New anti-bacterial coating inspired by dragonflies, cicadas

S'pore scientists develop nano coating that kills up to 99.9% of germs on surfaces

Esther Koh

Singapore researchers have found a powerful new tool in the fight against bacteria, and their discovery took flight on the wings of dragonflies and cicadas.

A group of scientists here has found that the wings of these insects are covered with minuscule "nails" known as nanopillars, which instantaneously tear apart bacteria that come into contact with them.

Inspired by this, the team at the Institute of Bioengineering and Nanotechnology (IBN) has spent the past four years developing an anti-bacterial nano coating using zinc oxide, a compound known for its non-toxic and anti-bacterial properties.

Tests on ceramic, glass, titanium and zinc surfaces have shown that this coating effectively kills up to 99.9 per cent of germs on surfaces.

By completely destroying the bacteria upon contact, the coating prevents the formation of resistant bacteria.

It also guards against environmental pollution by physically tearing apart the bacteria, rather than killing them chemically.

"Our nano coating is designed to disinfect surfaces in a novel yet practical way," IBN group leader Zhang Yugen told The Straits Times.

This new material may mark a pivot point in the world's fight against bacteria, which has been a long-drawn one with no clear solution. According to the BC Centre for Disease Control in Vancouver, 80 per cent of common infections are due to the spread of bacteria by touch.

While disinfectants can help to reduce bacteria, they have to be used regularly due to the quick multiplication of bacteria.

They also contain chemicals like triclosan which could be unsafe, and consistent use of disinfectants often leads to bacterial resistance and environmental contamination.

"There is an urgent need for a better way to disinfect surfaces," said IBN executive director Jackie Ying.

Knowing that the new surface-coating technology would be of interest to hospitals, Professor Ying has initiated a collaboration with Tan Tock Seng Hospital (TTSH) to test the commercial application of the new invention.

Dr Shawn Vasoo, a consultant at the Institute of Infectious Diseases and Epidemiology at TTSH, described this as a "natural partnership" to resolve a "pressing issue".

TTSH will test the effectiveness of the technology against resistant clinical and environmental strains of micro-organisms.

There are also plans to test the material in a hospital setting if the laboratory trial is successful.

Of the new technology, Dr Vasoo said: "It is an attractive strategy as it avoids the use of anti-microbials on surfaces or other chemicals which may leach into the environment, and is potentially very scalable."

Together with TTSH, IBN has also successfully applied for a grant from the National Research Foundation.

With greater funding and the opportunity to test this material in a real-life setting, Dr Zhang looks forward to "one day creating bacteria-free surfaces throughout Singapore with this technology".

IBN also plans on conducting further studies to see if the nano-coating technology can be used for water purification and air filtration.

kohes@sph.com.sg

Researchers at the Institute of Bioengineering and Nanotechnology are inspired by the wings of insects like the dragonfly, which are covered with minuscule "nails" known as nanopillars that instantly tear apart bacteria coming into contact with them. PHOTO: MEI HWANG

Taking a crack at solving the mystery of cracking knuckles

In some households, cracking your knuckles is a declaration of war. Whether you are in the camp that cannot stand the sound or the one that cannot see what the fuss is about, you might be surprised to learn that where exactly the sound is coming from – what precisely in the knuckle produces it – is still a subject of scientific research.

For more than 50 years, people have been publishing scholarly papers about what is going on in your finger as you pull it. Lately, an older theory, that the sound arises from the popping of a bubble in the joint, has been challenged by one that holds that the formation of the bubble itself is responsible.

Recently in the journal Scientific Reports, a pair of researchers at the Ecole Polytechnique in France reveal a mathematical model of a cracking knuckle and suggest that the old theory could accurately explain the sound.

The first thing to understand about the knuckle is that it is full of fluid. Where the two bones of the finger meet, a little lake of synovial fluid keeps them from grinding on each other. There is gas dissolved in the synovial fluid, mostly carbon dioxide, and it usually stays there. But when the bones are pulled away from each other, there is a sudden drop in pressure in the middle of the joint. Lower pressure allows the gases to come together, forming bubbles. Earlier work had suggested the collapse of such structures was behind the noise.

