Glow-Hard: Luminous cement could light roads, structures

By Berta Carreño, Scientific American on 06.27.16

Word Count **523**

Level **MAX**

Artist Dan Roosegaarde paid tribute to Vincent Van Gogh's painting "Starry Night" by creating this bike path in the artist's hometown of Eindhoven, Netherlands. Studio Roosegaarde

A bicycle lane inspired by Van Gogh's Starry Night can be found in the Netherlands. It was built using phosphorescent tiles, so at night passersby see where they are going without the need of electricity-consuming lighting. But despite the beauty of the scene, only a handful of constructions worldwide have this kind of lighting, because the microscopic structure of common building materials — such as cement, concrete or brick — prohibits adding this property.

But this could soon change. José Carlos Rubio Ávalos, a researcher at Michoacan University of San Nicolás de Hidalgo in Mexico, and his team have designed a new type of phosphorescent cement that could illuminate highways, bike paths or buildings without using electricity.

Using the same raw materials with which cement is manufactured and by adding certain additives, scientists modified the optical properties of the material, and it became phosphorescent. "Cement is an opaque body; it does not allow the passage of light to the interior, so we must make a change in its microstructure to allow a partial entry of light into the interior for it to have this behavior," Rubio Ávalos says.

By using additives, scientists are able to prevent the formation of crystals that occur normally during the production of cement, creating a material with a noncrystalline structure — similar to glass — that allows passage of light inside. Varying the proportion of additives added while manufacturing the cement regulates both its luminescent intensity and color — so as not to dazzle drivers, if used on roads, for example.

And although it is manufactured like ordinary cement, the change in the microscopic structure needed to make it glow modifies the structural properties of the material — thus it may not have the same applications as the ordinary kind and is intended to be used on surfaces as a coating material. Because of the inorganic nature of the cement components, the material can have a very long shelf life when compared with other phosphorescent materials such as plastics or paints — but this will always depend on how it is used.

Phosphorescent materials absorb energy from radiation such as the ultraviolet light emitted by the sun — or by lamps, if indoors — energy they later emit as light, which can be seen after dark. As it loads up energetically with ultraviolet rays, even on cloudy days the cement will be able to absorb enough energy to glow during dark periods for up to 12 hours.

According to Carmen Andrade, researcher at the Spanish National Research Council (CSIC) Institute of Building Sciences in Madrid, Spain, "It's an application that can be worth developing in countries and areas with poor access to electricity in communities with poor life levels, as it doesn't consume electricity." But she also adds, "Cement is a very alkaline material, so the stability of these compounds should be studied (...) and also how to repair it."

The project, which represents the first patent for Michoacan University, is in commercialization phase. Rubio Ávalos' plans, however, go beyond cement; he wants to develop a range of products capable of luminescence, this one is just the first.

Quiz

1 The author develops the importance of phosphorescent bricks in the article in each of the following ways EXCEPT:

(A) by providing a real-world example of their use

(B) by describing ways that experts believe they will change construction

(C) by highlighting the research that went into creating the materials

(D) by examining the estimated costs of using these materials

2 According to the article, each of the following contributes to the design and use of phosphorescent materials EXCEPT:

(A) cement's raw materials

(B) additives to stop crystal formation

(C) ultraviolet light

(D) alkaline materials to enhance stability

3 What is the overall tone of the article? Which excerpt supports your answer?

(A) optimistic; But this could soon change. José Carlos Rubio Ávalos, a researcher at Michoacan University of San Nicolás de Hidalgo in Mexico, and his team have designed a new type of phosphorescent cement that could illuminate highways, bike paths or buildings without using electricity.

(B) skeptical; it may not have the same applications as the ordinary kind and is intended to be used on surfaces as a coating material.

(C) celebratory; The project, which represents the first patent for Michoacan University, is in commercialization phase. Rubio Avalos' plans, however, go beyond cement; he wants to develop a range of products capable of luminescence, this one is just the first.

(D) cautious; But despite the beauty of the scene, only a handful of constructions worldwide have this kind of lighting, because the microscopic structure of common building materials — such as cement, concrete or brick — prohibits adding this property.

4 Read the sentence from the article.

> *As it loads up energetically with ultraviolet rays, even on cloudy days the cement will be able to absorb enough energy to glow during dark periods for up to 12 hours.*

What does the word "energetically" convey in the sentence?

