CHEMWATCH

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ASIA PACIFIC

Another step towards addressing water infrastructure challenge - Water NZ

2022-04-29

The Government's response to the Three Waters Working Group on Representation, Governance and Accountability is another step towards addressing the serious infrastructure deficit challenge facing the water sector.

Water New Zealand chief executive Gillian Blythe says that despite being critically important to the health, economic and environmental wellbeing of New Zealanders, the sector has been largely invisible with thousands of kilometres of drinking water, wastewater and stormwater network pipes buried underground.

She says recent discussions about the state of our ageing infrastructure have again highlighted the need to ensure water services are not forgotten about.

"Today's response to the 47 recommendations from the working group moves us closer to addressing the barriers that have led to the $125-185 billion deficit in water infrastructure across much of the country.

"It acknowledges the need to raise awareness of the water sector and the challenges we face in finding affordable and equitable ways to improve the safety and quality of water services.

"The Government has largely taken on board the working group's recommendations including the need to ensure that the new service delivery model is consistent with the wider regulatory framework.

"For instance, it acknowledges the need to ensure the regulatory settings for the new water service entities, and particularly the concept of Te Mana o te Wai, which focuses on restoring and preserving the balance between water, the wider environment and people, are aligned across resource management reform, the National Policy Statement for Freshwater Management, Taumata Arowai and the Water Services Act, as well as future economic regulation and consumer protection.

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Voxy, 29-04-22

http://www.voxy.co.nz/politics/5/401618

Frame rules to regulate indoor air quality in 4 months, NGT tells Centre

2022-04-29

Shopping malls, hotels, theatres, educational institutions, office buildings and similar places with public gatherings may soon have to regulate indoor air quality for the safety of their patrons. The National Green Tribunal (NGT), by an order issued on Wednesday, set a deadline of four months for the Union government to frame indoor air quality norms and provide protocols for their regulation.

A six-member panel, headed by tribunal's chairperson justice Adarsh Kumar Goel, underlined the absence of suitable norms pertaining to indoor air quality despite several studies highlighting presence of toxic gases and particulate matter inside buildings and their harmful effects.

The NGT referred to the WHO guidelines on indoor air quality and the Council of Scientific & Industrial Research guidelines on ventilation of residential and office buildings, as it held that "substantial question of environment arises" in the matter and that "there is need for regulation of indoor air quality at public places".

Read More

Hindustan Times, 29-04-22

https://www.hindustantimes.com/cities/delhi-news/frame-rules-to-regulate-indoor-air-quality-in-4-months-ngt-tells-centre-101651192630585.html

Try our new Inventory search (beta)

2022-04-28

We invite you to try our new search experience for the Australian Inventory of Industrial Chemicals (Inventory).

Features

- Table view - up to 50 results are displayed per page with each 'Inventory terms of listing' shown in columns

- Column sorting - sort any column in ascending or descending order (one column at a time only)
- Broader search - you can now also search other Inventory fields such as molecular formula, 'defined scope of assessment', 'conditions of introduction and use' and 'specific information requirements'
- 'Begins with' search - if you type in a few characters, it will find any matches beginning with those characters
- Wildcard search - this advanced search lets you use asterisks (*) to find words that start with or end with particular characters, or contain a set of characters
- More targeted results for chemical name searches - if you enter the exact CAS name of a chemical that's on the Inventory, you will get a single result
- 'Download the Inventory' button - a quick link to download a snapshot of the Inventory (important: the downloadable version of the Inventory is updated around twice per year, so it's not current and is not the official complete Inventory)
- Chemical record number or 'CR No.' is a unique number that AICIS assigns to each listing on the Inventory. You need to click the 'CR No.' link to see the chemical's Inventory listing details.

Read More

Australian Industrial Chemicals Introduction Scheme, 28-04-22

https://www.industrialchemicals.gov.au/news-and-notices/try-our-new-inventory-search-beta

Decision to approve EDN

2022-04-05

Decision Date: 05 April 2022

An EPA decision-making committee has approved an application to import or manufacture EDN, a fumigant for timber and logs.

Although the EPA has approved the EDN application, the fumigant cannot be imported or used immediately. Additional WorkSafe rules to protect workers, which are approved in principle, now require ministerial sign-off and gazetting. The EPA decision-making committee will then sign the HSNO approval to take effect at the same time as the WorkSafe rules.

Read about the WorkSafe rules: Safe Work Instruments

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EDN is a gas used to kill common pests found in wood. The active ingredient of EDN, ethanedinitrile, has not been previously been assessed by the EPA.

The decision-making committee:

- approved EDN on the basis that its benefits are significant, and adverse effects are negligible with the appropriate control measures
- accepted the evidence that EDN is the most viable replacement for methyl bromide for treating timber and logs
- also acknowledged the concerns of Māori and the wider public regarding the health and environmental effects of EDN.

Read the EDN decision document (PDF, 730KB)

Read the unsigned EDN approval document (PDF, 193KB)

Read More

EPA NZ, 05-04-22

https://www.epa.govt.nz/public-consultations/decided/decision-to-approve-edn/

AMERICA

EPA Updates Water Pollution Discharge Permitting to Cut PFAS

2022-04-29

The EPA is developing new water quality criteria for PFAS to protect aquatic life while updating its pollution discharge permitting to address the "forever chemicals," the agency announced Thursday.

Those measures—in addition to a new testing method that will help the agency detect per- and polyfluoroalkyl substances in water—advance the Environmental Protection Agency's strategy announced last October to cut down on PFAS, the agency said.

The EPA is using "all available tools to address PFAS contamination," Administrator Michael Regan said in a statement. "Today's actions help protect the health of all Americans as we deliver on our commitment to research, restrict, and remediate PFAS."

The EPA in October released a three-year "roadmap" for PFAS, which included possible regulations and research that will help the agency decide how best to control the substances.

PFAS are a group of thousands of human-created industrial chemicals used to make nonstick cookware, firefighting foam, water-resistant clothing and other products. They remain in the environment indefinitely and are associated with health problems, including increased risk of cancer.

Environmental groups said the EPA needs to do more to regulate PFAS.

"Today's actions are a step in the right direction, but stronger federal regulations are still urgently needed to curb industrial PFAS pollution," said Melanie Benesh, an attorney at the Environmental Working Group, which advocates for strong pollution controls. "The EPA should also speed up its efforts to limits discharges from polluting industries."

Read More

Bloomberg Law, 29-04-22

https://news.bloomberglaw.com/environment-and-energy/epa-updating-water-pollution-discharge-permitting-to-cut-pfas

EPA takes important steps to curb 'forever chemicals' in water, but more needed

2022-04-29

The Environmental Protection Agency today announced several new actions to address discharges of the "forever chemicals" known as PFAS into lakes, rivers, streams and other sources of drinking water, but more are needed to curb PFAS pollution.

First, the EPA released a memo addressing PFAS discharge limits and monitoring under industrial plants' and other facilities' Clean Water Act permits currently issued by the agency. States are responsible for issuing and enforcing most permits under the water law, but the EPA is responsible for permits in Massachusetts, New Hampshire, New Mexico, the District of Columbia, U.S. territories, and certain federal facilities, such as military bases. Incorporating discharge limits and monitoring requirements into these permits will help reduce PFAS releases into bodies of water near facilities in those states.

EWG estimates there may be nearly 30,000 sources of PFAS pollution from industries such as chemical manufacturers, textile mills, metal

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finishers and tanneries, among others. Because most facilities are not required to monitor for PFAS, it is impossible to know exactly how many manufacturers pollute nearby lakes, rivers and streams with the toxic forever chemicals that then make their way into the drinking water supply.

Second, the EPA announced a new draft method for measuring "adsorbable organic fluorine" in water. The presence of fluorine is a very strong indicator of PFAS. It provides a total measure of likely PFAS in drinking water samples and will help develop estimates of the amount of PFAS being released that can't yet be measured by methods that test for individual PFAS.

Finally, the EPA also announced draft limits on the two most notorious types of PFAS, PFOA and PFOS, in bodies of water. The draft limits reflect the amount of PFOA and PFOS that could harm plant and animal life. Determining that threshold is an important first step in creating industry-wide limits on discharges from manufacturers and wastewater treatment facilities. In the meantime, permit writers can use the new thresholds to create discharge limits that will protect plants and wildlife.

Read More

EWG, 29-04-22

https://www.ewg.org/news-insights/news-release/2022/04/epa-takes-important-steps-curb-forever-chemicals-water-more

Gillibrand bill further restricts PFAS-laden firefighting foam

2022-04-28

New York Senator Kirsten Gillibrand is introducing a bill to place more restrictions on firefighting foams containing PFAS chemicals.

Senator Gillibrand on Wednesday announced the PFAS Firefighter Protection Act. Michigan Congressman Dan Kildee, a fellow Democrat, is introducing a companion bill in the House.

PFAS substances, linked to several ill health effects including cancer, are used as an ingredient what is referred to as aqueous film forming foam – or AFFF.

On a virtual press conference Wednesday afternoon, Gillibrand said the new bill follows similar legislation passed three years ago.

"You may be aware that in 2019 we passed a ban on the use of PFAS-containing firefighting foams on military bases. So, you may be wondering why this legislation is still needed. The truth is, that 2019 law did not affect these PFAS chemicals in other areas, particularly on training sites. My bill goes one step further to ban all manufacturing, importation, and sale under the Toxic Substances Control Act," said Gillibrand.

The military use of firefighting foam has been linked to contamination of drinking water supplies, including in Lake Washington, the former drinking water supply for Newburgh, New York.

Representative Kildee explained that commercial airports – not just military – also used AFFF containing PFAS.

Read More

WAMC, 28-04-22

https://www.wamc.org/news/2022-04-28/gillibrand-bill-further-restricts-pfas-laden-firefighting-foam

MDE issues second report on sampling of Maryland public drinking water systems for PFAS

2022-04-28

The Maryland Department of the Environment has released the results of the second phase of the agency's sampling of public drinking water systems for a class of chemical compounds known as PFAS (per- and polyfluoroalkyl substances).

The report describes the results of sampling of 65 public water systems across the state. The sampling found no instances of levels exceeding the U.S. Environmental Protection Agency's current health advisory of 70 parts per trillion (ppt) of the sum of PFOA and PFOS, the two most studied PFAS compounds. The sampling showed two drinking water systems with levels between 35 and 70 ppt and one other system with a level between 28 and 35 ppt.

Currently, there are no enforceable federal regulatory drinking water standards for PFAS. MDE anticipates that an enforceable federal regulation for PFOA and PFOS will be finalized late next year.

MDE issued a report in July 2021 on the first phase of its sampling initiative, which included testing of 66 community drinking water systems

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serving about 4.3 million people. MDE has sampled for PFAS at drinking water systems serving about 70% of the state's population.

"Maryland is committed to reducing the risks of PFAS chemicals in our state and continuing our close coordination with scientific, local, state and federal partners," said Maryland Environment Secretary Ben Grumbles. "Our ongoing sampling for PFAS in public drinking water systems is a big part of our comprehensive approach to understanding and communicating risks to reduce the potential for harm."

PFAS refers to thousands of human-made chemicals that have been used since the 1940s in a range of products, including stain- and water-resistant fabrics and carpeting, cleaning products, paints, cookware, food packaging and fire-fighting foams. These uses have led to PFAS entering the environment, where they have been measured by several states in soil, surface water, groundwater and seafood. Most people have been exposed to PFAS because of their use in so many common consumer goods. There is evidence that exposure to certain PFAS — PFOA and PFOS — may lead to adverse health effects in humans.

The risk posed by exposure to PFAS is an emerging and evolving national concern. MDE has initiated a multi-pronged, risk-based, scientific approach to understand and communicate the risks associated with PFAS exposure and to reduce unacceptable risks. An integral part of this is a better understanding of the occurrence of PFAS in public drinking water supplies. After working to identify locations with the highest potential relative risk of PFAS occurrence, in September 2020 MDE initiated the first phase of public water system sampling.

Read More

Maryland.gov, 28-04-22

https://news.maryland.gov/mde/2022/04/28/mde-issues-second-report-on-sampling-of-maryland-public-drinking-water-systems-for-pfas/

EUROPE

Infographic: Reforming EU rules on the Classification, Labelling and Packaging of chemicals to better protect health

2022-04-20

What's that warning symbol written on the label of your bathroom cleaner, dishwasher detergent, tin of paint or scented candle? The Classification, Labelling and Packaging (CLP) Regulation sets out how the EU classifies and communicates about the hazardous properties of chemical substances and mixtures. To help you understand exactly what this juggernaut of EU chemicals legislation covers and why the upcoming revision of the CLP can be a health promotion opportunity, the Health and Environment Alliance (HEAL) has launched an easy-to-use infographic.

Open any cupboard in your home: how many items with a hazard warning symbol can you count? Many of us are familiar with at least some of these symbols, but few may fully understand them. Even fewer people have basic knowledge about the process for how the European Union decides which chemical substances and mixtures should be assigned a particular hazard and how it should be labelled for it.

Introduced in 2008, the CLP Regulation has created a single harmonized process to identify and label the hazardous properties of chemical substances and mixtures. It applies across all sectors and uses, and identified hazards are communicated in all EU languages to all actors and consumers.

The CLP Regulation is an important cornerstone of EU chemicals legislation in part because several sectoral chemicals regulations automatically take regulatory measures once a substance is classified under CLP. It is therefore very important that chemicals that are hazardous to human health and the environment are properly identified through CLP and that this classification can feed into other chemical legislations, which can then trigger adequate measures to restrict the use(s) of chemicals of concern.

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HEAL, 20-04-22

https://www.env-health.org/infographic-reforming-eu-rules-on-the-classification-labelling-and-packaging-of-chemicals-to-better-protect-health/

EU COULD BAN UP TO 12,000 CHEMICALS IN "GREAT DETOX" PLAN

2022-04-28

Earlier in the year, scientists warned about the threat of chemical pollution, claiming that the current levels had already crossed a "planetary boundary". This could pose a huge threat as it could lead to the breakdown of ecosystems.

