CHEMWATCH

Bulletin Board

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ASIA PACIFIC

Variations to Inventory listings after evaluation: CAS 84434-22-0 and 145-39-1

2023-01-10

An obligation to provide specific information to AICIS will be added to the terms of listing for musk tibetene and a structural analogue on the Australian Inventory of Industrial Chemicals (Inventory).

- Benzene, 3-(1,1-dimethylethyl)-1,5-dimethyl-2,4-dinitro- CAS no. 84434-22-0
- Benzene, 1-(1,1-dimethylethyl)-3,4,5-trimethyl-2,6-dinitro- CAS no. 145-39-1

Reason for varying the Inventory listings

AICIS completed an evaluation under Part 4 of the Industrial Chemicals Act 2019 (IC Act). AICIS published its final evaluation statement on 22 December 2022, following public consultation.

For the reasons set out in page 7/paragraph 3 of the evaluation statement, the Executive Director of AICIS concluded that a variation to the Inventory terms of listings of the chemicals is necessary to manage the risks from the introduction of these chemicals.

Therefore, the Executive Director is varying the terms of listing for these chemicals on the Inventory under section 86 of the IC Act. The variations will take effect on 8/02/2023.

Read More

AICIS, 10-01-23

https://www.industrialchemicals.gov.au/news-and-notices/variations-inventory-listings-after-evaluation-cas-84434-22-0-and-145-39-1

Removing an Inventory listing after evaluation: CAS 608-93-5

2023-01-10

Chemical details

Benzene, 1,2,3,4,5-pentachloro- (PeCB)

CAS no. 608-93-5

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Reasons for removal of Inventory listing

AICIS completed an evaluation of PeCB under Part 4 of the Industrial Chemicals 2019 Act. AICIS published its final evaluation statement on 22 December 2022 following public consultation.

For the reasons set out in page 10/paragraph 4 – paragraph 6 of the evaluation statement, the Executive Director of AICIS was not satisfied that the risks to the environment from the introduction or use of PeCB can be managed within existing regulatory frameworks

Therefore, the Executive Director will remove PeCB from the Australian Inventory of Industrial Chemicals (Inventory) on 8/02/2023 under section 95 of the IC Act.

Read More

AICIS, 10-01-23

https://www.industrialchemicals.gov.au/news-and-notices/removing-inventory-listing-after-evaluation-cas-608-93-5

Removing an Inventory listing after evaluation: CAS 118-74-1

2023-01-10

Chemical details

Benzene, hexachloro- (HCB)

CAS no. 118-74-1

Reasons for removal of Inventory listing

AICIS completed an evaluation of HCB under Part 4 of the Industrial Chemicals 2019 Act. AICIS published its final evaluation statement on 22 December 2022 following public consultation.

For the reasons set out in page 10/paragraph 3 - paragraph 5 of the evaluation statement, the Executive Director was not satisfied that the risks to the environment from the introduction or use of HCB can be managed within existing regulatory frameworks.

Therefore, the Executive Director of AICIS will remove the HCB from the Australian Inventory of Industrial Chemicals (Inventory) on 8/02/2023 under section 95 of the Industrial Chemicals Act 2019.

Read More

AICIS, 10-01-23

https://www.industrialchemicals.gov.au/news-and-notices/removing-inventory-listing-after-evaluation-cas-118-74-1

Chemicals added to the Inventory 5 years after issue of assessment certificate – 10 January 2023

2023-01-09

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

CAS Number	2871677-90-4
Chemical Name	1,3-Benzenedicarboxylic acid, polymer with 2,2-dimethyl-1,3-propanediol, 2-ethyl-2-(hydroxymethyl)-1,3-propanediol, 3-hydroxy-2,2-dimethylpropyl 3-hydroxy-2,2-dimethylpropanoate and 1,3-isobenzofurandione, benzoate
Molecular Formula	(C10H20O4.C8H6O4.C8H4O3.C6H14O3.C5H12O2)x.xC7H6O2
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	3 January 2023
CAS Number	2870701-51-0
Chemical Name	Propanoic acid, 3-hydroxy-2-(hydroxymethyl)-2-methyl-, polymer with N1-(2-aminoethyl)-1,2-ethanediamine, 1,4-cyclohexanedimethanol, dimethyl carbonate, 1,6-hexanediol, hydrazine and 1,1′ -methylenebis[4-isocyanatocyclohexane], compd. with N,N-diethylethanamine
Molecular Formula	(C15H22N2O2.C8H16O2.C6H14O2.C5H10O4.C4H13N3.C3H6O3.H4N2)x.xC6H15N

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CAS Number	2871677-90-4
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	3 January 2023
CAS Number	1881248-50-5
Chemical Name	2-Propenoic acid, 2-methyl-, C16-18-alkyl esters, polymers with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-octyl methacrylate, 1,1-dimethylpropyl 2-ethylhexaneperoxoate-initiated
Molecular Formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	3 January 2023

Read More

AICIS, 10-01-23

https://www.industrialchemicals.gov.au/news-and-notices/chemicals-added-inventory-5-years-after-issue-assessment-certificate-10-january-2023

AMERICA

EPA Announces Release of New PFAS Analytic Tools

2023-01-09

The U.S. Environmental Protection Agency (EPA) announced on January 5, 2023, the release of a new interactive web page on the "PFAS Analytic Tools" that provides information about per- and polyfluoroalkyl substances (PFAS) across the country. EPA states that this information will help the public, researchers, and other stakeholders better understand potential PFAS sources in their communities. According to EPA, the PFAS Analytic Tools draw from multiple national databases and reports to consolidate information on one web page. The PFAS Analytic Tools include information

on Clean Water Act PFAS discharges from permitted sources; reported spills containing PFAS constituents; facilities historically manufacturing or importing PFAS; federally owned locations where PFAS are being investigated; transfers of PFAS-containing waste; PFAS detection in natural resources, such as fish or surface water; and drinking water testing results.

EPA notes that because the regulatory framework for PFAS is emerging, "data users should pay close attention to the caveats found within the site so that the completeness of the data sets is fully understood." EPA states that rather than wait for complete national data to be available, it is publishing what is currently available while information continues to be filled in. Users should be aware that some of the data sets are complete at the national level, whereas others are not. For example, according to EPA, it included a national inventory for drinking water testing at larger public water utilities that was provided between 2013 and 2016. To include more recent data, EPA also compiled other drinking water data sets that are available online in select states. For the subset of states and tribes publishing PFAS testing results in drinking water, the percentage of public water supplies tested varied significantly from state to state. EPA cautions that because of the differences in testing and reporting across the country, the data should not be used for comparisons across cities, counties, or states.

EPA states that to improve the availability of the data in the future, it has published its fifth Safe Drinking Water Act Unregulated Contaminant Monitoring Rule to expand on the initial drinking water data reporting that was conducted from 2013 to 2016. According to EPA, this expansion will bring the number of drinking water PFAS samples collected by regulatory agencies into the millions. EPA notes that it also significantly expanded the Toxics Release Inventory (TRI) reporting requirements in recent years to over 175 PFAS and that more information should be received in 2023. EPA's proposal to designate perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) as hazardous substances would also improve data on spill or release incidents reported to the Emergency Response Notification System. EPA will incorporate these reporting enhancements into future versions of the interactive web page.

Read More

TSCA Blog, 09-01-2023

https://www.tscablog.com/entry/epa-announces-release-of-new-pfas-analytic-tools-will-hold-webinar-on-janua

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EPA Proposes to Add PFAS Subject to TRI Reporting to List of Chemicals of Special Concern

2022-12-09

The U.S. Environmental Protection Agency (EPA) proposed on December 5, 2022, to add per- and polyfluoroalkyl substances (PFAS) subject to reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) and the Pollution Prevention Act (PPA) pursuant to the National Defense Authorization Act for Fiscal Year 2020 (NDAA) to the list of Lower Thresholds for Chemicals of Special Concern (chemicals of special concern). 87 Fed. Reg. 74379. EPA notes that these PFAS already have a lower reporting threshold of 100 pounds. Adding these PFAS to the list of chemicals of special concern will cause such PFAS to be subject to the same reporting requirements as other chemicals of special concern (i.e., it would eliminate the use of the de minimis exemption and the option to use Form A and would limit the use of range reporting for PFAS). EPA states that "[r]emoving the availability of these burden-reduction reporting options will result in a more complete picture of the releases and waste management quantities for these PFAS." In addition, EPA proposes to remove the availability of the de minimis exemption for purposes of the Supplier Notification Requirements for all chemicals on the list of chemicals of special concern. According to EPA, this change will help ensure that purchasers of mixtures and trade name products containing such chemicals are informed of their presence in mixtures and products they purchase. Comments are due February 3, 2023.

Read More

JD Supra, 09-12-22

https://www.jdsupra.com/legalnews/epa-proposes-to-add-pfas-subject-to-tri-1737910/

EPA Updates New Chemical Review Program Webpage, Metrics, Affirming Commitment to Increased Transparency

2022-12-16

Today, the U.S. Environmental Protection Agency (EPA) announced a redesign and updates to the statistics webpage for the New Chemicals Review Program. The update includes additional information and metrics on the Agency's review of new chemicals under the Toxic Substances Control Act (TSCA), increasing transparency for the public, the regulated

community and other stakeholders. The new information and features will help users understand EPA's new chemicals review process, throughput, and trends, while highlighting the progress the program has made despite ongoing resource challenges.

"EPA is committed to building a culture of transparency and today's update is a significant step towards improving transparency in our review of new chemicals," said Assistant Administrator for the Office of Chemical Safety and Pollution Prevention Michal Freedhoff. "The newly enhanced webpage gives users an extensive look at the new chemical review process and provides a clear snapshot of the progress made by the program's dedicated career staff to ensure public health and environmental protections."

TSCA requires EPA to review the potential risks of new chemicals before they enter the U.S. marketplace and, when necessary, put safeguards in place to protect human health and the environment. Before TSCA was amended in 2016, EPA issued formal risk determinations for approximately 20% of new chemical submissions. In 80% of cases, EPA dropped the chemical from further review, which under the prior law would allow the manufacturer to take the chemical to market.

Under the 2016 amendments, EPA is required to make an affirmative determination on all new chemical notices submitted under TSCA, substantially increasing the Agency's workload. Despite the dramatic increase in responsibility, the budget for the TSCA program has remained essentially flat over the past six years.

To address resource limitations, EPA has taken several steps over the past year to create a sustainable program that follows the science and the law. Today's action represents another important step in that process. Data displayed on the enhanced webpage will be updated monthly. The data show that EPA continues to make positive progress on reviewing new chemicals and managing risks to human health and the environment. With more funding and resources, EPA could further increase the efficiency, effectiveness and transparency of its work.

Read More

US EPA, 16-12-22

https://www.epa.gov/reviewing-new-chemicals-under-toxic-substances-control-act-tsca/statistics-new-chemicals-review

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3M to phase out 'forever chemicals' PFAS by 2025

2022-12-20

US industrial giant 3M announced Tuesday it will phase out production of so-called "forever chemical" PFAS in light of tightening regulation connected to harmful health effects from their use.

3M will exit polyfluoroalkyl substances (PFAS) manufacturing by the end of 2025 and discontinue use across its product portfolio under the same timeframe, moves that are expected to result in pre-tax costs of $1.3 to $2.3 billion.

Known for the lengthy amount of time required before they break down and widely employed in Teflon and other goods, PFAS are man-made chemicals produced since the 1940s and now widely present in soil and water as well as in humans, fish and other wildlife.

"While PFAS can be safely made and used, we also see an opportunity to lead in a rapidly evolving external regulatory and business landscape to make the greatest impact for those we serve," said Mike Roman, chief executive of 3M, which is also the maker of Scotch tape, N-95 face masks and other goods.

PFAS have a strong bond between fluorine and carbon, promoting "strength, durability, stability and resilience" in cellphones, aircraft and other industrial products, according to the American Chemistry Council.

Read More

France 24, 20-12-22

https://www.france24.com/en/live-news/20221220-3m-to-phase-out-forever-chemicals-pfas-by-2025

EUROPE

Studded tires to be banned from Reykjavik in bid to cut air pollution

2022-12-09

As one of the word's most northerly capitals, Reykjavik has a reputation for snow and ice as the colder months and nights draw in. But now local authorities are proposing new rules that prevent the use of specialist

Iceland's spectacular city is taking bold measures to cull particulate matter and improve atmospheric conditions in winter.

studded tyres, designed to increase road safety in wintry conditions, because of concerns about the air pollution effects of such kit.

According to one study, use of these tyres in the city must fall by 15% to have any significant impact on air quality. Although current regulations mean people are fined for using the tyres outside the cold season, there is now a proposal to introduce an outright ban, and local powers now need permission from national government to implement.

The news comes at a time when northern Europe is bracing for its coldest time of the year, with air pollution overall significantly effected by the temperature and weather for a number of reasons. These include increased use of private transport and heating, alongside the behavioural changes of certain emissions and pollutants that result from contact with colder air.

Iceland is famous for its volcanoes. Revisit our investigation into the pollution caused by eruptions, then catch up with a recent study identifying the extent to which tiny particles released into the air through volcanic activity help significantly improve climate modelling and predictions, in turn informing authorities on the most effective policies to tackle air pollution.

Read More

Air Quality News, 09-12-22

https://airqualitynews.com/2022/12/09/studded-tires-to-be-banned-from-reykjavik-in-bid-to-cut-air-pollution/

Safety assessment of the process Polyfab Plastics, based on Starlinger deCON technology, used to recycle post-consumer PET into food contact materials

2022-11-09

The EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (CEP) assessed the safety of the recycling process Polyfab Plastics (EU register number RECYC245), which uses the Starlinger deCON technology. The input material is hot washed and dried poly(ethylene terephthalate) (PET) flakes originating from collected post-consumer PET containers, e.g. bottles, including no more than 5% PET from non-food consumer applications. The flakes are preheated before being submitted to solid-state polycondensation (SSP) in a continuous reactor at high temperature under vacuum and gas flow. Having examined the challenge test provided,

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the Panel concluded that the preheating (step 2) and the decontamination in the SSP reactor (step 3) are critical in determining the decontamination efficiency of the process. The operating parameters to control the performance of these critical steps are temperature, pressure, residence time and gas flow rate. It was demonstrated that this recycling process is able to ensure a level of migration of potential unknown contaminants into food below the conservatively modelled migration of 0.1 µg/kg food. Therefore, the Panel concluded that the recycled PET obtained from this process is not considered to be of safety concern, when used at up to 100% for the manufacture of materials and articles for contact with all types of foodstuffs for long-term storage at room temperature, with or without hotfill. The final articles made of this recycled PET are not intended to be used in microwave or conventional ovens and such uses are not covered by this evaluation.

