- Inhalation: If fumes or combustion products are inhaled remove from contaminated area. Lay patient down. Keep warm and rested.
- Note to physician: Any material aspirated during vomiting may produce lung injury. Therefore emesis should not be induced mechanically or pharmacologically. Treat symptomatically for poisons (where specific treatment regime is absent).

Workplace Controls & Practices [4]

- Engineering controls are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible. In addition, the following control is recommended: Where possible, automatically pump liquid dimethylacetamide from drums or other storage containers to process containers.
- Good work practices can help to reduce hazardous exposures. The following work practices are recommended: Workers whose clothing has been contaminated by dimethylacetamide should change into clean clothing promptly. Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to dimethylacetamide. Eye wash fountains should be provided in the immediate work area for emergency use. If there is the possibility of skin exposure, emergency shower facilities should be provided. At the end of the workshift, wash any areas of the body that may have contacted dimethylacetamide, whether or not known skin contact has occurred. Do not eat, smoke, or drink where dimethylacetamide is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating, drinking, smoking, or using the toilet.

Personal Protective Equipment [5]

- The following personal protective equipment is recommended when handling dimethylacetamide:
- Clothing: Wear solvent-resistant gloves and clothing. Safety equipment suppliers/manufacturers can provide recommendations on the most protective glove/clothing material for your operation.
- All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.
- Safety equipment manufacturers recommend- Butyl Rubber as a protective material.
- Eye Protection: Wear indirect-vent, impact and splash resistant goggles when working with liquids. Wear a face shield along with goggles when working with corrosive, highly irritating or toxic substances. Contact lenses should not be worn when working with this substance.
- Respiratory Protection: Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training,
- respirator fit testing and medical exams, as described in OSHA 1910.134. Where the potential exists for exposure over 10 ppm, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in a pressure-demand or other positive-pressure mode. For increased protection use in combination with an auxiliary self-

contained breathing apparatus operated in a pressure-demand or other positive-pressure mode. Exposure to 300 ppm is immediately dangerous to life and health. If the possibility of exposure above 300 ppm exists, use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in a pressure-demand or other positive-pressure mode.

REGULATION

United States

OSHA: The Occupational Safety & Health Administration has set the following Permissible Exposure Limits (PEL) for dimethylacetamide:

General Industry: 29 CFR 1910.1000 Z-1 Table -- 10 ppm, 35 mg/m3 TWA; Skin

Construction Industry: 29 CFR 1926.55 Appendix A -- 10 ppm, 35 mg/m3 TWA; Skin

Maritime: 29 CFR 1915.1000 Table Z-Shipyards -- 10 ppm, 35 mg/m3 TWA; Skin

ACGIH: The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (TLV) for dimethylacetamide of 10 ppm, 36 mg/m3 TWA; Skin; Appendix A4 - Not Classifiable as a Human Carcinogen; BEI (TLV listed under N,N-Dimethylacetamide)

NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for dimethylacetamide of 10 ppm, 35 mg/m3 TWA; Skin

REFERENCES

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4. http://www.cdc.gov/niosh/docs/81-123/pdfs/0218.pdf
5. http://datasheets.scbt.com/sc-250514.pdf
6. www.nj.gov/health/eoh/rtkweb/0736.pdf

7. https://www.osha.gov/dts/chemicalsampling/data/CH_235600.html

Common plant compound builds tougher cancer-fighting attack cells

2025-08-03

A carotenoid that's already widely available in fruit and vegetables, and as a supplement, has been found to bolster the cancer-fighting abilities of immune cells, making it a promising new candidate that could help shrink tumors during immunotherapy treatment.

Following years of work investigating natural compounds to enhance cancer therapies, researchers from the University of Chicago have discovered that zeaxanthin – a carotenoid that promotes eye health – boosts the activity of the immune system's CD8+ T cells, which seek and destroy cancerous tumor cells.

"We were surprised to find that zeaxanthin, already known for its role in eye health, has a completely new function in boosting anti-tumor immunity," said senior author Jing Chen, Professor of Medicine at the University of Chicago. "Our study show that a simple dietary nutrient could complement and strengthen advanced cancer treatments like immunotherapy."

Screening a large blood nutrient library – the range of nutrients measured in blood tests – the researchers found that zeaxanthin stabilizes and strengthens the formation of T-cell receptor (TCR) structures on CD8+ T cells when the immune cells encounter cancer growths. This then activates stronger signaling within cells, enhancing T-cell activation, cytokine production and tumor-killing abilities. Basically, it equips the immune cells with what they need to mount a fiercer fight.

In mouse models, animals given a diet high in zeaxanthin exhibited significantly slower tumor growth. When combined with immune checkpoint inhibitors – the breakthrough immunotherapy that prevents the immune system from attacking healthy cells – the T cells' tumor-fighting capacity was further enhanced. When tested on human T cells, which had been developed to recognize a range of tumor antigens, zeaxanthin bolstered the immune cells' power in killing off melanoma, multiple myeloma and glioblastoma cells.

"Our data show that zeaxanthin improves both natural and engineered T-cell responses, which suggests high translational potential for patients undergoing immunotherapies," Chen said.

Zeaxanthin is a type of xanthophyll – a yellow carotenoid pigment found broadly in nature – already available as a supplement for eye health, and

found in dark leafy greens like kale, as well as orange peppers, mango and corn. And because zeaxanthin has a well-known safety profile, it could be easily incorporated into existing cancer immunotherapy treatment regimens.

While clinical trials will be required to see if the positive results from the lab and mice studies can be replicated in cancer patients, zeaxanthin is a promising new avenue of research aimed at making immunotherapy more successful. Earlier studies have found that a range of natural compounds – like those found in licorice and beans – can potentially improve the body's response to cancer cells.

"Our findings open a new field of nutritional immunology that looks at how specific dietary components interact with the immune system at the molecular level," Chen said. "With more research, we may discover natural compounds that make today's cancer therapies more effective and accessible."

The research was published in the journal Cell Reports Medicine.

New Atlas, 3 September 2025

https://newatlas.com

Researchers Turn Cherry Waste Into Antioxidant-Rich Supplement

2025-08-22

The powder was found to protect against the harmful effects of age-related diseases such as Alzheimer's disease in laboratory models.

Kent biosciences researchers, working closely with RentACherryTree (a small agricultural business in East Sussex), have developed an innovative way to turn waste cherries into a valuable, health-boosting food ingredient.

Cherries are naturally rich in anthocyanins and quercetin, which are pigments known for their antioxidant and anti-inflammatory properties. The study, recently published in the journal Antioxidants, shows that by upcycling damaged or discoloured cherries destined for landfill into a natural powder rich in anthocyanins, food producers can both reduce agricultural waste and create affordable, nutritious products. The powder was found to protect against harmful effects linked to age-related diseases such as Alzheimer's disease in laboratory models, underlining its potential as a functional food ingredient.

The researchers analysed cherry juice, pulp and pomace's retention of anthocyanin to reach their conclusions. Notably, greater biological activity was observed in developing the pulp powder than juice alone, suggesting that consuming the anthocyanin-rich cherry powder may bring more health benefits than extracts or supplements.

Kent is known for being the largest cherry-producing region in the UK. This grower-researcher collaborative project highlights how academic expertise and local farming knowledge can come together to address pressing challenges in agriculture. By transforming produce that would otherwise be discarded, the initiative supports sustainability, strengthens local food systems, and opens up new opportunities for healthier, low-cost food options for communities.

Dr Marina Ezcurra, the project's lead researcher based in Kent's School of Natural Sciences, said: 'Working with local growers has been key to this success. Together we are showing that agricultural by-products don't need to go to waste – they can become part of the solution to producing sustainable and accessible healthy foods.

'Our newly discovered innovation is a scientific approach that could be adopted at scale in Kent and other agricultural regions, and we look forward to carrying out further research to help drive this forward.'

Dr Sarah Blackburn, first author of the study and a Senior Technician at Kent, added: 'What makes this work exciting is that we combined detailed analytical approaches with health measurements in inexpensive laboratory models that provide insights into human health. This allows us to demonstrate the potential of food waste to provide benefits for both people and the environment.'

The project was funded through grants from InnovateUK and Growing Kent & Medway.

Technology Networks, 22 August 2025

https://technologynetworks.com

Electrochemistry offers 'modest' boost to deuterium fusion reaction

2025-09-02

New experiments suggest that electrochemistry could influence nuclear fusion between deuterium atoms in a metal lattice. While the findings won't immediately pave the way for large-scale fusion reactors, they provide valuable insights for researchers striving to better understand the underlying processes.

'Nuclear fusion combines light atoms, like deuterium, into helium, releasing [substantial amounts of] energy,' says Curtis Berlinguette at the University of British Columbia in Canada. 'It's the same process that powers the sun.

The fusion of two atoms into a new one occurs when nuclei get close enough for the strong nuclear force to overcome their electrostatic repulsion. For deuterium atoms, this usually requires extremely high temperatures and pressures, which is why most conventional fusion experiments rely on massive reactors, like tokamaks, to confine super-hot plasmas, or lasers.

Berlinguette and his colleagues hoped that low-energy electrochemistry, operating at the modest eV scale, might nudge along fusion reactions that normally need energies millions of times higher. They used a palladium metal lattice to pack deuterium atoms close together, increasing the probability that two nuclei might fuse. 'We've shown that simple electrochemistry – using just one volt of electricity – can measurably increase nuclear fusion rates,' Berlinguette says.