A recent UN report also stated that chemical pollution could be causing more deaths than COVID-19 and called for immediate action to ban some of these toxic substances.

In response to this, the EU has published a plan to ban thousands of potentially harmful chemicals that are currently used in an array of products in Europe, including toys, cosmetics, baby products, and more.

Under the new regulations, any substances linked to cancer, infertility, reduced vaccine efficiency, and other health issues would be banned.

According to industry groups, there are up to 12,000 potentially toxic chemicals present in 74% of consumer and professional products that would be covered by the new restrictions.

The European Environmental Bureau (EEB) says that it would be the "largest ever ban" on toxic chemicals and that it would "open a new chapter" in protecting citizens against the threat of harmful substances in products.

The EEB also claims that the plan, which is also known as the "great detox", would improve the safety of almost all manufactured products by reducing the number of chemicals.

It would cover things like PVC plastic, flame retardants, and bisphenols, which are found in hard plastic items like plastic bottles. Additionally, it will cover "forever chemicals", also known as PFAs, as these are well known for taking a long time to degrade in the environment.

It is estimated that approximately 200,000 chemicals are used in the European Union and that 75% of these are dangerous. If the legislation is approved, the list of restricted substances will be released by the European Chemicals Agency and this will be reviewed regularly.

Read More

EU Policies, 28-04-22

http://eu-policies.com/competences/health/eu-ban-12000-chemicals-great-detox-plan/

INTERNATIONAL

Saudi Arabia to proceed with RoHS conformity assessments despite global objections

2022-04-27

Saudi Arabia will not change its plans to require conformity assessments under its RoHS-like regulation, set to come into effect on 4 July, despite governments around the world raising concerns that they have the potential "to create unnecessary obstacles to trade".

Saudi Arabia said the assessments are needed to "raise the level of quality in the national industry and the safety of imported goods presented in the Saudi market".

To support its plans, the government published guidelines on the assessment procedure and the documents companies will be required to submit.

The country announced last December that it was postponing the implementation of the technical regulation for six months because of concerns from companies and governments about the timeline.

Conformity assessment

The technical regulation, published on 9 July 2021 by the Standards, Metrology and Quality Organisation (SASO), aligns the country more closely with the EU's Directive on the restriction of hazardous substances (RoHS) in electrical and electronic equipment (EEE).

However, unlike in the EU, it will require both domestic manufacturers and importers to obtain a certificate – from an approved organisation – that proves the product conforms with the regulation. The United Arab

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Emirates (UAE)'s RoHS regulation, enacted in 2017, also requires such certificates.

To secure a certificate, suppliers will need to provide a test report for the complete product, according to the guidelines. Alternatively, the supplier can submit a report for at least three critical parts, selected based on a risk assessment.

In other countries with RoHS or RoHS-like legislation, it is usually the manufacturer that prepares technical documents proving a product's conformity and associated declaration. These documents only need to be disclosed to enforcement authorities upon request.

Read More

Chemical Watch, 27-04-22

https://chemicalwatch.com/468351/saudi-arabia-to-proceed-with-rohs-conformity-assessments-despite-global-objections

Additional studies in Combined Exposures database are now available in eChemPortal

2022-04-29

We are pleased to announce that 9 additional studies including 364 substance records are now available in Combined Exposures database in eChemPortal. Collection of Case Studies on Risk Assessments of Combined Exposures to Multiple Chemicals database includes a variety of studies where chemicals are grouped together for a risk assessment that is usually limited to one or a few human health or environmental endpoint(s).

This addition improves accessibility to risk assessment data for governments, scientists and industry.

Read More

OECD, 29-04-22

https://www.oecd.org/chemicalsafety/risk-assessment/echemportalglobalportaltoinformationonchemicalsubstances.htm

European Commission advances work on restrictions of harmful chemicals

2022-04-25

The European Commission has today published a Restrictions Roadmap, which is an important step forward to provide detailed information on all ongoing work on future restrictions under the EU's chemical legislation REACH.

Helsinki, 25 April 2022 – You can read more through the following links:

- Commission's news
- Restrictions Roadmap [PDF][EN]

ECHA's contribution to the roadmap is also available online:

- ECHA's contribution to the Restrictions Roadmap [PDF][EN]
- ECHA's topical page on the EU's Chemicals Strategy for Sustainability

Read More

ECHA, 25-04-22

https://echa.europa.eu/nl/-/european-commission-advances-work-on-restrictions-of-harmful-chemicals

EU Commission Staff Working Document Restrictions Roadmap under the Chemicals Strategy for Sustainability

2022-04-28

On 14 October 2020, the European Commission published its chemicals strategy for sustainability towards a toxic-free environment1 (the 'strategy') as part of the European Green Deal. The strategy highlights that chemicals are fundamental for society and a robust framework is needed to make Union legislation stronger and more coherent. It presents several actions to bring about a toxic-free environment and to protect people and the environment from hazardous chemicals.

In particular, the Commission is considering extending the 'generic approach to risk management', i.e. restricting certain substances in products for certain users while allowing limited exemptions under conditions clearly defined in law.

Until the proposed changes have been assessed and introduced in Regulation (EC) No 1907/2006) (REACH Regulation), the strategy

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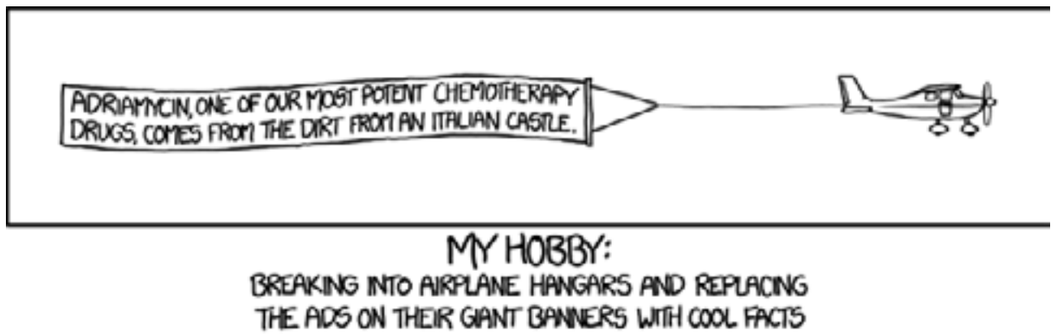
aims to 'prioritise carcinogenic, mutagenic and reprotoxic substances (CMRs), endocrine disruptors, persistent, bioaccumulative and toxic (PBT) and very persistent and very bioaccumulative (vPvB) substances, immunotoxicants, neurotoxicants, substances toxic to specific organs and respiratory sensitisers substances for (group) restrictions' for all uses. To facilitate this action, the Commission has prepared a roadmap to prioritise these substances for (group) restrictions under REACH (the 'Restrictions Roadmap').

Read More

Chemycal, 28-04-22

https://chemycal.com/news/b08d090a-9072-45a6-b1e2-bcc7ba7c1dc7/EU_Commission_Staff_Working_Document__Restrictions_Roadmap_under_the_Chemicals_Strategy_for_Sustainability

2022-05-06



https://xkcd.com/1355/

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Barium

2022-05-06

Barium is a chemical element with symbol Ba and atomic number 56. It is a silvery-white metal that can be found in the environment, where it exists naturally. Because of its high chemical reactivity barium is never found in nature as a free element. It occurs combined with other chemicals, such as sulphur, carbon or oxygen. Barium is very light and its density is half that of iron. It oxidises in air, reacts vigorously with water to form the hydroxide, liberating hydrogen. Barium reacts with almost all the non-metals, often forming poisonous compounds. This substance does not occur as a mineral, but can be prepared by heating barium carbonate. [1,2]

USES [2]

Barium is often used in barium-nickel alloys for spark-plug electrodes and in vacuum tubes as a drying and oxygen-removing agent. In addition, it is used in fluorescent lamps: impure barium sulphide phosphoresces after exposure to the light. Barium compounds are used by the oil and gas industries to make drilling mud. Drilling mud simplifies drilling through rocks by lubricating the drill. Furthermore, barium compounds are used to make paint, bricks, tiles, glass, and rubber. Barium nitrate and clorate give fireworks a green colour.

IN THE ENVIRONMENT [3]

- Barium enters the environment naturally through the weathering of rocks and minerals. Anthropogenic releases are primarily associated with industrial processes.
- In the atmosphere, barium is likely to present in particulate form and is primarily removed by wet and dry deposition.
- In aquatic media, barium is likely to precipitate out of solution as an insoluble salt.
- Barium is not very mobile in most soil systems due to the formation of water-insoluble salts and the inability of barium to form soluble complexes with fulvic and humic acids.
- Barium has the potential to bioconcentrate in marine animals and plants and in some terrestrial plants such as legumes, forage plants, Brazil nuts, and mushrooms.

Barium is a chemical element with symbol Ba and atomic number 56.

SOURCES & ROUTES OF EXPOSURE [3]

Sources of Exposure

- The general population is exposed to barium through consumption of drinking water and food, usually at low levels.
- Exposure may also occur during x-ray diagnosis. Barium sulphate is frequently utilised as a benign, radiopaque aid to x-ray diagnosis in colorectal and some upper gastrointestinal examinations.
- Exposure to barium and compounds may also occur via contact with oil and gas drilling muds, automotive paints, stabilisers for plastics, case hardening steels, bricks, tiles, lubricating oils, and jet fuel as well as in various types of pesticides.
- Occupational exposure to barium primarily occurs in barium mining or processing industries.

Routes of Exposure

- Inhalation – generally limited to occupational exposure.
- Oral – Primary route of exposure for general population. Some foods, such as Brazil nuts, seaweed, fish, and certain plants, may contain high amounts of barium.
- Dermal – minor route of exposure.

HEALTH EFFECTS [4]

Acute Effects

Barium has been found to potentially cause gastrointestinal disturbances and muscular weakness when people are exposed to it at levels above the EPA drinking water standards for relatively short periods of time. Some people who eat or drink amounts of barium above background levels found in food and water for a short period may experience vomiting, abdominal cramps, diarrhoea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness. Eating or drinking very large amounts of barium compounds that easily dissolve can cause changes in heart rhythm or paralysis and possibly death.

Chronic Effects

Animals that drank barium over long periods had damage to the kidneys, decreases in body weight, and some died.

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Carcinogenic Effects

The Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) have not classified barium as to its carcinogenicity. The EPA has determined that barium is not likely to be carcinogenic to humans following ingestion and that there is insufficient information to determine whether it will be carcinogenic to humans following inhalation exposure.

SAFETY [5]

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. Warm water must be used. 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 immediate medical attention.
- Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
- Serious Inhalation: Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.
- Ingestion: Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

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 Protection

The following personal protective equipment is recommended when handling barium:

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

Personal Protection in Case of a Large Spill:

- Splash goggles;
- Full suit;
- Dust respirator;
- Boots;
- Gloves;
- A self-contained breathing apparatus should be used to avoid inhalation of the product.

Note: Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling.

REGULATION [4,6]

Exposure Limits

United States:

- EPA has set a limit of 2.0 milligrams of barium per litre of drinking water (2.0 mg/L), which is the same as 2 ppm.
- Occupational Safety and Health Administration (OSHA) has set Permissible Exposure Limits (PELs) of 0.5 milligrams of soluble barium compounds per cubic metre of workplace air (0.5 mg/m3) for 8-hour shifts and 40-hour work weeks. The OSHA limits for barium sulphate dust are 15 mg/m3 of total dust and 5 mg/m3 for respirable fraction.
- The National Institute for Occupational Safety and Health (NIOSH) has set Recommended Exposure Limits (RELs) of 0.5 mg/m3 for soluble barium compounds. The NIOSH has set RELs of 10 mg/m3 (total dust) for barium sulphate and 5 mg/m3 (respirable fraction).

Australia:

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- Safe Work Australia has set a TWA exposure limit for barium sulphate of 10 mg/m^3
- Safe Work Australia has set a TWA exposure limit for barium, soluble compounds of 0.5 mg/m^3

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5. http://www.sciencelab.com/msds.php?msdsId=9927090
6. http://www.safeworkaustralia.gov.au/sites/swa/search/results.aspx?k=sulphuryl fluoride&s=Swa

Brain chemical linked to kindness and generosity in old age

2022-04-27

A fascinating new study has suggested a link between increased generosity in older age and levels of a neurochemical called oxytocin. The research found older people with higher levels of oxytocin were more likely to donate money to charity and be satisfied with their lives.

"We have previously shown a link between how kind and generous people are, known as prosocial behaviors, and the release of oxytocin," said first author on the new study Paul Zak, a neuroeconomist from Claremont Graduate University. "Seniors spend more time volunteering and donate a larger proportion of their income to charity than do younger people, so we wanted to see if there was a neurochemical basis for these behaviors."

To explore the link between prosocial behavior, age, and oxytocin the research team recruited around 100 adults with ages spanning 18 to 99. The subjects were paid a small amount for their participation in the research and shown a short video featuring a father talking about his two-year-old son, who is dying of brain cancer. Prior studies have found this video effectively stimulates the release of oxytocin when viewed.

"Participants had the option to donate some of their earnings from the study to a childhood cancer charity, and this was used to measure their immediate prosocial behavior," Zak explained. "We also collected data on their emotional states, to provide information on their overall satisfaction with life."

The findings revealed older adults released more oxytocin in response to watching the video compared to younger subjects. And those older adults with higher levels of oxytocin generally reported greater degrees of life satisfaction.

"People who released the most oxytocin in the experiment were not only more generous to charity, but also performed many other helping behaviors," said Zak. "This is the first time a distinct change in oxytocin has been related to past prosocial behaviors."

The study was not able to establish a direct causal link between oxytocin and generous behavior. Instead, the researchers hypothesize oxytocin plays more of a bi-directional role in the positive feedback loop between empathetic behavior and chemically-enhanced feelings of life satisfaction.

"Seniors spend more time volunteering and donate a larger proportion of their income to charity than do younger people, so we wanted to see if there was a neurochemical basis for these behaviors."