Read More

EFSA, 09-11-22

https://www.efsa.europa.eu/en/efsajournal/pub/7579

Commission sets up rules to identify endocrine disruptors and long-lasting chemicals and to improve labelling

2022-12-19

Today, the Commission proposed a revised Regulation on classification, labelling and packaging of chemicals (CLP) and introduced new hazard classes for endocrine disruptors and other harmful chemical substances to better protect people and the environment from hazardous chemicals.

The revised Regulation clarifies rules on labelling and for chemicals sold online. This will hence facilitate business, including for SMEs, and the free movement of substances and mixtures at EU level.

The Commission adopted a Delegated Act to introduce new hazard classes under the CLP for endocrine disruptors, as well as for chemicals that do not break down in the environment and can accumulate in living organisms, or risk entering and spreading across the water cycle, including drinking water.

The new hazard classes are the result of extensive scientific discussions and will provide easier access to information to all users of such chemicals, notably consumers, workers and businesses. They could allow further

action to address and mitigate the risks of substances and mixtures under other EU downstream legislation such as e.g. REACH, while taking account of socio-economic impacts.

In addition, the legislative proposal amending the CLP Regulation caters for:

- Better and faster processes for all actors to inform on hazards of chemicals placed in the EU market.
- Improved communication of chemical hazards, including online, through simpler and clarified labelling and advertising requirements. Among those, the proposal sets up a minimal font size for labels of chemicals.
- The right for the Commission to develop classification proposals on potentially hazardous substances, in addition to Member States and industry. This will speed up the pace at which hazardous substances are identified.
- First ever specific rules for refillable chemical products, so consumers buy and use chemical products, such as home care chemicals, sold in bulk in a safe way.

Read More

European Commission, 19-12-22

https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7775

'A drop in the ocean': England bans some single-use plastics - but does it go far enough?

2023-01-09

Each year, the country uses around 1.1 billion single-use plates and 4.25 billion items of cutlery, according to government estimates. Only 10 per cent of these are recycled.

Now, environment secretary Thérèse Coffey has confirmed that such items will be outlawed in England.

'A plastic fork can take 200 years to decompose'

Plastic objects used for takeaway food and drink - including containers, trays and cutlery - are the biggest polluters of the world's oceans, studies have shown.

Single-use plastic items including cutlery and plates will soon be banned in England, the government has announced.

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"A plastic fork can take 200 years to decompose, that is two centuries in landfill or polluting our oceans," says Coffey.

Billions of single-use plastic items are disposed of each year in England, rather than recycled.

England bans single use plastic

England is now set to ban single-use items including plastic plates, knives and forks.

The decision comes after a consultation by the Department for Environment, Food and Rural Affairs (Defra) that took place from November 2021 to February 2022.

"I am determined to drive forward action to tackle this issue head on," Coffey says.

"We've already taken major steps in recent years - but we know there is more to do, and we have again listened to the public's calls.

"This new ban will have a huge impact to stop the pollution of billions of pieces of plastic and help to protect the natural environment for future generations."

Read More

Euronews, 09-01-23

https://www.euronews.com/green/2023/01/09/a-drop-in-the-ocean-england-bans-some-single-use-plastics-but-does-it-go-far-enough

Completeness check of REACH registration dossiers: what changes in 2023 and how you can prepare

2023-01-12

Webinar date

8 February 2023 11:00 - 13:00 EET, GMT +2

Summary

The European Commission has revised some of the information requirements for registering chemicals under REACH (Action 1, Action 2). This webinar focuses on the new and amended completeness check rules brought by this revision to help you prepare a complete registration dossier. We will also give you an overview of the process in general.

Completeness check will be aligned with the revised information requirements in May 2023, after the next major IUCLID release.

Join from our home page on 8 February at 11:00 EET, GMT +2. No registration required.

Read More

ECHA, 12-01-23

https://echa.europa.eu/en/-/completeness-check-of-reach-registration-dossiers-what-changes-in-2023-and-how-you-can-prepare

Guidance on REACH

2022-12-07

The list below contains all the Guidance Documents which are available, or will be available, on this website. These documents have been developed with the participation of many stakeholders: Industry, Member States and NGOs. The objective of these documents is to facilitate the implementation of REACH by describing good practice on how to fulfil the obligations.

Some of these documents have been or will be translated into official EU languages. You can access the translations from this webpage: use the language menu on the top right corner of the page.

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Read More

ECHA, 07-12-22

https://echa.europa.eu/web/guest/guidance-documents/guidance-on-reach

Janet's Corner

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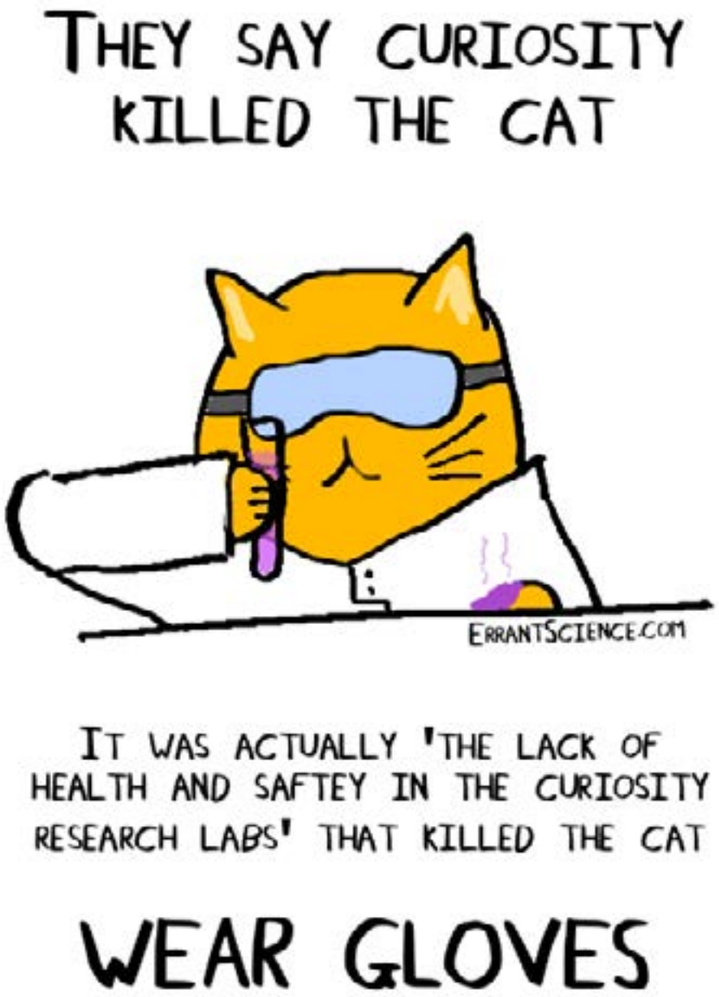
A year without lab accidents is a good year! Wear your gear!

2023-02-03



twitter.com/ErrantScience/status/1616763947171946497

Hazard Alert

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Chromium

2023-02-03

Chromium is a chemical element with the symbol Cr and atomic number 24. It is a steely-grey, lustrous, hard and brittle metal, which takes a high polish, resists tarnishing, and has a high melting point. [1] Chromium is a naturally occurring element found in rocks, animals, plants, and soil. It can exist in several different forms. Depending on the form it takes, it can be a liquid, solid, or gas. The most common forms are chromium(0), chromium(III), and chromium(VI). No taste or odour is associated with chromium compounds. [2]

Chromium is a chemical element with the symbol Cr and atomic number 24.

USES [2,3]

The metal chromium, which is the chromium(0) form, is used for making steel. Chromium(VI) and chromium(III) are used for chrome plating, dyes and pigments, leather tanning, wood preserving and water treatment.

IN THE ENVIRONMENT [4]

Chromium is released into the atmosphere via industrial, commercial, and residential fuel combustion of natural gas, oil, and coal and from emissions from metal industries such as chrome plating and steel production.

Approximately 1/3 of atmospheric releases are believed to be in the form of chromium(VI).

Electroplating, leather tanning, and textile industries release large amounts of chromium to surface water.

Chromium is primarily removed from the atmosphere by fallout and precipitation, the residence time is expected to be <10 days.

Most of the chromium released in water will be deposited in the sediments.

Chromium is not believed to biomagnify in the food chain.

SOURCES & ROUTES OF EXPOSURE

Sources of Emission [3]

- Industry sources: Emissions to air and water from chemical manufacturing industry e.g. dyes for paints, rubber and plastic products, metal finishing industry e.g. chrome plating, manufacturers

of pharmaceuticals, wood, stone, clay and glass products, electrical and aircraft manufacturers, steam and air conditioning supply services, cement producing plants as cement contains chromium, incineration of council refuse and sewage sludge and combustion of oil and coal.

- Diffuse sources: Facilities below the reporting threshold.
- Natural sources: Chromium (VI) compounds are not found in nature. Chromium is usually found as the Cr(III) form, as the mineral Chromite and in many soils.
- Transport sources: Emission to air from the wearing down of brake linings containing chromium. Motor vehicle exhaust (crude oil contains traces of chromium (III) compounds, these may oxidise to the chromium (VI) state during fuel combustion in vehicle engines).
- Consumer products: Some inks, paints and paper. Some rubber and composite floor coverings. Some treated (preserved) timber products. Some toner powders used in copying machines.

Routes of Exposure [2,4]

- Exposure to chromium may occur by eating food containing chromium(III).
- Breathing contaminated workplace air or skin contact during use in the workplace.
- Drinking contaminated well water.
- Living near uncontrolled hazardous waste sites containing chromium or industries that use chromium.

The major routes of exposure are as follows:

- Inhalation – Predominant route of exposure for occupational populations.
- Oral – Predominant route of exposure for the general population.
- Dermal – Minor route of exposure for the general population.

HEALTH EFFECTS [5]

Acute Effects

Chromium VI

Chromium (VI) is much more toxic than chromium (III), for both acute and chronic exposures. The respiratory tract is the major target organ for chromium (VI) following inhalation exposure in humans. Shortness

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of breath, coughing, and wheezing were reported in cases where an individual inhaled very high concentrations of chromium trioxide.

Other effects noted from acute inhalation exposure to very high concentrations of chromium (VI) include gastrointestinal and neurological effects, while dermal exposure causes skin burns in humans.

Ingestion of high amounts of chromium (VI) causes gastrointestinal effects in humans and animals, including abdominal pain, vomiting, and haemorrhage.

Acute animal tests have shown chromium (VI) to have extreme toxicity from inhalation and oral exposure.

Chromium III

Chromium (III) is an essential element in humans, with a daily intake of 50 to 200 µg/d recommended for adults.

Acute animal tests have shown chromium (III) to have moderate toxicity from oral exposure.

CHRONIC EFFECTS

Chromium VI

Chronic inhalation exposure to chromium (VI) in humans results in effects on the respiratory tract, with perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, asthma, and nasal itching and soreness reported.

Chronic human exposure to high levels of chromium (VI) by inhalation or oral exposure may produce effects on the liver, kidney, gastrointestinal and immune systems, and possibly the blood.

Rat studies have shown that, following inhalation exposure, the lung and kidney have the highest tissue levels of chromium.

Dermal exposure to chromium (VI) may cause contact dermatitis, sensitivity, and ulceration of the skin.

The Reference Concentration (RfC) for chromium (VI) (particulates) is 0.0001 mg/m^3 based on respiratory effects in rats.

The Reference Concentration (RfC) for chromium (VI) (chromic acid mists and dissolved Cr (VI) aerosols) is 0.000008 mg/m^3 based on respiratory effects in humans.

The Reference Dose (RfD) for chromium (VI) is 0.003 mg/kg/d based on the exposure at which no effects were noted in rats exposed to chromium in the drinking water.

Chromium III

Although data from animal studies have identified the respiratory tract as the major target organ for chronic chromium exposure, these data do not demonstrate that the effects observed following inhalation of chromium (VI) particulates are relevant to inhalation of chromium (III).

EPA has not established an RfC for chromium (III).

The RfD for chromium (III) is 1.5 mg/kg/d based on the exposure level at which no effects were observed in rats exposed to chromium (III) in the diet.

Reproductive/Developmental Effects

Chromium VI

Limited information on the reproductive effects of chromium (VI) in humans exposed by inhalation suggest that exposure to chromium (VI) may result in complications during pregnancy and childbirth.

Animal studies have not reported reproductive or developmental effects from inhalation exposure to chromium (VI).

Oral studies have reported severe developmental effects in mice such as gross abnormalities and reproductive effects including decreased litter size, reduced sperm count, and degeneration of the outer cellular layer of the seminiferous tubules.

Chromium III

No information is available on the reproductive or developmental effects of chromium (III) in humans.

A study of mice fed high levels of chromium (III) in their drinking water has suggested a potential for reproductive effects, although various study characteristics preclude a definitive finding.

No developmental effects were reported in the offspring of rats fed chromium (III) during their developmental period.

Cancer Risk

Chromium VI

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Epidemiological studies of workers have clearly established that inhaled chromium is a human carcinogen, resulting in an increased risk of lung cancer. Although chromium-exposed workers were exposed to both chromium (III) and chromium (VI) compounds, only chromium (VI) has been found to be carcinogenic in animal studies, so EPA has concluded that only chromium (VI) should be classified as a human carcinogen.

Animal studies have shown chromium (VI) to cause lung tumours via inhalation exposure.

EPA has classified chromium (VI) as a Group A, known human carcinogen by the inhalation route of exposure.

EPA used a mathematical model, based on data from an occupational study of chromate production workers, to estimate the probability of a person developing cancer from continuously breathing air containing a specified concentration of chromium. EPA calculated an inhalation unit risk estimate of 1.2×10^{-2} $(\mu g/m3)^{-1}$.

Chromium III

No data are available on the carcinogenic potential of chromium (III) compounds alone.

EPA has classified chromium (III) as a Group D, not classifiable as to carcinogenicity in humans.

EPA has stated that "the classification of chromium (VI) as a known human carcinogen raises a concern for the carcinogenic potential of chromium (III)".

SAFETY [6]

First Aid Measures

- Eye Contact: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.
- Skin Contact: In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.
- Serious Skin Contact: Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

- Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
- Ingestion: Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Fire & Explosion Information

Chromium is a moderate fire hazard when it is in the form of a dust (powder) and burns rapidly when heated in flame. Chromium is attacked vigorously by fused potassium chlorate producing vivid incandescence. Pyrophoric chromium unites with nitric oxide with incandescence. Incandescent reactions occur with nitrogen oxide or sulfur dioxide.

Powdered Chromium metal +fused ammonium nitrate may react violently or explosively. Powdered Chromium will explode spontaneously in air.