(A) a sense that phosphorescent bricks can be quickly dislodged from their location

(B) a sense that phosphorescent bricks are capable of quickly absorbing a large amount of ultraviolet rays

(C) a sense that phosphorescent bricks are able to absorb energy at night as well

(D) a sense that phosphorescent bricks are better than other materials at absorbing ultraviolet rays newsela

Using diamonds, scientists squeeze hydrogen into a strange new state

By Amina Khan, Los Angeles Times on 01.14.16
Word Count **831**
Level **MAX**

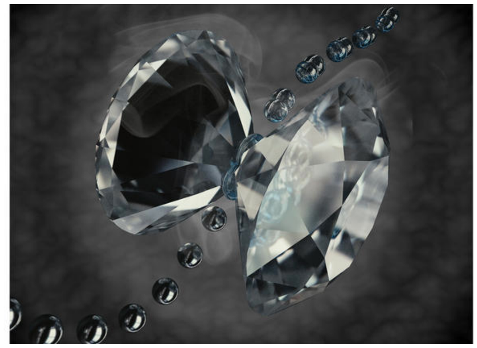
A model displays a 110.03-carat Sun-Drop Diamond described as fancy vivid yellow at a Sotheby's preview show in Geneva, Switzerland, Nov 9, 2011. Photo: AP/Anja Niedringhaus. BOTTOM: This artistic representation shows a hydrogen molecule being compressed by two diamond anvils. Scientists believe they've discovered a new physical state of hydrogen using this device. Berkeley Lab via Twitter/Philip Dalladay-Simpson and Eugene Gregoryanz

Molecular hydrogen is normally a gas at room temperature, but when crushed with diamond anvils, it can convert into a totally different, previously unknown state of matter, according to a team of condensed-matter physicists.

The so-called “phase V,” described in the journal Nature, poses a significant step toward finding what’s been called the holy grail of high-pressure physics: solid metallic hydrogen.

Hydrogen is the most abundant element in the universe – stars are made almost entirely out of the stuff, with a little helium and traces of heavier chemicals for good measure. It’s an essential ingredient in the building blocks of life, an atom necessary to make water and organic molecules. It’s extremely lightweight, often found as a gas of molecular hydrogen (two hydrogen atoms bonded together). It’s the most basic atom, made up of a single proton and electron, and it has served as an important model for scientists studying physics at smaller scales.

“The hydrogen system is very important to fundamental physics, and (has) paved the way to applied models in the early stages of quantum mechanics,” study coauthor Philip Dalladay-Simpson, a high-pressure physicist at the University of Edinburgh, said in an email.



In spite of all this, relatively little is known about hydrogen’s behavior in extreme conditions, Dalladay-Simpson said. After all, molecular hydrogen gas is pretty rare in Earth’s atmosphere, and at Earth’s temperatures and pressures it ventures into no other physical states (such as solid or liquid). That’s not the case with other planets such as gas giant Jupiter, which holds enormous amounts of hydrogen under extreme pressures and temperatures.

So, if we want to fully understand the stars and planets around us, we have to have a better fundamental understanding of how hydrogen behaves in distinctly unearthly conditions, the thinking goes.

“Understanding it under these extended regimes can open up windows to large astrophysical bodies,” Dalladay-Simpson said, “such as the interiors of the hydrogen-rich Jovian planets such as Jupiter.”

We know a little bit about how hydrogen’s physical state changes under different conditions. Hydrogen can be liquefied at extremely cold temperatures, and has long been used as liquid rocket fuel. At high temperatures like those found in the corona of the sun, the atom’s electrons are stripped from the protons, forming an ionized gas known as plasma.

But for a long time, theorists have predicted that, under extreme pressures but at mild temperatures, hydrogen should actually form a solid – one where the covalent bonds holding two hydrogen molecules together break apart and the atoms’ electrons roam free, turning the normally clear gas into a shiny, grayish, metallic solid.

Finding this state through actual experiments, however, has proven far more difficult than expected when it was first predicted in 1935, Dalladay-Simpson said. Back then, scientists figured that this state would emerge if molecular hydrogen was put under 25 billion pascals, or 25 gigapascals, of pressure – “an unfathomable pressure for the time,” he added.

“Since (then) we’ve far exceeded 10 times this pressure, and it remains experimentally elusive,” Dalladay-Simpson said. “As such it has often been dubbed as the ‘holy grail’ of high-pressure physics.”

To get at this question, Dalladay-Simpson and colleagues took hydrogen molecules and crushed them between two anvils made of diamond, keeping the temperature a balmy 80 degrees Fahrenheit but raising the pressure to 325 gigapascals, equivalent to 3.21 million Earth atmospheres.