For their experiments, the researchers created a custom benchtop particle accelerator, dubbed the Thunderbird Reactor. The device integrates three components: a plasma thruster, a vacuum chamber, and an electrochemical cell.

During the experiment, deuterium atoms are packed into a solid palladium lattice, which serves multiple roles in the setup: it acts as a cathode and membrane for the electrochemical cell, a target for D+ ions sourced from the plasma thruster, and a physical separator between the vacuum and the electrochemical cell.

'Our twist on lattice confinement fusion is that we use electrochemistry to enhance [the effect],' says Berlinguette. The team reports that by increasing the likelihood of fusion, deuterium–deuterium fusion rates were boosted by 15%.

'It's a small but important step toward understanding how to control fusion,' states Berlinguette. He describes the results as evidence that electrochemistry at room temperature can influence fusion rates, though the effect was modest.

No shortcut to the sun's core

Karl Lackner of the Max Planck Institute for Plasma Physics in Germany, who was not involved in the study, stresses that the results should not be mistaken for a breakthrough in 'cold fusion,' since the underlying reactions are still driven by ordinary particle collisions and increased fuel density rather than a new physical mechanism.

'I worry about how this may be perceived by a broader audience,' says Lackner. 'The publication could be taken as evidence of a novel synergy between electrochemistry and fusion, hinting at a path to 'cold', or at least cooler, fusion. The research itself is careful, but it reinforces points that have never really been in doubt.'

Lackner explains that it is well established that hydrogen isotopes such as deuterium can be packed into metal lattices at densities far higher than in gases at room temperature. When high-energy deuterium ions strike a palladium lattice loaded with deuterium, they penetrate to depths of 160–180 nanometers, encountering other deuterium atoms along the way, colliding with the trapped atoms and increasing the probability of fusion.

Omar Hurricane, an expert on nuclear fusion from the Lawrence Livermore National Laboratory in the US who was also not involved in the work, also says that it is 'unsurprising' that increasing the deuterium density would result in a small increase in the rate of fusion.

Hurricane also notes that even standard fusion setups can give variable results. 'For perspective, fusion reaction-rate formulas in the literature can differ by [up to] 10% – depending upon the temperature – when compared against each other,' says. A 15% increase in fusion rate is interesting, but not necessarily outside the uncertainty range, he adds.

The researchers themselves acknowledge the modesty of their results, emphasising that room-temperature electrochemistry is not a shortcut to the sun's core. Instead, their work demonstrates that careful control of deuterium can produce measurable changes in fusion rates, offering valuable insight into the subtle interplay between materials science and nuclear physics.

'Every credible advance brings us closer,' says Berlinguette. 'When you go exploring you are bound to learn something along the way.'

Update: This story was amended on 3 September 2025 to clarify the depth to which high-energy deuterium ions penetrate the palladium lattice.

Chemistry World, 2 September 2025

https://chemistryworld.com

Polymer ink fine-tunes water flow, boosting ethylene yield and cutting energy costs

2025-09-04

Maintaining American energy independence requires minimizing reliance on foreign countries to produce commodity chemicals and fuels. Using carbon dioxide electrolyzers to produce valuable chemical precursors such as ethylene provides one way to diversify domestic feedstocks. But, so far, these devices have been limited by their low efficiency, which makes them energy-intensive and costly.

In a new study, published in Chem Catalysis, researchers at Lawrence Livermore National Laboratory (LLNL) designed a new polymer ink, called an ionomer, that controls how gas and water move in electrochemical devices. By carefully balancing and directing the device chemistry, the ionomer improves energy efficiency of the conversion process.

"Adding the right ionomer lowered the overall voltage needed to run the device," said LLNL scientist and author Aditya Prajapati. "That means the device requires less electricity usage to make the same amount of product."

The ionomer is one small but crucial part of the electrochemical device.

"Our device is about the size of a sandwich, with several thin layers stacked together. Carbon dioxide gas flows in on one side and electricity drives the reaction inside," said LLNL postdoctoral researcher and author Nicholas Cross.

Inside the device, carbon dioxide encounters a copper catalyst layer that triggers a reaction to turn it into ethylene, a building block for plastics. The ionomer was sprayed as a coating onto this copper layer.

"You can think of the ionomer as a traffic controller for molecules: it controls the chemistry of the catalyst surface and makes sure the right amount of water and carbon dioxide reach the catalyst," said LLNL scientist and author Maxwell Goldman. "Without it, too much water can flood the device, or too little can starve the reaction."

The ionomer keeps the reaction balanced, which cuts down the energy needed to make valuable products like ethylene.

To create this important traffic controller, the team carefully attached chemicals to a stable polymer backbone. They tested the device with and without the ionomer and explored a number of ionomers with different water uptakes.

"We discovered that the amount of water the ionomer holds—the 'water content'—is a powerful lever that controls how much ethylene is produced," said LLNL scientist and author Chris Hahn. "Too little ionomer and the device floods; too much and it wastes energy. Finding the right balance allowed us to run the device at high performance and low voltage."

The researchers emphasized that the improved device performance and the deep understanding of the ionomer were made possible by combining polymer chemistry, experiments and multiphysics modeling. They hope this work will guide the design of the next generation of polymers in electrochemical devices.

Phys Org, 4 September 2025

https://phys.org

Artificial sweeteners linked to 60% acceleration in cognitive decline

2025-09-04

While artificial sweeteners were once touted as healthy alternatives to sugar, research continues to prove otherwise. Yet another study has now come along saying that six popular sweeteners might be truly terrible for our brains.

It's hard to find any good news about artificial sweeteners these days. This year alone, we've reported on how consuming just one diet soda a day that contains artificial sweeteners can increase type 2 diabetes risk by 38%; how aspartame works to cause cardiovascular disease; and how the popular sugar substitute, erythritol, can increase stroke risk.

Another study from 2023 pointed to aspartame's negative impact on learning and memory. Now, a new study from researchers in Brazil concludes that it's not only aspartame that can hurt our brains. The sweeteners aspartame, saccharin, acesulfame-k, erythritol, sorbitol, and xylitol were all found to impact overall cognition.

To reach their conclusion, the researchers examined questionnaires completed by 12,772 adults across Brazil with the average age of 52. Based on their answers, they divided the group into three subgroups based on their consumption of foods containing artificial sweeteners.

The highest group contained people who consumed about 191 mg/day, which is about the amount of aspartame found in a can of diet soda. The middle group took in about 64 mg/day of artificial sweeteners in their food, and the lowest group consumed an average of 20 mg/day.

The group was followed over the course of eight years and given cognitive tests at the beginning, middle, and end of the study. The tests measured working memory, word recall, processing speed, and verbal fluency.

After adjusting for natural aging and variables such as blood pressure, history of cardiovascular disease, and gender, the team concluded that those in the high-consumption group showed a 62% faster decline in cognitive health than those in the lowest group. The researchers say that this corresponds to about 1.6 years of brain aging. The middle group showed a 35% faster cognitive decline than the lowest group, equaling about 1.3 years of aging.

Additionally, the study revealed that the link between artificial sweeteners and cognitive decline was higher in those who had diabetes.

"While we found links to cognitive decline for middle-aged people both with and without diabetes, people with diabetes are more likely to use artificial sweeteners as sugar substitutes," said study co-author Claudia Kimie Suemoto from the University of São Paulo in Brazil. "More research is needed to confirm our findings and to investigate if other refined sugar alternatives, such as applesauce, honey, maple syrup or coconut sugar, may be effective alternatives."

There was a bit of good news – sort of – in the study. The researchers found that the links they discovered were not present in people over 60. They also discovered that consumption of the artificial sweetener, tagatose, did not correspond to cognitive decline regardless of how much was consumed.

The researchers acknowledge that a weakness in the study is that it relied on self-reported data from the questionnaires filled out by participants and that not all artificial sweeteners were included in the analysis. Still, they feel their work adds to the growing body of knowledge that refutes the health benefits of sugar substitutes.

“Low- and no-calorie sweeteners are often seen as a healthy alternative to sugar, however our findings suggest certain sweeteners may have negative effects on brain health over time,” concluded Suemoto.

The research has been published in the journal, Neurology.

New Atlas, 4 September 2025

https://newatlas.com

A simple metal could solve the world’s plastic recycling problem

2025-09-03

The future of plastic recycling may soon get much less complicated, frustrating and tedious.

In a new study, Northwestern University chemists have introduced a new plastic upcycling process that can drastically reduce -- or perhaps even fully bypass -- the laborious chore of pre-sorting mixed plastic waste.

The process harnesses a new, inexpensive nickel-based catalyst that selectively breaks down polyolefin plastics consisting of polyethylenes and polypropylenes -- the single-use kind that dominates nearly two-thirds of global plastic consumption. This means industrial users could apply the catalyst to large volumes of unsorted polyolefin waste.

When the catalyst breaks down polyolefins, the low-value solid plastics transform into liquid oils and waxes, which can be upcycled into higher-value products, including lubricants, fuels and candles. Not only can it be used multiple times, but the new catalyst can also break down plastics contaminated with polyvinyl chloride (PVC), a toxic polymer that notoriously makes plastics “unrecyclable.”