Exposure Controls & Personal Protection

Engineering Controls

- Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits.
- If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protective Equipment

The following personal protective equipment is recommended when handling chromium:

- Splash goggles;
- Lab coat;
- Dust respirator (be sure to use an approved/certified respirator or equivalent);
- Gloves.

Personal protective equipment in case of a large spill:

- Splash goggles;
- Full suit;
- Dust respirator;
- Boots;
- Gloves;

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- A self contained breathing apparatus should be used to avoid inhalation of the product.
- Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATIONS [3,7,8]

United States

Regulations and Guidelines for Chromium			
Agency	**Focus**	**Level**	**Comments**
American Conference of Governmental Industrial Hygienists	Air: workplace	10 µg/m^3 as Cr	Advisory; TWA* to avoid carcinogenic risk from insoluble Cr(VI) compounds
		50 µg/m^3 as Cr	TWA for water-soluble Cr(VI) compounds
		500 µg/m^3 as Cr	TWA for chromium metal and Cr(III) compounds
National Institute for Occupational Safety and Health	Air: workplace	1 µg/m^3 as Cr	Advisory; TWA (10-hour) for chromic acid and all Cr(VI) compounds
		500 µg/m^3 as Cr	Advisory; TWA (10-hour) for chromium metal and Cr(II) and Cr(III) compounds

Regulations and Guidelines for Chromium			
Occupational Safety and Health Administration	Air: workplace	5 µg/m³ as CrO_3/m³	Regulation; PEL† for chromic acid and chromates, (8-hour TWA)
		500 µg/m³ as Cr	PEL for Cr(II) and Cr(III) compounds (8-hour TWA)
		1,000 µg/m³ as Cr	PEL for chromium metal and insoluble compounds (8-hour TWA)
Environmental Protection Agency	Air: environment	Not available	Chromium is listed as a hazardous pollutant
	Drinking water	100 µg/L	Regulation; current MCL‡ for total chromium
*TWA (time-weighted average): TWA concentration for a normal workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed. †PEL (permissible exposure limit): highest level of chromium in air, to which a worker may be exposed, averaged over an 8-hour workday. ‡MCL (maximum contaminant level) enforceable level for drinking water.			

Australia

Safe Work Australia has established the following exposure limits for Chromium:

Chemical Name	CAS No.	TWA (ppm)	TWA (mg/m³)	Advisory Carcinogen Category	Other Advisory Information
Chromium (II)			0.5		
Chromium (III)			0.5		
Chromium (metal)	7440-47-3		0.5		
Chromium (VI)			0.05	Carc. 1A	Sens
Chromium (VI)			0.05		Sens

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Australian Drinking Water Quality Guidelines (NHMRC and ARMCANZ, 1996) specify a limit of 0.05 mg/L (i.e. 0.00005 g/L).

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http://www.npi.gov.au/resource/chromium-vi-compounds

http://www.atsdr.cdc.gov/toxguides/toxguide-7.pdf

http://www.epa.gov/ttn/atw/hlthef/chromium.html

http://www.sciencelab.com/msds.php?msdsId=9927136

http://www.atsdr.cdc.gov/csem/csem.asp?csem=10&po=8

http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/772/Workplace-exposure-standards-airborne-contaminants.pdf

Tire Dust Is the 'DDT Of Our Generation'

2023-01-24

Research scientists are sounding the alarm in the Pacific Northwest after this month's "atmospheric river" drenched much of the state's roads, sending brake and tire dust into rivers, streams and, eventually, the Pacific Ocean.

We all know the exhaust from our cars is bad for our health and the environment, but dust from tire and brake wear is just as damaging. California experienced heavy storms in the early half of January, which sent heavily polluted runoff from the roads to the waterways. It turns out there's a particular chemical found in tires that seem to suffocate the highly endangered coho salmon. From Forbes (paywall):

A growing body of research indicates that in addition to being a major source of microplastic pollution, the chemical 6PPD, an additive that's used to keep tires from wearing out, reacts with ozone in the atmosphere to form a toxic new substance scientists call 6PPD-Quinone. It's killing coho salmon and likely harms other types of fish, which exhibit symptoms resembling suffocation.

The devastation of the coho, which the U.S. designates as an endangered species, has reached crisis level. In California's Central Coast, estimates suggest the fish is already close to extinction, with its population plunging from as high as 500,000 fish in the 1940s to a few thousand currently. While generally more abundant in Washington state, the population of wild coho salmon was estimated to have plunged to around 200,000, a third of the level of 2021, according to Puget Sound Institute. And while tire manufacturers say they're following the issue closely, they don't know when or if they'll have a safe alternative to 6PPD. They've been using it for decades.

"This is the DDT of our generation," David Troutt, head of natural resources for the Nisqually Tribe in Washington, told Forbes. "This thing is killing salmon every time it rains in the Puget Sound region. We can't take it anymore."

But it isn't just this one fish pollution we should worry about. Tire dust accounts for 6 million tons of micro-pollutants each year, current estimates suggest. With such a mass of material it's not just salmon which are threatened by chemicals in tire dust. And it's almost certainly not just 6PPD-Quinone we have to worry about. California's Department of Toxic Substance Control is also investigating six other harmful chemicals found

Companies know their products threaten wild fish habitats, but they have no plans to stop using the deadly chemicals.

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in tires. 6PPD-Quinone is considered the "low hanging fruit" of researchers investigating tire dust's impact on the environment, Forbes reports. Tires contain all sorts of heavy metals, chemicals and synthetic compounds, the effects of which on humans and their environment are not completely understood.

Though found in its highest concentrations in runoff water, according to a study published in Environment International, tire dust can be fine enough to be inhaled as well. The Union For Concerned Scientists found cars, trucks and buses are a significant source for some of the pollution most harmful to human health — particulate matter smaller than 2.5 micrometers in diameter, or PM 2.5:

While PM2.5 is not the only air pollutant that adversely affects health, it is estimated to be responsible for approximately 95 percent of the global public health impacts from air pollution. Long-term exposure to PM2.5 causes increased death rates attributed to cardiovascular diseases, including heart attacks, and has been linked to other adverse impacts such as lung cancer. Chronic exposure to PM2.5 in children has also been linked to slowed lung-function growth, development of asthma, and other negative health impacts.

The coming age of EVs will only make things worse as the heavier cars are harder on consumer tires and brakes. While there are some companies experimenting with do-dads that scoop up tire particulate or create tires with less shedding, those solutions are worthless without some serious legislation and regulation. Tire manufactures have known about the 6PPD-Quinone problems for years and are still sitting on their hands when it comes to finding a solution.

Jalopnik, 24 January 2023

https://jalopnik.com

Peptide spray kills bacteria in wounds without using antibiotics

2023-01-26

It's always good if the use of antibiotics can be avoided, to keep harmful bacteria from developing a resistance to them. A new wound-treatment spray could help, as it kills bacteria using peptides that occur naturally in our bodies – no antibiotics required.

While previous studies had explored the use of such peptides for eradicating bacteria in medical applications, a major stumbling block lay in the fact that the peptides quickly break down upon coming into contact with blood or other body fluids.

Building on the success of an earlier project, scientists at Sweden's Chalmers University of Technology developed a workaround to that problem.

In the spray that they created – which is intended to be applied directly to open wounds – the peptide molecules are attached to specially structured microparticles of hydrogel. That gel protects the peptides from the blood, while still allowing them to destroy bacteria by compromising the microbes' protective outer membranes.

As an added bonus, because the spray does kill bacteria in this particular manner, it is believed that the bacteria won't develop a resistance to it.

In lab tests, the spray was found to kill 99.99% of bacteria on contact, including antibiotic-resistant types such as MRSA (Methicillin-resistant Staphylococcus aureus). What's more, it remained effective for approximately 48 hours.

The scientists are also looking into using the spray to coat medical implants, to keep infections from occurring when the devices are first placed within the body. They have already tested it on the silicone which is commonly used for catheters.

"The substance in this wound spray is completely non-toxic and does not affect human cells," said doctoral student Edvin Blomstrand, one of the lead authors of a paper on the study. "Unlike existing bactericidal sprays, it does not inhibit the body's healing process. The materials, which are simply sprayed onto the wound, can also kill the bacteria in a shorter time."

The paper was recently published in the journal ASC Applied Bio Materials.

New Atlas, 26 January 2023

https://newatlas.com

In lab tests, the spray was found to kill 99.99% of bacteria on contact, including antibiotic-resistant types such as MRSA.

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An ALS patient set a record for communicating via a brain implant: 62 words per minute

2023-01-24

Eight years ago, a patient lost her power of speech because of ALS, or Lou Gehrig's disease, which causes progressive paralysis. She can still make sounds, but her words have become unintelligible, leaving her reliant on a writing board or iPad to communicate.

Now, after volunteering to receive a brain implant, the woman has been able to rapidly communicate phrases like "I don't own my home" and "It's just tough" at a rate approaching normal speech.

That is the claim in a paper published over the weekend on the website bioRxiv by a team at Stanford University. The study has not been formally reviewed by other researchers. The scientists say their volunteer, identified only as "subject T12," smashed previous records by using the brain-reading implant to communicate at a rate of 62 words a minute, three times the previous best.

Philip Sabes, a researcher at the University of California, San Francisco, who was not involved in the project, called the results a "big breakthrough" and said that experimental brain-reading technology could be ready to leave the lab and become a useful product soon.

"The performance in this paper is already at a level which many people who cannot speak would want, if the device were ready," says Sabes. "People are going to want this."

People without speech deficits typically talk at a rate of about 160 words a minute. Even in an era of keyboards, thumb-typing, emojis, and internet abbreviations, speech remains the fastest form of human-to-human communication.

The new research was carried out at Stanford University. The preprint, published January 21, began drawing extra attention on Twitter and other social media because of the death the same day of its co-lead author, Krishna Shenoy, from pancreatic cancer.

Shenoy had devoted his career to improving the speed of communication through brain interfaces, carefully maintaining a list of records on his laboratory website. In 2019, another volunteer Shenoy worked with managed to use his thoughts to type at a rate of 18 words a minute, a record performance at the time, as we related in MIT Technology Review's special issue on computing.

Brain interfaces could let paralyzed people speak at almost normal speeds.

The brain-computer interfaces that Shenoy's team works with involve a small pad of sharp electrodes embedded in a person's motor cortex, the brain region most involved in movement. This allows researchers to record activity from a few dozen neurons at once and find patterns that reflect what motions someone is thinking of, even if the person is paralyzed.

In previous work, paralyzed volunteers have been asked to imagine making hand movements. By "decoding" their neural signals in real time, implants have let them steer a cursor around a screen, pick out letters on a virtual keyboard, play video games, or even control a robotic arm.

In the new research, the Stanford team wanted to know if neurons in the motor cortex contained useful information about speech movements, too. That is, could they detect how "subject T12" was trying to move her mouth, tongue, and vocal cords as she attempted to talk?

These are small, subtle movements, and according to Sabes, one big discovery is that just a few neurons contained enough information to let a computer program predict, with good accuracy, what words the patient was trying to say. That information was conveyed by Shenoy's team to a computer screen, where the patient's words appeared as they were spoken by the computer.

The new result builds on previous work by Edward Chang at the University of California, San Francisco, who has written that speech involves the most complicated movements people make. We push out air, add vibrations that make it audible, and form it into words with our mouth, lips, and tongue. To make the sound "f," you put your top teeth on your lower lip and push air out—just one of dozens of mouth movements needed to speak.

A path forward

Chang previously used electrodes placed on top of the brain to permit a volunteer to speak through a computer, but in their preprint, the Stanford researchers say their system is more accurate and three to four times faster.

"Our results show a feasible path forward to restore communication to people with paralysis at conversational speeds," wrote the researchers, who included Shenoy and neurosurgeon Jaimie Henderson.

David Moses, who works with Chang's team at UCSF, says the current work reaches "impressive new performance benchmarks." Yet even as records continue to be broken, he says, "it will become increasingly important to demonstrate stable and reliable performance over multi-year time

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scales." Any commercial brain implant could have a difficult time getting past regulators, especially if it degrades over time or if the accuracy of the recording falls off.

The path forward is likely to include both more sophisticated implants and closer integration with artificial intelligence.

The current system already uses a couple of types of machine learning programs. To improve its accuracy, the Stanford team employed software that predicts what word typically comes next in a sentence. "I" is more often followed by "am" than "ham," even though these words sound similar and could produce similar patterns in someone's brain.

Adding the word prediction system increased how quickly the subject could speak without mistakes.

Language models

But newer "large" language models, like GPT-3, are capable of writing entire essays and answering questions. Connecting these to brain interfaces could enable people using the system to speak even faster, just because the system will be better at guessing what they are trying to say on the basis of partial information. "The success of large language models over the last few years makes me think that a speech prosthesis is close at hand, because maybe you don't need such an impressive input to get speech out," says Sabes.

Shenoy's group is part of a consortium called BrainGate that has placed electrodes into the brains of more than a dozen volunteers. They use an implant called the Utah Array, a rigid metal square with about 100 needle-like electrodes.

Some companies, including Elon Musk's brain interface company, Neuralink, and a startup called Paradromics, say they have developed more modern interfaces that can record from thousands—even tens of thousands—of neurons at once.

While some skeptics have asked whether measuring from more neurons at one time will make any difference, the new report suggests it will, especially if the job is to brain-read complex movements such as speech.

The Stanford scientists found that the more neurons they read from at once, the fewer errors they made in understanding what "T12" was trying to say.

"This is a big deal, because it suggests efforts by companies like Neuralink to put 1,000 electrodes into the brain will make a difference, if the task is sufficiently rich," says Sabes, who previously worked as a senior scientist at Neuralink.

Technology Review, 24 January 2023

https://website

The World's Farms Are Hooked on Phosphorus. It's a Problem

2023-01-23

Disrupting earth's chemical cycles brings trouble. But planet-warming carbon dioxide isn't the only element whose cycle we've turned wonky—we've got a phosphorus problem too. And it's a big one, because we depend on this element to grow the world's crops. "I don't know if it would be possible to have a full world without any mineral phosphorus fertilizer," says Joséphine Demay, a PhD student at INRAE, France's National Research Institute for Agriculture, Food and the Environment.

Since the 1800s, agriculturalists have known that elemental phosphorus is a crucial fertilizer. Nations quickly began mining caches of "phosphate rock," minerals rich in the element. By the middle of the 20th century, companies had industrialized chemical processes to turn it into a form suitable for supercharging crops, hardening them against disease and making them able to support more people and livestock. That approach worked remarkably well: The post-World War II "Green Revolution" fed countless people thanks to fertilizers and pesticides. But sometimes there's too much of a good thing.