“These experiments are highly technically demanding – to reach the pressures desired, we have to use two brilliant-cut diamonds (the same as in your jewelry) but with the tips polished to a very fine point (8 microns, typically the width of a human hair),” Dalladay-Simpson said. “A small amount of hydrogen gas is then trapped between them and pressurized to greater pressures that are found at the center of the Earth, all on a volume of hydrogen comparable to that of a single human red blood cell!"

The scientists found that at these pressures, the structure of the material started to change in significant ways. Though it's hard to say what a chunk of hydrogen in this state would look like, it might resemble layers of molecular hydrogen interspersed with layers of atomic hydrogen. With that in mind, it could well be the precursor to the long-theorized solid metallic state, in which all molecular bonds are broken down.

The next step is to ratchet the pressure up by a few tens of gigapascals to see if they can actually reach the predicted metallic state – which shouldn't be too hard, "considering we reached 400 GPa," Dalladay-Simpson said.

Solid metallic hydrogen might exhibit such far-out properties as superfluidity and superconductivity – and so, if it were ever able to be mass produced, it could have game-changing technological implications, he added.

For example, "current superconducting devices, such as MRI machines, require (a) large amount of cryogenics. A room-temperature superconductor would mean you could reduce the size of these machines significantly and also increase the efficiency of all electronics," he said.

Quiz

1 Which of the following sentences from the article explains why scientists lack knowledge about hydrogen under extreme conditions?

(A) After all, molecular hydrogen gas is pretty rare in Earth's atmosphere, and at Earth's temperatures and pressures it ventures into no other physical states (such as solid or liquid).

(B) "Understanding it under these extended regimes can open up windows to large astrophysical bodies," Dalladay-Simpson said, "such as the interiors of the hydrogen-rich Jovian planets such as Jupiter."

(C) "Since (then) we've far exceeded 10 times this pressure, and it remains experimentally elusive," Dalladay-Simpson said. "As such it has often been dubbed as the 'holy grail' of high-pressure physics."

(D) The next step is to ratchet the pressure up by a few tens of gigapascals to see if they can actually reach the predicted metallic state – which shouldn't be too hard, "considering we reached 400 GPa," Dalladay-Simpson said.

2 Read the selection from the article.

But for a long time, theorists have predicted that, under extreme pressures but at mild temperatures, hydrogen should actually form a solid – one where the covalent bonds holding two hydrogen molecules together break apart and the atoms' electrons roam free, turning the normally clear gas into a shiny, grayish, metallic solid.

Finding this state through actual experiments, however, has proven far more difficult than expected when it was first predicted in 1935, Dalladay-Simpson said. Back then, scientists figured that this state would emerge if molecular hydrogen was put under 25 billion pascals, or 25 gigapascals, of pressure – "an unfathomable pressure for the time," he added.

Which of the following conclusions can be drawn from the selection above?

(A) For a long time, there was not enough scientific interest in hydrogen to support major experiments.

(B) For a long time, scientists did not have the technological capabilities to test their theories about hydrogen.

(C) Though scientists have been able to do experiments with hydrogen, they have gained little valuable information.

(D) Though scientists can recognize solidified hydrogen, they cannot yet create it under experimental conditions.

3 Read the excerpt from the article.

Though it's hard to say what a chunk of hydrogen in this state would look like, it might resemble layers of molecular hydrogen interspersed with layers of atomic hydrogen. With that in mind, it could well be the precursor to the long-theorized solid metallic state, in which all molecular bonds are broken down.

Which of the following words would CHANGE the meaning of the sentence if it replaced "precursor to" in the excerpt above?

(A) initial sign of

(B) first instance of

(C) forerunner of

(D) result of

4 What is the connotation of "far-out" in the sentence below?

Solid metallic hydrogen might exhibit such far-out properties as superfluidity and superconductivity – and so, if it were ever able to be mass produced, it could have game-changing technological implications, he added.

(A) Positive, because the speaker is imagining the potential of solid hydrogen

(B) Positive, because the speaker is referring to the properties of solid hydrogen with the word "super"

(C) Negative, because the speaker is thinks solid hydrogen is a completely unrealistic idea

(D) Negative, because the speaker is disappointed that technological progress is in the distant future

Researchers invent camouflaged membrane that hides like an octopus

By Ben Guarino, Washington Post on 10.18.17

Word Count **774**

Level **MAX**

An octopus swims in the Octopus Cave in an aquarium in Timmendorfer Strand, Germany. Photo from AP.