The study was published on Sept. 2 in the journal Nature Chemistry.

“One of the biggest hurdles in plastic recycling has always been the necessity of meticulously sorting plastic waste by type,” said Northwestern’s Tobin Marks, the study’s senior author. “Our new catalyst could bypass this costly and labor-intensive step for common polyolefin plastics, making recycling more efficient, practical and economically viable than current strategies.”

“When people think of plastic, they likely are thinking about polyolefins,” said Northwestern’s Yosi Kratish, a co-corresponding author on the paper.

“Basically, almost everything in your refrigerator is polyolefin based -- squeeze bottles for condiments and salad dressings, milk jugs, plastic wrap, trash bags, disposable utensils, juice cartons and much more. These plastics have a very short lifetime, so they are mostly single-use. If we don’t have an efficient way to recycle them, then they end up in landfills and in the environment, where they linger for decades before degrading into harmful microplastics.”

A world-renowned catalysis expert, Marks is the Vladimir N. Ipatieff Professor of Catalytic Chemistry at Northwestern’s Weinberg College of Arts and Sciences and a professor of chemical and biological engineering at Northwestern’s McCormick School of Engineering. He is also a faculty affiliate at the Paula M. Trienens Institute for Sustainability and Energy. Kratish is a research assistant professor in Marks’ group, and an affiliated faculty member at the Trienens Institute. Qingheng Lai, a research associate in Marks’ group, is the study’s first author. Marks, Kratish and Lai co-led the study with Jeffrey Miller, a professor of chemical engineering at Purdue University; Michael Wasielewski, Clare Hamilton Hall Professor of Chemistry at Weinberg; and Takeshi Kobayashi a research scientist at Ames National Laboratory.

The polyolefin predicament

From yogurt cups and snack wrappers to shampoo bottles and medical masks, most people interact with polyolefin plastics multiple times throughout the day. Because of its versatility, polyolefins are the most used plastic in the world. By some estimates, industry produces more than 220 million tons of polyolefin products globally each year. Yet, according to a 2023 report in the journal Nature, recycling rates for polyolefin plastics are alarmingly low, ranging from less than 1% to 10% worldwide.

The main reason for this disappointing recycling rate is polyolefin’s sturdy, stubborn composition. It contains small molecules linked together with carbon-carbon bonds, which are famously difficult to break.

“When we design catalysts, we target weak spots,” Kratish said. “But polyolefins don’t have any weak links. Every bond is incredibly strong and chemically unreactive.”

Problems with current processes

Currently, only a few, less-than-ideal processes exist that can recycle polyolefin. It can be shredded into flakes, which are then melted and downcycled to form low-quality plastic pellets. But because different types of plastics have different properties and melting points, the process requires workers to scrupulously separate various types of plastics. Even small amounts of other plastics, food residue or non-plastic materials can compromise an entire batch. And those compromised batches go straight into the landfill.

Another option involves heating plastics to incredibly high temperatures, reaching 400 to 700 degrees Celsius. Although this process degrades polyolefin plastics into a useful mixture of gases and liquids, it's extremely energy intensive.

"Everything can be burned, of course," Kratish said. "If you apply enough energy, you can convert anything to carbon dioxide and water. But we wanted to find an elegant way to add the minimum amount of energy to derive the maximum value product."

Precision engineering

To uncover that elegant solution, Marks, Kratish and their team looked to hydrogenolysis, a process that uses hydrogen gas and a catalyst to break down polyolefin plastics into smaller, useful hydrocarbons. While hydrogenolysis approaches already exist, they typically require extremely high temperatures and expensive catalysts made from noble metals like platinum and palladium.

"The polyolefin production scale is huge, but the global noble metal reserves are very limited," Lai said. "We cannot use the entire metal supply for chemistry. And, even if we did, there still would not be enough to address the plastic problem. That's why we're interested in Earth-abundant metals."

For its polyolefin recycling catalyst, the Northwestern team pinpointed cationic nickel, which is synthesized from an abundant, inexpensive and commercially available nickel compound. While other nickel nanoparticle-based catalysts have multiple reaction sites, the team designed a single-site molecular catalyst.

The single-site design enables the catalyst to act like a highly specialized scalpel -- preferentially cutting carbon-carbon bonds -- rather than a less controlled blunt instrument that indiscriminately breaks down the plastic's entire structure. As a result, the catalyst allows for the selective breakdown of branched polyolefins (such as isotactic polypropylene) when they are mixed with unbranched polyolefins -- effectively separating them chemically.

"Compared to other nickel-based catalysts, our process uses a single-site catalyst that operates at a temperature 100 degrees lower and at half the hydrogen gas pressure," Kratish said. "We also use 10 times less catalyst loading, and our activity is 10 times greater. So, we are winning across all categories."

Accelerated by contamination

With its single, precisely defined and isolated active site, the nickel-based catalyst possesses unprecedented activity and stability. The catalyst is so thermally and chemically stable, in fact, that it maintains control even when exposed to contaminants like PVC. Used in pipes, flooring and medical devices, PVC is visually similar to other types of plastics but significantly less stable upon heating. Upon decomposition, PVC releases hydrogen chloride gas, a highly corrosive byproduct that typically deactivates catalysts and disrupts the recycling process.

Amazingly, not only did Northwestern's catalyst withstand PVC contamination, PVC actually accelerated its activity. Even when the total weight of the waste mixture is made up of 25% PVC, the scientists found their catalyst still worked with improved performance. This unexpected result suggests the team's method might overcome one of the biggest hurdles in mixed plastic recycling -- breaking down waste currently deemed "unrecyclable" due to PVC contamination. The catalyst also can be regenerated over multiple cycles through a simple treatment with inexpensive alkylaluminium.

"Adding PVC to a recycling mixture has always been forbidden," Kratish said. "But apparently, it makes our process even better. That is crazy. It's definitely not something anybody expected."

The study, "Stable single-site organo-Ni catalyst preferentially hydrogenolyzes branched polyolefin C-C bonds," was supported by the U.S. Department of Energy (award number DE-SC0024448) and The Dow Chemical Company.

Science Daily, 3 September 2025

https://sciencedaily.com

Sustainable process breaks down keratin, turning leftover wool and feathers into useful products

2025-09-04

The textile and meat-processing industries produce billions of tons of waste annually in the form of feathers, wool and hair, all of which are rich in keratin—the strong, fibrous protein found in hair, skin and nails.

Turning all that animal waste into useful products—from wound dressings to eco-friendly textiles to health extracts—would be a boon for the environment and for new, sustainable industries. But upcycling proteins is challenging: Breaking down, or denaturing, proteins into their component parts typically requires corrosive chemicals in large, polluting facilities, keeping any cost-effective protocol out of reach.

Researchers in the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) have uncovered key fundamental chemistry involved in the denaturing of proteins like keratin in the presence of certain salt compounds—an insight that could take protein recycling to the next level.

A team led by Kit Parker, the Tarr Family Professor of Bioengineering and Applied Physics at SEAS, combined experiments and molecular simulations to better illuminate the chemical mechanisms by which salts cause proteins to unfold.

They've shown that a solution of concentrated lithium bromide, a salt compound known to break apart keratin, interacts with the protein molecules in a completely unexpected way—not by binding to the proteins directly, as was conventional wisdom, but by changing the structure of the surrounding water molecules to create a setting more favorable for spontaneous protein unfolding.

This insight allowed the researchers to design a gentler, more sustainable keratin extraction process, separating the protein out of solution easily and without the need for harsh chemicals. The process can also be reversed with the same salt mixture, enabling recovery and reuse of lithium bromide denaturants.

The research is published in Nature Communications and is also featured in a Behind the Paper blog post.

Inspired by keratin biomaterials

First author Yichong Wang, a graduate student in chemistry who works in Parker's group, said the research builds on the lab's longstanding interest in developing keratin biomaterials with shape memory for biomedical applications.

They had previously observed that keratin extracted from lithium bromide solvents can form thick, shapeable gels that readily separate from the surrounding solution and solidify almost immediately when placed back in water. While useful, they found the behavior odd, and they wanted to understand it better.

"We thought there might be a gap between current mechanistic understanding of how denaturation works, and what we were seeing," Wang said. "That's when we got very interested in the mechanism itself to see if we could optimize our extraction procedures by explaining this phenomenon better."

Molecular dynamics reveal shifts in surrounding water

To dig deeper, the team turned to the lab of Professor Eugene Shakhnovich in the Department of Chemistry and Chemical Biology, whose expertise is in protein biophysics. Molecular dynamics simulations led by co-author Junlang Liu allowed them to see that the lithium bromides were not working on the proteins at all, but rather, on the water around them.

It turns out lithium bromide ions cause water molecules to shift into two different populations—normal water, and water molecules that become trapped by the salt ions. As the normal water volume decreases, the proteins start to unfold due to the thermodynamic shift in the environment, rather than being directly ripped apart like in other denaturation methods.

"Making the water less like water, allows the protein to unfold itself," Wang said. They had similar results by testing simpler proteins like fibronectin, pointing to a universal mechanism.

Better understanding and designing protein extraction methods that are less energy-intensive and less polluting than conventional ones opens potential avenues for protein-upcycling industries. In the Parker lab, using keratin as a substrate for tissue engineering is a major research thrust; having a reliable, sustainable method to extract and re-use such products would bolster their efforts.