In 2015, however, Professor Greg Kawchuk of University of Alberta and collaborators used an MRI scanner to record what was happening in the finger of a volunteer who was a frequent knuckle-cracker. In the images, one can see the sudden appearance of a bulge in the knuckle as it is cracked.

This is the result, they wrote, of the formation of a bubble, which persisted for some time afterwards, and whose creation might be responsible for the cracking noise. They posited that the bubble generated a pressure wave in the fluid, producing a sound. But it was not clear how that wave could be powerful enough to make the distinctive crack.

Professor of biomechanics at the Ecole Polytechnique in France Abdul Barakat and Mr Vineeth Suja, then a master's student, came across the 2015 paper. To see whether even the old theory could produce a sound of that magnitude, they created a simplified mathematical model of a joint with a bubble in it and ran simulations, comparing the theoretical sounds of the bubble collapsing in the model with recordings of Mr Suja, who is now a doctoral student at Stanford University, and others cracking their knuckles.

They found that the sounds predicted by the model would have the volume and frequency to match the recordings fairly well – even if the bubble only shrank suddenly, rather than disappearing.

"You don't need full bubble collapse for the sound to be generated," Prof Barakat said.

"All you need is partial collapse." That could help their results line up with those of Prof Kawchuk, whose images showed the existence of a bulge in the knuckle long after the sound had passed. The bubble only needed to contract by 30 to 40 per cent to make that popping noise, said Prof Barakat, leaving a gas pocket intact, albeit a smaller one than what is visible in the MRI.

The researchers did not model what happens as the bubble forms – the model merely assumes its existence. Prof Kawchuk suggests that a plausible next step would be to see whether the formation of the bubble in a similar model could create sound. Prof Barakat agrees, saying that the best way to proceed would be to model the entire process from beginning to finish, to see how both bubble formation and bubble collapse contribute.

The quest to understand knuckle cracking, it seems, is not over.

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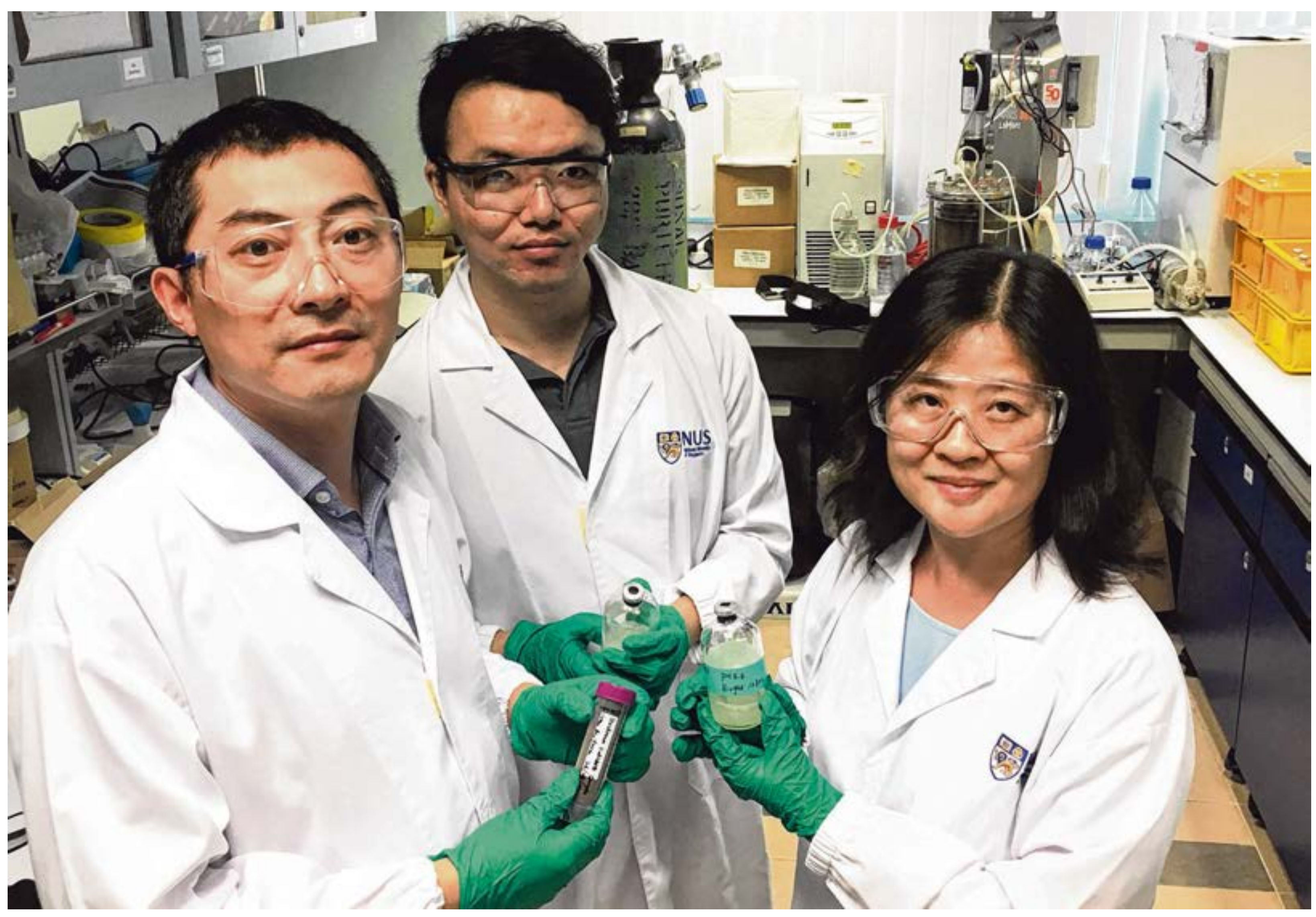
TNP FILE PHOTO