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According to Zak this oxytocin-enhanced feedback loop most likely plays a role in the consistently observed link between charitable religious behavior and increased life satisfaction. Helping others tends to make you feel good by triggering the release of oxytocin, which then enhances sensations of empathy leading to more prosocial behaviors.

"The findings of our study are consistent with many religions and philosophies, where satisfaction with one's life is enhanced by helping others," said Zak. "Participants in our study who released the most oxytocin were more generous to charity when given the opportunity and performed many other helping behaviors. The change in oxytocin was also positively related to participants' empathy, religious participation, and gratitude."

So the million dollar question … Could administering oxytocin to older adults improve feelings of life satisfaction? Or could synthetic oxytocin enhance prosocial behaviors and make people more kind or generous to others?

In the new study Zak and his team indicate these questions are a little premature considering how little is currently known about endogenous oxytocin release in senior citizens. It is more likely, according to the researchers, that oxytocin is simply one of many factors influencing prosocial behavior in old age.

There have been a small number of studies looking at the effects of intranasal oxytocin on older adults and the results have been decidedly mixed. Some studies have found oxytocin improves mood in older men but not older women, while other experiments found no acute impact on mood.

So are we on the verge of some brave new world where drugs help us act more kindly and generously as we get older? Not really. More pragmatically the study concludes these findings are a reminder of the benefits in maintaining social activity as we get older. If we know social interaction triggers oxytocin release, and we know endogenous oxytocin release in old age enhances feelings of life satisfaction, then the value of socializing is even more important in our senior years.

The new study was published in the journal Frontiers in Behavioral Neuroscience.

New Atlas, 27 April 2022

https://newatlas.com

F.D.A. Moves to Ban Sales of Menthol Cigarettes

2022-04-28

The Food and Drug Administration on Thursday announced a plan to ban sales of menthol-flavored cigarettes in the United States, a measure many public health experts hailed as the government's most meaningful action in more than a decade of tobacco control efforts.

The ban would most likely have the deepest impact on Black smokers, nearly 85 percent of whom use menthol cigarettes, compared with 29 percent of white smokers, according to a government survey. If effective in reducing smoking, the ban could significantly diminish the burden of chronic disease and limit the number of lives cut short by one of the most hazardous legal products available.

Menthol, a chemical derived from the mint plant that can also be made in a lab, is added to cigarettes to make smoking less harsh, providing a cooling sensation in the throat and making the experience more appealing. Menthol cigarettes make up about one third of the $80 billion U.S. cigarette market, and about 18.5 million Americans smoke them.

Banning them "would help prevent children from becoming the next generation of smokers and help adult smokers quit," Xavier Becerra, the health and human services secretary, said, adding that it would significantly reduce tobacco-related deaths among Black people.

The proposed ban was announced after a frenzy of lobbying by tobacco and retail interests. Kingsley Wheaton, the chief marketing officer of British American Tobacco, which owns Reynolds, the leading seller of menthol cigarettes in the United States, said the company believed there were more effective ways to reduce the risk of tobacco than banning menthol.

"The scientific evidence shows no difference in the health risks associated with menthol cigarettes compared to non-menthol cigarettes, nor does it support that menthol cigarettes adversely affect initiation, dependence or cessation," Mr. Wheaton said in a statement. "As a result, we do not believe the published science supports regulating menthol cigarettes differently from non-menthol cigarettes."

Public health experts say menthol cigarettes have been heavily marketed to Black people, to devastating effect: African American men have the highest rates of lung cancer in America, according to the Centers for Disease Control and Prevention.

Public health experts say the proposal could save hundreds of thousands of lives, especially among Black smokers — 85 percent of whom use menthol products.

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"These products have killed our children, our parents, our brothers, sisters and livelihoods," Mr. Johnson said in a statement. "After fighting against deadly menthol products for decades, today is a victory for Black America."

Smoking rates overall have been falling for 20 years, although a small uptick was reported in 2020, attributed to the pandemic. Still, cigarettes are estimated to cause 480,000 deaths each year, and among those starting the habit, menthol is popular, with about half of teenage smokers reporting that they use them.

Taking menthol cigarettes off the market is expected to further reduce smoking levels. If the United States' experience mirrors that of Canada after it banned menthol cigarettes, 1.3 million people would quit smoking and potentially hundreds of thousands of premature deaths could be averted, said Geoffrey Fong, principal investigator of the International Tobacco Control Policy Evaluation Project.

"This is potentially an extraordinary, landmark intervention to reduce the No. 1 preventable cause of death and disease," Mr. Fong said.

The ban does not cover menthol e-cigarettes. The F.D.A. is currently reviewing all vaping products being sold in the United States to determine whether to allow them to stay on the market. (Sales of these products began before the F.D.A. had regulatory authority over them.) The agency has so far granted marketing approval to makers of some tobacco-flavored vapes. Some menthol products remain on the market as the agency mulls how to rule on some of the top-selling devices.

The blueprint for the ban will be published as a proposed regulation in the May 4 Federal Register, and will be open for public comments for at least 60 days after that, then finalized with possible revisions. The F.D.A. said it would also convene listening sessions to engage with the public on the proposal in June.

It is expected that it will take a least a year to go into effect. The tobacco companies are likely to contest the rule in court, which could result in a long legal battle and more delay. A spokesman for Altria, which owns Philip Morris USA, which sells about 9 percent of the U.S. menthol cigarettes, warned that banning menthol would push the products into illegal, underground markets with no oversight and unfortunate health consequences.

"Taking these products out of the legal marketplace will push them into unregulated, criminal markets that don't follow any regulations and ignore

minimum age laws," the spokesman, David Sutton, said in a statement. "We will continue to engage in this long-term regulatory process."

Erika Sward, advocacy assistant vice president for the American Lung Association, reviewed the draft rules, which also ban flavored, small cigars, and said they appeared strong. That the F.D.A. "fended off inevitable attempts to weaken these proposed rules is quite remarkable," she said.

Public health advocates have long sought a menthol ban. When the landmark Tobacco Control Act passed in 2009, giving the F.D.A. the authority to regulate tobacco products, menthol was exempted from the tobacco flavors that would be banned.

The exception rankled public health groups and a cadre of former U.S. cabinet health secretaries, who noted the 47,000 Black lives lost each year to smoking-related disease. Allowing menthol cigarettes to remain on the market "caves to the financial interests of tobacco companies and discriminates against African Americans," the health secretaries wrote in a letter to the Senate, when the tobacco control law was moving through Congress.

The law left the matter in the hands of the F.D.A. and its advisers, who took incremental steps forward. Agency advisers in 2011 said removing menthol cigarettes from the marketplace would benefit public health, but stopped short of calling for a ban. Two years later, the F.D.A. said menthol made it easier to start smoking and harder to quit, seeking comment on "potential regulation."

A half decade passed before Dr. Scott Gottlieb, the F.D.A. commissioner at the time, announced his intent to seek a menthol cigarette ban in 2018. He left the agency before achieving that goal. Last year, the agency said it would pursue the ban again, as well as eliminating flavors in the small, mass-produced cigars that are popular with Black and Latino teenagers.

White House records show recent meetings with supporters of a ban, including the American Heart Association and American Academy of Pediatrics. The Public Law Health Center and others left officials with a review of Canada's experience with banning menthol cigarettes in 2017, which led to 59 percent of menthol smokers picking up unflavored cigarettes, 20 percent of the menthol smokers quitting and nearly the same proportion continuing to buy them on Native reservations, where they can still be sold.

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Business groups including Americans for Tax Reform and the Tax Foundation warned White House officials of losing federal and state tax dollars — as much as $6.6 billion in the first year of a menthol cigarette ban.

Though supporters of the ban say it is an important step toward reducing disease inequities in the United States, the step has, to some degree, divided Black communities. The Rev. Al Sharpton has sharply criticized it, and recently secured a meeting with White House officials along with King & Spalding, a lobbying firm with an extensive record of advocating for RAI Services Company, the cigarette maker formerly known as R.J. Reynolds.

Mr. Sharpton, president of the National Action Network, wrote a letter to Susan Rice, the Domestic Policy Council director, saying the ban would lead Black smokers to tamper with cigarettes or use unregulated herbal menthol varieties, which would "promote criminal activity." Mr. Sharpton has acknowledged that Reynolds has supported his organization for two decades but would not say how much it contributed.

Reynolds is one of the world's largest cigarette companies and maker of Newport menthol cigarettes, which it calls "America's No. 1-selling menthol cigarette brand."

Reynolds raised similar concerns in a letter to White House officials, suggesting the F.D.A. extend the timeline on a ban to ensure local enforcement does not roll out "in a way that creates negative effects, such as disparate impacts on communities of color."

"A menthol ban would impose serious risks," Mr. Sharpton wrote, "including increasing the illegal sale of smuggled, black market menthol cigarettes as well as the street sales of individual menthol cigarettes — 'loosies' and in turn place menthol smokers at a significant risk of entering the criminal justice system."

Carol McGruder, co-founder of the African American Tobacco Control Leadership Council, said it's "shameful" that Mr. Sharpton and others take tobacco funding. She said that the need for police reform is real but that the lives taken early by menthol tobacco are far greater in number.

"To cynically use our pain, to say, 'Oh, we want to protect you from that by leaving these products on the market that are killing you' is crazy," Ms. McGruder said.

In an interview, Mr. Sharpton said his position is not financially motivated but borne out of deep concern about how the ban will be enforced in

Black neighborhoods by local police. "You can't pay me to take a position," he said.

The F.D.A. made it clear in its announcement that it "cannot and will not enforce against individual consumers for possession or use of menthol cigarettes or flavored cigars."

The New York Times, 28 April 2022

https://nytimes.com

Scientists model landscape formation on Titan, revealing an Earth-like alien world

2022-04-25

Saturn's moon Titan looks very much like Earth from space, with rivers, lakes, and seas filled by rain tumbling through a thick atmosphere. While these landscapes may look familiar, they are composed of materials that are undoubtedly different -- liquid methane streams streak Titan's icy surface and nitrogen winds build hydrocarbon sand dunes.

The presence of these materials -- whose mechanical properties are vastly different from those of silicate-based substances that make up other known sedimentary bodies in our solar system -- makes Titan's landscape formation enigmatic. By identifying a process that would allow for hydrocarbon-based substances to form sand grains or bedrock depending on how often winds blow and streams flow, Stanford University geologist Mathieu Lapôtre and his colleagues have shown how Titan's distinct dunes, plains, and labyrinth terrains could be formed.

Titan, which is a target for space exploration because of its potential habitability, is the only other body in our solar system known to have an Earth-like, seasonal liquid transport cycle today. The new model, published in Geophysical Research Letters April 25, shows how that seasonal cycle drives the movement of grains over the moon's surface.

"Our model adds a unifying framework that allows us to understand how all of these sedimentary environments work together," said Lapôtre, an assistant professor of geological sciences at Stanford's School of Earth, Energy & Environmental Sciences (Stanford Earth). "If we understand how the different pieces of the puzzle fit together and their mechanics, then we can start using the landforms left behind by those sedimentary processes to say something about the climate or the geological history of Titan -- and how they could impact the prospect for life on Titan."

A new hypothesis reveals that a global sedimentary cycle driven by seasons could explain the formation of land-scapes on Saturn's moon Titan. The research shows the alien world may be more Earth-like than previously thought.

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A missing mechanism

In order to build a model that could simulate the formation of Titan's distinct landscapes, Lapôtre and his colleagues first had to solve one of the biggest mysteries about sediment on the planetary body: How can its basic organic compounds -- which are thought to be much more fragile than inorganic silicate grains on Earth -- transform into grains that form distinct structures rather than just wearing down and blowing away as dust?

On Earth, silicate rocks and minerals on the surface erode into sediment grains over time, moving through winds and streams to be deposited in layers of sediments that eventually -- with the help of pressure, groundwater, and sometimes heat -- turn back into rocks. Those rocks then continue through the erosion process and the materials are recycled through Earth's layers over geologic time.

On Titan, researchers think similar processes formed the dunes, plains, and labyrinth terrains seen from space. But unlike on Earth, Mars, and Venus, where silicate-derived rocks are the dominant geological material from which sediments are derived, Titan's sediments are thought to be composed of solid organic compounds. Scientists haven't been able to demonstrate how these organic compounds may grow into sediment grains that can be transported across the moon's landscapes and over geologic time.

"As winds transport grains, the grains collide with each other and with the surface. These collisions tend to decrease grain size through time. What we were missing was the growth mechanism that could counterbalance that and enable sand grains to maintain a stable size through time," Lapôtre said.

An alien analog

The research team found an answer by looking at sediments on Earth called ooids, which are small, spherical grains most often found in shallow tropical seas, such as around the Bahamas. Ooids form when calcium carbonate is pulled from the water column and attaches in layers around a grain, such as quartz.

What makes ooids unique is their formation through chemical precipitation, which allows ooids to grow, while the simultaneous process of erosion slows the growth as the grains are smashed into each other by waves and storms. These two competing mechanisms balance each other

out through time to form a constant grain size -- a process the researchers suggest could also be happening on Titan.

"We were able to resolve the paradox of why there could have been sand dunes on Titan for so long even though the materials are very weak, Lapôtre said. "We hypothesized that sintering -- which involves neighboring grains fusing together into one piece -- could counterbalance abrasion when winds transport the grains."

Global landscapes

Armed with a hypothesis for sediment formation, Lapôtre and the study co-authors used existing data about Titan's climate and the direction of wind-driven sediment transport to explain its distinct parallel bands of geological formations: dunes near the equator, plains at the mid-latitudes, and labyrinth terrains near the poles.

Atmospheric modeling and data from the Cassini mission reveal that winds are common near the equator, supporting the idea that less sintering and therefore fine sand grains could be created there -- a critical component of dunes. The study authors predict a lull in sediment transport at mid-latitudes on either side of the equator, where sintering could dominate and create coarser and coarser grains, eventually turning into bedrock that makes up Titan's plains.

Sand grains are also necessary for the formation of the moon's labyrinth terrains near the poles. Researchers think these distinct crags could be like karsts in limestone on Earth -- but on Titan, they would be collapsed features made of dissolved organic sandstones. River flow and rainstorms occur much more frequently near the poles, making sediments more likely to be transported by rivers than winds. A similar process of sintering and abrasion during river transport could provide a local supply of coarse sand grains -- the source for the sandstones thought to make up labyrinth terrains.