What's more, the process could lay a path for a whole new biomaterials industry, turning a massive waste stream like hair or chicken feathers into low-cost recycled materials, possibly as an alternative for traditional plastics, for example.

Phys Org, 4 September 2025

https://phys.org

Giving food waste fermentation a 'jolt' increases chemical production

2025-09-04

Adding an electrical jolt to fermentation of industrial food waste speeds up the process and increases the yield of platform chemicals that are valuable components in a wide range of products, new research shows.

In developing the new system, researchers at The Ohio State University also discovered that combining two bacterial species in the electro-fermentation mix not only helped accelerate the process, but allowed for more targeted chemical production.

In this study, the food waste consisted of ice cream and sour cream—but the team has expanded the work with experiments using coffee grounds and lake algae.

Eventual adoption of the technology could reap many benefits: efficient, sustainable and cost-effective production of multipurpose chemicals using source materials that would otherwise end up incinerated or in a landfill, contributing to greenhouse gas emissions.

"We are creating an industry from another industry's waste," said first author Beenish Saba, a research scientist in food, agricultural and biological engineering at Ohio State.

"We're making use of waste that a contractor charges businesses to take to a landfill, where it produces methane gas. We are suggesting that industries can put up a simple bioreactor in which they can produce other important byproducts."

The study was published recently in the Journal of Environmental Chemical Engineering.

This work builds upon previous waste valorization research done by Saba and Katrina Cornish, professor emerita of horticulture and crop science and food, agricultural and biological engineering at Ohio State and a co-lead author of the current study.

The valorization work involved analysis of physical and chemical properties of 46 food waste samples to identify good candidates for conversion to chemicals and biogases through a variety of processes—including fermentation.

In the new study, Saba and colleagues compared the output and duration of conventional fermentation and electro-fermentation. Conventional practices consist of placing food waste and bacteria in a bottle, adjusting nutrient levels and incubating the materials at 98.6 degrees Fahrenheit. Electro-fermentation is accomplished at room temperature inside a bioreactor outfitted with an electrode powered by minimal external voltage.

"In conventional fermentation, the bacteria are happily growing and they will produce some solvents and gases," Saba said. "In the second step, we gave them a little tingling electricity so the bacteria can feel a little irritation, and the metabolism was fast. They were growing and happily eating, and they produced more byproducts—meaning we can increase the yield."

There was another bonus to the development of this new microbial electrochemical system: production of hydrogen gas.

Experiments showed that combining two bacterial species from the Clostridium family contributed to hydrogen gas production while also reducing fermentation waste—it is known that the commonly used species C. bijerinckii generates carbon dioxide while converting food waste into alcohols, but it turns out another species, C. carboxidivorans, consumes that CO2.

"It means the waste product of one bacteria is utilized by the other bacteria," Saba said. "It was possible that there could have been an antagonistic relationship, but we tested growing them together and found there's a synergistic relationship between these two bacteria that works well."

And in addition to consuming the CO2, C. carboxidivorans produces hydrogen gas and solvents.

"Carbon dioxide is still there, but most of it is consumed, and it gives us hydrogen gas—an additional product. We now have two valuable products and one waste product," she said.

The work dovetails with an increased focus on using food waste and agricultural residue to create biobased products, Saba said.

"We are working on improving the yield, cost efficiency and scalability," she said. "The government is asking for work in this area and industry is interested in getting value from waste and not paying for its disposal.

"So much material that is agricultural or biological in nature is just going to waste. It's much better to utilize them and make valuable products."

Phys Org, 4 September 2025

https://phys.org

A tiny chip may have solved one of clean energy's biggest problems

2025-08-28

For decades, researchers around the world have searched for alternatives to iridium, an extremely rare, incredibly expensive metal used in the production of clean hydrogen fuels.

Now, a powerful new tool has found one -- within a single afternoon.

Invented and developed at Northwestern University, that tool is called a megalibrary. The world's first nanomaterial "data factory," each megalibrary contains millions of uniquely designed nanoparticles on one tiny chip. In collaboration with researchers from the Toyota Research Institute (TRI), the team used this technology to discover commercially relevant catalysts for hydrogen production. Then, they scaled up the material and demonstrated it could work within a device -- all in record time.

With a megalibrary, scientists rapidly screened vast combinations of four abundant, inexpensive metals -- each known for its catalytic performance -- to find a new material with performance comparable to iridium. The team discovered a wholly new material that, in laboratory experiments, matched or in some cases even exceeded the performance of commercial iridium-based materials, but at a fraction of the cost.

This discovery doesn't just make affordable green hydrogen a possibility; it also proves the effectiveness of the new megalibrary approach, which could completely change how researchers find new materials for any number of applications.

The study was published on August 19 in the Journal of the American Chemical Society (JACS).

"We've unleashed arguably the world's most powerful synthesis tool, which allows one to search the enormous number of combinations available to chemists and materials scientists to find materials that matter," said Northwestern's Chad A. Mirkin, the study's senior author and primary inventor of the megalibrary platform. "In this particular project, we have channeled that capability toward a major problem facing the energy sector. That is: How do we find a material that is as good as iridium but is more plentiful, more available and a lot cheaper? This new tool enabled us to find a promising alternative and to find it rapidly."

A nanotechnology pioneer, Mirkin is the George B. Rathmann Professor of Chemistry at Northwestern's Weinberg College of Arts and Sciences; professor of chemical and biological engineering, biomedical engineering and materials science and engineering at the McCormick School of Engineering; and executive director of the International Institute for Nanotechnology. Mirkin co-led the work with Ted Sargent, the Lynn Hopton Davis and Greg Davis Professor of Chemistry at Weinberg, professor of electrical and computer engineering at McCormick and executive director of the Paula M. Trienens Institute for Sustainability and Energy.

'Not enough iridium in the world'

As the world moves away from fossil fuels and toward decarbonization, affordable green hydrogen has emerged as a critical piece of the puzzle. To produce clean hydrogen energy, scientists have turned to water splitting, a process that uses electricity to split water molecules into their two constituent components -- hydrogen and oxygen.

The oxygen part of this reaction, called the oxygen evolution reaction (OER), however, is difficult and inefficient. OER is most effective when scientists use iridium-based catalysts, which have significant disadvantages. Iridium is rare, expensive and often obtained as a byproduct from platinum mining. More valuable than gold, iridium costs nearly $5,000 per ounce.

"There's not enough iridium in the world to meet all of our projected needs," Sargent said. "As we think about splitting water to generate alternative forms of energy, there's not enough iridium from a purely supply standpoint."

‘Full army deployed on a chip’

Mirkin, who introduced the megalibraries in 2016, decided with Sargent that finding new candidates to replace iridium was a perfect application for his revolutionary tool. While materials discovery is traditionally a slow and daunting task filled with trial and error, megalibraries enable scientists to pinpoint optimal compositions at breakneck speeds.

Each megalibrary is created with arrays of hundreds of thousands of tiny, pyramid-shaped tips to print individual “dots” onto a surface. Each dot contains an intentionally designed mix of metal salts. When heated, the metal salts are reduced to form single nanoparticles, each with a precise composition and size.

“You can think of each tip as a tiny person in a tiny lab,” Mirkin said. “Instead of having one tiny person make one structure at a time, you have millions of people. So, you basically have a full army of researchers deployed on a chip.”

And the winner is…

In the new study, the chip contained 156 million particles, each made from different combinations of ruthenium, cobalt, manganese and chromium. A robotic scanner then assessed how well the most promising particles could perform an OER. Based on these tests, Mirkin and his team selected the best-performing candidates to undergo further testing in the laboratory.

Eventually, one composition stood out:a precise combination of all four metals (Ru52Co33Mn9Cr6 oxide). Multi-metal catalysts are known to elicit synergistic effects that can make them more active than single-metal catalysts.

“Our catalyst actually has a little higher activity than iridium and excellent stability,” Mirkin said. “That’s rare because oftentimes ruthenium is less stable. But the other elements in the composition stabilize ruthenium.”

The ability to screen particles for their ultimate performance is a major new innovation. “For the first time, we were not only able to rapidly screen catalysts, but we saw the best ones performing well in a scaled-up setting,” said Joseph Montoya, a senior staff research scientist at TRI and study co-author.

In long-term tests, the new catalyst operated for more than 1,000 hours with high efficiency and excellent stability in a harsh acidic environment.

It is also dramatically cheaper than iridium -- about one-sixteenth of the cost.

“There’s lots of work to do to make this commercially viable, but it’s very exciting that we can identify promising catalysts so quickly -- not only at the lab scale but for devices,” Montoya said.

Just the beginning

By generating massive high-quality materials datasets, the megalibrary approach also lays the groundwork for using artificial intelligence (AI) and machine learning to design the next generation of new materials. Northwestern, TRI and Mattiq, a Northwestern spinout company, have already developed machine learning algorithms to sift through the megalibraries at record speeds.

Mirkin says this is only the beginning. With AI, the approach could scale beyond catalysts to revolutionize materials discovery for virtually any technology, such as batteries, biomedical devices and advanced optical components.