No other animal has mastered camouflage like the octopus. The mightiest of these morphing creatures, the mimic octopus, contorts its body into a thin ribbon and adopts the colors of a venomous sea serpent to scare predators away. Divers have seen mimic octopuses masquerade as lion fish, sea stars, shrimp and anemones. When peckish, the octopus takes the form of a lusty crab. Crustaceans fooled by the display end up eaten.

Materials scientists and engineers also have fallen under the octopuses' spell. A team of Cornell University researchers, with the aid of octopus expert Roger Hanlon, successfully mimicked the mimic using sheets of rubber and mesh.

As they report in a study published Thursday in the journal Science, the researchers created a thin membrane that contorts into complex 3-D shapes — much like the shape-shifting skin of an octopus. The membranes can inflate in seconds to the shapes of everyday objects, such as potted plants or a cluster of stones.

Octopuses are covered in muscly bundles called papillae, Hanlon and his colleagues documented in the Journal of Morphology in 2014. The papillae go slack when an octopus wants to decrease the drag of water against skin, allowing it to speed away in a hurry. Contractions cause fleshy nubs to appear, and the skin bulges. Octopuses can match the texture of seaweed so closely they become almost invisible.

Itai Cohen, a materials expert at Cornell and an author of the new study, said he was awed by videos of the shape-shifters. (Such a scene, filmed by Hanlon and posted to YouTube, is described as the Woods Hole Marine Biological Laboratory scientist's "most famous underwater video clip.")

"You are staring at this coral reef. You have no idea [an octopus] is there." And then: "It changes color. It changes texture. It appears out of nowhere."

Cohen was impressed and inspired. "That is just awesome," he thought. "How the heck do we do that?"

He and fellow Cornell researcher Robert Shepherd assigned James Pikul the grunt work of figuring it out. "For a few decades, scientists and engineers have been trying to control the shape of soft, stretchable materials," said Pikul, a graduate student at the time of this research and now an assistant professor at the University of Pennsylvania. But cheaply fabricating these materials proved difficult.

Success brought together two concepts: the musculature of the octopus with the mechanics of blowing up a balloon. The trick was to cut concentric rings into a thin surface of silicone rubber and mesh. Inflating the rubber caused the membrane to contort following the shape of the cuts.

"The width of the concentric rings determines how much radial stretch there is in the membrane," Pikul said. The wider the rings, the less stretch it had. "This stretch is directly related to the slope of the inflated shape, so if you know your final shape, you can calculate the slope and match the ring patterns to that slope."

Programming the laser cuts in just the right way enabled the rubber to inflate not only outwardly, like a kickball, but as a 3-D structure with concave regions. It's a bit like the sculptures made by twisting together sausage-shaped balloons. Except, in this case, it's all one membrane.

To show their membrane in action, the researchers had it take the shape of river stones, collected in Ithaca. During demonstrations of their work, Shepherd begins with the inflated membrane tucked among real stones. "Many times people are surprised that they weren't actually rocks," he said.

The team also picked a succulent with spiral leaves — Graptoveriaamethorum — to show that the membrane can mimic lifelike shapes. "And succulents are pretty cool plants," Pikul said.

Theirs is the latest invention in the field of soft materials to borrow ideas from the cephalopods. Researchers at Harvard University announced in August 2016 that they'd created the first autonomous soft robot, patterned after the eight-legged creatures.

"I have been thinking about octopuses for a while," Shepherd said. In previous research, he and his colleagues created flexible, color-changing robots also inspired by octopus skin.

The Army Research Office provided funding for the recent work. "You could imagine shipping out camouflage sheets," Cohen said. Once delivered to the field, an inflated sheet might obscure a location from the enemy.

"We didn't go into this with an application in mind," Shepherd said. But he envisions creating touch mechanisms used in concert with virtual reality. A person running a finger along a morphing membrane might feel something like gravel suddenly switch to a glassy surface — or a virtual-reality octopus that goes from nubby to smooth in the blink of an eye.

Quiz

1 Read the selection below from the article.

> *"For a few decades, scientists and engineers have been trying to control the shape of soft, stretchable materials," said Pikul, a graduate student at the time of this research and now an assistant professor at the University of Pennsylvania. But cheaply fabricating these materials proved difficult.*
>
> *Success brought together two concepts: the musculature of the octopus with the mechanics of blowing up a balloon. The trick was to cut concentric rings into a thin surface of silicone rubber and mesh. Inflating the rubber caused the membrane to contort following the shape of the cuts.*

Which conclusion is BEST supported by these paragraphs?

(A) Researchers who has previously tried to control the shape of soft, stretchable materials had been unsuccessful in their endeavors.