We have liberated Earth's caches of phosphorus so rapidly that the element now pollutes freshwater ecosystems, where excesses cause harmful algal blooms, infiltrates the snowpack, and decreases levels of dissolved oxygen in lakes and rivers. Studies suggest that humanity has grown too dependent on it for feeding the planet—and we are running out of this nonrenewable resource, which comes from geologic deposits that take millenia to form. When it washes from soil into waterways, it essentially disappears forever. A looming "peak phosphorus" moment threatens to increase prices and foment political tension if demand eclipses supply, as a large majority of reserves exist only in one corner of North Africa.

Half of the globe's crop productivity comes from a key fertilizer ingredient that's nonrenewable—and literally washing away.

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In a paper published this month in Nature Geoscience, Demay broke down how much phosphorus 176 countries have used between the years 1950 and 2017, and she estimated how much the use of mineral fertilizer contributes to soil fertility in each nation. Remarkably, phosphate rock accounts for around 50 percent of the world's soil productivity. "It has never been quantified like that," Demay says. And those numbers matter, she says, because "the work really highlights the high gap that exists between different world regions." Wealthy countries in Western Europe, North America, and Asia use far more of the world's phosphate rock than Africa, despite African soils being relatively deficient in it. "There is a need to distribute more equally the remaining first rock reserves," Demay says.

James Elser, an ecologist with Arizona State University and the University of Montana who studies the global phosphorus cycle, was taken aback by that 50 percent figure. "That we've been able to mobilize phosphorus from these ancient geological deposits, and spread it around the world enough so that half of soil phosphorus is now comprised of industrial anthropogenic fertilizer, is pretty stunning," he says.

And if the remaining supply goes down, prices will go up, exacerbating the access gap between rich and poor countries, says Dana Cordell, an associate professor and research director of food systems sustainability at the University of Technology Sydney. In 2008, phosphate prices spiked 800 percent due to supply and demand issues, and again 400 percent last year, due to Covid-related disruptions. The new study "shows how our global food system has now become heavily dependent on mined, nonrenewable phosphate rock," she says. "And even if there is phosphate rock in the ground, it might not be economically viable to access it."

Scientists have been pointing out the "broken" phosphorus cycle for more than a decade: Humanity has unearthed huge quantities of the element, which winds up in waterways instead of returning to cropland.

The problem comes down to crap. People and livestock eat crops and excrete phosphorus as a result. (A University of Iowa researcher calculated that the state's livestock produce a load of excrement equivalent to a nation of 168 million people.) But most of it won't end up feeding plants again. Waste treatment can loop sludge or manure back to being fertilizer, but transporting and treating it is often impractical, so it may sit in stockpiles and "dry stacks" without the chance to boost another crop.

Or the system may be leaky: Sewage, septic tanks, stockpiles, and eroded soil drip phosphorus into oceans and rivers, where it dilutes to oblivion while degrading those ecosystems. For instance, phosphorus runoff drives

the harmful algal blooms that have killed Florida's seagrass, starving thousands of manatees.

Demay's model determined that in a 67-year span, humans pumped almost a billion tons of nonrenewable phosphorus into food systems. Her team's figures are derived from statistical data from the Food and Agriculture Organization of the United Nations. The global data, broken up by country, reported agricultural yields—like the amount of wheat grown, or headcounts of pigs and cows—from 1961 to 2017. (Data from 1950 to 1961 came from other data sets.)

Her team also broke down use trends. In 2017, Western European, North American, and Asian reliance climbed to nearly 60 percent of the total plant-ready phosphorus available in each region's soil. Brazil, China, and India are quickly increasing their use, to 61, 74, and 67 percent respectively. The numbers for France and the Netherlands are no longer rising, because they've replaced some use of phosphate rock with manure; now they sit at roughly 70 and 50 percent. Yet in African countries like Zimbabwe, a lack of soil phosphorus limits crop yields. Demay's estimates pin mineral fertilizer use in Zimbabwe to the 20 to 30 percent range, which is even lower than the 32 percent average for all of Africa.

To Elser, this illuminates a global inequity: Poorer countries access far less fertilizer, despite needing it more. And wealthy countries have been able to amass stockpiles from the rock reserves for decades, while countries that struggle with food security can't afford to do the same.

This raises concerns over who will control the future of fertilizer. Nearly 75 percent of the world's supply sits in the mines of Morocco and the Western Sahara. Economists get anxious when a commodity is consolidated in the hands of a few powerful people. (OPEC controls roughly the same fraction of the world's oil, but with 13 member states.)

And it's not entirely clear how long supplies will last. In 2009, Cordell estimated that a global "peak phosphorus" moment could happen as soon as 2030, which would leave 50 to 100 years of dwindling reserves. Today, she and Elser agree that the peak will likely come later, although it's hard to predict when, because demand may skyrocket for other uses, like lithium iron phosphate batteries. Elser notes that new analyses now put the maximum supply at around 300 to 400 years.

To Cordell, it's frustrating that this supply chain has been mismanaged. "If this was water—or another resource that we know humanity is dependent on—we would have so many measures in place to monitor those

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resources, to ensure more equitable and secure access," she says. And if any other crucial resource was running out, she continues, "we would look for alternatives."

She worries that phosphorus is "slipping through the institutional cracks." But, she says, it's not clear who is responsible for overseeing its supply—which government, or even which department. Agriculture? Environment? Health? Water? Trade? "It cuts across all of those sectors," she says.

Demay hopes that her study will encourage more careful agricultural practices: combining cropland and livestock areas to more easily recycle phosphorus from manure, or planting trees or cover crops, like mustard or barley, that prevent soil erosion in a farm's off-season—sparing waterways from fertilizer pollution. Better recycling programs might also help ween the world off phosphate rock. Right now, recycling mostly means using manure or sludge from wastewater systems on croplands, which is primarily for preventing water pollution rather than fertilizing plants. "It's happening in such an inefficient, ineffective way," Cordell says.

But other tech is growing in popularity. Urine diverting toilets can recapture the phosphorus in liquids. Adding magnesium to wastewater can create "struvite" crystals, an alternative fertilizer. Another method could make fertilizer pellets from dried manure sludge after anaerobic digestion (which also generates biogas fuel).

Biotech might lessen the need for fertilizer, says Elser—although these concepts are in earlier stages. Theoretically, biologists could breed or engineer crops to extract phosphorus more efficiently; researchers have already identified genes that boost phosphorus absorption. Lab-grown meat could cut demand for livestock and the cropland that supports them. And as a simpler solution, eating less meat could do the same. "The less meat we have to grow in the form of cows or pigs, the less feed we have to grow to feed them," Elser says.

Elser takes inspiration from the progress the world has made in its transition to renewable energy—he thinks agriculture can become more sustainable too. With better phosphorus recycling throughout the food system, the world's fertilizer could flow more easily to the places that need it. "Eventually, we're going to have to get to a system that's better than the one we have," Elser says. "When that happens—I'm not sure."

Wired, 23 January 2023

https://wired.com

Supercharged T Cells: A New Way To Kill Pancreatic Cancer With Minimal Side Effects

2023-01-29

A new immunotherapy releases cancer-killing cytokines only within the tumor.

Researchers at the University of California San Francisco (UCSF) have developed a new T cell-based immunotherapy that selectively targets cancer cells, producing a powerful anti-cancer cytokine specifically when it encounters tumors. This therapy effectively eliminated melanoma and pancreatic cancer in mice, with minimal side effects. This represents a promising new approach for treating these and other difficult-to-treat cancers.

The cells deliver IL-2, a naturally-occurring inflammatory molecule produced by the immune system that has powerful anti-cancer effects. It supercharges T cells, which are immune cells that can eliminate cancer cells and fight infection. IL-2 potent anti-cancer effects have been long-known, however, systemic administration of IL-2 has been limited due to the severe side effects it can cause.

In the study, which was recently published in the journal Science, the researchers were able to keep the cytokine contained within the cancer by programming the tumor-infiltrating T cells to make their own IL-2 when they recognized a cancer cell.

"We've taken advantage of the ability of these cells to be local delivery agents and to crank out their T-cell amplifiers only when they recognize they're in the right place," said Wendell Lim, Ph.D., the Byers Distinguished Professor in cellular and molecular biology, director of the UCSF Cell Design Institute and senior author on the study. "I think this is a model for how we can use cell therapies to deliver many types of potent but toxic therapeutic agents in a much more targeted manner."

Slipping past the barriers

Cellular therapies have been highly effective against many blood cancers, where the cells are easily accessible because they are floating freely. Solid tumors, however, build multiple defensive walls that prevent therapeutic T cells from entering. And even if the cells do get into the tumor, they often tire out before they're able to finish off the cancerous cells.

Since the 1980s, oncologists have known that high doses of IL-2 enable T cells to overcome these barriers, and the cytokine has been used as a

Pancreatic cancer is often referred to as a "silent killer" because it often goes undetected until it has advanced and spread to other parts of the body.

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cancer therapy in challenging cancer cases. But simply infusing patients systemically with IL-2 can cause high fever, leaky blood vessels, and organ failure.

Lim and lead author Greg Allen, MD, Ph.D., adjunct assistant professor of medicine and a fellow at the Cell Design Institute, aimed to tame IL-2's effects by engineering cells that enhance the cancer-killing immune response only where it's needed: in the tumor.

They chose to go after notoriously difficult-to-treat tumors, like those of the pancreas, ovary, and lung, that form nearly iron-clad barriers against T cells.

To engineer cells T cells that could sense when they were in the tumor, the researchers used a synthetic Notch (or synNotch) receptor, a flexible type of molecular sensor, which Lim's lab developed several years earlier. These receptors span the cell membrane, with ends that protrude both inside and outside the cell. The outside portion recognizes and binds to tumor cells, triggering the inside portion to set the production of IL-2 in motion.

The team tested the synNotch cells on a number of deadly tumors, including melanoma and pancreatic cancer, and found that the cells worked exactly as planned.

"We were able to design these therapeutic cells to slip past the tumor's defensive barriers. Once in the tumor, they could establish a foothold, and begin effectively killing cancerous cells," said Allen. "We got on top of these tumors and in some cases cured them."

A Positive-Feedback Circuit

The approach owes its success to engineering a circuit in the cell that amplifies the immune response in a controlled way. This induces the cell to produce IL-2 only under the specific conditions it's programmed to recognize.

"This induction circuit is really a positive-feedback loop, an important element behind making these designer T cells that are able to operate so effectively," Allen said.

The circuit begins when the synNotch receptor tells the T cell to make IL-2. That IL-2 feeds back on the cell, causing it to divide, in turn creating more cells that make even more IL-2. The entire process is confined within the tumor, protecting the rest of the body from harm.

Allen, who is both a researcher and an oncologist, hopes to begin testing the therapeutic approach in clinical trials with pancreatic cancer patients in 2024.

"The most advanced immunotherapies are just not working in a lot of these difficult solid tumors," he said. "We think this type of design can overcome one of the major barriers and do it in a way that's safe and free of side effects."

Sci Tech Daily, 29 January 2023

https://scitechdaily.com

A fairy-like robot flies by the power of wind and light

2023-01-30

The development of stimuli-responsive polymers has brought about a wealth of material-related opportunities for next-generation small-scale, wirelessly controlled soft-bodied robots. For some time now, engineers have known how to use these materials to make small robots that can walk, swim and jump. So far, no one has been able to make them fly.

Researchers of the Light Robots group at Tampere University are now researching how to make smart material fly. Hao Zeng, Academy Research Fellow and the group leader, and Jianfeng Yang, a doctoral researcher, have come up with a new design for their project called FAIRY—Flying Aero-robots based on Light Responsive Materials Assembly. They have developed a polymer-assembly robot that flies by wind and is controlled by light.

"Superior to its natural counterparts, this artificial seed is equipped with a soft actuator. The actuator is made of light-responsive liquid crystalline elastomer, which induces opening or closing actions of the bristles upon visible light excitation," explains Hao Zeng.

The artificial fairy is controlled by light

The artificial fairy developed by Zeng and Yang has several biomimetic features. Because of its high porosity (0.95) and lightweight (1.2 mg) structure, it can easily float in the air directed by the wind. What is more, a stable separated vortex ring generation enables long-distance wind-assisted traveling.

"The fairy can be powered and controlled by a light source, such as a laser beam or LED," Zeng says.

"The fairy can be powered and controlled by a light source, such as a laser beam or LED."

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This means that light can be used to change the shape of the tiny dandelion seed-like structure. The fairy can adapt manually to wind direction and force by changing its shape. A light beam can also be used to control the take-off and landing actions of the polymer assembly.

Potential application opportunities in agriculture

Next, the researchers will focus on improving the material sensitivity to enable the operation of the device in sunlight. In addition, they will up-scale the structure so that it can carry micro-electronic devices such as GPS and sensors as well as biochemical compounds.

According to Zeng, there is potential for even more significant applications.

"It sounds like science fiction, but the proof-of-concept experiments included in our research show that the robot we have developed provides an important step towards realistic applications suitable for artificial pollination," he says.

In the future, millions of artificial dandelion seeds carrying pollen could be dispersed freely by natural winds and then steered by light toward specific areas with trees awaiting pollination.

"This would have a huge impact on agriculture globally since the loss of pollinators due to global warming has become a serious threat to biodiversity and food production," Zeng says.

Challenges remain to be solved

However, many problems need to be solved first. For example, how to control the landing spot in a precise way, and how to reuse the devices and make them biodegradable? These issues require close collaboration with materials scientists and people working on microrobotics.

The FAIRY project started in September 2021 and will last until August 2026. The flying robot is researched in cooperation with Dr. Wenqi Hu from Max Planck Institute for Intelligent Systems (Germany) and Dr. Hang Zhang from Aalto University.

Tech Xplore, 30 January 2023

https://techxplore.com

Green hydrogen produced with near 100% efficiency using seawater

2023-01-31

It's not quite splitting the Red Sea, but new research into splitting seawater to produce hydrogen may be a scientific miracle that puts us on a path to replacing fossil fuels with the environmentally-friendly alternative.

"We have split natural seawater into oxygen and hydrogen with nearly 100 percent efficiency, to produce green hydrogen by electrolysis, using a non-precious and cheap catalyst in a commercial electrolyser," says project leader Professor Shi-Zhang Qiao from the University of Adelaide's School of Chemical Engineering.

Electrolysis is the process of splitting water (H2O) into hydrogen and oxygen using electricity. So, the process itself requires energy.

The process also requires catalysts. But not all catalysts are created equal. Catalysts used in electrolysis tend to be rare precious metals like iridium, ruthenium and platinum.

Typical non-precious catalysts are transition metal oxide catalysts, for example cobalt oxide coated with chromium oxide.

The new breakthrough in splitting seawater to produce green energy was achieved by adding a layer of Lewis acid (a specific type of acid, for example chromium(III) oxide, Cr2O3) on top of the transition metal oxide catalyst.