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Science Daily, 28 August 2025

https://sciencedaily.com

Rewriting Chemical Rules: Researchers Accidentally Create Unprecedented New Gold Compound

2025-08-30

SLAC scientists created gold hydride in extreme lab conditions. The work sheds light on dense hydrogen and fusion processes.

By chance and for the first time, an international team of researchers led by scientists at the U.S. Department of Energy's SLAC National Accelerator Laboratory succeeded in creating solid binary gold hydride—a compound composed solely of gold and hydrogen atoms.

The team had originally set out to investigate how hydrocarbons, molecules made of carbon and hydrogen, transform into diamonds under extreme pressure and heat. During experiments at the European XFEL (X-ray Free-Electron Laser) in Germany, they placed hydrocarbon samples with a thin layer of gold foil, intended only to absorb X-rays and transfer heat to the relatively weakly absorbing hydrocarbons. Unexpectedly, alongside diamond formation, they observed the creation of gold hydride.

"It was unexpected because gold is typically chemically very boring and unreactive – that's why we use it as an X-ray absorber in these experiments," explained Mungo Frost, a staff scientist at SLAC and the study's lead author. "These results suggest there's potentially a lot of new chemistry to be discovered at extreme conditions where the effects of temperature and pressure start competing with conventional chemistry, and you can form these exotic compounds."

The findings, published in Angewandte Chemie International Edition, demonstrate how chemical behavior can shift dramatically under extreme environments, such as those found deep inside planets or within hydrogen-fusing stars.

Studying dense hydrogen

To achieve these results, the researchers compressed hydrocarbon samples to pressures exceeding those inside Earth's mantle using a diamond anvil cell. They then exposed the samples to bursts of X-ray pulses from the European XFEL, heating them above 3,500 degrees Fahrenheit. By analyzing how the X-rays scattered from the samples, the team tracked the structural changes taking place.

As anticipated, the data confirmed that carbon atoms had arranged into a diamond lattice. However, they also revealed unexpected signals: hydrogen atoms had reacted with the gold foil to form gold hydride.

At the conditions generated in the experiment, hydrogen existed in a dense, "superionic" state, in which hydrogen atoms moved freely within the rigid gold lattice. This behavior enhanced the conductivity of the gold hydride, offering new insight into the behavior of materials under extreme pressures and temperatures.

Hydrogen, which is the lightest element of the periodic table, is tricky to study with X-rays because it scatters X-rays only weakly. Here, however, the superionic hydrogen interacted with the much heavier gold atoms, and the team was able to observe hydrogen's impact on how the gold lattice scattered X-rays. "We can use the gold lattice as a witness for what the hydrogen is doing," Mungo said.

The gold hydride offers a way to study dense atomic hydrogen under conditions that might also apply to other situations that are experimentally not directly accessible. For example, dense hydrogen makes up the interiors of certain planets, so studying it in the lab could teach us more about those foreign worlds. It could also provide new insights into nuclear fusion processes inside stars like our sun and help develop technology to harness fusion energy here on Earth.

Exploring new chemistry

In addition to paving the way for studies of dense hydrogen, the research also offers an avenue for exploring new chemistry. Gold, which is commonly regarded as an unreactive metal, was found to form a stable hydride at extremely high pressure and temperature. In fact, it appears to be only stable at those extreme conditions as when it cools down, the gold and hydrogen separate. The simulations also showed that more hydrogen could fit in the gold lattice at higher pressure.

The simulation framework could also be extended beyond gold hydride. “It’s important that we can experimentally produce and model these states under these extreme conditions,” said Siegfried Glenzer, High Energy Density Division director and professor for photon science at SLAC and the study’s principal investigator. “These simulation tools could be applied to model other exotic material properties in extreme conditions.”

Sci Tech Daily, 30 August 2025

https://scitechdaily.com

Heat-Based Hair Care Routines May Expose You to More Than 10 Billion Nanoparticles

2025-08-21

A typical morning hair care routine can expose you to as much immediate nanoparticle pollution as standing in dense highway traffic, report Purdue University engineers.

A Purdue research team led by Nusrat Jung, an assistant professor in the Lyles School of Civil and Construction Engineering, and her PhD student Jianghui Liu found that a 10-20 minute heat-based hair care routine exposes a person to upward of 10 billion nanoparticles that are directly deposited into their lungs. These particles can lead to serious health risks such as respiratory stress, lung inflammation and cognitive decline. The team’s findings were recently published in Environmental Science & Technology.

“This is really quite concerning,” Jung said. “The number of nanoparticles inhaled from using typical, store-bought hair care products was far greater than we ever anticipated.”

Until this study, Jung said, no real-time measurements on nanoparticle formation during heat-based hair styling had been conducted in full-scale residential settings. Their research addresses this gap by examining temporal changes in indoor nanoparticle number concentrations and size distributions during realistic heat-based hair styling routines.

“By providing a detailed characterization of indoor nanoparticle emissions during these personal care routines, our research lays the groundwork for future investigations into their impact on indoor atmospheric chemistry and inhalation toxicity,” Jung said. “Studies of this kind have not been done before, so until now, the public has had little understanding of the potential health risks posed by their everyday hair care routines.”

What makes these hair care products so harmful, Liu said, is when they are combined with large amounts of heat from styling appliances such as curling irons and straighteners. When combined with heat exceeding 300 degrees Fahrenheit, the chemicals not only rapidly release into the air but also lead to the formation of substantial numbers of new airborne nanoparticles.

“Atmospheric nanoparticle formation was especially responsive to these heat applications,” Liu said. “Heat is the main driver — cyclic siloxanes and other low-volatility ingredients volatilize, nucleate and grow into new nanoparticles, most of them smaller than 100 nanometers."

In a study Jung published in 2023, her team found that heat significantly increased emissions of volatile chemicals such as decamethylcyclopentasiloxane (aka D5 siloxane) from hair care routines. D5 siloxane in particular was identified as a compound of concern when inhaled.

"When we first studied the emissions from hair care products during heat surges, we focused on the volatile chemicals that were released, and what we found was already quite concerning," Jung said. "But when we took an even closer look with aerosol instrumentation typically used to measure tailpipe exhaust, we discovered that these chemicals were generating bursts of anywhere from 10,000 to 100,000 nanoparticles per cubic centimeter."

Jung said that D5 siloxane is an organosilicon compound and is often listed first or second in the ingredient lists of many hair care products, indicating it can be among the most abundant ingredients. It has become a common ingredient over the past few decades in many personal care products due to its low surface tension, inertness, high thermal stability and smooth texture.

According to the European Chemicals Agency, D5 siloxane is classified as "very persistent, very bioaccumulative." And while the test results on laboratory animals are already concerning, Jung said, there is little information on its human impact. The chemical in wash-off cosmetic products has already been restricted in the European Union because of this.

"D5 siloxane has been found to lead to adverse effects on the respiratory tract, liver and nervous system of laboratory animals," Jung said previously. However, under high heat, cyclic siloxanes and other hair care product ingredients can volatilize and contribute to the formation of large numbers of airborne nanoparticles that deposit efficiently throughout the respiratory system. These secondary emissions and exposures remain far less characterized than the primary chemical emissions.

"And now it appears that the airborne hazards of these products — particularly 'leave-on' formulations designed to be heat-resistant, such as hair sprays, creams and gels — are even greater than we expected," Liu said.

According to the report, respiratory tract deposition modeling indicated that more than 10 billion nanoparticles could deposit in the respiratory system during a single hair styling session, with the highest dose occurring in the pulmonary region — the deepest part of the lungs. Their findings identified heat-based hair styling as a significant indoor source of airborne nanoparticles and highlight previously underestimated inhalation exposure risks.

As for how to avoid putting oneself at risk of inhaling mixtures of airborne nanoparticles and volatile chemicals, Jung and Liu said the best course of action is simply to avoid using such products — particularly in combination with heating devices. If that is not possible, Jung recommends reducing exposure by using bathroom exhaust fans for better room ventilation.

"If you must use hair care products, limit their use and ensure the space is well ventilated," Liu said. "Even without heating appliances, better ventilation can reduce exposure to volatile chemicals, such as D5 siloxane, in these products."

To more fully capture the complete nanoparticle formation and growth process, Jung said future studies should integrate nano mobility particle sizing instruments capable of detecting particles down to a single nanometer. The chemical composition of these particles should also be evaluated.

"By addressing these research gaps, future studies can provide a more holistic understanding of the emissions and exposures associated with heat-based hair styling, contributing to improved indoor air pollution assessments and mitigation strategies," Jung said.

Gathering the data

Jung and Liu's experimental research was conducted in a residential architectural engineering laboratory that Jung designed: the Purdue zero Energy Design Guidance for Engineers (zEDGE) tiny house.

The zEDGE lab is a mechanically ventilated, single-zone residential building with a conditioned interior. A state-of-the-art high-resolution electrical low-pressure impactor (HR-ELPI+) from Jung's laboratory was used to measure airborne nanoparticles in indoor air in real time, second by second. In parallel, a proton transfer reaction time-of-flight mass spectrometer (PTR-TOF-MS) was used to monitor volatile chemicals in real time.

The hair care routine emission experiments were conducted during a measurement campaign in zEDGE over a period of several months, including three experiment types: realistic hair care experiments that replicate actual hair care routines in the home environment, hot plate emission experiments that explore the relationship between the temperature of the hair care tools and nanoparticle formation, and surface area emission experiments that investigate how hair surface area impacts nanoparticle emissions during hair care events.