"We're showing that on Titan -- just like on Earth and what used to be the case on Mars -- we have an active sedimentary cycle that can explain the latitudinal distribution of landscapes through episodic abrasion and sintering driven by Titan's seasons," Lapôtre said. "It's pretty fascinating to think about how there's this alternative world so far out there, where things are so different, yet so similar."

Lapôtre is also an assistant professor, by courtesy, of geophysics. Study co-authors are from NASA's Jet Propulsion Laboratory (JPL).

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This research was supported by a NASA Solar System Workings grant.

Science Daily, 25 April 2022

https://sciencedaily.com

Alternative process for converting white phosphorus promises more sustainability in the chemical industry

2022-04-25

Chemists at the Technische Universität Dresden have developed a new, more sustainable process for synthesizing numerous important everyday chemicals from white phosphorus. The new process has the potential to establish innovative, more resource-efficient processes in the chemical industry. The groundbreaking results, which are the product of more than a decade of intensive research, have now been published in the journal Nature Chemistry.

The chemical element phosphorus (P) is one of the essential building blocks of all biological life and, based on it, a function-giving component of many products: in medicines, food products or fertilizers. In nature, phosphorus occurs exclusively in bound form as phosphate in the earth's crust. However, continental deposits are finite and are estimated to last for only a few more decades.

For industrial use, phosphates are converted into the so-called white phosphorus by laborious chemical processes. Alongside red, black and violet phosphorus, white phosphorus is the most important modification of the element in industrial terms and, to date, is still an irreplaceable starting point for the production of many pharmaceuticals, flame retardants, battery electrolytes, herbicides and other phosphorus fine chemicals.

For the production of phosphorus-containing everyday chemicals, the white phosphorus is mostly converted by chlorination with chlorine gas to phosphorus trichloride (PCl3); a corrosive and toxic liquid, which is of central importance for the chemical industry as a large-scale industrial intermediate. However, the production and use of PCl3, which has so far been without alternative, is highly problematic.

The chemist Prof. Jan J. Weigand of the TU Dresden and his team have now succeeded in specifically converting white phosphorus (P4) into an alternative and much less problematic phosphorus intermediate reagent. In this process, the use of chlorine gas can be completely omitted. Instead,

TUD chemists have succeeded in specifically converting white phosphorus (P4) into an alternative and much less problematic P intermediate reagent.

the process chemicals needed to convert the white phosphorus are recyclable.

"Economic factors still stand in the way of industrial application of the process, however a rethink is currently taking place here due to necessary, more sustainable aspects in the chemical industry. The more resource-conserving and efficient use of finite raw materials and the development of sustainable processes in many areas of chemistry are of the utmost importance. This work is a decisive breakthrough in phosphorus chemistry and of great importance for the further development of more sustainable and environmentally friendly processes," affirms Dr. Kai Schwedtmann, one of the two first authors of the publication.

Prof. Weigand and his group are currently developing further concepts with the aim of completely eliminating the need to use white phosphorus or PCl3 for the synthesis of pharmaceuticals, flame retardants, battery electrolytes, herbicides and other phosphorus fine chemicals: "In order to meet the greatest challenges of our time, a rethink must also take place in the chemical industry. We want to make a small contribution to this with our research by developing a 'blueprint' for a more modern and more sustainable phosphorus chemistry."

Phys Org, 25 April 2022

https://phys.org

Six sunscreens recalled over potential cancer-causing chemical

2022-04-29

Six sunscreen products have been recalled in Australia due to the detection of low levels of benzene, which is a chemical that can cause cancer in humans.

As sunscreens are regulated as medicines in Australia, the Therapeutic Goods Administration has issued the recall.

Brands affected include Cancer Council, Nivea, Bondi Sands and Baby Bum.

Only the following batches are being recalled:

- Cancer Council Sensitive Sunscreen SPF50+ 110mL (Tube), batch number 1103178
- Cancer Council Sensitive Sunscreen SPF50+ 200mL (Pump), batch number 1099751

"Benzene is not an ingredient in sunscreens but can be a contaminant in raw materials used in the manufacturing process."

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- NIVEA Sun Protect & Moisture SPF30 Lotion 200ml, batch number 12640440-BN
- NIVEA Sun Protect & Moisture SPF50+ Roll On 65ml, batch number 12669940BN
- SPF 50+ Lotion Spray Coconut Beach 200ml, batch numbers 104263, 1104743 and 1104264
- Baby Bum Mineral SPF50+ Lotion 88mL, batch numbers N1118B and N1118C

The TGA warned other products may be added to the recall as investigations continued.

"Benzene is a chemical that can cause cancer in humans, depending on the level and length of exposure," the recall notice read.

"Benzene is not an ingredient in sunscreens but can be a contaminant in raw materials used in the manufacturing process.

"It has been detected in one batch of a raw material used in the manufacture of a number of products and the TGA is working with affected companies to confirm if benzene is present in their medicines and if it is, how much is there."

It noted that exposure at the levels detected would not be expected to cause serious adverse health effects and the risk to sunscreen users was considered low.

However, the products were recalled to ensure consumer safety.

Benzene levels in sunscreens sold in Australia must be below two parts per million.

You can return the products listed to the place you purchased them for a refund, and anyone with concerns about benzene is instructed to speak to their doctor.

Last year, three other sunscreen products were recalled over the possible presence of benzene.

They included three Banana Boat products and a Neutrogena sunscreen.

Banana Boat recall (all batches with an expiry date of 31st January 2024 or earlier):

- Banana Boat Ultra Very High Protection Clear Sunscreen Spray SPF 50+, AUST L 206508

- Banana Boat Simply Protect Kids Very High Protection Sunscreen Lotion Spray SPF 50+, AUST L 311003
- Banana Boat Dry Balance Very High Protection Clear Sunscreen Spray SPF 50+, AUST L 342636.

Neutrogena recall (all batches with an expiry date of 30th August 2023 or earlier):

- Neutrogena Ultra Sheer Body Mist Sunscreen Spray SPF 50+ (aerosol sunscreen), AUST L 202301

News.com.au, 29 April 2022

New miniature heart could help speed heart disease cures

2022-04-23

There's no safe way to get a close-up view of the human heart as it goes about its work: you can't just pop it out, take a look, then slot it back in. Scientists have tried different ways to get around this fundamental problem: they've hooked up cadaver hearts to machines to make them pump again, attached lab-grown heart tissues to springs to watch them expand and contract. Each approach has its flaws: reanimated hearts can only beat for a few hours; springs can't replicate the forces at work on the real muscle. But getting a better understanding of this vital organ is urgent: in America, someone dies of heart disease every 36 seconds, according to the Centers for Disease Control and Prevention.

Now, an interdisciplinary team of engineers, biologists, and geneticists has developed a new way of studying the heart: they've built a miniature replica of a heart chamber from a combination of nanoengineered parts and human heart tissue. There are no springs or external power sources—like the real thing, it just beats by itself, driven by the live heart tissue grown from stem cells. The device could give researchers a more accurate view of how the organ works, allowing them to track how the heart grows in the embryo, study the impact of disease, and test the potential effectiveness and side effects of new treatments—all at zero risk to patients and without leaving a lab.

The Boston University–led team behind the gadget—nicknamed miniPUMP, and officially known as the cardiac miniaturized Precision-enabled Unidirectional Microfluidic Pump—says the technology could

A miniature replica of a heart chamber made from engineered parts and tissue from stem cells—and all contained on a chip not much bigger than a postage stamp—could help researchers study disease and test new treatments.

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also pave the way for building lab-based versions of other organs, from lungs to kidneys. Their findings have been published in Science Advances.

"We can study disease progression in a way that hasn't been possible before," says Alice White, a BU College of Engineering professor and chair of mechanical engineering. "We chose to work on heart tissue because of its particularly complicated mechanics, but we showed that, when you take nanotechnology and marry it with tissue engineering, there's potential for replicating this for multiple organs."

According to the researchers, the device could eventually speed up the drug development process, making it faster and cheaper. Instead of spending millions—and possibly decades—moving a medicinal drug through the development pipeline only to see it fall at the final hurdle when tested in people, researchers could use the miniPUMP at the outset to better predict success or failure.

The project is part of CELL-MET, a multi-institutional National Science Foundation Engineering Research Center in Cellular Metamaterials that's led by BU. The center's goal is to regenerate diseased human heart tissue, building a community of scientists and industry experts to test new drugs and create artificial implantable patches for hearts damaged by heart attacks or disease.

"Heart disease is the number one cause of death in the United States, touching all of us," says White, who was chief scientist at Alcatel-Lucent Bell Labs before joining BU in 2013. "Today, there is no cure for a heart attack. The vision of CELL-MET is to change this."

Personalized medicine

There's a lot that can go wrong with your heart. When it's firing properly on all four cylinders, the heart's two top and two bottom chambers keep your blood flowing so that oxygen-rich blood circulates and feeds your body. But when disease strikes, the arteries that carry blood away from your heart can narrow or become blocked, valves can leak or malfunction, the heart muscle can thin or thicken, or electrical signals can short, causing too many—or too few—beats. Unchecked, heart disease can lead to discomfort—like breathlessness, fatigue, swelling, and chest pain—and, for many, death.

"The heart experiences complex forces as it pumps blood through our bodies," says Christopher Chen, BU's William F. Warren Distinguished Professor of Biomedical Engineering. "And while we know that heart

muscle changes for the worse in response to abnormal forces—for example, due to high blood pressure or valve disease—it has been difficult to mimic and study these disease processes. This is why we wanted to build a miniaturized heart chamber."

At just 3 square centimeters, the miniPUMP isn't much bigger than a postage stamp. Built to act like a human heart ventricle—or muscular lower chamber—its custom-made components are fitted onto a thin piece of 3-D-printed plastic. There are miniature acrylic valves, opening and closing to control the flow of liquid—water, in this case, rather than blood—and small tubes, funneling that fluid just like arteries and veins. And beating away in one corner, the muscle cells that make heart tissue contract, cardiomyocytes, made using stem cell technology.

"They're generated using induced pluripotent stem cells," says Christos Michas (ENG'21), a postdoctoral researcher who designed and led the development of the miniPUMP as part of his Ph.D. thesis.

To make the cardiomyocyte, researchers take a cell from an adult—it could be a skin cell, blood cell, or just about any other cell—reprogram it into an embryonic-like stem cell, then transform that into the heart cell. In addition to giving the device literal heart, Michas says the cardiomyocytes also give the system enormous potential in helping pioneer personalized medicines. Researchers could place a diseased tissue in the device, for instance, then test a drug on that tissue and watch to see how its pumping ability is impacted.

"With this system, if I take cells from you, I can see how the drug would react in you, because these are your cells," says Michas. "This system replicates better some of the function of the heart, but at the same time, gives us the flexibility of having different humans that it replicates. It's a more predictive model to see what would happen in humans—without actually getting into humans."

According to Michas, that could allow scientists to assess a new heart disease drug's chances of success long before heading into clinical trials. Many drug candidates fail because of their adverse side effects.

"At the very beginning, when we're still playing with cells, we can introduce these devices and have more accurate predictions of what will happen in clinical trials," says Michas. "It will also mean that the drugs might have fewer side effects."

Thinner than a human hair

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One of the key parts of the miniPUMP is an acrylic scaffold that supports, and moves with, the heart tissue as it contracts. A series of superfine concentric spirals—thinner than a human hair—connected by horizontal rings, the scaffold looks like an artsy piston. It's an essential piece of the puzzle, giving structure to the heart cells—which would just be a formless blob without it—but not exerting any active force on them.

"We don't think previous methods of studying heart tissue capture the way the muscle would respond in your body," says Chen, who's also director of BU's Biological Design Center and an associate faculty member at Harvard University's Wyss Institute for Biologically Inspired Engineering. "This gives us the first opportunity to build something that mechanically is more similar to what we think the heart is actually experiencing—it's a big step forward."

To print each of the tiny components, the team used a process called two-photon direct laser writing—a more precise version of 3-D printing. When light is beamed into a liquid resin, the areas it touches turn solid; because the light can be aimed with such accuracy—focused to a tiny spot—many of the components in the miniPUMP are measured in microns, smaller than a dust particle.

The decision to make the pump so small, rather than life-size or larger, was deliberate and is crucial to its functioning.

"The structural elements are so fine that things that would ordinarily be stiff are flexible," says White. "By analogy, think about optical fiber: a glass window is very stiff, but you can wrap a glass optical fiber around your finger. Acrylic can be very stiff, but at the scale involved in the miniPUMP, the acrylic scaffold is able to be compressed by the beating cardiomyocytes."

Chen says that the pump's scale shows "that with finer printing architectures, you might be able to create more complex organizations of cells than we thought was possible before." At the moment, when researchers try to create cells, he says, whether heart cells or liver cells, they're all disorganized—"to get structure, you have to cross your fingers and hope the cells create something." That means the tissue scaffolding pioneered in the miniPUMP has big potential implications beyond the heart, laying the foundation for other organs-on-a-chip, from kidneys to lungs.

Refining the technology

According to White, the breakthrough is possible because of the range of experts on CELL-MET's research team, which included not just mechanical, biomedical, and materials engineers like her, Chen, and Arvind Agarwal of Florida International University, but also geneticist Jonathan G. Seidman of Harvard Medical School and cardiovascular medicine specialist Christine E. Seidman of Harvard Medical School and Brigham and Women's Hospital. It's a breadth of experience that's benefited not just the project, but Michas. An electrical and computer engineering student as an undergraduate, he says he'd "never seen cells in my life before starting this project." Now, he's preparing to start a new position with Seattle-based biotech Curi Bio, a company that combines stem cell technology, tissue biosystems, and artificial intelligence to power the development of drugs and therapeutics.

"Christos is someone who understands the biology," says White, "can do the cell differentiation and tissue manipulation, but also understands nanotechnology and what's required, in an engineering way, to fabricate the structure."