(B) The silicone rubber and mesh used by researchers to create an octopus-like membrane were inexpensive to fabricate.

(C) When creating the membrane, knowing the musculature of the octopus was more important than knowing how to blow up a balloon.

(D) The invention of the octopus-like membrane resulted from performing a trick with concentric rings in the silicone rubber.

2 Over the course of the article, HOW does the author describe the researchers who invented the octopus-like membrane?

(A) as greatly appreciative of the capabilities of the octopus and interested in duplicating them

(B) as striving to be the first to be able to mimic the capabilities of the octopus in a financially lucrative way

(C) as focused on the idea of being able to create an octopus-like membrane that had numerous applications

(D) as enthusiastic about creating an octopus-like membrane that could compete against other membranes

3 Which sentence from the article is the STRONGEST evidence that the invention of the octopus-like membrane was a collaborative effort?

(A) A team of Cornell University researchers, with the aid of octopus expert Roger Hanlon, successfully mimicked the mimic using sheets of rubber and mesh.

(B) Octopuses are covered in muscly bundles called papillae, Hanlon and his colleagues documented in the Journal of Morphology in 2014.

(C) He and fellow Cornell researcher Robert Shepherd assigned James Pikul the grunt work of figuring it out.

(D) Researchers at Harvard University announced in August 2016 that they'd created the first autonomous soft robot, patterned after the eight-legged creatures.

4 Which of the following did the author develop the LEAST in the article about the invention of an octopus-like membrane?

(A) the method used by the researchers to create an octopus-like membrane

(B) the connection the creators of the membrane had established with the military

(C) the various forms the mimic octopus can take when it contorts its body in camouflage

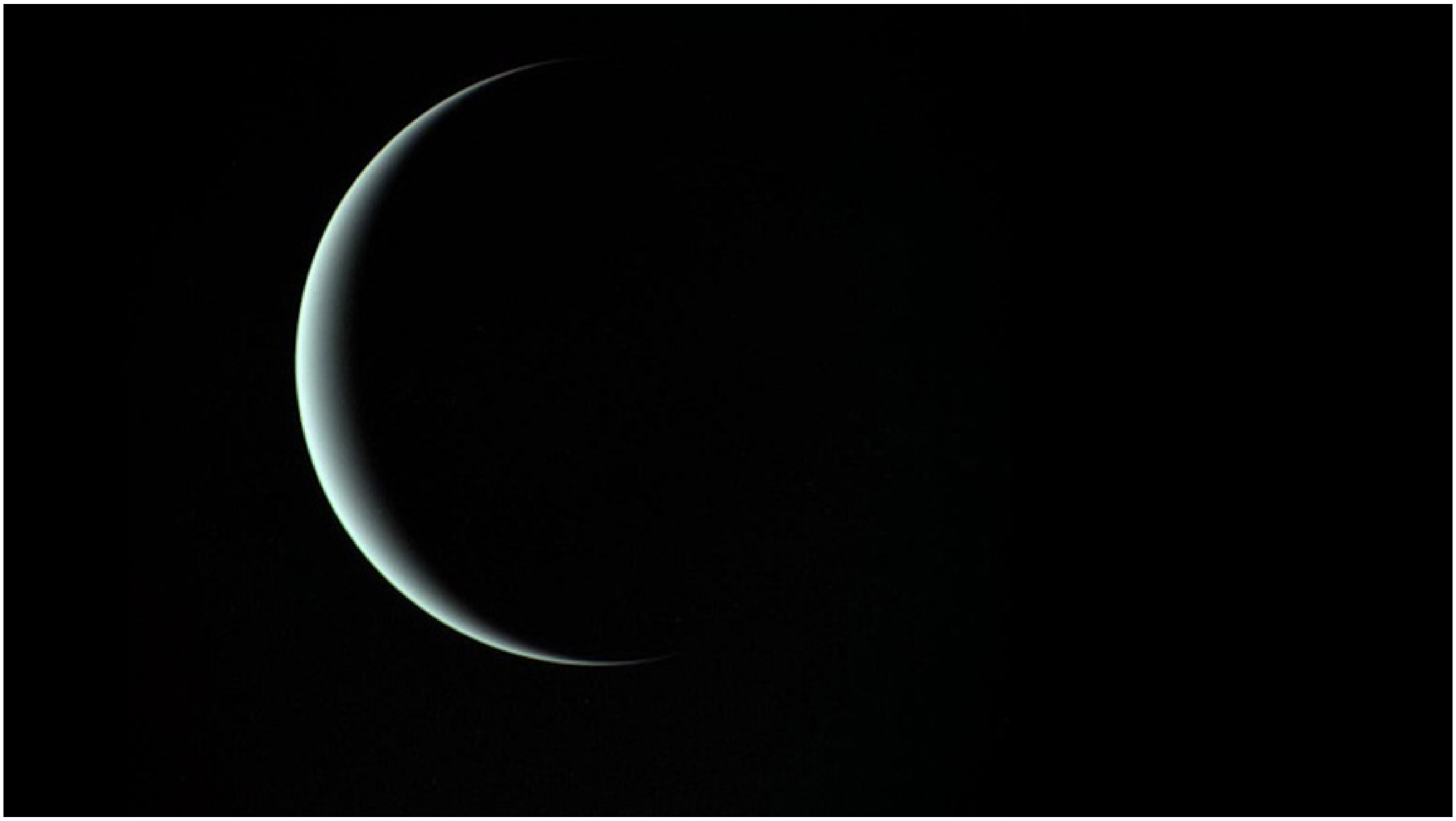
(D) the method used by the researchers to demonstrate their membrane invention in action