For the realistic hair care routine emission experiments, participants were asked to bring their own hair care products and hair styling tools to replicate their routines in zEDGE. Prior to each experiment, the participants were instructed to separate their hair into four sections. The hair length of each participant was categorized as long hair (below the shoulder) or short hair (above the shoulder). The sequence of each experiment consisted of four periods, to replicate a real-life routine.

After hair styling, the participants had two minutes to collect the tools and leave zEDGE; this was followed by a 60-minute concentration decay period in which zEDGE was unoccupied, and the HR-ELPI+ monitored the decay in indoor nanoparticle concentrations. The experiments and subsequent analysis focused on the formation of nanoparticles and resulting exposure during and after active hair care routine periods.

Technology Networks, 21 August 2025

https://technologynetwork.com

Nuclear waste could provide tritium fuel for future fusion reactors

2025-09-02

A critical shortage of fuel for nuclear fusion reactors may have a rather counterintuitive solution. A physicist at the Los Alamos National Laboratory (LANL) says that fusion reactor fuel could be made from nuclear waste from fission reactors.

If fusion power can be made practical, it would be no exaggeration to say it would be an unprecedented revolution, providing humanity with, for all practical purposes, unlimited energy available on demand. However, there is a problem that isn't so much a barrier as a nasty bottleneck.

Instead of splitting heavy atoms like uranium or plutonium to release energy, fusion works by fusing hydrogen atoms to form helium for energy.

The tricky bit was that the kind of fusion reactors we're developing don't run on run-of-the-mill hydrogen – they need deuterium and tritium, which are heavy isotopes of hydrogen.

Deuterium is relatively rare in the Earth's oceans, but since we're talking about trillions of tonnes of the stuff, that's not a problem. However, tritium is really, really rare to the point where there are only reserves of about 55 lb ± 31 lb (25 lb ± 14 kg), which means that it retails for about US$15 million per pound ($33 million per kilogram), with the current major commercial source from fission reactors in Canada.

Since it's estimated that it would take about 32.2 lb (14.61 kg) of tritium to power one million US homes per year, 55 lb wouldn't be near enough to run even a small economy for very long. Oddly, that wouldn't be a problem if fusion plants were already abundant because there'd be so much surplus power that brute force methods could be used to produce tritium. But we haven't caught that rabbit yet for our nuclear stew, so another solution is needed in the meantime.

To sort this out, Terence Tarnowsky of Los Alamos has been running simulated reactor designs with a view to using the thousands of tonnes of nuclear waste from fission reactors as a source of tritium.

The basic idea has been around for decades, but Tarnowsky contends that modern technology would make it efficient enough to be practical. It involves taking waste consisting of uranium, plutonium, and various other radioactive elements, encasing it in molten lithium salt, and bombarding it with high-energy particles from a superconducting linear accelerator. This would initiate a series of nuclear processes where the atoms split in a process called spallation, which releases a shower of neutrons. These neutrons interact with the lithium to eventually produce tritium.

One positive is that the process would be subcritical. That is, the nuclear reaction would only occur when the accelerator is switched on, making it extremely safe. Tarnowsky estimates that this process is highly efficient and that a one-gigawatt reactor would produce enough tritium per year to run 800,000 homes, or 10 times as much as a fusion reactor of the same thermal power could make.

"Energy transitions are a costly business, and anytime you can make it easier, we should try," said Tarnowsky.

Tarnowsky presented his results at the fall meeting of the American Chemical Society held last week.

New Atlas, 2 September 2025

https://newatlas.com

Gold-enhanced TiO_2 catalyst enables efficient and selective flow synthesis of propane from methane

2025-09-04

Methane (CH_4), the colorless and odorless gas that makes up most natural gas on Earth, has so far been converted into useful fuels and chemicals via energy-intensive processes that need to be carried out at high temperatures. Some energy researchers, however, have been exploring the possibility of transforming this gas into useful hydrocarbons and chemicals via photocatalysis.

Photocatalysis is a process through which the energy contained in light, typically solar energy, activates a material known as a "catalyst," driving desired chemical reactions. Converting CH_4 into specific fuels or chemicals via photocatalysis instead of conventional methods that rely on the burning of fossil fuels could be highly advantageous, as it could contribute to the reduction of greenhouse gas emissions.

Researchers at Hebei University and other institutes in China recently introduced a new photocatalysis-driven approach to convert CH_4 into propane (C_3H_8), a hydrocarbon that is easier to use in real-world settings, as it becomes liquid at specific pressures, which facilitates its storage and transport.

Their proposed method, outlined in a paper published in Nature Energy, enables the efficient photocatalytic oxidative coupling of methane (POCM), a process through which methane molecules exposed to oxygen can combine and form larger hydrocarbons, utilizing titanium dioxide (TiO_2) as a catalyst.

"POCM enables the production of value-added fuels and chemicals using renewable solar energy," wrote Wenfeng Nie, Liwei Chen and their colleagues in their paper. "Unfortunately, despite recent advances in the production of C2 chemicals (for example, ethane), POCM systems that selectively produce industrially useful and transportable C3+ hydrocarbons remain elusive."

The photocatalytic process through which this team of researchers converted CH_4 into C_3H_8 is driven by an enhanced version of the photocatalyst TiO_2. This is a widely used semiconducting material, yet the team improved its photocatalytic capabilities by embedding gold (Au) nanoparticles in its pores (i.e., confined spaces in its structure).

"We report that Au-embedded porous TiO2, activated by steam during the POCM process, enables efficient and selective flow synthesis of propane with a productivity of 1.4 mmol h−1," wrote Nie, Chen and their colleagues. "At this productivity, we achieve a high propane selectivity of 91.3% and an apparent quantum efficiency of 39.7% at a wavelength of 365 nm."

In initial tests, the enhanced TiO2-based catalyst introduced by the researchers was found to enable the synthesis of propane with remarkable productivity, quantum efficiency and selectivity. The results so far are highly promising, hinting at the possibility of realizing the efficient solar energy-powered photocatalytic conversion of methane into more valuable fuels on a large scale.

"Mechanistic studies reveal that the tensile-strained Au and the nanopore-confined catalytic microenvironment jointly stabilize key ethane intermediates, boosting deeper C2–C1 coupling to form propane," wrote the authors. "Meanwhile, the steam-activated surface lattice oxygen on TiO2 accelerates hydrogen species transfer, thus enhancing POCM kinetics. This approach is economically feasible for practical application under concentrated solar light."

This recent study could soon open new possibilities for the clean upgrading of methane into hydrocarbons and chemicals that are still widely used both for transportation and in industrial settings. In the future, other research teams could build on the findings gathered by Nie, Chen and their colleagues to design other highly performing catalysts and POCM approaches.

Phys Org, 4 September 2025

https://phys.org

Don't Throw Away Those Cannabis Leaves – They're Packed With Rare Compounds

2025-08-31

Stellenbosch University researchers identify rare phenolic compounds in Cannabis leaves for the first time.

Chemists at Stellenbosch University (SU) have uncovered the first evidence of a rare group of phenolic compounds, known as flavoalkaloids, in Cannabis leaves.

Phenolic compounds—particularly flavonoids—are highly valued in the pharmaceutical field because of their antioxidant, anti-inflammatory, and anti-carcinogenic effects.

In their study, the researchers analyzed three commercially cultivated Cannabis strains from South Africa and identified 79 distinct phenolic compounds. Of these, 25 had never before been reported in Cannabis, and 16 were tentatively classified as flavoalkaloids. Notably, these rare compounds were found primarily in the leaves of just one strain. The findings were published in the Journal of Chromatography A.

Challenges of studying plant phenolics

Dr Magriet Muller, an analytical chemist in the LC-MS laboratory of the Central Analytical Facility (CAF) at Stellenbosch University and first author on the paper, says the analysis of plant phenolics is challenging due to their low concentration and extreme structural diversity.

“Most plants contain highly complex mixtures of phenolic compounds, and while flavonoids occur widely in the plant kingdom, the flavoalkaloids are very rare in nature,” she explains.

“We know that Cannabis is extremely complex – it contains more than 750 metabolites – but we did not expect such high variation in phenolic profiles between only three strains, nor to detect so many compounds for the first time in the species. Especially the first evidence of flavoalkaloids in Cannabis was very exciting.”

Developing new analytical methods

As part of her postgraduate work in SU’s Department of Chemistry and Polymer Science, she designed advanced analytical techniques that integrate comprehensive two-dimensional liquid chromatography with high-resolution mass spectrometry to achieve detailed characterization of phenolic compounds.

“We were looking for a new application for the methods that I developed, after successfully testing them on rooibos tea, grapes, and wine. I then decided to apply the methods to Cannabis because I knew it was a complex sample, and that Cannabis phenolics have not been well characterized,” she explains.

According to Prof. André de Villiers, her study leader and main author on the paper, he was blown away by the chromatographic results that Muller obtained: “The excellent performance of two-dimensional liquid chromatography allowed separation of the flavoalkaloids from the much more abundant flavonoids, which is why we were able to detect these rare compounds for the first time in Cannabis.” He leads the analytical chemistry research group in SU’s Department of Chemistry and Polymer Science.