The next immediate goal for the miniPUMP team? To refine the technology. They also plan to test ways to manufacture the device without compromising its reliability.

"There are so many research applications," says Chen. "In addition to giving us access to human heart muscle for studying disease and pathology, this work paves the way to making heart patches that could ultimately be for someone who had a defect in their current heart."

Medical Xpress, 23 April 2022

https://medicalxpress.com

An easier way to teach robots new skills

2022-04-25

With e-commerce orders pouring in, a warehouse robot picks mugs off a shelf and places them into boxes for shipping. Everything is humming along, until the warehouse processes a change and the robot must now grasp taller, narrower mugs that are stored upside down.

Reprogramming that robot involves hand-labeling thousands of images that show it how to grasp these new mugs, then training the system all over again.

Researchers have developed a technique that enables a robot to learn a new pick-and-place task with only a handful of human demonstrations.

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But a new technique developed by MIT researchers would require only a handful of human demonstrations to reprogram the robot. This machine-learning method enables a robot to pick up and place never-before-seen objects that are in random poses it has never encountered. Within 10 to 15 minutes, the robot would be ready to perform a new pick-and-place task.

The technique uses a neural network specifically designed to reconstruct the shapes of 3D objects. With just a few demonstrations, the system uses what the neural network has learned about 3D geometry to grasp new objects that are similar to those in the demos.

In simulations and using a real robotic arm, the researchers show that their system can effectively manipulate never-before-seen mugs, bowls, and bottles, arranged in random poses, using only 10 demonstrations to teach the robot.

"Our major contribution is the general ability to much more efficiently provide new skills to robots that need to operate in more unstructured environments where there could be a lot of variability. The concept of generalization by construction is a fascinating capability because this problem is typically so much harder," says Anthony Simeonov, a graduate student in electrical engineering and computer science (EECS) and co-lead author of the paper.

Simeonov wrote the paper with co-lead author Yilun Du, an EECS graduate student; Andrea Tagliasacchi, a staff research scientist at Google Brain; Joshua B. Tenenbaum, the Paul E. Newton Career Development Professor of Cognitive Science and Computation in the Department of Brain and Cognitive Sciences and a member of the Computer Science and Artificial Intelligence Laboratory (CSAIL); Alberto Rodriguez, the Class of 1957 Associate Professor in the Department of Mechanical Engineering; and senior authors Pulkit Agrawal, a professor in CSAIL, and Vincent Sitzmann, an incoming assistant professor in EECS. The research will be presented at the International Conference on Robotics and Automation.

Grasping geometry

A robot may be trained to pick up a specific item, but if that object is lying on its side (perhaps it fell over), the robot sees this as a completely new scenario. This is one reason it is so hard for machine-learning systems to generalize to new object orientations.

To overcome this challenge, the researchers created a new type of neural network model, a Neural Descriptor Field (NDF), that learns the

3D geometry of a class of items. The model computes the geometric representation for a specific item using a 3D point cloud, which is a set of data points or coordinates in three dimensions. The data points can be obtained from a depth camera that provides information on the distance between the object and a viewpoint. While the network was trained in simulation on a large dataset of synthetic 3D shapes, it can be directly applied to objects in the real world.

The team designed the NDF with a property known as equivariance. With this property, if the model is shown an image of an upright mug, and then shown an image of the same mug on its side, it understands that the second mug is the same object, just rotated.

"This equivariance is what allows us to much more effectively handle cases where the object you observe is in some arbitrary orientation," Simeonov says.

As the NDF learns to reconstruct shapes of similar objects, it also learns to associate related parts of those objects. For instance, it learns that the handles of mugs are similar, even if some mugs are taller or wider than others, or have smaller or longer handles.

"If you wanted to do this with another approach, you'd have to hand-label all the parts. Instead, our approach automatically discovers these parts from the shape reconstruction," Du says.

The researchers use this trained NDF model to teach a robot a new skill with only a few physical examples. They move the hand of the robot onto the part of an object they want it to grip, like the rim of a bowl or the handle of a mug, and record the locations of the fingertips.

Because the NDF has learned so much about 3D geometry and how to reconstruct shapes, it can infer the structure of a new shape, which enables the system to transfer the demonstrations to new objects in arbitrary poses, Du explains.

Picking a winner

They tested their model in simulations and on a real robotic arm using mugs, bowls, and bottles as objects. Their method had a success rate of 85 percent on pick-and-place tasks with new objects in new orientations, while the best baseline was only able to achieve a success rate of 45 percent. Success means grasping a new object and placing it on a target location, like hanging mugs on a rack.

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Many baselines use 2D image information rather than 3D geometry, which makes it more difficult for these methods to integrate equivariance. This is one reason the NDF technique performed so much better.

While the researchers were happy with its performance, their method only works for the particular object category on which it is trained. A robot taught to pick up mugs won't be able to pick up boxes or headphones, since these objects have geometric features that are too different than what the network was trained on.

"In the future, scaling it up to many categories or completely letting go of the notion of category altogether would be ideal," Simeonov says.

They also plan to adapt the system for nonrigid objects and, in the longer term, enable the system to perform pick-and-place tasks when the target area changes.

"How efficiently we can teach robots new manipulation skills depends on the robots' ability to generalize from just a few demonstrations. This work shows how a robot can robustly transfer demonstrations of picking up or placing an object to previously unseen objects," says Dieter Fox, a professor of computer science and engineering at the University of Washington, who was not involved with this research. "This research leverages recent advances in deep learning for neural object representations and introduces several very clever innovations that make them well suited to imitation learning for robot manipulation. The real world experiments are extremely impressive and I expect that many researchers will build on top of these results."

This work is supported, in part, by the Defense Advanced Research Projects Agency, the Singapore Defense Science and Technology Agency, and the National Science Foundation.

MIT, 25 April 2022

https://news.mit.edu

Recycled glass waste used as sand replacement in 3D printing

2022-04-26

Researchers from Nanyang Technological University, Singapore (NTU Singapore) have developed the capability to use recycled glass in 3D printing, opening doors to a more environmentally sustainable way of building and construction.

Glass is one material that can be 100% recycled with no reduction in quality, yet it is one of the least recycled waste types.

Glass is one material that can be 100% recycled with no reduction in quality, yet it is one of the least recycled waste types. Glass is made up of silicon dioxide, or silica, which is a major component of sand, and therefore it offers significant untapped potential to be recycled into other products.

At the same time, due to growing populations, urbanization and infrastructure development, the world is facing a shortage of sand, with climate scientists calling it one of the greatest sustainability challenges of the 21st century.

For these reasons, the NTU research team is trying to find ways to recycle glass by 3D printing it into items for everyday use.

One of their innovations published recently in the Journal of Building Engineering, used a specially formulated concrete mix comprising recycled glass, commercial cement products, water, and additives to 3D print a concrete bench. By figuring out the optimal concrete formulation, the NTU research team was able to successfully 3D-print a 40cm tall L-shaped bench (see image) as a proof of concept that their material could be 3D printed into an everyday structural (weight-bearing) product.

In lab compression tests and filament quality (strength) tests, the 3D printed structure showed excellent buildability—the printed concrete does not deform or collapse before the concrete cures—and extrudability, meaning the special concrete mix is fluid enough to flow through the hoses and print nozzle.

A new pathway for recycling glass

According to the latest data by the National Environment Agency of Singapore, only 13% of the 74,000 tons of glass waste generated in the country was recycled in 2021. Without being fully exploited for other purposes, most of the glass waste finds its way into incinerators before being disposed of in a landfill.

While scientists elsewhere have described the use of glass in concrete mixtures, none of them has been able to successfully 3D-print a structure using a glass-based concrete mixture, until now.

The principal investigator of the study Professor Tan Ming Jen of the NTU School of Mechanical and Aerospace Engineering (MAE) said, "The main challenge in formulating 3D-printable concrete mixtures is to figure out just how much of each component to add to obtain a structurally sound structure with minimal defects. Our team has come up with a feasible

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formula, demonstrating for the first time that glass can indeed be used to 3D-print a bench with excellent structural integrity."

"The research also exemplifies the concept of a 'Circular Economy.' 70% of glass is made up of silicon dioxide, or silica. What our research does is to essentially return the silica found in glass to be reused again as sand in our 3D printing concrete mixture," Prof Tan added.

As a result of the successful proof-of-concept, the NTU research team believes their development offers a new pathway to recycling glass waste and can contribute to a greener building and construction industry for Singapore and beyond.

The new development builds on previous 3D printing for construction research by Prof Tan and his team at NTU's Singapore Centre for 3D Printing (SC3DP).

The NTU scientist was also behind the 3D printed bathroom project in 2019, where an unfurnished bathroom was printed in 12 hours in Singapore—half the time required for conventional construction of the same facility.

The latest innovation is an example of groundbreaking research that supports the NTU 2025 strategic plan, which seeks to address humanity's grand challenges on sustainability and accelerate the translation of research discoveries into innovations that mitigate human impact on the environment.

Replacing sand in concrete

As the second most widely used substance after water, concrete relies on sand as a vital ingredient to ensure its durability.

Reports by the United Nations Environment Programme have also revealed that around the world, aggressive sand extraction from rivers has led to pollution, flooding, and other environmental consequences.

First author of the NTU-led study, Andrew Ting, a researcher at the SC3DP said, "Our research has shown that recycled glass can be used to replace up to 100% of the sand in concrete for 3D printing. The result is a concrete bench with a mechanical strength that meets acceptable industrial standards. Given that sand is being exploited at a rate much quicker than it can be replenished naturally, the prospect of using recycled glass in building and construction is becoming more attractive. We believe our

development has great potential to relieve the demand on sand for this sector in the future."

Moreover, as glass is a material that is naturally hydrophobic—meaning it does not absorb water—less water is required to create a concrete mix suitable for 3D printing use.

How the L-shaped bench is 3D printed

Through detailed and extensive analysis and testing, the NTU research team established the optimal parameters for the recycled-glass concrete mixture that would allow it to be 3D-printed.

Components of the mixture include recycled glass crushed to different size classes (Medium, Fine and Superfine), commercial cement product, water, and other additives.

To enable printing, the team adjusted the control systems of the 3D printer to match the flow rate of the nozzle to the hardening properties of the concrete.

The printing was then carried out in a single build using a 4-axis gantry robotic printer which has a print volume of 1.2 meter x 1.2 meter x 1 meter. The specially designed concrete mixture was fed to a pump and transported to a nozzle mounted on the robotic arm, depositing the material layer by layer according to the digital blueprint.

The technology and know-how employed in this research project are protected by a Technology Disclosure filed through NTU's innovation and enterprise company, NTUitive, and is owned by the university.

Moving forward, the NTU research team, in collaboration with Singapore start-up company Soda Lemon, will look at 3D printing larger scale and more diverse structures using the recycled glass concrete mix, and to optimize the printing algorithm for consistent performance.

Tech Xplore, 26 April 2022

https://techxplore.com

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UN warns of looming sand crisis as population and city growth lead to surging demand

2022-04-28

A United Nations report calls for urgent action to avert a "sand crisis" — including a ban on beach extraction — as demand surges to 50 billion tonnes a year amid population growth and urbanisation.

Sand is the most-exploited natural resource in the world after water, but its use is largely ungoverned, meaning we are consuming it faster than it can be replaced by geological processes that take hundreds of thousands of years, a UN Environment Programme (UNEP) report says.

Global consumption for use in glass, concrete and construction materials has tripled over two decades, to reach 50 billion tonnes a year — or about 17 kilograms per person each day — it said, harming rivers and coastlines and even wiping out small islands.

"We now find ourselves in the position where the needs and expectations of our societies cannot be met without improved governance of sand resources," Sheila Aggarwal-Khan, director of the Economy Division at UNEP, said in the report's foreword.

"If we act now, it is still possible to avoid a sand crisis."

UNEP's Pascal Peduzzi — who coordinated the report written by 22 authors — said that some of the impacts of over-exploitation were already being felt.

In the Mekong River — the longest in South-East Asia — sand extraction was causing the delta to sink, leading to salinisation of previously fertile lands.

In a Sri Lankan river, sand removal had reversed the water flow, meaning ocean water was heading inland and bringing salt-water crocodiles with it, Dr Peduzzi told journalists.

Demand is now seen as shifting to Africa, where villagers often remove sand from beaches to build growing cities.

In some cases, this can make coastlines more vulnerable to the impacts of climate change, such as more powerful storms, the report said.

Among the report's recommendations were a ban on beach extraction and the creation of an international standard for marine dredging that could harm ocean biodiversity.

The UN report recommends a ban on beach extraction and greater use of sand from recycled materials

It also called for reducing demand by reusing sand from recycled materials such as concrete and mining tailings instead of using naturally occurring sand.

ABC News, 28 April 2022

https://abc.net.au

New polymer system may help revolutionize the next generation of medications

2022-04-27

Researchers at the University of Massachusetts Amherst recently announced that they have engineered a new class of material, called a "polyzwitterionic complex," or "pZC," which is able to both withstand the harsh acidic conditions of the stomach and then dissolve predictably in the comparatively gentle environment of the small intestine. This property means that pZCs could help revolutionize the delivery of medicines of all sorts, from familiar oral antibiotics to new classes of delicate protein therapeutics.

"Despite the common experience of swallowing medications orally, there is a huge number of therapies that are not available orally," says Khatcher Margossian, the lead author of the study and a candidate for a dual M.D./Ph.D. from Rush Medical College and the UMass Amherst Department of Polymer Science and Engineering, respectively. This is because there are many drugs that can't withstand the stomach's harshly acidic environment. Two ways around this problem are to either inject or implant medications; but in both cases, the pain, fear and potential side effects can limit a patient's willingness to undergo treatment or to stick with the treatment plan through its full course. And even those drugs that are strong enough to withstand the stomach's acid and make it through to the small intestine, where they can be absorbed into the bloodstream, often do not make it through entirely intact.

"The doses of oral medications are usually larger than what our body really needs," explains Murugappan Muthukumar, the Wilmer D. Barrett Professor in Polymer Science and Engineering at UMass Amherst and the study's senior author. "This is because some of the medication decomposes in the stomach."