SOUND CHECK

You don't need full bubble collapse for the sound to be generated. All you need is partial collapse.

PROFESSOR ABDUL BARAKAT, of biomechanics at the Ecole Polytechnique in France.



(From left): Dr Li Tinggang, research fellow; Mr Zhang Chen, a PhD student; and Associate Professor He Jianzhong from the Department of Civil and Environmental Engineering at NUS are part of a team that has found that a natural bacterium isolated from mushroom crop residue can directly convert cellulose to biobutanol, a biofuel. PHOTO: NATIONAL UNIVERSITY OF SINGAPORE

A game-changer for biofuel production

Jasia Shamdasani

Scientists here are turning trash to treasure by transforming unwanted farming byproducts into fuel.

The National University of Singapore researchers have discovered how to isolate and harness a naturally occurring bacterium from mushroom crop residue. This is then used to convert cellulose, a plant-based material, to biobutanol, which can replace petrol in car engines.

Micro organisms in the waste generated after harvesting mushrooms are left to evolve naturally for over two years to get the bacterium, said the scientists. When cellulose is added, the bacterium digests it to produce biobutanol.

The bacterium – *named Thermoanaerobacterium thermosaccharolyticum TG57* – was first discovered and cultured in 2015 by the team led by Associate Professor He Jianzhong of the university's Department of Civil and Environmental Engineering.

Traditional biofuels produced from food crops are costly and compete with food crops in the use of land, water, energy and other environmental resources, said Prof He.

However, those produced from unprocessed cellulosic materials like plant biomass such as tree leaves are in great abundance, environmentally friendly and economically sustainable.

Professor William Chen, director of Nanyang Technological University's Food Science and Technology Programme, said the new technique is interesting, and potentially significant if it could increase the yield of biobutanol production from microbial fermentation, or reduce or even remove the production of by-products, among other improvements.

Commercial production of biobutanol is hindered by the lack of potent microbes capable of converting cellulosic biomass into biofuels.

So over the next one to two years, the team says it will optimise the performance of the TG57 strain so that it will be able to produce more biobutanol.

sjasia@sph.com.sg