While using cheaper materials, the process is shown to be very effective.

"The performance of a commercial electrolyser with our catalysts running in seawater is close to the performance of platinum/iridium catalysts running in a feedstock of highly purified deionised water," explains the University of Adelaide's Associate Professor Yao Zheng.

Another typical part of the electrolysis process is some form of treatment of the water. For that reason, freshwater is the main source of green hydrogen. But freshwater is increasingly scarce.

So, scientists are looking to seawater, particularly in regions with long coastlines and abundant sunlight.

"We used seawater as a feedstock without the need for any pre-treatment processes like reverse osmosis desolation, purification, or alkalisation," Zheng adds. "Current electrolysers are operated with highly purified water

Adelaide University leads research that avoids use of ever-depleting freshwater sources.

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electrolyte. Increased demand for hydrogen to partially or totally replace energy generated by fossil fuels will significantly increase scarcity of increasingly limited freshwater resources."

Seawater electrolysis is relatively new compared to pure water electrolysis. Complications include side reactions on the electrodes, as well as corrosion.

"It is always necessary to treat impure water to a level of water purity for conventional electrolysers including desalination and deionisation, which increases the operation and maintenance cost of the processes," Zheng says. "Our work provides a solution to directly utilise seawater without pre-treatment systems and alkali addition, which shows similar performance as that of existing metal-based mature pure water electrolyser."

The team hopes to scale their experiment up for commercial production in generating hydrogen fuel cells and ammonia synthesis.

Their research is published in Nature Energy.

Cosmos, 31 January 2023

https://cosmosmagazine.com

A Completely New Way To Kill Cancer: Artificial DNA

2023-01-30

University of Tokyo researchers have made a breakthrough in the fight against cancer with the use of artificial DNA. In laboratory tests, the method effectively targeted and destroyed human cervical and breast cancer cells, as well as malignant melanoma cells from mice. The team designed a pair of chemically synthesized DNA, shaped like hairpins, specifically to kill cancer cells. When injected into cancer cells, the DNA pairs attached to microRNA (miRNA) molecules that are overproduced in certain cancers.

The DNA pairs, upon attaching to the miRNA, unraveled and combined, forming longer chains of DNA that activated an immune response. This response not only eliminated the cancer cells but also prevented the continuation of cancerous growth. This innovative approach stands apart from traditional cancer drug treatments and is hoped to usher in a new era in drug development.

Cancer is a sadly familiar global health concern and current methods of treatment have their limitations. However, drugs based on nucleic acids —

Hairpin-shaped DNA interacts with microRNA in cancer cells, activating an immune response.

namely DNA and RNA, the vital information-carrying molecules — can control the biological functions of cells and are expected to transform the future of medicine and provide a significant boost towards efforts to overcome cancer and other hard-to-treat illnesses, caused by viruses and genetic diseases.

A research group at the University of Tokyo, led by Assistant Professor Kunihiko Morihiro and Professor Akimitsu Okamoto from the Graduate School of Engineering, were inspired to create a new anticancer drug using artificial DNA. "We thought that if we can create new drugs that work by a different mechanism of action from that of conventional drugs, they may be effective against cancers that have been untreatable up to now," said Okamoto.

Nucleic acid drug use for cancer treatment has been challenging because it is difficult to make the nucleic acids distinguish between cancer cells and other healthy cells. This means there is a risk of adversely affecting the patient's immune system if healthy cells are inadvertently attacked. However, for the first time, the team was able to develop a hairpin-shaped DNA strand that can activate a natural immune response to target and kill specific cancerous cells.

Cancer cells can overexpress, or make too many copies of, certain DNA or RNA molecules, causing them to not function normally. The team created artificial oncolytic (cancer-killing) hairpin DNA pairs called oHPs. These oHPs were triggered to form longer DNA strands when they encountered a short (micro) RNA called miR-21, which is overexpressed in some cancers.

Typically, oHPs don't form longer strands due to their curved hairpin shape. However, when the artificial oHPs enter a cell and encounter the target microRNA, they open up to combine with it and form a longer strand. This then causes the immune system to recognize the presence of the overexpressed miR-21 as dangerous and activate an innate immune response, which ultimately leads to the death of the cancer cells.

The tests were effective against overexpressed miR-21 found in human cervical cancer-derived cells, human triple-negative breast cancer-derived cells, and mouse malignant melanoma-derived cells. "The formation of long DNA strands due to the interaction between short DNA oHPs and overexpressed miR-21, found by this research group, is the first example of its use as a selective immune amplification response which can target tumor regression, providing a new class of nucleic acid drug candidates with a mechanism that is completely different from known nucleic acid drugs," said Okamoto.

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"The results of this study are good news for doctors, drug discovery researchers, and cancer patients, as we believe it will give them new options for drug development and medication policies. Next, we will aim for drug discovery based on the results of this research, and examine in detail the drug efficacy, toxicity, and potential administration methods." This research still has many steps to go before a treatment can be made available, but the team is confident in the benefits of nucleic acids for new drug discovery.

Sci Tech Daily, 30 January 2023

https://scitechdaily.com

Monitoring an 'anti-greenhouse' gas: Dimethyl sulfide in Arctic air

2023-01-30

Data stored in ice cores dating back 55 years bring new insight into atmospheric levels of a molecule that can significantly affect weather and climate.

Dimethyl sulfide (C2H6S) is a small molecule released by phytoplankton in the ocean, which can play a big role in regulating the Earth's climate. It encourages cloud formation above the sea, and is often called an 'anti-greenhouse gas', since clouds block radiation from the sun and lower sea surface temperatures. At least some blocked heat will be retained in the atmosphere, however, so the effects can be complex. Researchers at Hokkaido University have charted evidence for increasing dimethyl sulfide emissions linked to the retreat of sea ice from Greenland as the planet warms. They report their findings in the journal Communications Earth & Environment.

Modelling studies have long suggested that the decline in Arctic sea ice could lead to increased dimethyl sulfide emission, but direct evidence for this has been lacking. Assistant Professor Sumito Matoba and colleagues have inferred dimethyl sulfide levels over 55 years by quantifying the related compound, methane sulfonic acid (MSA), in ice core samples from the south-east Greenland ice sheet. MSA is directly produced from dimethyl sulfide, serving as a stable record of dimethyl sulfide levels. This process is part of a variety of chemical interactions among aerosols in the atmosphere.

The team, including researchers from Nagoya University and Japan's Aerospace Exploration Agency, reconstructed the annual and seasonal MSA flux from 1960 to 2014, at a monthly resolution. The annual MSA levels decreased from 1960 to 2001, but then markedly increased after 2002.

"We found that July to September MSA fluxes were three to six times higher between 2002 and 2014 than between 1972 and 2001," says Matoba. "We attribute this to the earlier retreat of sea ice in recent years."

Supporting evidence comes from satellite data that has monitored the levels of the crucial sunlight-absorbing green pigment chlorophyll-a in the surrounding seas. The chlorophyll-a serves as an indicator of phytoplankton abundance, which in turn should correlate well with the amount of dimethyl sulfide released by the phytoplankton.

Arctic temperatures are rising twice as fast as the global average, and the summer seasonal sea ice extent has declined sharply in recent decades. This increases the amount of light striking the ocean and promotes the growth of phytoplankton.

While the latest results from the Hokkaido team add important confirmation of the changing dimethyl sulfide levels, Matoba emphasises that long-term and continuous monitoring of aerosols is needed. "This will be essential to follow the current impact, and predict future impacts, of dimethyl sulfide emissions on the global climate," he says.

Science Daily, 30 January 2023

https://sciencedaily.com

For More Sustainable Affordable Housing, Just Add Mushrooms

2023-01-27

David Benjamin's recipe for construction materials sounds like witchcraft: Mix corn stalks with hemp and mushroom roots, pour the mixture into molds that resemble the shapes you need, and voilà, the building material will grow all by itself. In five days!

Simply put, this is the process of mycotecture, architecture with mushrooms.

Fungi and facades are unlikely friends architects usually prefer not to mention in the same breath. But Benjamin named his New York architecture firm The Living because he wants exactly that: to bring architecture alive, literally. "Biological systems are adaptable; they live, breathe and regenerate themselves," he says in his office in the Brooklyn Navy Yard. "Imagine buildings had these traits! This would change our way of life radically."

"We're trying to combine the high-performance qualities of the fiber-glass composite with a carbon-sequestering mycelium core."

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Maybe even more importantly, organic materials do not create trash. "Forty percent of the trash in our landfills is from construction," notes Benjamin, who is also an architecture professor at Columbia. "We architects like to build for eternity, with steel and cement, but not all buildings need to last forever, and when we look at the landfills, we realize: Maybe we better look for materials which don't sit in landfills for centuries and millennia."

He integrates living organisms into his designs to create dynamic buildings that interact with their environment and leave a small CO2 footprint. His first foray into fungitecture together with the New York company Ecovative consisted of three towers, 13 meters high, that served as an event space at MOMA in 2014 and were entirely built from mycelium and hemp bricks. After three months, the towers were deconstructed and composted. In 2021, Benjamin built an arc for the Centre Pompidou in Paris for which he let mushrooms grow on hemp until the structure naturally fused together. Fuzzy cardboard-like clumps the size of ping-pong balls grown from hemp-fungi in his office are the last reminder of the perishable structure.

Admittedly, these projects served primarily to show the world that building with fungi was doable — the prototypes weren't exactly move-in ready. This year, however, Benjamin will test the concept for the first time on a large scale and build a 300-unit affordable housing complex in Oakland, California. In partnership with Ecovative, the prefab company Factory OS, and the composite façade specialists at Kreysler and Associates, he wants to tackle one of the most urgent problems in the US: the housing crisis.

Kreysler specializes in prefab composite materials, such as fiber-reinforced polymers (FRP). The company claims that its lightweight FRP façade of the San Francisco MOMA saved 15 tons of steel. "The material has a lot of advantages: it's long-lasting, durable, lightweight," Benjamin says about FRP. "It is the same material used in wind turbine blades. But it has one big disadvantage: It's carbon-intensive."

The solution: A "mushroom sandwich." On his screen, Benjamin pulls up the colorful renderings of the Oakland project: Between the fiberglass shell and the interior walls, filler grown from mushrooms and hemp will serve both as natural insulation and carbon storage. "We're trying to combine the high-performance qualities of the fiberglass composite with a carbon-sequestering mycelium core," Benjamin says. "Together, the combination results in a net zero or even carbon-negative footprint." The

carbon-intensive fiberglass could be as thin as three millimeters, and the four to six inches of mushroom filling would compensate for the resource-intensive production of the façade.

Also, conventional insulation often contains toxic chemicals. "Typically, a lot of plastic petroleum-based foam would be used for insulation," Benjamin says. In Oakland, the first three 12-unit houses that will start to be constructed in April will serve as test cases. One will have conventional insulation. The second will have insulation made from hemp and resin. The third will have mycelium-hemp insulation. "Like a petri dish experiment at the scale of buildings, we will compare the energy consumption, acoustics and livability of the three different scenarios," Benjamin says. The goal: To streamline the production of affordable housing units in a way that is sustainable, fast and cost-effective.

Other materials might be just as sustainable as the mycelium mix — for instance, certain kinds of wood such as balsa. According to Benjamin, however, balsa does not meet the California fireproof standards, but mycelium does. "Also, there might not be enough wood to do everything we need in construction," Benjamin says. "So we take some existing systems that have a lot of benefits but are not so sustainable and inject some sustainability into them to increase our palette of options as designers."

To demonstrate how he balances the various challenges, his team created open-source software that tracks various aspects of a design project, such as cost, livability, carbon footprint and sustainability. By moving parameters for the Oakland project on the screen, it becomes apparent which building materials and construction methods might be cheaper but more carbon-intensive, or vice versa. "There are a lot of carbon calculators out there, which is great," Benjamin acknowledges. "More and more people want to do the right thing. But what we're addressing with this software is the right framework to make tradeoffs between your carbon goals and other priorities like cost, schedule and habitability. You want a good unit to live in."

With a combination of pre-fab housing, high-performance facades and sustainable insulation, Benjamin hopes to unlock subsidies that the Biden administration has promised for sustainable affordable housing. If he and his partners prove they are able to build entire complexes in under a year, the California Homekey initiative could provide additional financing for solving California's housing crisis.

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Mushrooms meet a lot of the criteria for sustainable, comfortable living. Benjamin's construction partner, Ecovative, operates the largest production plant for mycelium materials in the world at its base of operations in Green Island, New York, and has already been producing sustainable packaging from grain stalks and mycelium for companies like Dell and Puma. The white mycelium acts as a natural glue and grows until all the space in the molds has been filled. After drying the product, the result is stable, compact and resilient. "The material is fire-resistant, compostable and uses almost no energy in its production," Ecovative co-founder Eben Bayer says. "Our goal is to replace plastic and insulation foam in all industries. Mushrooms are nature's plastic."

Fungi can also replace the styrofoam in coffee cups. "Styrofoam is toxic," Bayer says. "After one cup of coffee, we throw the cup in the trash, but it stays on the planet for thousands of years. The recycling system of nature, however, is flawless." Ecovative co-founder Gavin McIntyre seconds. "We only have one planet, and if we want to have a future, we need to use materials that can be recycled or upcycled." Even the US military has turned to Ecovative with a $9.1 million defense research contract: When a soldier gets wounded in the field, first aid medics could grow a protective structure from mycelium where needed. And NASA is seriously contemplating mycelium structures on Mars.

"The method generates no trash and is 100 percent organic," says Benjamin, who has pursued other elements of living architecture. For instance, he recently created a façade from sandblasted Douglas fir for a gallery in New York. Instead of mounting a slick front, he sandblasted the wood to create meandering furrows "as a way to harness the microbiome," Benjamin explains while showing off small pieces of the treated wood that looks like a furrowed landscape. "When a biologist tested the microbiome after construction, the storefront near Chinatown showed a lot of microbes associated with rice. In a different facade installed in the Brooklyn Navy Yard, we find a lot of microbes that are known for breaking down heavy metals." What interests Benjamin is "that you can use DNA sequencing as a kind of sensor to learn about these invisible things in the environment."

His unconventional ideas might stem from Benjamin's background in art. He studied philosophy and history, and played in an indie-rock band before working in various tech startups and turning to architecture. But what keeps him up at night is the size of the problem he's trying to solve. "What I'm thinking about a lot is the pure amount of construction that's going to happen in the near future," Benjamin says with a sigh. "Experts

predict that the amount of built environment we have now will double in the next 30 years. This translates to 13,000 buildings going up every day for 30 years." One reason why he's turning to affordable housing is the impact sustainable construction would have there. And still, he says, "what we've been doing is insufficient, it's too incremental. We need bigger levers."