"If there were some way to protect this precious therapeutic cargo," says Margossian, "we could expand the library of medications that we can

In their system, two types of charged polymers, a polyzwitterion and a polyelectrolyte, associate to form a protective droplet inside of which medications can travel.

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deliver orally." Figuring out how to protect the precious cargo is exactly what Margossian, Muthukumar, and their colleagues have done.

The study, recently published in Nature Communications, details a new class of material, called a pZC, which forms through a process known as "complex coacervation." In their system, two types of charged polymers, a polyzwitterion and a polyelectrolyte, associate to form a protective droplet inside of which medications can travel. The trick that the pZC has to perform is that it not only needs to be tough enough to withstand the highly acidic stomach environment, it also has to disassemble in the much gentler, neutral conditions of the small intestine.

Paradoxically, the key to the group's success was not to strengthen the bonds between the polyzwitterion and polyelectrolyte but to weaken them. "Weakening the association between the two materials," says Muthukumar, "allows us to control precisely when they come apart. If the bonds are too strong, then there's no room to play."

The group's research is driven by the real-life needs of medical practitioners. Not only will these materials allow clinicians to more efficiently deliver the right dosages of drugs, but they will vastly increase the number of medications that can be taken orally. "This is a foundational technology that can alter how we treat disease," says Margossian. "We hope that our work will make its way into clinicians' hands and help them save lives."

Medical Xpress, 27 April 2022

https://medicalxpress.com

Fossilized pollen may reveal 'fingerprints' of environmental stress

2022-04-22

It's around this time every year that we start to remember the existence of pollen, the microscopic reproductive cells of cone-bearing and flowering plants. Airborne pollen may induce annoying congestion for some, but a new paper shows that these grains may provide a new way of looking at the climate over 300 million years into the fossil record.

Burke Museum Research Associate Jeffrey Benca thinks about pollen year-round. His new paper in the journal Paleobiology investigates what pollen malformations, or abnormally shaped pollen grains, can tell us about stress in the environment. Previous studies showed that stressors like heightened UV-B radiation exposure and environmental pollution can affect the shape of pollen grains that cone-bearing trees produce and even cause trees to become temporarily sterile.

In this study, Benca and colleagues investigated not only how often these malformations were produced in a wide variety of living conifer species, but also what kind of abnormal pollen shapes they produced when presented with different amounts of environmental stress.

Pollen is incredibly well documented in the fossil record and goes back hundreds of millions of years. Many types of pollen have a hard coating that makes them more likely to be preserved in the fossil record. Conifer pollen is also airborne, meaning it rides the wind and falls over huge swathes of both land and water. These pollen grains are especially useful for looking at long-term changes in climate because they accumulate in environments conducive to fossilization and are found in many different ages of rock.

"Pollen can rain into the ocean where we see the marine animal records and we can get a snapshot of what's happening with animals in the ocean and the plants on land at the same time, which is really unusual," Benca said. "The pollen records have given us an idea where you can take a walnut-sized sample of sediment and reconstruct kilometers of forests and ecosystems. So it's a really powerful technique to try and get a broader scale picture of what's going on."

While at the University of California Berkeley, he and his co-authors Ivo Duijnstee and Cindy Looy sampled pollen grains from 14 different species of conifer from around the world mostly grown in their Botanical Garden. These trees can be considered under relatively low-stress conditions

Pollen is incredibly well documented in the fossil record and goes back hundreds of millions of years.

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because they receive daily care and sufficient water from landscaping staff. All but two of the 14 species under baseline conditions showed a malformation rate of below 3%, which previous studies suggest is normal for conifers under low stress, based on historic field observations.

But when they exposed one modern pine species to high levels of UV-B radiation, essentially simulating an ozone weakening event, these plants produced a much higher rate of malformed pollen grains. The kinds of malformations they produced also became much more uniform in trees exposed to the highest UV-B radiation doses.

"It was like a signal that the tree is extremely stressed," Benca said. "It's leaving a sort of fingerprint or mark of 'okay, I'm really not doing well.'"

Most of these conifer plants produce pollen called bisaccate grains, or winged pollen grains. Think of a Mickey Mouse head with a big pollen grain in the middle and two smaller wings branching off to the side. These wings, or sacci, help the pollen grains ride the wind, sometimes hundreds of miles away from the tree that produced it.

Under low-stress conditions, these trees produced a mix of different malformations, some with only one wing or even three wings. But exposure to UV-B radiation made trees overwhelmingly produce three-winged pollen malformations.

Looking back into the fossil record, the researchers propose that not only can you use the 3% rule to find times of increased environmental stress, but you may also be able to use certain types of malformations to indicate what kind of stress these long-extinct plants were experiencing. In this case, a spike in three-winged pollen grains could be an indicator of ozone weakening events.

"The crazy part is the trees were luxuriantly growing," Benca said. "They looked perfectly fine and pampered like they had been growing in a garden rather than under these horrible UV regimes. So we started thinking back, if people were strolling around a mass extinction with an ozone weakening event, you wouldn't notice it until you start getting sunburn because the trees would all look fine."

There may have been numerous ozone weakening events throughout earth's history, largely due to massive volcanic activity such as during the formation of the Siberian Traps 250 million years ago. This was the largest volcanic event in the last half billion years and is believed to have caused the largest mass extinction event on earth: the End-Permian Extinction.

More recently, we experienced an ozone weakening event over Antarctica in the 1980s due to manmade aerosols from products like refrigerators, air conditioners and hairspray. But after the Montreal Protocol severely limited these chemicals, the ozone layer started to heal.

We don't need pollen as a proxy to measure the modern ozone layer; we can do that directly. But it could be a powerful tool to look as far back as 320 million years into the past to understand how ecosystems reacted during times of heightened environmental stress, such as mass extinctions or climate changes. Other types of environmental stressors like heavy metals, acid rain, or pathogens may also produce unique pollen malformations we can use to better interpret the past.

Benca hopes to investigate some of these questions in the future with modern plants and pollen in the fossil record. Sampling 14 different tropical and temperate conifer species grown side by side in the same gardens was a rare opportunity to compare how different plant lineages from both hemispheres reacted to the same baseline environmental conditions.

The consistently low rate of malformations in garden trees suggests that researchers can more confidently use pollen malformations as a stress indicator in the fossil record. Understanding broader regional patterns in pollen malformations may also inform stress detection in the fossil record, so the researchers hope to see future studies on how trees in different locations and at varying elevations might produce different malformations.

Phys Org, 22 April 2022

https://phys.org

How synthetic biology can help fix the supply chain crisis

2022-04-25

Supply-chain disruptions are testing companies around the world. Can solutions be found in a fermentation tank? We believe the crisis could accelerate the adoption of synthetic biology to ensure local, sustainable supply of many products from materials to food.

Crises inevitably lead to great changes and opportunities. Today's supply chain crisis may be no different. Since the beginning of COVID-19, companies and countries have struggled to ensure steady supply of

Beyond the biotech industry, where synthetic biology was first adopted, falling costs are promoting its use to create materials that improve the quality of products such as pet food, watch straps and cement

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key inputs to the normal functioning of our economies. This year, key commodities and other products from Russia and Ukraine have been disrupted amid the war. And the increasing prevalence of natural disasters driven by climate change in recent years has also interfered with supply chains.

Car factories lie dormant because a missing microchip has thwarted production. Pharmaceutical providers rely on overseas supply for active ingredients in many medicines. Food producers that depend on wheat exports from Ukraine, a country known as "the breadbasket of Europe," are at risk because the spring planting season is in jeopardy. Companies facing challenges like these in a variety of industries may find innovative ways to redesign supply chains by turning to synthetic biology.

Synthetic biology is a revolutionary technology that could make a profound impact on the way a vast array of products are manufactured. In our recent white paper, we explained how the science works and is rapidly expanding into new applications (See The Synthetic Biology Revolution: Investing in the Science of Sustainability). It all happens in a brewery-like environment. Production organism cells (yeast, for instance) are typically grown and fed in a fermenter, and the downstream output (purified protein, for example) is harvested. Beyond the biotech industry, where synthetic biology was first adopted, falling costs are promoting its use to create materials that improve the quality of products such as pet food, watch straps and cement. Now, the retreat of globalization may be a catalyst for broader adoption.

Reversing Decades of Globalization

Decades of relative peace prompted companies to globalize their supply chains. Car parts often cross the US-Mexico border several times before they're installed into a vehicle. Apple's iPhone contains parts made in over 40 different countries. This supply chain optimization enabled companies to squeeze out ever higher profit margins—but also created hidden vulnerabilities.

The savings gained from sourcing cheaper supply for a component overseas can quickly evaporate when a local COVID-19 outbreak causes ports to close or a geopolitical conflict disrupts supply. Many inputs for products we rely on every day, like fertilizers for farming, come from far away around the world, often from countries governed by non-democratic rulers. Even if the current conflict is resolved, we believe companies and economies won't simply revert back to the old-normal supply chains, having realized their inherent fragility.

How can synthetic biology help? By providing cost-effective local production. Anywhere you can brew beer, you can make things with synthetic biology. Here are some examples of potential opportunities for synthetic biology to alleviate tricky supply issues.

Oil and natural gas—are not only used for generating energy. Plastics and nylon are byproducts of petroleum that could be produced using synthetic biology. Some fertilizers are derived from natural gas and a recent study reported engineered bacteria could be used as a substitute for ammonia-based fertilizers, which currently rely on natural gas.

Pharmaceutical ingredients—about half the world's drugs are derived from plants and nature-based materials. According to the FDA, some 78% of active pharmaceutical ingredients manufacturers are located outside the US. As more pharmaceutical companies tap into the power of synthetic biology to create these chemicals, dependence on supply from abroad will wane.

Food and flavors—recent events have exposed vulnerabilities in different parts of the food supply chain. For example, during the pandemic, as US consumers faced major meat shortages, Tyson Foods warned that the "food supply chain is breaking." Synthetic biology can be used to create alternative protein sources, which can be manufactured in a variety of locations because they can be economically viable at relatively small scale, according to the Good Food Institute; a distributed supply system is more resilient to disruption. In Singapore, 90% of all food is imported, so the country has been at the vanguard of regulatory approval for cell-culture meat. Synthetic vanilla now commands up to 85% of global supply, solving chronic supply difficulties for a flavoring that is naturally produced mainly in Madagascar.

Clothing—it's become the norm to find that your shirt or shoes were manufactured on the other side of the planet. But McKinsey reports that 71% of apparel and fashion companies are planning to increase nearshoring by 2025. McKinsey predicts that synthetic biology fermentation can yield significant cost savings in production of materials such as nylon, silk, cotton and clothing dyes.

Electric vehicle batteries—a professor from Columbia University used synthetic biology to develop a special microbe that can extract precious materials from a mine in a more environmentally sustainable way. This can help improve local sourcing for electric vehicle batteries in the US.

Using Science for Strategic Advantage

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Many companies might have scoffed at synthetic biology as a futuristic, expensive technology that wasn't aligned with globally dispersed supply chains. We believe it may become a more attractive option as established companies seek to re-orient their operations, and younger companies grow and build out new supply chains from scratch. Greater investments in synthetic biology lead to discoveries that push down the costs of production, opening up more applications and markets, and creating a virtuous cycle that draws in further investment.

Investors should take note. Select innovative companies that are enabling the synthetic biology revolution offer attractive growth potential, in our view. And companies across industries that are embracing the technology to address supply chain challenges may enjoy strategic advantages versus peers that can unlock promising long-term return potential.

CSR Wire, 25 April 2022

https://csrwire.com

Could eating bug powder and fungus meat help fight climate change? Yes, but there are easier ways

2022-04-25

A new study from researchers in Finland, published Monday, found that diets that simply cut down on meat and dairy are nearly as climate-friendly as diets that rely on culture-grown meat and milk.

Global agriculture and food systems, especially the production of meat and milk, accounted for 31% of greenhouse gas emissions in 2021, according to the United Nations' Food and Agricultural Organization.

Could eating bug powder and fungus meat help stop climate change? Yes, say scientists in Finland, but they've also got some more palatable suggestions.

The researchers created a model that calculates how different diets reduce the potential for global warming. With some tweaking, they got that reduction as high as 80% but it came at a price—some variants of the diet got much of their protein from things like cell-based cultured meat, microalgae and milk produced in a tank from cow mammary cells.

The happy surprise was that diets that simply cut down on actual meat and dairy were almost as climate-friendly.

Global agriculture and food systems, especially the production of meat and milk, accounted for 31% of greenhouse gas emissions in 2021, according to the United Nations' Food and Agricultural Organization.

"It doesn't need to be technology," said Rachel Mazac, a food systems researcher at the University of Helsinki and one of the paper's authors.

Their model showed that even replacing 80% of animal food sources with plant-based options resulted in a 75% reduction in climate impact. Reducing meat consumption alone was responsible for a 60% lower environmental impact.

"The real take-home message," she said, "is we have food pathways forward."

Those pathways will be necessary, say experts. The world is expected to have 9.7 billion mouths to feed in 2050, up 1.9 billion from today. At the same time, almost every country has signed on to the Paris Climate Agreement, a pledge to begin shifting to a carbon-neutral economy to fight climate change.

Food will be a big part of that. Global agriculture and food systems accounted for as much as 31% of greenhouse gas emissions in 2021, according to the United Nations' Food and Agricultural Organization. For the United States, agriculture alone accounts for 11%.

"We need to make some pretty sweeping changes if we want to minimize our impacts," said Mazac.

Future foods: Vat-grown milk, culture-grown meat and microbial proteins

The authors of the paper, published in the scientific journal Nature Food, focused on what they call "novel or future foods" which include some very old fare and some very new.

In the ancient category would be insect meal. In the Bible, John the Baptist ate locusts and wild honey. Many cultures still eat insects, which provide an excellent source of protein and healthy fat.

In the new category are things like spirulina, mushroom meat and kelp.

Spirulina is a blue-green algae powder that's vitamin-rich and added to smoothies and other foods. Mushroom meat, which is actually made from a fungus, is sold in the U.S. as Quorn. Kelp burgers and jerky are already available.