Uranus has a familiar odor, scientists say, and earthlings wouldn't like it

By Allyson Chiu, Washington Post on 04.27.18

Word Count **588**

Level **MAX**



This image of a crescent Uranus, taken by Voyager 2 on January 24, 1986, reveals its icy blue atmosphere. Photo by: NASA/JPL.

Uranus stinks and there's scientific proof.

Researchers confirmed Monday, April 23, the seventh planet from the sun has an upper atmosphere full of one of the smelliest chemicals known to humans, hydrogen sulfide, according to a study published by Nature Astronomy.

The odorous gas is what gives rotten eggs — and human flatulence — their distinctive and unpleasant smell. According to the Environmental Protection Agency, people can smell the gas when it makes up as little as three out of every billion molecules in the air, so imagine what being surrounded by clouds of the stuff would smell like.

"If an unfortunate human were ever to descend through Uranus' clouds, they would be met with very unpleasant and odoriferous conditions," Patrick Irwin, a physicist at the University of Oxford, who led the study, said in a statement.

Scientists discovered evidence of "the noxious gas swirling high in the giant planet's cloud tops" after observing how sunlight bounced off Uranus' atmosphere, according to a news release from the Gemini Observatory, a high-powered telescope located on top of Hawaii's Mauna Kea volcano.

The new findings come after decades of observations and even a visit by the Voyager 2 spacecraft to the blue-green ice giant, the release said. Before making the discovery, scientists had long inferred hydrogen sulfide existed in the planet's atmosphere, but never "conclusively detected" the gas before, according to Science News.

Using a 26-foot Gemini North telescope, the team of scientists studied the reflected sunlight in infrared and determined what types of molecules made up the planet's atmosphere, the release said. While evidence of the molecular compounds was "barely there," Irwin said scientists were still "able to detect them unambiguously" given the sensitivity of their instruments and the "exquisite conditions" on Mauna Kea.

Uranus' atmospheric composition was so difficult to nail down because when a cloud deck forms by condensation, it hides the gas responsible for forming the clouds beneath levels that can usually be seen with telescopes, Leigh Fletcher, a member of the research team, said in the release.

"Only a tiny amount remains above the clouds as a saturated vapor," said Fletcher, who is a planetary scientist at the University of Leicester in the United Kingdom. "The superior capabilities of Gemini finally gave us that lucky break."

Aside from lending credence to Uranus jokes, the hydrogen sulfide discovery sheds light (or maybe smell) on how planets and the solar system formed, the release said.

Being able to confirm the composition information is "invaluable in understanding Uranus' birthplace, evolution and refining models of planetary migrations," the release said.

Understanding what makes up distant planets, such as Uranus, could help scientists determine where in the solar system the planets first formed and how far they moved from the sun over time, Business Insider reported.

Glenn Orton, a co-author of the new study and a planetary scientist at NASA's Jet Propulsion Laboratory, told Business Insider the new research points to "evidence of a big shakeup early on in the solar system's formation."

"There was definitely a migration taking place," Orton said.

While the planet's smell may be more than enough to repel most from wanting to visit, Orton said researchers are working on a proposal for a new Uranus spacecraft, which they hope will help them learn more about where the outer planets actually formed and how the solar system came to be.

Hopefully, the proposed spacecraft will be unmanned like its predecessor, Voyager 2, because Orton said the probe will be expected to plunge through Uranus' pungent clouds.