Prof. De Villiers says it is obvious there is still much to gain from studying Cannabis, as the bulk of research in this field to date has been focused on the pharmacological properties of the mood-altering cannabinoids.

“Our analysis again highlights the medicinal potential of Cannabis plant material, currently regarded as waste. Cannabis exhibits a rich and unique non-cannabinoid phenolic profile, which could be relevant from a biomedical research perspective,” he concludes.

Sci Tech Daily, 31 August 2025

https://scitechdaily.com

Discovery of unusual iodine–silver bond opens up new possibilities for coordination chemistry

2025-09-02

A collaborative effort between scientists has led to the isolation of a complex with two iodine(I)-silver(I) coordination bonds, opening up possibilities for other complexes with unconventional bonding.

Metal–metal bonds between metal cations are common, ranging from the manganese–manganese single bond in Mn2(CO)10 to the quadruple rhenium–rhenium bond in Re2Cl82-. Similar bonds between non-metal and metal cations are much rarer, often due to a mismatch in orbital energy which limits overlap.

A group of scientists in Finland, Germany and Spain has now synthesised a compound containing such a bond. To do this, the researchers combined silver triflate with a pyridine N-oxide to create a polymeric silver compound, which reacts further with iodine. Within the resulting complex, two silver cations are bridged by four bidentate triflate ions, forming what is known as a paddlewheel structure. Each iodine cation – found at the heart of an unusual three-centre-four-electron complex with two pyridine ligands – forms a single orthogonal coordination bond to a silver cation.

X-ray crystallography revealed that the iodine–silver bond length is 2.86Å, much shorter than the sum of the van der Waals radii of the cations (3.54Å). The reported bond length is similar to typical single metal–metal bonds. Computational analysis confirmed that there is significant covalent character within the iodine–silver bond, with the iodine(I) cation donating electron density to the silver(I) cation, owing to the increased electron density around the iodine from the N-oxide ligands.

The researchers note that future studies will explore similar complexes with other metals and various other ligand systems, with the aim of expanding the breadth of compounds with unusual coordination bonds.

Chemistry World, 2 September 2025

https://chemistryworld.com

Research findings offer new insight into blood thinners and bone builders

2025-09-04

If biomolecules were people, heparin would be a celebrity. Best known as a powerful blood thinner with a global market of more than $7 billion, heparin is used during and after surgery and is essential to kidney dialysis. Most of today’s heparin comes from pigs, but the Food and Drug Administration is encouraging the use of alternative sources, including cows and synthetic forms of heparin, to diversify the supply cha

Unfortunately, heparin from animals other than pigs just doesn’t work as well.

The reasons are connected to ongoing questions in modern cell biology. Now, an interdisciplinary Virginia Tech team has uncovered new molecular clues that may explain why some sources of heparin are more effective than others. The findings, published recently in the Proceedings of the National Academy of Sciences, may open doors for designing safer, more reliable heparin therapies.

“The structure of heparin and how that structure impacts function is an ongoing puzzle,” said Brenna Knight, first author of the study and recent graduate student studying in the Department of Chemistry. “Seemingly small differences in the content and arrangement of [chemical entities called] sulfates on the molecule cause substantial differences in the energetics that drive chemical activity.”

From mineralization to medicine

Heparin hails from a family called heparan sulfates, or heparans, present in all living creatures. These chains of sugars are diverse, serve many functions in organisms, and many, including heparin, are incredibly complex.

As a student of Patricia Dove in the Departments of Geosciences and Chemistry, Knight was originally looking at heparans for a completely different reason: to understand how the sulfates could impact biological mineralization, which is the process by which organisms build crystal-strengthened tissues such as bones, teeth, shells, and corals.

Dove, University Distinguished Professor and the C.P. Miles Professor of Science, is one of today’s preeminent geochemists and was elected to the National Academy of Sciences in 2012. Unraveling the process of biomineralization has been one of her major passions over the past three decades.

“Animals grow crystals in specific places, usually to make structures that serve to support, defend, or feed themselves.” said Dove. “It’s a coordinated result of many chemical reactions within the organism and a crowning achievement of biology. We’ve been trying to better understand the reactions that produce these working biomaterials for a long time.”

That mineralization process unexpectedly linked back to medicine.

Heparan sulfates are just one of many different agents that interact with calcium to trigger a diverse portfolio of biochemical operations. One of those operations is integral to blood clotting.

Team science

To better understand how heparan sulfates help facilitate biomineralization, Dove and Knight teamed with Kevin Edgar, professor in the Department of Sustainable Biomaterials, who was interested in heparans from the health care angle. To study the interactions of calcium with heparin, they worked with Michael Schulz and graduate student Connor Gallagher in the chemistry department.

When they applied their combined expertise to calcium–heparin interactions, they found that slight variations in heparin’s molecular composition changed how effective it was at binding calcium. These differences could affect its ability to form biominerals and blood thinners.

"This paper provides insights for how to bioengineer synthetic pathways to effective heparin products for applications in therapeutics and drug delivery," Edgar said.

Phys Org, 4 September 2025

https://phys.org

This Plant-Inspired Molecule Could Be the Key to Artificial Photosynthesis

2025-08-27

Swiss researchers have designed a plant-inspired molecule that mimics photosynthesis and can hold four electric charges when exposed to light.

This ability to store multiple charges could be the key to creating solar fuels such as hydrogen, methanol, or synthetic petrol — fuels that would be carbon-neutral because they release only as much CO2 as was used to produce them.

Harnessing Plant-Inspired Solar Power

Plants capture sunlight and use it to transform carbon dioxide into sugars that store energy. This process, known as photosynthesis, underpins nearly all life on Earth. The sugars produced by plants serve as fuel for animals and humans, who release the stored energy by breaking them down. That process returns carbon dioxide to the atmosphere, completing the natural cycle.

Scientists hope to use this same principle as a guide for developing clean fuels. By copying the way plants convert light, researchers aim to generate energy-rich compounds directly from sunlight. These solar fuels include hydrogen, methanol, and synthetic petrol. When burned, they would release only the same amount of carbon dioxide that was originally required to create them. In effect, the entire process would be carbon-neutral.

A Molecule That Stores Four Charges

In Nature Chemistry, Professor Oliver Wenger and doctoral student Mathis Brändlin describe an important advance toward this goal of artificial photosynthesis. They have engineered a specially designed molecule that, when exposed to light, can hold four charges at the same time – two positive and two negative.

Being able to temporarily store several charges is a crucial step in turning sunlight into usable chemical energy. Those charges can then be applied to trigger reactions, such as splitting water into hydrogen and oxygen.

The molecule itself is built from five linked components, each with a distinct role. On one end, two parts release electrons and in doing so become positively charged. At the opposite end, two other parts absorb those electrons and turn negatively charged. At the center, the researchers placed a light-sensitive unit that captures solar energy and initiates the electron transfer.

Two Flashes of Light, Four Charges

In order to generate the four charges, the researchers took a stepwise approach using two flashes of light. The first flash of light hits the molecule and triggers a reaction in which a positive and a negative charge are generated. These charges travel outward to the opposite ends of the molecule. With the second flash of light, the same reaction occurs again, so that the molecule then contains two positive and two negative charges.

Works Even in Dim Light

"This stepwise excitation makes it possible to use significantly dimmer light. As a result, we are already moving close to the intensity of sunlight," explains Brändlin. Earlier research required extremely strong laser light, which was a far cry from the vision of artificial photosynthesis. "In addition, the charges in the molecule remain stable long enough to be used for further chemical reactions."

That being said, the new molecule has not yet created a functioning artificial photosynthesis system. "But we have identified and implemented an important piece of the puzzle," says Oliver Wenger. The new findings from the study help to improve our understanding of the electron transfers that are central to artificial photosynthesis. "We hope that this will help us contribute to new prospects for a sustainable energy future," says Wenger.

Sci Tech Daily, 27 August 2025

https://scitechdaily.com

Making diamonds with electron radiation

2025-09-04

There are various ways to create artificial diamonds, but a new method developed by researchers, including those at the University of Tokyo, yields some extra benefits.

By specially preparing samples for conversion to diamond by means of an electron beam, the team found their method can be used to protect organic samples from the damage usually caused by such a beam. This could lead to new and powerful imaging and analytical techniques.

The work has been published in the journal Science.

Diamond synthesis is a process that conventionally requires conversion from carbon sources under extreme conditions—pressures of tens of gigapascals and temperatures of thousands of Kelvin—where diamond is thermodynamically stable, or chemical vapor deposition techniques where it is unstable.

A team led by University Professor Eiichi Nakamura of the Department of Chemistry at the University of Tokyo explored an alternative low-pressure approach through controlled electron irradiation of a carbon cage molecule called adamantane ($C_{10}H_{16}$).

Diamond and adamantane share a tetrahedral symmetric carbon skeleton, with the carbon atoms arranged in the same spatial pattern, making adamantane an attractive precursor for the production of nanodiamonds.

Successful conversion, however, requires precise cutting of adamantane's C–H termination bonds to form new C–C bonds, while assembling the monomers into a three-dimensional diamond lattice. While this was common knowledge in the field, "The real problem was that no one thought it feasible," said Nakamura.