Plant-based meat substitutes such as Beyond Burgers and Impossible Burgers are already popular—even at fast-food restaurants including Burger King, KFC, Starbucks and others.

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In the future category are milk grown from cells, culture-grown meat and microbial proteins.

These last aren't on the market yet but there are several companies working on them. Singapore-based Turtle Tree Labs has an operation in West Sacramento, California, that's testing cell-based dairy. Several companies around the world are working on lab-grown meat. A San Franciso company is working on brewing precision food-grade proteins.

Adding these novel foods to a daily diet wouldn't require chowing down on whole crickets or having big strings of kelp in your salads, said Mazac. Most come in powder form.

"It's more like you can incorporate it into breads, protein shakes, those kind of things," she said.

For those who want to double down on future foods, Mazac offered a possible menu.

The day could start with a protein shake for breakfast made from cow milk brewed in cell cultures, with added insect powder for protein, blue-green algae for vitamins and lab-grown cloudberry slurry for taste. At lunch there could be a burger made from beef grown in a vat and for dinner a burrito made from scrambled cultured fungal protein.

It's not much of a contrast with a meal available today from plant-based options, she noted. That might include a breakfast of whole grain toast with peanut butter and a smoothie made from banana and oat milk. For lunch, an Impossible Burger and for dinner a burrito filled with spicy jackfruit in barbecue sauce.

The transition to diets including foods that contribute less to global warming is already beginning, said Fabrice DeClerck, director of science at EAT, an international foundation that works to make food systems more sustainable.

Speaking from Amsterdam, he said it's much more common to find healthier and more plant-forward foods at train stations, airports and the like today than it was even five years ago.

That might include a carrot or lentil salad, or a sandwich menu with several vegetarian options. Even the meat sandwiches "might come with one slice of ham instead of six," he said.

How to fight global warming at mealtime: Less meat, more veggies

While novel foods could work to lower the carbon impact of food, there's a much easier way to get to the same goal, said DeClerck. His organization helped write a 2019 report outlining what a healthy and sustainable global diet would look like.

Like most other research into this realm, it found that lowering meat and dairy consumption down made diets both healthier and less likely to contribute to global warming.

"When you look at the ranges, we're talking about beef once per week. Poultry twice per week. Fish two to three times per week," he said.

Some of the change is likely to happen naturally. As the population rises, more people will put more demand on agriculture, raising costs and making things like meat and dairy products more expensive, causing consumption to go down.

In the end, shifting to a diet heavier in fruits and vegetables, whole grains and meat added more for flavor than substance may be easier than getting humanity over its collective "food neophobia," the avoidance of new foods.

It's not simply a question of having the right chemical composition, said Geoffrey Heal, a professor of environmental economics at Columbia University business school.

"Do people like it? Does it have the right taste and mouth-feel?" he said. "There are a lot of things that go into deciding if something is acceptable to humans as food."

Mazac said their models showed lowering food's environmental impact doesn't require an entirely new food technology, or for everyone to become vegan.

"It just says that we need to start consuming less and focusing a bit more on the quality of the nutrition and the quality of the production," she said.

Phys Org, 25 April 2022

https://phys.org

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Time travel could be possible, but only with parallel timelines

2022-04-25

Have you ever made a mistake that you wish you could undo? Correcting past mistakes is one of the reasons we find the concept of time travel so fascinating. As often portrayed in science fiction, with a time machine, nothing is permanent anymore—you can always go back and change it. But is time travel really possible in our universe, or is it just science fiction?

Our modern understanding of time and causality comes from general relativity. Theoretical physicist Albert Einstein's theory combines space and time into a single entity—"spacetime"—and provides a remarkably intricate explanation of how they both work, at a level unmatched by any other established theory. This theory has existed for more than 100 years, and has been experimentally verified to extremely high precision, so physicists are fairly certain it provides an accurate description of the causal structure of our universe.

For decades, physicists have been trying to use general relativity to figure out if time travel is possible. It turns out that you can write down equations that describe time travel and are fully compatible and consistent with relativity. But physics is not mathematics, and equations are meaningless if they do not correspond to anything in reality.

Arguments against time travel

There are two main issues which make us think these equations may be unrealistic. The first issue is a practical one: building a time machine seems to require exotic matter, which is matter with negative energy. All the matter we see in our daily lives has positive energy—matter with negative energy is not something you can just find lying around. From quantum mechanics, we know that such matter can theoretically be created, but in too small quantities and for too short times.

However, there is no proof that it is impossible to create exotic matter in sufficient quantities. Furthermore, other equations may be discovered that allow time travel without requiring exotic matter. Therefore, this issue may just be a limitation of our current technology or understanding of quantum mechanics.

The other main issue is less practical, but more significant: it is the observation that time travel seems to contradict logic, in the form of time

It turns out that you can write down equations that describe time travel and are fully compatible and consistent with relativity. But physics is not mathematics.

travel paradoxes. There are several types of such paradoxes, but the most problematic are consistency paradoxes.

A popular trope in science fiction, consistency paradoxes happen whenever there is a certain event that leads to changing the past, but the change itself prevents this event from happening in the first place.

For example, consider a scenario where I enter my time machine, use it to go back in time five minutes, and destroy the machine as soon as I get to the past. Now that I destroyed the time machine, it would be impossible for me to use it five minutes later.

But if I cannot use the time machine, then I cannot go back in time and destroy it. Therefore, it is not destroyed, so I can go back in time and destroy it. In other words, the time machine is destroyed if and only if it is not destroyed. Since it cannot be both destroyed and not destroyed simultaneously, this scenario is inconsistent and paradoxical.

Eliminating the paradoxes

There's a common misconception in science fiction that paradoxes can be "created." Time travelers are usually warned not to make significant changes to the past and to avoid meeting their past selves for this exact reason. Examples of this may be found in many time travel movies, such as the "Back to the Future" trilogy.

But in physics, a paradox is not an event that can actually happen—it is a purely theoretical concept that points towards an inconsistency in the theory itself. In other words, consistency paradoxes don't merely imply time travel is a dangerous endeavor, they imply it simply cannot be possible.

This was one of the motivations for theoretical physicist Stephen Hawking to formulate his chronology protection conjecture, which states that time travel should be impossible. However, this conjecture so far remains unproven. Furthermore, the universe would be a much more interesting place if instead of eliminating time travel due to paradoxes, we could just eliminate the paradoxes themselves.

One attempt at resolving time travel paradoxes is theoretical physicist Igor Dmitriyevich Novikov's self-consistency conjecture, which essentially states that you can travel to the past, but you cannot change it.

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According to Novikov, if I tried to destroy my time machine five minutes in the past, I would find that it is impossible to do so. The laws of physics would somehow conspire to preserve consistency.

Introducing multiple histories

But what's the point of going back in time if you cannot change the past? My recent work, together with my students Jacob Hauser and Jared Wogan, shows that there are time travel paradoxes that Novikov's conjecture cannot resolve. This takes us back to square one, since if even just one paradox cannot be eliminated, time travel remains logically impossible.

So, is this the final nail in the coffin of time travel? Not quite. We showed that allowing for multiple histories (or in more familiar terms, parallel timelines) can resolve the paradoxes that Novikov's conjecture cannot. In fact, it can resolve any paradox you throw at it.

The idea is very simple. When I exit the time machine, I exit into a different timeline. In that timeline, I can do whatever I want, including destroying the time machine, without changing anything in the original timeline I came from. Since I cannot destroy the time machine in the original timeline, which is the one I actually used to travel back in time, there is no paradox.

After working on time travel paradoxes for the last three years, I have become increasingly convinced that time travel could be possible, but only if our universe can allow multiple histories to coexist. So, can it?

Quantum mechanics certainly seems to imply so, at least if you subscribe to Everett's "many-worlds" interpretation, where one history can "split" into multiple histories, one for each possible measurement outcome—for example, whether Schrödinger's cat is alive or dead, or whether or not I arrived in the past.

But these are just speculations. My students and I are currently working on finding a concrete theory of time travel with multiple histories that is fully compatible with general relativity. Of course, even if we manage to find such a theory, this would not be sufficient to prove that time travel is possible, but it would at least mean that time travel is not ruled out by consistency paradoxes.

Time travel and parallel timelines almost always go hand-in-hand in science fiction, but now we have proof that they must go hand-in-hand in real science as well. General relativity and quantum mechanics tell us that

time travel might be possible, but if it is, then multiple histories must also be possible.

Phys Org, 25 April 2022

https://phys.org

How nature inspires strong, lightweight material for planes, buildings and bone implants

2022-04-25

Material coming from a Princeton research lab is full of holes—but that's a good thing. Designed to mimic bone, wood and other natural materials, the porous objects are lighter than traditional products and can be strategically inserted into structures to provide higher stiffness in areas with high demand.

These porous structures, created by researchers at Princeton University and Georgia Tech, feature spinodal microstructures—networks of specially designed holes that can be tuned to achieve optimized behavior at the macroscale. In a new study, published online March 16 in the journal Advanced Materials, the team combined different realizations of these spinodal microstructures to design and prototype facial implants for reconstructive surgery and stiff, lightweight parts for aircraft.

Davide Bigoni, a professor of solid and structural mechanics at the University of Trento who was not involved with the research, called the results a "breakthrough." He said, "The authors have found a clever way to allow a continuous transition between zones with different architectures. This is the ultimate concept of biomimicking, as all natural structures form continuous systems. This is a fact known since ancient times—'natura non facit saltus'—nature does not make jumps."

Many natural materials, including bone, animal horns, wood and sand dollar skeletons, are full of holes. The empty spaces make the materials light, and in some cases, allow body fluids to move through the pores. In bones, these spaces allow for a remodeling process that makes the bone more or less dense in response to physical demands. Creating synthetic materials with similar properties has been a challenge for engineers.

In the new study, the researchers mimicked these natural materials by designing microstructures with holes of different sizes, shapes and orientations. The new objects are known as architected materials, which have customizable performance based on the relation of material and

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geometry. The holes can be shaped like spheres (like the ones in sand dollar skeletons), diamonds (bone), columns (wood), or lentils (horn). The researchers could imbue the material with stiffness in different directions by varying the shape. They controlled the material's density by changing the holes' size, and altered the holes' orientation within an object to increase stiffness in regions under strain.

"You have the actual structure and the microstructure working together to get superior performance," said Fernando Vasconcelos da Senhora, a graduate student at Georgia Tech and first author on the new study.

To demonstrate potential uses, the researchers designed and 3D-printed a facial implant, such as the kind used to repair a major facial injury from a car accident. Currently, surgeons use plastic or titanium to create porous implants that allow bone to regrow through holes, but these implants do not have the same tunability achievable with spinodal architectures. The researchers combined sections with column- and lentil-shaped holes to create an implant that was stiff enough to withstand the forces of chewing and had the right size holes to promote bone growth and healing. The prototype implant was made of a photopolymer resin, but it could be 3D-printed using biocompatible materials for future use in patients.

The researchers said the technique opens the door to creating implants with many different types of material because the combination of geometry and material allows designers to finely tune performance.

"It's not the base material that is better. It is the microscale features that are better," said Emily Sanders, a co-author and an assistant professor of mechanical engineering at Georgia Tech. "In theory, we could make the scaffolds out of any material—most appropriate would be to explore biocompatible materials."

To show an entirely different use, the researchers combined three types of microstructures to construct a jet engine bracket—a critical part of an aircraft, which holds the engine in place and must be both strong and lightweight.

"We have a technique that is quite powerful in the sense that it combines material architectures with optimization at different scales and its integration with additive manufacturing," said Glaucio Paulino, the Margareta E. Augustine Professor of Engineering and principal investigator on the project. "It can have a broad range of applications in the sense that it scales, so it can be applied in nano- and microtechnology, as well as at meso- and macroscales."

A key aspect of the materials' success is the seamless transitions from one type of microstructure to another within the same object. Abruptly switching between microstructures without connecting the network of pores would cause the material to split along the seams. Materials made with spinodal microstructures are also less likely to have weak spots because the holes occur randomly, instead of in regular patterns.

"A major part was figuring out how to take advantage of the manufacturing platform and [work out] mathematically the structure of these architected materials and then link the two together so that we could actually fabricate something," said Sanders.

The team is already exploring additional uses for the microstructures. Currently, the technology is at the prototype stage, but they are eager to test the properties of the materials more fully. "I'm interested in understanding the fundamental questions about how these architected materials behave," Sanders said.

TechXplore, 25 April 2022

https://techxplore.com

Fast-acting enzyme breaks down plastics in as little as 24 hours

2022-04-27

The idea of deploying enzymes to break down plastic waste is gaining momentum through a string of breakthroughs demonstrating how they can do so with increasing efficiency, and even reduce the material to simple molecules. A new study marks yet another step forward, with scientists leveraging machine learning to engineer an enzyme that degrades some forms of plastic in just 24 hours, with a stability that makes it well-suited to large-scale adoption.

Scientists have been exploring the potential of enzymes to aid in plastics recycling for more than a decade, but the last six years or so has seen some significant advances. In 2016, researchers in Japan unearthed a bacterium that used enzymes to break down PET plastics in a matter of weeks. An engineered version of these enzymes, dubbed PETase, improved the performance further, and in 2020 we saw scientists develop an even more powerful version that digested PET plastics at six times the speed.

A team at the University of Texas set out to address some of the shortcomings of these enzymes so far. According to the scientists,

This newly created enzyme […] was able to almost entirely degrade 51 different untreated PET products in the space of a week, and in some experiments broke down plastics in as little as 24 hours.

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the application of the technology has been held back by an inability to function well at low temperatures and different pH ranges, lack of effectiveness directly tackling untreated plastic waste, and slow reaction rates.

To resolve these problems, the team developed a machine learning model that could predict which mutations in a PETase enzyme would afford it these capabilities. This involved closely studying a range of PET plastic products, including containers, water bottles and fabrics, and then using the model to design and engineer a new and improved enzyme dubbed FAST-PETase (functional, active, stable and tolerant PETase).