Quiz

1 The following evidence was gathered to support the idea that the recent discovery provides important information to researchers.

> *Being able to confirm the composition information is "invaluable in understanding Uranus' birthplace, evolution and refining models of planetary migrations," the release said.*
>
> *Understanding what makes up distant planets, such as Uranus, could help scientists determine where in the solar system the planets first formed and how far they moved from the sun over time, Business Insider reported.*

Which additional piece of evidence helps create the MOST COMPLETE argument that the recent discovery provides important information to researchers?

(A) "If an unfortunate human were ever to descend through Uranus' clouds, they would be met with very unpleasant and odoriferous conditions," Patrick Irwin, a physicist at the University of Oxford, who led the study, said in a statement.

(B) Glenn Orton, a co-author of the new study and a planetary scientist at NASA's Jet Propulsion Laboratory, told Business Insider the new research points to "evidence of a big shakeup early on in the solar system's formation."

(C) While the planet's smell may be more than enough to repel most from wanting to visit, Orton said researchers are working on a proposal for a new Uranus spacecraft, which they hope will help them learn more about where the outer planets actually formed and how the solar system came to be.

(D) Hopefully, the proposed spacecraft will be unmanned like its predecessor, Voyager 2, because Orton said the probe will be expected to plunge through Uranus' pungent clouds.

2 Read the paragraph from the article.

> *The new findings come after decades of observations and even a visit by the Voyager 2 spacecraft to the blue-green ice giant, the release said. Before making the discovery, scientists had long inferred hydrogen sulfide existed in the planet's atmosphere, but never "conclusively detected" the gas before, according to Science News.*

Which of the following can be inferred from this paragraph?

(A) Scientists had long inferred hydrogen sulfide existed in the planet's atmosphere because of the work of Voyager 2.

(B) Since scientists had inferred hydrogen sulfide existed in the planet's atmosphere, the confirmation is not particularly significant.

(C) Scientists had long tried to conclusively understand the precise chemical makeup of the planet's atmosphere.

(D) Since scientists were unable to conclusively detect the gas during Voyager 2's visit, most see that visit as a failure.

3 Read the following statements.

1. *People dislike the smell of hydrogen sulfide and can smell it even when there is only a little bit in the air.*
2. *Scientists finally confirmed the presence of the smelly gas hydrogen sulfide in the atmosphere around Uranus.*
3. *Scientists had long suspected the presence of the smelly gas hydrogen sulfide in the atmosphere around Uranus.*
4. *The discovery of hydrogen sulfide may help scientists better understand the origin and movements of the planets.*

Which two statements BEST represent two CENTRAL ideas of the article?

(A) 1 and 2

(B) 1 and 3

(C) 2 and 4

(D) 3 and 4

4 Read the selection from the article.

> *Uranus' atmospheric composition was so difficult to nail down because when a cloud deck forms by condensation, it hides the gas responsible for forming the clouds beneath levels that can usually be seen with telescopes, Leigh Fletcher, a member of the research team, said in the release.*
>
> *"Only a tiny amount remains above the clouds as a saturated vapor," said Fletcher, who is a planetary scientist at the University of Leicester in the United Kingdom. "The superior capabilities of Gemini finally gave us that lucky break."*

Select the option that BEST details how the selection develops a CENTRAL idea of the article.

(A) The selection helps the reader understand why it had taken so long to confirm the gas and the role sophisticated tools played in the discovery.

(B) The selection helps the reader understand how significant it is that Uranus's atmosphere is made up of hydrogen sulfide, as opposed to a different gas.

(C) The selection helps the reader understand why it was so important for the researchers to conclusively identify hydrogen sulfide as the gas surrounding Uranus.

(D) The selection helps the reader understand why figuring out Uranus' atmospheric composition was so much more difficult than determining the atmospheric composition of other planets.

Why Roman concrete still stands strong while modern version decays

By Nicola Davis, The Guardian on 07.18.17
Word Count **510**
Level **MAX**

Structures like the Colosseum could not have been built without the use of Roman concrete. The secret to Roman concrete? Seawater and volcanic ash made it last thousands of years, scientists found. Photo by: Pixabay

Their structures are still standing more than 1,500 years after the last centurion snuffed it: now the Romans' secret of durable marine concrete has finally been cracked.

The Roman recipe – a mix of volcanic ash, lime (calcium oxide), seawater and lumps of volcanic rock – held together piers, breakwaters and harbours. Moreover, in contrast to modern materials, the ancient water-based structures became stronger over time.