Previously, mass spectrometry, an analytical technique that sorts ions according to their differing mass and charge, has shown that single-electron ionization could be used to facilitate such C–H bond cleavage. Mass spectrometry, however, can only infer structure formation in the gas phase, and is unable to isolate products from intermolecular reactions.

The team was prompted to monitor electron-impact ionization of solid adamantane at atomic resolution using an analytical and imaging technique called transmission electron microscopy (TEM), irradiating submicrocrystals at 80–200 kiloelectron volts at 100–296 Kelvin in vacuum for tens of seconds.

Not only would the method reveal the evolution of the polymerized nanodiamond formation, but provide powerful ramifications for the potential of TEM as a tool to resolve the controlled reactions of other organic molecules.

For Nakamura, who has worked on synthetic chemistry for 30 years and computational quantum chemical calculations for 15 years, the study offered a breakthrough opportunity. "Computational data gives you 'virtual' reaction paths, but I wanted to see it with my eyes," he said.

"However, the common wisdom among TEM specialists was that organic molecules decompose quickly as you shine an electron beam on them. My research since 2004 has been a constant battle to show otherwise."

The process yielded defect-free nanodiamonds of cubic crystal structure accompanied by hydrogen gas eruptions, up to 10 nanometers in diameter under prolonged irradiation.

The time-resolved TEM images illustrated the passage of formed adamantane oligomers transforming into spherical nanodiamonds, moderated by the C–H cleavage rate. The team also tested other hydrocarbons, which failed to form nanodiamonds, highlighting the suitability of adamantane as a precursor.

The findings open a new paradigm for understanding and controlling chemistry in the fields of electron lithography, surface engineering and electron microscopy. Analysis of the nanodiamond conversion supports long-standing ideas that diamond formation in extraterrestrial meteorites and uranium-bearing carbonaceous sedimentary rocks may be driven by high-energy particle irradiation.

Nakamura also pointed to the basis it provides for synthesizing doped quantum dots, essential to the construction of quantum computers and sensors.

As the latest chapter in a 20-year-long research dream, Nakamura said, "This example of diamond synthesis is the ultimate demonstration that electrons do not destroy organic molecules but let them undergo well-defined chemical reactions, if we install suitable properties in molecules to be irradiated."

By forever changing the game in fields employing electron beams for research, his dream could now provide the vision for scientists to uncloud interactions under electron irradiation.

Phys Org, 4 September 2025

https://phys.org

Scientists create biodegradable plastic stronger than PET

2025-09-04

The PET-alternative PDCA is biodegradable and has superior physical properties. A Kobe University team of bioengineers engineered E. coli bacteria to produce the compound from glucose at unprecedented levels and without byproducts -- and opened up a realm of possibilities for the future of bioengineering.

The durability of plastics is both the reason why they have become so wide-spread and why they pose environmental problems. In addition, they are mainly sourced from petroleum, making them non-renewable and contingent on geopolitics. Research groups worldwide work on both biodegradable and bio-sourced alternatives, but there often are issues with yield, purity and -- as a result -- associated production cost.

Kobe University bioengineer Tsutomu Tanaka says: "Most biomass-based production strategies focus on molecules consisting of carbon, oxygen and hydrogen. However, there are highly promising compounds for high-performance plastics that include other elements such as nitrogen, but there are no efficient bioproduction strategies. And purely chemical reactions inevitably generate unwanted byproducts." PDCA, which stands for pyridinedicarboxylic acid, is such a candidate. It is biodegradable, and materials incorporating this show physical properties comparable to or even surpassing those of PET, which is widely used in containers and textiles. "Our group approached the challenge from a new angle: We aimed to harness cellular metabolism to assimilate nitrogen and build the compound from start to finish," says Tanaka.

In the journal Metabolic Engineering, the Kobe University group now published that they achieved the production of PDCA in bioreactors at concentrations more than seven-fold higher than previously reported. Tanaka explains, "The significance of our work lies in demonstrating that metabolic reactions can be used to incorporate nitrogen without producing unwanted byproducts, thereby enabling the clean and efficient synthesis of the target compound."

The group, however, did have some stubborn problems to solve along the way. The most stubborn of these came when they discovered a bottleneck where one of the enzymes they had introduced produced the highly reactive compound hydrogen peroxide, H_2O_2. The compound then attacked the enzyme that produced it, thereby deactivating it. "Through refining the culture conditions, in particular by adding a compound that can scavenge H_2O_2, we could finally overcome the issue, although this addition may present new economic and logistical challenges for large-scale production," says Tanaka.

The bioengineers already have plans on how to improve the production going forward, with every problem pointing the way to its solution. Looking at the future, Tanaka says: "The ability to obtain sufficient quantities in bioreactors lays the groundwork for the next steps toward practical implementation. More generally, though, our achievement in incorporating enzymes from nitrogen metabolism broadens the spectrum of molecules accessible through microbial synthesis, thus enhancing the potential of bio-manufacturing even further."

Science Daily, 4 September 2025

https://sciencedaily.com

Metformin Alters Copper, Iron and Zinc in the Body

2025-09-01

For decades, scientists have puzzled over how metformin, the world's most prescribed diabetes drug, works beyond lowering blood sugar.

Now, a study from Kobe University reports that metformin users have lower blood copper and iron levels and higher zinc levels compared with non-users.

The findings, published in BMJ Open Diabetes Research & Care, suggest that the drug's ability to bind metals may play a role in its wide-ranging benefits.

Metformin's mechanism of action remains unclear

Metformin has been prescribed for more than 60 years and remains the first-line treatment for type 2 diabetes. Its glucose-lowering effect is thought to arise mainly from reduced glucose production in the liver, but the exact mechanisms remain only partly defined.

Beyond glycemic control, metformin is associated with a range of additional benefits, including anti-inflammatory, anti-tumor, anti-atherosclerotic and anti-obesity effects. These broader actions are well documented but poorly explained.

One hypothesis is that some of these effects relate to metformin's ability to bind metals. Laboratory studies have shown that the drug can form complexes with transition metals, particularly copper. This binding has been suggested to influence mitochondrial function and cell signaling. However, it has not been clear whether such interactions occur in patients, and earlier small studies measuring copper levels in people taking metformin produced inconsistent results.

Altered levels of metals such as copper, iron and zinc are themselves linked to diabetes and its complications. Higher copper and iron levels are often associated with poorer glucose control and increased risk of cardiovascular disease. Zinc, in contrast, is generally thought to play a protective role in glucose metabolism and in limiting complications.

“It is known that diabetes patients experience changes in the blood levels of metals such as copper, iron and zinc. In addition, chemical studies found that metformin has the ability to bind certain metals, such as copper, and recent studies showed that it is this binding ability that might be responsible for some of the drug's beneficial effects,” said corresponding author Dr. Wataru Ogawa, a professor at Kobe University.

“We wanted to know whether metformin actually affects blood metal levels in humans, which had not been clarified,” he added.

Metformin's effect on blood metals

The cross-sectional analysis involved a total of 189 adults with type 2 diabetes. Of these, 93 participants had been taking metformin for at least 6 months, while the remaining 96 had not used the drug during the same period. Blood samples from all participants were analyzed for copper, iron, zinc, vitamin B12 and other related biochemical markers. The researchers identified serum copper concentration as the primary outcome, with secondary outcomes including iron and zinc levels, vitamin B12, homocysteine and parameters linked to copper and iron metabolism.

Patients taking metformin had lower serum copper levels than non-users (16.0 vs 17.8 µmol/L). Iron levels were also reduced in the metformin group

(16.3 vs 17.3 µmol/L), along with ferritin and other markers that pointed to latent iron deficiency.

By contrast, zinc levels were higher in metformin users (13.3 vs 12.5 µmol/L). Vitamin B12 was significantly lower in those on metformin, consistent with earlier reports, and was accompanied by higher homocysteine levels.

Cobalt measurements showed no difference, although analysis was limited by detection sensitivity.

The associations remained after accounting for age, sex, body mass index, kidney function and medications that might affect metal metabolism. Multiple regression analysis identified metformin use as an independent predictor of reduced copper and iron and increased zinc levels.

Subgroup analyses by sex and medication use produced similar results, strengthening confidence in the findings.

What changes in copper, iron and zinc mean for metformin's role

The findings suggest that metformin's long-recognized ability to bind metals is not just a laboratory observation but has measurable effects in patients. The lower copper and iron levels, together with higher zinc, may contribute to the drug's glucose-lowering activity and its protective effects against complications. This aligns with preclinical studies showing that reducing copper availability can influence mitochondrial function, dampen inflammation and even slow tumor growth.

“It is significant that we could show this in humans. Furthermore, since decreases in copper and iron concentrations and an increase in zinc concentration are all considered to be associated with improved glucose tolerance and prevention of complications, these changes may indeed be related to metformin's action,” said Ogawa.

The results also raise questions about how different antidiabetic drugs might work. Imeglimin, a recently approved derivative of metformin in Japan, does not share the same metal-binding properties. Direct comparisons between the two could help clarify which effects depend on metal interactions.

“Imeglimin is thought to have a different method of action and we are already conducting studies to compare the effects the two drugs have,” Ogawa added.

“We need both clinical trials and animal experiments to pinpoint the causal relationship between the drug’s action and its effects. If such studies progress further, they may lead to the development of new drugs for diabetes and its complications by properly adjusting the metal concentrations in the body,” said Ogawa.

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