This newly created enzyme proved superior at breaking down PET plastics at temperatures between 30 and 50 °C (86 and 122 °F) and at a range of pH levels. It was able to almost entirely degrade 51 different untreated PET products in the space of a week, and in some experiments broke down plastics in as little as 24 hours. The scientists also demonstrated a closed-loop PET recycling process, in which FAST-PETase was used to break down the plastics and then the recovered monomers were used to chemically reconstruct the material.

"When considering environmental cleanup applications, you need an enzyme that can work in the environment at ambient temperature," said study author Hal Alper. "This requirement is where our tech has a huge advantage in the future."

With the ability to quickly break down post-consumer plastic waste at low temperatures, the researchers believe they have landed on a technique that is portable, affordable and able to be adopted on an industrial scale. They have filed a patent for the technology and hope to see it put to use in landfills and polluted areas.

"The possibilities are endless across industries to leverage this leading-edge recycling process," said Alper. "Beyond the obvious waste management industry, this also provides corporations from every sector the opportunity to take a lead in recycling their products. Through these more sustainable enzyme approaches, we can begin to envision a true circular plastics economy."

The research was published in the journal Nature, while the video below offers an overview of the breakthrough.

New Atlas, 27 April 2022

Microplastics are everywhere, but their dangers largely remain a mystery, experts say

2022-04-26

They are everywhere: in riverbanks, on glaciers, in deserts, in fish populations, even in the air we breathe. And these are just a few of the places where scientists have found microplastics, plastic debris roughly the size of a sesame seed that move easily through the environment, the impact of which remains somewhat of a mystery, Northeastern University experts say.

Microplastics continue to be highlighted in the news for being discovered in various human body parts, including the lungs, blood, and even the placenta. These tiny particles result from bigger substances, mainly large plastic debris, breaking down. They pass easily through water filters, make their way into bodies of water, and potentially threaten aquatic life, according to the National Oceanic and Atmospheric Administration. And because plastics are made to remain durable, they take years to erode, and microplastics maintain a lasting presence on Earth.

"Plastic was designed to be a material that breaks down slowly, so it can certainly break down into smaller and smaller particles, but those particles don't disappear. They just get smaller and smaller and move around, no matter how much erosion happens," explains Samuel Munoz, Northeastern professor of marine and environmental sciences and civil and environmental engineering.

Munoz's area of study is geology, specifically how plastics and sediments move around the environment, where they get stored, and why they accumulate where they do. He notes that with countries' escalating plastic production for the past several decades, microplastics' prominence in ecosystems is an increasing concern. In 2017, more than 300 million tons of plastic was produced, compared to only 1.5 million tons in 1950, according to the International Union for Conservation of Nature.

"It's a growing problem, because our production of plastics has been increasing since the 1950s and will increase in the coming decades, unless we change something," Munoz explains.

Part of the reason why plastic production is continuing to accelerate around the world is because of human reliance on fossil fuels. Plastic is made using waste from coal, crude oil, and natural gas, so it is incredibly cheap to produce, says Aron Stubbins, Northeastern professor of marine

Microplastics continue to be highlighted in the news for being discovered in various human body parts, including the lungs, blood, and even the placenta.

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and environmental sciences, civil and environmental engineering, and chemistry and chemical biology.

"Plastic overproduction is a result of our reliance on fossil fuels to drive our industries. Producing cheap plastics is one of the ways we profit off the waste of fossil fuels," Munoz explains. "In terms of the scale of production, it's potentially alarming."

A significant concern, emphasized by the NOAA, is microplastics in the ocean, particularly because the percentage of these particles in the ocean represents only a small fraction of the actual plastic waste out there, Munoz notes. He says this raises the question: Where is all the waste going?

To try to answer this, Munoz and Stubbins are exploring how microplastics accumulate in floodplains next to rivers. In February, the professors submitted a proposal to sample a floodplain they have already studied, as well as its soil, to see how much plastic resides there.

According to Munoz, researchers in other parts of the globe, including Germany, have already studied microplastics in particular bodies of water, but he and Stubbins hope to add to the growing body of research on where these tiny particles accumulate and why.

"There's been other work done showing it's everywhere," Munoz says about microplastics. "They've found microplastics in glaciers, at the bottom of the sea, in deserts, in every conceivable location. It's wild."

Despite the fact that microplastics have been found throughout the world, the dangers of these particles to human health, as well as the environment, is an area of much-needed research, Munoz, Stubbins, and other scientists agree.

"With respect to health, there's a lot we don't know," Stubbins says, noting, however, that exposure to any type of particle is detrimental to respiratory health. "Particles in general are bad for our respiratory system, so anything that adds particles to the air is bad for our bodies."

Beyond human health, researchers have detailed instances of aquatic animals ingesting microplastics and dying. The work of Northeastern professor Zhenyu Tian, an environmental chemist, has focused on how rubber tire particles, and the chemicals that leach out of them, make their way into rivers and harm salmon.

There are two ways in which microplastics, like rubber tire particles, can potentially cause harm, Tian explains: first, by breaking down and releasing contaminants used to make the plastic, like flame retardants and antioxidants; and second, by latching onto other harmful chemicals that already exist in the environment, like pesticides.

Unlike fish, humans have longer life spans, and microplastic exposure to people is incredibly complicated, so it is hard to study the substance's impact on humans, according to Tian. Still, the kinds of contaminants that leach out of and onto microplastics are generally not good for our bodies, he points out.

"It has to be recognized that many of these contaminants are bioactive in the human body," Tian says. "They have a harmful effect on the human body if the concentration is high enough."

There is also the concern, though unconfirmed, that even though these plastics are tiny, they could potentially cause blood clots or other physically damaging effects, Tian adds.

There is already research on the dangers of specific additives used to make plastics, like BPA, known to impact brains, fetuses, infants, and children. But that is only one chemical, and there is an assortment used to make plastics, Stubbins notes. Along with decreasing the production of unnecessary plastics to curb the potentially harmful effects of microplastics, greater regulations are needed to restrict what substances companies use to create plastics, he says.

"In the U.S., there's this 'beg-for-forgiveness,' rather than 'ask-for-permission' attitude toward companies putting certain chemicals in their products. It's only when there's a toxic impact identified that you get public pushback against it," Stubbins says. "If public safety, rather than profits, were the dominant concern, then you'd have to take each of those chemicals through checks before you use it. This would create problems for industry but would likely benefit public health."

Phys Org, 26 April 2022

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An epigenetic cause of miscarriages is identified and cured in mice

2022-04-27

Researchers led by Azusa Inoue at the RIKEN Center for Integrative Medical Sciences (IMS) in Japan have discovered a gene responsible for prenatal death when critical transgenerational instructions are missing from egg cells. Published April 28 in Genes & Development, the study shows that in mice, failed epigenetic suppression of an X-chromosome gene called Xist leads to miscarriage and developmental abnormalities.

"This study identified genes critical for fetal development whose expression is controlled by histone modifications transmitted from eggs to the next generation," says Inoue. "The findings have implications for understanding infertility and developing treatments."

For embryos to develop normally, egg and sperm cells need to receive important biological instructions before they meet up. Once an egg is fertilized, some of these instructions tell genes to be turned on or off depending on whether they came from the mother or father. This process is called genomic imprinting and is the focus of the new study.

When modifications in gene expression are passed on to the next generation, they are called transgenerational epigenetic changes because they're inheritable changes even though the DNA code remains unchanged. Inoue and his team have been studying a specific set of transgenerational epigenetic instructions given to egg cells called histone H3 lysine 27 (H3K27) trimethylation. In previous studies, they found that preventing these instructions led to prenatal death, particularly for male embryos, and also to enlarged placentas in the mothers. The new study asked whether those outcomes were directly related to failed imprinting.

The study began by knocking out a gene required for H3K27 trimethylation in eggs so that the transgenerational instructions could not be given. Next, the team added a knockout of the Xist gene to these eggs. Because the male offspring tended to die, the researchers suspected that the culprit was a gene on the sex chromosome. As it turns out, there are nine maternal genes known to be suppressed in embryos in favor of the ones with paternal origins. And only one, Xist, is on the X-chromosome.

The results were almost as expected. Prenatal death was greatly reduced, and the male-skewed lethality was gone after knocking out Xist. This showed that failed Xist imprinting was the reason for the prenatal death. However, the placenta was still enlarged. Reasoning that this was likely

Published April 28 in Genes & Development, the study shows that in mice, failed epigenetic suppression of an X-chromosome gene called Xist leads to miscarriage and developmental abnormalities.

related excess expression of the other eight genes that failed to imprint, the team created eight different deletion mutants in the double knockout embryos. They found that for three of the genes, this resulted in normal-sized placentas.

"We succeeded in curing developmental defects in a mouse model that otherwise suffers from prenatal lethality and placental malformation due to the lack of transgenerational epigenetic instructions from mothers," says Inoue. The researchers plan to conduct more experiments to determine how these specific biological instructions are established when egg cells are created, and whether environmental factors can influence the process.

Medical Xpress, 27 April 2022

https://medicalxpress.com

Disposable masks could be used to improve concrete

2022-04-27

With the pervasive single-use masks during the pandemic now presenting an environmental problem, researchers have demonstrated the idea of incorporating old masks into a cement mixture to create stronger, more durable concrete.

In a paper published in the journal, Materials Letters, a Washington State University research team showed that the mixture using mask materials was 47% stronger than commonly used cement after a month of curing.

"These waste masks actually could be a valuable commodity if you process them properly," said Xianming Shi, professor and interim chair of the Department of Civil and Environmental Engineering and the corresponding author on the paper. "I'm always looking out for waste streams, and my first reaction is 'how do I turn that into something usable in concrete or asphalt?'"

Production of cement is a carbon-intensive process, responsible for as much as 8% of carbon emissions worldwide. Microfibers are already sometimes added to cement concrete to strengthen it, but they're expensive. The microfiber-reinforced concrete can potentially reduce the amount of cement needed for a project or make the concrete last longer, saving carbon emissions as well as money for builders and owners.

Made of a polypropylene or polyester fabric where it contacts the skin and an ultra-fine polypropylene fiber for the filtering layers, medical masks have fibers that can be useful for the concrete industry. If they are not

The WSU researchers developed a process to fabricate tiny mask fibers, ranging from five to 30 millimeters in length, and then added them to cement concrete to strengthen it and to prevent its cracking

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reused, disposable masks can remain in the environment for decades and pose a risk for the ecosystem.

"This work showcases one technology to divert the used masks from the waste stream to a high-value application," Shi said.

In their proof-of-concept work, the researchers developed a process to fabricate tiny mask fibers, ranging from five to 30 millimeters in length, and then added them to cement concrete to strengthen it and to prevent its cracking. For their testing, they removed the metal and cotton loops from the masks, cut them up and incorporated them into ordinary Portland cement, the most common type of cement used around the world and the basic ingredient for concrete, mortar and grout.

They mixed the mask microfibers into a solution of graphene oxide before adding the mixture to cement paste. The graphene oxide provides ultrathin layers that strongly adhere to the fiber surfaces. Such mask microfibers absorb or dissipate the fracture energy that would contribute to tiny cracks in the concrete. Without the fibers, these microscopic cracks would eventually lead to wider cracks and the material's failure.

The researchers are conducting more studies to test their idea that the graphene oxide-treated microfibers could also improve the durability of the concrete and protect it from frost damage and from deicing chemicals that are used on roadways. They also envision applying this technology to the recycling of other polymer materials, such as discarded clothing, to incentivize the collection of such waste.

Phys Org, 27 April 2022

https://phys.org

RNA binding proteins help T cells pick their weapons before battle

2022-04-27

Scientists at the Babraham Institute have shown that two RNA binding proteins hold the key to a stronger immune response to influenza in mice. Their findings, published today in Nature Communications, reveal that the absence of these proteins changes the potency of T cells that arise at the start on an infection. Further research could lead to implications for therapies that harness the immune system, and for vaccine design.

Researchers from the Turner lab focused on the activity of the RNA binding proteins ZFP36 and ZFP36L1. By studying mice lacking these RNA binding

Further research could lead to implications for therapies that harness the immune system, and for vaccine design.

proteins, the researchers were able to show that their absence in T cells during the initial phase of a viral infection leads to a superior cytotoxic immune response.

When the researchers infected mice with influenza, those lacking their RNA binding proteins in T cells showed signs of fighting the infection more successfully than those with the proteins present. The researchers also transferred cells that lacked ZFP36 and ZFP36L1 into normal mice and found that even small numbers of transferred T cells provided the same advantage for fighting an influenza infection.

Their results were surprising, explains Dr. Georg Petkau, a postdoctoral researcher who led the work: "One striking observation of our study is that although the absence of RNA binding proteins in T cells results in stable accelerated differentiation and enhanced cytotoxicity, this does not lead to signs of disease or tissue damage, which is often a logical consequence of overt cytotoxicity during an immune response."

The researchers speculate that the lack of negative knock-on effects could be due to accelerated viral clearance and could be explained by a faster resolution of infection in young mice. It would be interesting to see whether upon recurrent infections a large accumulation of memory cells showing enhanced cytotoxicity in absence of RNA binding proteins would become potentially dangerous with age. Understanding how these RNA binding proteins limit T cell activation may also have implications for autoimmune disease formation in aged individuals.

The priming of the immune response once a pathogen is detected is a critical step that significantly changes the course of an immune response; it is the point at which immune cells decide to adjust the quality and duration of the immune response to a threat. In a sense, the T cells in this study have to choose their weapons before they start to battle the infection and this choice is made by RNA binding proteins. By understanding more about how the immune system processes information within hours of infection and how RNA binding proteins integrate signals to activate T cells, the researchers hope to inform how we approach vaccine design and cell therapies.

"Going forward, we want to investigate how the absence of RNA binding proteins affects the formation of immune memory and whether the superior cytotoxic traits acquired early in the response are epigenetically imprinted and maintained in the memory phase," explained Dr. Martin Turner, head of the Immunology research program. Therefore, the researchers will seek to explain their findings by investigating how the

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stable cytotoxic program is set up early after activation by looking at changes in the epigenome.

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