Whenever he can, he takes a page from nature's playbook. For jet maker Airbus he mimicked the structure of slime mold, single-cell organisms that can form giant constructs. With 3D printers, he designed the lightest and largest bionic airplane partition ever designed for a plane. It's currently in the last review stages and will be implemented in the next generation of A320 Airbuses. According to Benjamin, "it reduces the weight by 45 percent, so it will save a million tons of carbon per year." (Lighter airplanes burn less fuel.)

For his most recent contribution to the Venice Architecture Biennale in 2021, he tried to create the opposite of a "sick" building by designing "Alive: A New Spatial Contract for Multi-Species Architecture," an immersive installation made from the vine vegetable loofah that asks: "What if we could change our architectural environments to be better hosts for a diversity of microbes and to decrease the amount of harmful ones?" For a previous Biennale, he had planted live mussels in the Venice canals. The speed of their opening and closing, translated into colorful light, indicated to every passerby the health of the water.

The most vivid example of his living architecture is probably the glass wall he built for the Art Institute in Chicago: since most windows contain air space, he simply enlarged them until they were big enough to serve as terrariums for live frogs, algae and snails. "A mini-version of the natural ecosystem." The purpose beyond the beauty: "Frogs swim up to breathe more often when the oxygen in the room is lower. They are natural sensors for the oxygen in the building."

Benjamin loves the unpredictable nature of his creations. "Design with organic growth means that we are not in complete control of the process. When we architects can make friends with this idea, we might build better structures."

Reasons to be Cheerful, 27 January 2023

https://reasonstobecheerful.world

How antidepressants help bacteria resist antibiotics

2023-01-24

The emergence of disease-causing bacteria that are resistant to antibiotics is often attributed to the overuse of antibiotics in people and livestock. But researchers have homed in on another potential driver of resistance: antidepressants. By studying bacteria grown in the laboratory, a team has now tracked how antidepressants can trigger drug resistance.

"Even after a few days exposure, bacteria develop drug resistance, not only against one but multiple antibiotics," says senior author Jianhua Guo, who works at the Australian Centre for Water and Environmental Biotechnology at the University of Queensland in Brisbane. This is both interesting and scary, he says.

Globally, antibiotic resistance is a significant public-health threat. An estimated 1.2 million people died as a direct result of it in 2019, and that number is predicted to climb.

Early clues

Guo became interested in the possible contributions of non-antibiotic drugs to antibiotic resistance in 2014, after work by his lab found more antibiotic-resistance genes circulating in domestic wastewater samples than in samples of wastewater from hospitals, where antibiotic use is higher.

Guo's group and other teams also observed that antidepressants — which are among the most widely prescribed medicines in the world — killed or stunted the growth of certain bacteria. They provoke "an SOS response", Guo explains, triggering cellular defence mechanisms that, in turn, make the bacteria better able to survive subsequent antibiotic treatment.

In a 2018 paper, the group reported that Escherichia coli became resistant to multiple antibiotics after being exposed to fluoxetine, which is commonly sold as Prozac. The latest study examined 5 other antidepressants and 13 antibiotics from 6 classes of such drugs and investigated how resistance in E. coli developed.

In bacteria grown in well-oxygenated laboratory conditions, the antidepressants caused the cells to generate reactive oxygen species: toxic molecules that activated the microbe's defence mechanisms. Most prominently, this activated the bacteria's efflux pump systems, a general expulsion system that many bacteria use to eliminate various molecules,

A laboratory study unravels ways non-antibiotic drugs can contribute to drug resistance.

including antibiotics. This probably explains how the bacteria could withstand the antibiotics without having specific resistance genes.

But exposure of E. coli to antidepressants also led to an increase in the microbe's mutation rate, and the subsequent selection of various resistance genes. However, in bacteria grown in anaerobic conditions, levels of reactive oxygen species were much lower and antibiotic resistance developed much more slowly.

Moreover, at least one antidepressant, sertraline, promoted the transfer of genes between bacterial cells, a process that can speed up the spread of resistance through a population. Such transfer can occur between different types of bacterium, allowing resistance to hop between species — including from harmless bacteria to pathogenic ones.

Growing recognition

Kiran Patil, who studies microbiome–chemical interactions at the University of Cambridge, UK, says that in the past five years there has been a growing appreciation that many non-antibiotic medicines that target human cells can also affect bacteria and contribute to antibiotic resistance. "The strength of the study is the mechanistic details," says Patil.

Lisa Maier, who is based at the University of Tübingen in Germany and studies interactions between drugs and the microbiome, says that to understand how antidepressants can drive antibiotic resistance, researchers need to determine what molecules the drugs are targeting in the bacteria and to assess the effects of the medications on a wider variety of clinically relevant bacterial species. In 2018, Maier and her colleagues surveyed 835 medicines that did not target microbes and found that 24% inhibited the growth of at least one strain of human gut bacteria.

Patil and Maier say it is important to gather evidence to assess the real-world impact of antidepressants on resistance, such as whether antidepressants are driving the accumulation of antibiotic-resistant bacteria, particularly disease-causing ones, in people, animals or the environment.

Although significant amounts of antidepressants have been found in wastewater, reported levels tend to fall below the concentrations at which Guo's group saw significant effects in E. coli. But concentrations of some of the antidepressants that had strong effects in this study are expected to be reached in the large intestines of people taking the drugs.

Follow-up studies

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Maier says that several studies now link antidepressants and other non-antibiotic pharmaceuticals to changes in bacteria, and that preliminary studies have given the "first hints" regarding how such drugs can affect the microbiomes of people taking them.

But in healthy humans, E. coli is found mainly in the large intestine, where conditions are anaerobic, meaning that the process described in the paper might not occur at the same rate in people, says Maier. Future studies should use bacterial growing conditions that model sites at which antidepressants might be acting, says Patil.

Guo says his lab is now looking at the microbiomes of mice given antidepressants. Early, unpublished data suggest that the drugs can change the animals' gut microbiota and promote gene transfer.

But Guo and Maier caution people against stopping taking antidepressants on the basis of this research. "If you have depression, that needs to be treated in the best possible way. Then, bacteria second," says Maier.

Researchers and pharmaceutical companies need to quantify the contribution of non-antibiotic pharmaceuticals to antibiotic resistance, says Guo. "Non-antibiotic pharmaceuticals are a big concern that we shouldn't overlook," he says.

Nature, 24 January 2024

https://nature.com

Metal robot can melt its way out of tight spaces to escape

2023-01-25

A miniature, shape-shifting robot can liquefy itself and reform, allowing it to complete tasks in hard-to-access places and even escape cages. It could eventually be used as a hands-free soldering machine or a tool for extracting swallowed toxic items.

Robots that are soft and malleable enough to work in narrow, delicate spaces like those in the human body already exist, but they can't make themselves sturdier and stronger when under pressure or when they must carry something heavier than themselves. Carmel Majidi at Carnegie Mellon University in Pennsylvania and his colleagues created a robot that can not only shape-shift but also become stronger or weaker by alternating between being a liquid and a solid.

A millimetre-sized robot made from a mix of liquid metal and microscopic magnetic pieces can stretch, move or melt. It could be used to fix electronics or remove objects from the body.

They made the millimetre-sized robot from a mix of the liquid metal gallium and microscopic pieces of a magnetic material made of neodymium, iron and boron. When solid, the material was strong enough to support an object 30 times its own mass. To make it soften, stretch, move or melt into a crawling puddle as needed for different tasks, the researchers put it near magnets. The magnets' customised magnetic fields exerted forces on the tiny magnetic pieces in the robot, moving them and deforming the surrounding metal in different directions.

For instance, the team stretched a robot by applying a magnetic field that pulled these granules in multiple directions. The researchers also used a stronger field to yank the particles upwards, making the robot jump. When Majidi and his colleagues used an alternating magnetic field – one whose shape changes predictably over time – electrons in the robot's liquid metal formed electric currents. The coursing of these currents through the robot's body heated it up and eventually made it melt.

"No other material I know of is this good at changing its stiffness this much," says Majidi.

Exploiting this flexibility, the team made two robots carry and solder a small light bulb onto a circuit board. When they reached their target, the robots simply melted over the light bulb's edges to fuse it to the board. Electricity could then run through their liquid metal bodies and light the light bulb.

In an experiment inside an artificial stomach, the researchers applied another set of magnetic fields to make the robot approach an object, melt over it and drag it out. Finally, they shaped the robot like a Lego minifigure, then helped it escape from a cage by liquefying it and making it flow out between the bars. Once the robot puddle dribbled into a mould, it set back into its original, solid shape.

These melty robots could be used for emergency fixes in situations where human or traditional robotic hands become impractical, says Li Zhang at the Chinese University of Hong Kong. For example, a liquefied robot might replace a lost screw on a spacecraft by flowing into its place and then solidifying, he says. However, to use them inside living stomachs, researchers must first develop methods for precisely tracking the position

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of the robot at every step of the procedure to ensure the safety of the patient, says Zhang.

New Scientist, 25 January 2023

https://newscientist.com

What time is it on the Moon?

2023-01-24

The coming decade will see a resurgence in lunar exploration — including dozens of missions and plans to establish permanent bases on the Moon. The endeavours pose myriad challenges. Among them is a subtle, but fundamental, question that metrologists worldwide are working to answer: what time is it on the Moon?

"We're just starting to lay this out," says Cheryl Gramling, an aerospace engineer who leads the position, navigation and timing team at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

The Moon doesn't currently have an independent time. Each lunar mission uses its own timescale that is linked, through its handlers on Earth, to coordinated universal time, or UTc — the standard against which the planet's clocks are set. But this method is relatively imprecise and spacecraft exploring the Moon don't synchronize the time with each other. The approach works when the Moon hosts a handful of independent missions, but it will be a problem when there are multiple craft working together. Space agencies will also want to track them using satellite navigation, which relies on precise timing signals.

"The idea is to produce a Solar System internet," says Gramling. "And the first part would be at the Moon."

It's not obvious what form a universal lunar time would take. Clocks on Earth and the Moon naturally tick at different speeds, because of the differing gravitational fields of the two bodies. Official lunar time could be based on a clock system designed to synchronize with UTC, or it could be independent of Earth time.

Representatives of space agencies and academic organizations worldwide met in November 2022 to start drafting recommendations on how to define lunar time at the European Space Research and Technology Centre of the European Space Agency (ESA) in Noordwijk, the Netherlands.

Decisions must be made soon, says Patrizia Tavella, who leads the time department at the International Bureau of Weights and Measures in Sèvres, France. If an official lunar time is not established, space agencies and private companies will come up with their own solutions, she says.

"This is why we want to raise an alert now, saying let's work together to take a common decision."

Tracking satellites

The most pressing need for lunar time comes from plans to create a dedicated global satellite navigation system (GNSS) for the Moon, similar to how GPS and other satellite navigation networks enable precise location tracking on Earth. Space agencies plan to install this lunar GNSS from around 2030. ESA approved a lunar satellite navigation project called Moonlight at its ministerial council meeting on 22 and 23 November 2022 in Paris, and NASA established a similar project, called Lunar Communications Relay and Navigation Systems, last January.

Until now, Moon missions have pinpointed their locations using radio signals sent to large antennas on Earth at scheduled times. But with dozens of missions planned, "there's just not enough resources to cover everybody", says Joel Parker, an engineer who works on lunar navigation at the Goddard Center.

As a first step, from 2024, ESA and NASA will trial deriving positions on the Moon using faint satellite navigation signals from Earth-based craft. Next, the lunar GNSS projects plan to place dedicated satellites around the Moon, each containing their own atomic clock (see 'Satnav on the Moon'). A receiver, for example on the Moon's surface, will then triangulate its position using the time it takes for satellite signals to reach it. ESA has planned an initial constellation of four spacecraft that would cover navigation at the lunar south pole, which harbours much of the Moon's water and is an important target for exploration, says Jörg Hahn, an engineer working on ESA's Moonlight project.

Moon missions will also need an official lunar time to cooperate and communicate, says Hahn. "All this has to trace to one kind of a time reference, otherwise you have chaos and things do not work together."

Another open question, says Hahn, is whether astronauts would use universal lunar time everywhere on the Moon. Although lunar time would remain the official timescale, its users might, as on Earth, want to offset it in time zones that link to the Sun's position in the sky. This is less a question for metrologists and more one of convention. "When somebody really lives there on the Moon, I think it makes sense," he says.

Characterizing time

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Defining lunar time is not simple. Although the definition of the second is the same everywhere, the special theory of relativity dictates that clocks tick slower in stronger gravitational fields. The Moon's gravitational pull is weaker than Earth's, meaning that, to an observer on Earth, a lunar clock would run faster than an Earth one. Gramling estimates that a lunar clock would gain about 56 microseconds over 24 hours. Compared with one on Earth, a clock's speed would also subtly change depending on its position on the lunar surface, because of the Moon's rotation, says Tavella. "This is a paradise for experts in relativity, because you have to take into account so many things," she adds.

Defining a lunar standard, with which all clocks are compared, will involve installing at least three master clocks that tick at the Moon's natural pace, and whose output is combined by an algorithm to generate a more accurate virtual timepiece (see 'How to build a Moon clock').

What happens then depends on which option metrologists choose. They might decide to base lunar time on UTC. In that case, this virtual lunar time would be synchronized regularly with terrestrial UTC. Between the check-ins, the lunar master clocks would keep marking time until the next synchronization. This has the advantage of being simple for users back on Earth to interact with.

The alternative would be to use the synthesized output of the lunar atomic clocks as the Moon's own independent, continuous time, and to track its relationship to UTC. That way, even if the connection with Earth is lost, clocks on the Moon will still agree with each other and allow safe navigation and communications, says Gramling. Establishing an independent time is a model that will also work for the more-distant planets that space agencies are ultimately targeting, such as Mars. Transmitting UTC there would be more complicated than to the Moon, she adds.

In this scenario, days on the Moon could even be defined differently from those on Earth, to account for the time from solar noon to solar noon taking an average of 29.5 Earth days. Earth days will always matter to astronauts, given the human need for sleep on a roughly 24-hour cycle. But the definition is something metrologists will need to agree on.

Metrologists will also need to decide where on the Moon to place the master clocks. As on Earth, the devices' altitude will affect ticking speed. The clocks could be in lunar orbit or on the surface, says Hahn. "This is what we are discussing right now with our NASA colleagues."

Space agencies are also considering other necessary standards — such as which maps of the lunar terrain and coordinate systems to use for navigation — through the Interagency Operations Advisory Group, a council of national space agencies and the United Nations International Committee on GNSS. To make various countries' systems interoperable, reference systems will have to be agreed internationally, says Gramling.