Scientists say this is the result of seawater reacting with the volcanic material in the cement and creating new minerals that reinforced the concrete.

"They spent a tremendous amount of work [on developing] this – they were very, very intelligent people," said Marie Jackson, a geologist at the University of Utah and co-author of a study into Roman structures.

As the authors note, the Romans were aware of the virtues of their concrete, with Pliny the Elder waxing lyrical in his Natural History that it is "impregnable to the waves and every day stronger."

Now, they say, they've worked out why. Writing in the journal American Mineralogist, Jackson and colleagues describe how they analysed concrete cores from Roman piers, breakwaters and harbours.

Previous work had revealed lime particles within the cores that surprisingly contained the mineral aluminous tobermorite – a rare substance that is hard to make.

The mineral, said Jackson, formed early in the history of the concrete, as the lime, seawater and volcanic ash of the mortar reacted together in a way that generated heat.

But now Jackson and the team have made another discovery. "I went back to the concrete and found abundant tobermorite growing through the fabric of the concrete, often in association with phillipsite [another mineral]," she said.

She said this revealed another process that was also at play. Over time, seawater that seeped through the concrete dissolved the volcanic crystals and glasses, with aluminous tobermorite and phillipsite crystallising in their place.

These minerals, say the authors, helped to reinforce the concrete, preventing cracks from growing, with structures becoming stronger over time as the minerals grew.

By contrast, modern concrete, based on Portland cement, is not supposed to change after it hardens – meaning any reactions with the material cause damage.

Jackson said, "I think [the research] opens up a completely new perspective for how concrete can be made – that what we consider corrosion processes can actually produce extremely beneficial mineral cement and lead to continued resilience, in fact, enhanced perhaps resilience over time."

The findings offer clues for a concrete recipe that does not rely on the high temperatures and carbon dioxide production of modern cement, but also providing a blueprint for a durable construction material for use in marine environments. Jackson has previously argued Roman concrete should be used to build the seawall for the Swansea lagoon.

"There's many applications but further work is needed to create those mixes. We've started but there is a lot of fine-tuning that needs to happen," said Jackson. "The challenge is to develop methods that use common volcanic products – and that is actually what we are doing right now."

Quiz

1 Read the selection from the article.

> *The Roman recipe – a mix of volcanic ash, lime (calcium oxide), seawater and lumps of volcanic rock – held together piers, breakwaters and harbours. Moreover, in contrast to modern materials, the ancient water-based structures became stronger over time.*

Which of the following conclusions can be drawn from this selection?

(A) Modern concrete use weaker materials in its recipes and is therefore less likely to withstand damage from water and weather.

(B) Roman concrete used materials that were easily accessible to the builders, but these materials are not as easy to acquire for modern builders.

(C) The success of the Roman's concrete recipe in withstanding water damage was primarily due their creative use of natural materials in their location.

(D) Now that scientists know the recipe that was used by Romans for their concrete, it is apparent that modern concrete would benefit from the addition of volcanic ash.

2 Read the sentence from from the article.

> *Jackson said, “I think [the research] opens up a completely new perspective for how concrete can be made – that what we consider corrosion processes can actually produce extremely beneficial mineral cement and lead to continued resilience, in fact, enhanced perhaps resilience over time.”*

Which sentence BEST supports this idea?

(A) Scientists say this is the result of seawater reacting with the volcanic material in the cement and creating new minerals that reinforced the concrete.

(B) Previous work had revealed lime particles within the cores that surprisingly contained the mineral aluminous tobermorite – a rare substance that is hard to make.

(C) By contrast, modern concrete, based on Portland cement, is not supposed to change after it hardens – meaning any reactions with the material cause damage.

(D) “The challenge is to develop methods that use common volcanic products – and that is actually what we are doing right now.”

3 Which of the following ideas did the author develop the LEAST in this article about Roman concrete?

(A) the possible modern applications for Roman concrete

(B) the contrast between Roman concrete and modern concrete

(C) that Roman concrete changes chemically over time to become stronger

(D) that Romans carefully developed their concrete using knowledge of chemical changes

4 Which of the following accurately describes how Marie Jackson has reacted to her new discoveries about Roman concrete?

(A) She has written extensively about her discoveries to give a more accurate historical account of Roman construction.

(B) Marie Jackson believes that replicating Roman concrete will be difficult and we might need to find a substitute for volcanic ash.

(C) Marie Jackson believes that her new discoveries should change the way cement is produced and be applied to construction in marine settings.

(D) She has begun research on developing new versions of modern concrete that can be used to make marine construction more economical.