With ESA's help, NASA is developing a framework called LunaNet, for which it hopes to get international buy-in. LunaNet consists of a set of rules that would enable all lunar satellite navigation, communication and computing systems to form a single network similar to the Internet, regardless of which nation installs them. Setting lunar time is part of a much bigger picture.

"The idea is to produce a Solar System internet," says Gramling. "And the first part would be at the Moon."

Nature, 24 January 2023

https://nature.com

How Do Heavy Metals Like Lead Get in Baby Food?

2023-01-26

The Food and Drug Administration's new plan to keep high levels of lead out of baby foods like mashed sweet potatoes, apple sauce and dry cereal is part of a larger effort to eliminate heavy metals from the foods the youngest children eat.

The push follows years of studies by public health, consumer and government experts revealing concerning levels of arsenic in rice cereal and other items fed to infants, including big-name brands like Gerber and organic staples like Earth's Best.

This problem is not confined to baby-food factories, though. Metals like cadmium and mercury often get into crops as the plants burrow into the ground, drawing in nutrients from contaminated soil — or from naturally occurring compounds. Here are some possible answers to how these heavy metals get into food, what growers can do to keep it out — and how parents of the tiniest diners can steer clear of tainted food.

How do heavy metals get into foods in the first place?

Rain washes pollutants from factories, landfills, animal feed lots or from roadway auto emissions into lakes, rivers and streams. These pollutants

The problem begins at the farm where plants draw toxins from the soil. There's no washing them away.

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can travel through groundwater or irrigation streams and contaminate crops or soil, according to Laurie Beyranevand, director of the Center for Agriculture and Food Systems at Vermont Law and Graduate School.

Some of the metals occur naturally in the soil. Others can get added by certain fertilizers and insecticides, said Arthur Villordon, a professor at Louisiana State University who specializes in sweet potato farming.

As plants grow, some, like leafy greens, are particularly efficient at drawing in heavy metals and storing them in their leaves, roots or fruit.

Why do these metals get into baby foods?

Beyond contamination because of absorption from the soil, heavy metals can also find their way into baby food through additives like fortified vitamin mixes, said Evelyn Rusli, co-chief executive of Yumi, a baby food company that does extensive testing of its ingredients and finished products.

Why is that a particular concern for babies?

Heavy metals are not healthy for adults, but they are particularly bad for babies. Infants and toddlers grow rapidly, developing key body systems and laying the foundation for lifelong cardiovascular, immune and brain health. Because they are far smaller than adults, a small dose of any toxin can be harmful. They may also be less efficient at metabolizing toxins than adults. Small amounts of lead, for instance, have been found to affect behavior, I.Q. and academic achievement, according to the American Academy of Pediatrics.

What products should I avoid if I'm feeding a baby?

Rice, used in baby cereal and snack puffs, is consistently identified in studies as the food with the highest levels of arsenic, which is associated with cancer. The problem is believed to stem from rice farming in fields that are flooded year after year with water that can contaminate the soil. (Scientists are working on ways to minimize the problem.)

Dry rice cereal is often one of the first foods parents are urged to mix with breast milk or formula when a baby begins the transition from a liquid diet to solid food. Dry oatmeal cereal is a better alternative, according to a report by Healthy Babies Bright Futures, an advocacy group.

Other foods found to have the lowest levels of heavy metals include peas, green beans, butternut squash and bananas. Beans, eggs and soft meat in traditional baby food or prepared at home are low-metal forms of protein,

the report says. Serving a wide variety of fruits and vegetables — instead of relying heavily on carrots and sweet potatoes — can help reduce overall exposure to heavy metals.

Why aren't the foods tested before they get on the market?

While some food companies monitor toxin levels, they are not required to report the results to the public or to list them on product labels. The F.D.A. has broad mandates that food makers ensure their products are safe, but there are few actual limits for specific toxins. The F.D.A. has set an "action limit" for inorganic arsenic in rice cereal marketed for babies and has proposed one for lead in juice.

These limits — like those proposed for lead in baby food — do not set a strict bar. Rather, they create guidelines for food makers to voluntarily follow. If the F.D.A. finds that a company exceeds the levels, it can pursue enforcement action, which can lead to a product recall, seizure or a recommendation for criminal prosecution.

What can be done to remove metals from foods?

Washing produce will not help. But there are agricultural techniques that can reduce the levels seeping into crops. Farmers can test soil and use contaminated fields for crops that do not tend to pick up the metals, like beans. They can also use fields with suboptimal soil to grow lavender or other crops that might not be eaten, Ms. Beyranevand, of Vermont Law, said. Farmers are also trying to reduce toxins by growing crops — such as sunflowers and poplar trees — that are efficient at drawing impurities out of the soil and then disposing of the plants.

Agriculture experts are studying hundreds of varieties of plants that people eat to determine which are the least likely to harbor heavy metals, according to the Healthy Babies Bright Futures report.

What can food companies do?

Ms. Rusli, of Yumi, said her company reviewed soil content data from the Environmental Protection Agency to buy produce for its baby food from regions with lower levels of contamination. It also conducts testing before entering into contracts with farmers and tests finished products to ensure that metals aren't added during processing.

The New York Times, 26 January 2023

https://website

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What will it take to give babies a phthalate-free start in the world?

2023-01-30

Since the late 1960s research has shown that a plastic additive in polyvinyl chloride (PVC), leaches from medical devices and is toxic to multiple organs, especially for premature infants.

Despite more than two decades of evidence, advocacy and education around the issue, PVC products containing this harmful phthalate chemical still dominate the neonatal intensive care unit (NICU) environment.

Feeding tubes, fluid bags, syringes, respiratory support tubes, intravenous lines, nasal cannulas, catheters, incubators – this is only a short list of the PVC medical supplies that assist in everything from eating, to breathing, to sleeping for premature infants in NICU. The majority of these devices contain DEHP, a class of chemical called phthalates, which are used to make plastic softer and more flexible. Phthalates mimic the body's hormones and can disrupt important processes during an infant's rapid development. Scientists have linked phthalate exposure for newborn infants, also known as neonates, with several toxic endpoints including damage to the developing brain, liver, heart, lungs, male reproductive tract and more.

While training as a clinical neonatology fellow and pursuing a masters of public health in the early 2000s, Dr. Annemarie Stroustrup Smith, the vice president and director of neonatal services at Northwell Health in New York, started to draw connections between the emerging research on prenatal phthalate exposure and the health outcomes observed among premature infants.

"We tend to chalk up health challenges that children born preterm have as due to prematurity, but that's not really a mechanism," Stroustrup Smith told EHN, "So my question was, are some of those [health challenges] due to phthalate exposure? And if it is, that's something we can fix because we totally control the NICU environment."

Stroustrup Smith's research adds to a growing body of studies seeking to understand levels of neonatal exposure to DEHP, health effects and the benefits and drawbacks of alternatives. And the science is making a difference — there is positive movement in the marketplace with phthalate-free devices becoming increasingly available. However, cost remains an issue and the contaminated medical devices continue to fall through the regulatory cracks.

It is currently impossible to have a completely phthalate-free neonatal intensive care unit in the U.S. Health experts say that needs to change.

Lack of medical device regulation

Some DEHP-free medical supplies, such as feeding tubes, are readily available on the market. However, it is impossible to have a completely phthalate-free NICU in the U.S. due to unavailability and the high cost of alternative options. While the U.S. Food and Drug Administration (FDA) released a guidance document for the pharmaceutical industry on avoiding DEHP in 2012, they have yet to ban or restrict its use in medical supplies, like the European Union has done. This is despite ongoing research, advocacy and a direct ask from members of Congress who wrote a letter to the FDA last year.

"Patients should not be exposed to phthalates and [endocrine-disrupting chemicals] when they seek medical treatment," the representatives wrote in a letter to acting Food and Drug Administration chief Dr. Janet Woodcock.

According to Joel Tickner, a chemical policy expert and professor at the University of Massachusetts Lowell, two big reasons industry hasn't switched from DEHP are cost and resistance to change, but regulation would solve that. "It's policy," he told EHN, "if the FDA put their foot down and said, 'we need to move in the next five years,' that would change things very quickly."

The FDA says that DEHP is on their radar and they issued a discussion paper last year for the public and stakeholders to comment. However, the paper does not specifically mention DEHP. In addition, the FDA only approves devices in their final form. "The FDA does not clear or approve individual materials that are used in the fabrication of medical devices, but does take the chosen components and materials into consideration," FDA media representative Audra Harrison wrote to EHN.

Market-based medical device solutions

The international organization Healthcare Without Harm started working with researchers in the late 1990s to raise awareness about phthalate exposure in the NICU. Today, their sub-organization Practice Greenhealth focuses on leveraging the purchasing power of more than 1,500 healthcare organizations in their network and helping health systems make informed purchaces. "At the end of the day, I think the most expedient and long-lasting impact is a market-based solution," John Ulman, director of safer chemicals and procurement at Healthcare Without Harm, told EHN.

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For example, In 2012, Kaiser Permenante, one of the largest U.S. healthcare companies, switched to non-DEHP and non-PVC IV bags. According to Seema Wadhwa, the executive director for environmental stewardship, Kaiser made this switch in six months, including product performance testing, and saved $5 million in annual costs. In 2021, the medical supplier B. Braun launched CARESAFE, the first PVC-and-DEHP-free IV sets on the U.S. market. The three-year process from development to launch was rigorous and resource intensive, requiring creative engineering, process validation, testing and FDA clearance. "Four decades ago we recognized environmental and safety risks from DEHP and PVC," Scott Moyer, the associate director of research and development at B. Braun, told EHN. "The goal is from the bag to the patient making sure that pathway is free from harmful chemicals overall."

In order to bolster the market around safer NICU medical devices, Stroustrup Smith said researchers need more data to prove to clinicians that switching materials will improve infant health outcomes, which takes time. "If you look at making changes in medical care, typically from the first point an intervention is shown to be effective, it often takes a decade before you actually get that change," she said, "and that's when it's a slam dunk, totally obvious visible change…this is not that straightforward."

Key considerations for swapping phthalate-contaminated medical devices

All DEHP substitutions are not created equal. "We have to be wary of regrettable substitutions," said Ulman when describing the dangers of replacement chemicals that are not well studied and could have similar effects. For example, some alternative plasticizers, such as DINH, have thorough toxicological data, but others have little to none.

Some experts argue that the material itself, PVC, is problematic and that instead of swapping DEHP for another plasticizer, manufacturers should switch to materials that don't require plasticizers. The entire life cycle of PVC is harmful — production requires a lot of energy and releases toxic chemicals such as mercury and asbestos into water and air. For disposal, PVC is the least recyclable plastic and is often incinerated by healthcare facilities, creating highly toxic and persistent pollutants called dioxins and furans. For this reason, PCV-free materials, such as the thermoplastic polyurethane in B. Braun's CARESAFE line, are the preferred substitutes.

Toward phthalate-free

Outside of medical supplies, phthalates are found in a wide range of products including building materials, cosmetics, furniture, food packaging and more. Thus, there are several opportunities across a person's lifespan to come into contact with phthalates, starting from the womb. A 2022 study linked prenatal phthalate exposure to an increased risk of preterm birth – meaning there is a chance infants born preterm due to phthalate exposure are then exposed to even more phthalates in the NICU.

Since scientists first raised concern about DEHP, progress towards reducing exposure to children and infants in the U.S. has inched along. In 2008, Congress banned DEHP and two other phthalates in toys and in 2017 the U.S. The Consumer Product Safety Commission banned five additional phthalates in toys. Prominent health organizations, such as the American Public Health Association and the American Academy of Pediatrics have published policy statements on the issue. NICU's across the country have committed to buying DEHP-free products whenever possible.

Individuals can also play a role. Healthcare professionals can advocate for DEHP-free products with healthcare administration, researchers can continue to study the impact of DEHP exposure and the benefit of replacements, and patients can ask their doctors about exposure to phthalates during care.

Change takes time, but some argue that we shouldn't wait to act on protecting the most vulnerable patients. "The science was there 20 years ago," Tickner said, "Why is it taking so long to act on this?"

Environmental Health News, 30 January 2023

https://ehn.org

Device transmits radio waves with almost no power—without violating the laws of physics

2023-01-24

A new ultra-low-power method of communication at first glance seems to violate the laws of physics. It is possible to wirelessly transmit information simply by opening and closing a switch that connects a resistor to an antenna. No need to send power to the antenna.

Our system, combined with techniques for harvesting energy from the environment, could lead to all manner of devices that transmit data, including tiny sensors and implanted medical devices, without needing batteries or other power sources. These include sensors for smart agriculture, electronics implanted in the body that never need battery changes, better contactless credit cards and maybe even new ways for satellites to communicate.

Apart from the energy needed to flip the switch, no other energy is needed to transmit the information.

Apart from the energy needed to flip the switch, no other energy is needed to transmit the information. In our case, the switch is a transistor, an electrically controlled switch with no moving parts that consumes a minuscule amount of power.

In the simplest form of ordinary radio, a switch connects and disconnects a strong electrical signal source—perhaps an oscillator that produces a sine wave fluctuating 2 billion times per second—to the transmit antenna. When the signal source is connected, the antenna produces a radio wave, denoting a 1. When the switch is disconnected, there is no radio wave, indicating a 0.

What we showed is that a powered signal source is not needed. Instead, random thermal noise, present in all electrically conductive materials because of the heat-driven motion of electrons, can take the place of the signal driving the antenna.

Electrons that naturally move around inside a room-temperature resistor affect electrons in a connected antenna, which causes the antenna to generate radio waves. Connecting and disconnecting the antenna produces the ones and zeros of a binary signal. Credit: Zerina Kapetanovic, CC BY-ND

No free lunch

We are electrical engineers who research wireless systems. During the peer review of our paper about this research, published recently in Proceedings of the National Academy of Sciences, reviewers asked us to explain why the method did not violate the second law of thermodynamics, the main law of physics that explains why perpetual motion machines are not possible.

Perpetual motion machines are theoretical machines that can work indefinitely without requiring energy from any external source. The reviewers worried that if it were possible to send and receive information with no powered components, and with both the transmitter and receiver at the same temperature, that would mean that you could create a perpetual motion machine. Because this is impossible, it would imply that there was something wrong with our work or our understanding of it.

One way the second law can be stated is that heat will flow spontaneously only from hotter objects to colder objects. The wireless signals from our transmitter transport heat. If there were a spontaneous flow of signal from the transmitter to the receiver in the absence of a temperature difference between the two, you could harvest that flow to get free energy, in violation of the second law.

The resolution of this seeming paradox is that the receiver in our system is powered and acts like a refrigerator. The signal-carrying electrons on the receive side are effectively kept cold by the powered amplifier, similar to how a refrigerator keeps its interior cold by continuously pumping heat out. The transmitter consumes almost no power, but the receiver consumes substantial power, up to 2 watts. This is similar to receivers in other ultra-low-power communications systems. Nearly all of the power consumption happens at a base station that does not have constraints on energy use.

A simpler approach

Many researchers worldwide have been exploring related passive communication methods, known as backscatter. A backscatter data transmitter looks very similar to our data transmitter device. The difference is that in a backscatter communication system, in addition to the data transmitter and the data receiver, there is a third component that generates a radio wave. The switching performed by the data transmitter has the effect of reflecting that radio wave, which is then picked up at the receiver.

A backscatter device has the same energy efficiency as our system, but the backscatter setup is much more complex, since a signal-generating component is needed. However, our system has lower data rate and range than either backscatter radios or conventional radios.

What's next

One area for future work is to improve our system's data rate and range, and to test it in applications such as implanted devices. For implanted devices, an advantage of our new method is that there is no need to expose the patient to a strong external radio signal, which can cause tissue heating. Even more exciting, we believe that related ideas could enable other new forms of communication in which other natural signal sources, such as thermal noise from biological tissue or other electronic components, can be modulated.

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Finally, this work may lead to new connections between the study of heat (thermodynamics) and the study of communication (information theory). These fields are often viewed as analogous, but this work suggests some more literal connections between them.

Tech Xplore, 24 January 2023

https://yechxplore.com

Color-changing material could warm or cool buildings

2023-01-27

On hot days, the material can emit up to 92% of the infrared heat it contains, helping cool the inside of a building. On colder days, however, the material emits just 7% of its infrared, helping keep a building warm.

"We've essentially figured out a low-energy way to treat a building like a person; you add a layer when you're cold and take off a layer when you're hot," says assistant professor Po-Chun Hsu of the University of Chicago's Pritzker School of Molecular Engineering (PME).

"This kind of smart material lets us maintain the temperature in a building without huge amounts of energy."

According to some estimates, buildings account for 30% of global energy consumption and emit 10% of all global greenhouse gas. About half of this energy footprint is attributed to the heating and cooling of interior spaces.

"For a long time, most of us have taken our indoor temperature control for granted, without thinking about how much energy it requires," says Hsu, who led the research published in Nature Sustainability. "If we want a carbon-negative future, I think we have to consider diverse ways to control building temperature in a more energy-efficient way."

Researchers have previously developed radiative cooling materials that help keep buildings cool by boosting their ability to emit infrared, the invisible heat that radiates from people and objects. Materials also exist that prevent the emission of infrared in cold climates.

"A simple way to think about it is that if you have a completely black building facing the sun, it's going to heat up more easily than other buildings," says graduate student Chenxi Sui, the first author of the paper.

That kind of passive heating might be a good thing in the winter, but not in the summer.

A chameleon-like building material changes its infrared color—and how much heat it absorbs or emits—based on the outside temperature.

As global warming causes increasingly frequent extreme weather events and variable weather, there is a need for buildings to be able to adapt; few climates require year-round heating or year-round air conditioning.

Hsu and colleagues designed a non-flammable "electrochromic" building material that contains a layer that can take on two conformations: solid copper that retains most infrared heat, or a watery solution that emits infrared. At any chosen trigger temperature, the device can use a tiny amount of electricity to induce the chemical shift between the states by either depositing copper into a thin film, or stripping that copper off.

In the new paper, the researchers detailed how the device can switch rapidly and reversibly between the metal and liquid states. They showed that the ability to switch between the two conformations remained efficient even after 1,800 cycles.

Then, the team created models of how their material could cut energy costs in typical buildings in 15 different US cities. In an average commercial building, they reported, the electricity used to induce electrochromic changes in the material would be less than 0.2% of the total electricity usage of the building, but could save 8.4% of the building's annual HVAC energy consumption.

"Once you switch between states, you don't need to apply any more energy to stay in either state," says Hsu. "So for buildings where you don't need to switch between these states very frequently, it's really using a very negligible amount of electricity."

So far, Hsu's group has only created pieces of the material that measure about six centimeters across. However, they imagine that many such patches of the material could be assembled like shingles into larger sheets. They say the material could also be tweaked to use different, custom colors—the watery phase is transparent and nearly any color can be put behind it without affecting its ability to absorb infrared.

The researchers are now investigating different ways of fabricating the material. They also plan to probe how intermediate states of the material could be useful.

"We demonstrated that radiative control can play a role in controlling a wide range of building temperatures throughout different seasons," says

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Hsu. "We're continuing to work with engineers and the building sector to look into how this can contribute to a more sustainable future."

Futurity, 27 January 2023

https://futurity.org

Forget red meat, red seaweed might be the vital food needed on our plates

2023-01-31

Seaweed farming might hold the key to massive improvements in carbon sequestration, biodiversity loss and food security say Queensland researchers.

They investigated a red seaweed genus known as Asparagopsis for its potential as a source of dietary energy for humans, a supplement for livestock thanks to its potent ability to reduce methane, a constituent in biofuels for the transport industry, and in combination.

They found up to 2.6 billion tonnes of greenhouse gas emission could be diverted as a result of introducing seaweed farming, with Australian and Indonesian economic waters providing a viable location among all possible areas of production.

Notably, if seaweed was to take up just one tenth of everyone's diet, 100 million hectares of on-land production could be avoided – about the combined land area of New South Wales and Victoria.

University of Queensland researcher Scott Spillas says a cultivated seaweed industry could provide a viable economic and sustainability-focussed opportunity for western nations to consider as part of their efforts to combat carbon emissions and food shortages.

Some countries – particularly East Asian nations like China, Japan and Korea – already cultivate dietary seaweed. Korean diets are estimated to consist of two percent of seaweed alone.

Even introducing that amount of dietary seaweed globally could make a substantial dent in carbon emissions from agriculture.

"The ocean is really big, it's most of the planet's surface, so there's a lot of space there. We don't really use it," Spillas says.

By growing seaweed, UQ researchers say an area the size of Egypt could be saved from farming.

Spillas' research is built on available information, but says developing knowledge of where seaweed species can best grow would enhance the potential of a new industry.

Seaweed farming also promises opportunities for habitat regeneration as well as restoring ecosystem balance due to nutrient overload in aquatic and marine environments.

But although growing a tonne of biomass under the sea would divert the possible loss of biodiversity and negative land use impacts of doing so across a hectare of land, Spillas also warns such a move would need to be properly considered.

That's to prevent potentially diverting environmental damage from land to sea.

"We need to be careful when we have this conversation, because the ocean is also under threat from a variety of sources," he says.

"And so we definitely don't want to be saying we should just go out and start pillaging the ocean to start growing seaweed farms.

"But if we want to create an extra tonne of biomass, potentially growing it in the sea would have lesser impacts when it comes to global sustainability."

Cosmos, 31 January 2023

https://cosmosmagazine.com

Coffee with milk may have an anti-inflammatory effect

2023-01-30

Whenever bacteria, viruses and other foreign substances enter the body, our immune systems react by deploying white blood cells and chemical substances to protect us. This reaction, commonly known as inflammation, also occurs whenever we overload tendons and muscles and is characteristic of diseases like rheumatoid arthritis.

Antioxidants known as polyphenols are found in humans, plants, fruits and vegetables. This group of antioxidants is also used by the food industry to slow the oxidation and deterioration of food quality and thereby avoid off flavors and rancidity. Polyphenols are also known to be healthy for humans, as they help reduce oxidative stress in the body that gives rise to inflammation.

A combination of proteins and anti-oxidants doubles the anti-inflammatory properties in im-mune cells.

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But much remains unknown about polyphenols. Relatively few studies have investigated what happens when polyphenols react with other molecules, such as proteins mixed into foods that we then consume.

In a new study, researchers at the Department of Food Science, in collaboration with researchers from the Department of Veterinary and Animal Sciences, at University of Copenhagen investigated how polyphenols behave when combined with amino acids, the building blocks of proteins. The results have been promising.

"In the study, we show that as a polyphenol reacts with an amino acid, its inhibitory effect on inflammation in immune cells is enhanced. As such, it is clearly imaginable that this cocktail could also have a beneficial effect on inflammation in humans. We will now investigate further, initially in animals. After that, we hope to receive research funding which will allow us to study the effect in humans," says Professor Marianne Nissen Lund from the Department of Food Science, who headed the study.

The study has just been published in the Journal of Agricultural and Food Chemistry.

Twice as good at fighting inflammation

To investigate the anti-inflammatory effect of combining polyphenols with proteins, the researchers applied artificial inflammation to immune cells. Some of the cells received various doses of polyphenols that had reacted with an amino acid, while others only received polyphenols in the same doses. A control group received nothing.

The researchers observed that immune cells treated with the combination of polyphenols and amino acids were twice as effective at fighting inflammation as the cells to which only polyphenols were added.

"It is interesting to have now observed the anti-inflammatory effect in cell experiments. And obviously, this has only made us more interested in understanding these health effects in greater detail. So, the next step will be to study the effects in animals," says Associate Professor Andrew Williams of the Department of Veterinary and Animal Sciences at the Faculty of Health and Medical Sciences, who is also senior author of the study.

Found in coffee with milk

Previous studies by the researchers demonstrated that polyphenols bind to proteins in meat products, milk and beer. In another new study they

tested whether the molecules also bind to each other in a coffee drink with milk. Indeed, coffee beans are filled with polyphenols, while milk is rich in proteins.

"Our result demonstrates that the reaction between polyphenols and proteins also happens in some of the coffee drinks with milk that we studied. In fact, the reaction happens so quickly that it has been difficult to avoid in any of the foods that we've studied so far," says Marianne Nissen Lund.

Therefore, the researcher does not find it difficult to imagine that the reaction and potentially beneficial anti-inflammatory effect also occur when other foods consisting of proteins and fruits or vegetables are combined.

"I can imagine that something similar happens in, for example, a meat dish with vegetables or a smoothie, if you make sure to add some protein like milk or yogurt," says Marianne Nissen Lund.

Industry and the research community have both taken note of the major advantages of polyphenols. As such, they are working on how to add the right quantities of polyphenols in foods to achieve the best quality. The new research results are promising in this context as well:

"Because humans do not absorb that much polyphenol, many researchers are studying how to encapsulate polyphenols in protein structures which improve their absorption in the body. This strategy has the added advantage of enhancing the anti-inflammatory effects of polyphenols," explains Marianne Nissen Lund.

The research is funded by Independent Research Fund Denmark and conducted in collaboration with the Technical University of Dresden in Germany.

Polyphenol Facts

- Polyphenols are a group of naturally occurring antioxidants important for humans.
- They prevent and delay the oxidation of healthy chemical substances and organs in our bodies, thereby protecting them from damage or destruction.
- Polyphenols are found in a variety of fruits and vegetables, tea, coffee, red wine and beer.

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- Due to their antioxidant properties, polyphenols are used in the food industry to minimize the oxidation of fats in particular, as well as the quality deterioration of foods, to avoid off flavours and rancidity.

Science Daily, 30 January

https://sciencedaily.com

Scientists release newly accurate map of all the matter in the universe

2023-01-31

When the universe began, matter was flung outward and gradually formed the planets, stars and galaxies that we know and love today. By carefully assembling a map of that matter today, scientists can try to understand the forces that shaped the evolution of the universe.

A group of scientists, including several with the University of Chicago and Fermi National Accelerator Laboratory, have released one of the most precise measurements ever made of how matter is distributed across the universe today.

Analysis combines Dark Energy Survey, South Pole Telescope data to understand evolution of universe.

Combining data from two major telescope surveys of the universe, the Dark Energy Survey and the South Pole Telescope, the analysis involved more than 150 researchers and is published as a set of three articles Jan. 31 in Physical Review D.

Among other findings, the analysis indicates that matter is not as "clumpy" as we would expect based on our current best model of the universe, which adds to a body of evidence that there may be something missing from our existing standard model of the universe.

Cooling and clumps

After the Big Bang created all the matter in the universe in a very hot, intense few moments about 13 billion years ago, this matter has been spreading outward, cooling and clumping as it goes. Scientists are very interested in tracing the path of this matter; by seeing where all the matter ended up, they can try to recreate what happened and what forces would have had to have been in play.

The first step is collecting enormous amounts of data with telescopes.

In this study, scientists combined data from two very different telescope surveys: The Dark Energy Survey, which surveyed the sky over six years from a mountaintop in Chile, and the South Pole Telescope, which looks

for the faint traces of radiation that are still traveling across the sky from the first few moments of the universe.

Combining two different methods of looking at the sky reduces the chance that the results are thrown off by an error in one of the forms of measurement. "It functions like a cross-check, so it becomes a much more robust measurement than if you just used one or the other," said UChicago astrophysicist Chihway Chang, one of the lead authors of the studies.

In both cases, the analysis looked at a phenomenon called gravitational lensing. As light travels across the universe, it can be slightly bent as it passes objects with lots of gravity, like galaxies.

This method catches both regular matter and dark matter -- the mysterious form of matter that we have only detected due to its effects on regular matter -- because both regular and dark matter exert gravity.

By rigorously analyzing these two sets of data, the scientists could infer where all the matter ended up in the universe. It is more precise than previous measurements -- that is, it narrows down the possibilities for where this matter wound up -- compared to previous analyses, the authors said.

The majority of the results fit perfectly with the currently accepted best theory of the universe.

But there are also signs of a crack -- one that has been suggested in the past by other analyses, too.

"It seems like there are slightly less fluctuations in the current universe, than we would predict assuming our standard cosmological model anchored to the early universe," said analysis coauthor and University of Hawaii astrophysicist Eric Baxter (UChicago PhD'14).

That is, if you make a model incorporating all the currently accepted physical laws, then take the readings from the beginning of the universe and extrapolate it forward through time, the results look slightly different from what we actually measure around us today.

Specifically, today's readings find the universe is less "clumpy" -- clustering in certain areas rather than evenly spread out -- than the model would predict.

If other studies continue to find the same results, scientists say, it may mean there is something missing from our existing model of the universe,

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but the results are not yet to the statistical level that scientists consider to be ironclad. That will take further study.

However, the analysis is a landmark as it yielded useful information from two very different telescope surveys. This is a much-anticipated strategy for the future of astrophysics, as more large telescopes come online in the next decades, but few had actually been carried out yet.

"I think this exercise showed both the challenges and benefits of doing these kinds of analyses," Chang said. "There's a lot of new things you can do when you combine these different angles of looking at the universe."

University of Chicago Kavli Associate Fellow Yuuki Omori was also a lead co-author for the papers. The South Pole Telescope is primarily funded by the National Science Foundation and the Department of Energy and is operated by a collaboration led by the University of Chicago. The Dark Energy Survey was an international collaboration coordinated through Fermi National Accelerator Laboratory and funded by the Department of Energy, the National Science Foundation, and many institutions around the world.

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