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Chip emits UV light to keep food fresh

Nanyang Technological University, Singapore (NTU Singapore) scientists from LUMINOUS! Center of Excellence for Semiconductor Lighting and Displays, together with Swedish technology company PureFize Technologies, have developed a small chip that harnesses the power of ultraviolet (UV) light for disinfection. The innovation has been integrated into a commercially available product that preserves the freshness of food stored in containers.

Unlike conventional UV lamps, the chip does not require mercury and is only a few centimetres in size. The chip can also operate at full intensity in small, confined spaces without the need for cooling, making it suitable to be used when UV lamps cannot be installed.

Safe and effective disinfection in an instant

UV light effectively eliminates microorganisms such as bacteria, fungi and viruses. The most effective UV light for inactivating microorganisms is short wave UV, known as UVC, as it damages DNA and kills microorganisms.

Mercury lamps that emit UVC are commonly used to disinfect water and air. However, due to mercury's high toxicity, sustainability initiatives are phasing out mercury-based lamps and encouraging the development of safer and environmentally friendly disinfection technologies.

Instead of vapourising mercury to produce UV light, as in mercury lamps, the chip generates UVC through a process called cathodoluminescence. The chip contains two electrodes: a cathode made of ZnO nanostructures and an anode coated with a material that emits mainly UVC when excited by electrons. When a voltage is applied, electrons are emitted from the cathode through field-emission, then accelerated in a vacuum by the electric field towards the anode, which emits UV light when hit by the electrons.

The chip is designed to target a wide range of microorganisms (bacteria, viruses, fungi) and emits UVC primarily around a wavelength of 265 nm, along with a significant portion extending into the UVB (280 – 315 nm) and UVA (315 – 400 nm) regions. This combination leverages UVC to directly disrupt DNA while UVB and UVA penetrate and destroy difficult-to-eradicate communities of microorganisms known as biofilms and cellular components such as proteins and lipids.

The chip operates at temperatures from -20 to 100 degrees Celsius and can be turned on and off instantly, which is crucial for applications requiring immediate disinfection.

Zapping microbes with UV light

Laboratory tests showed that the UV chip effectively reduced pathogenic waterborne bacteria *Pseudomonas aeruginosa*, *Escherichia coli* and *Legionella pneumophila* after a few minutes of irradiation. The UV chip also effectively eliminated SARS-CoV-2, the virus that causes COVID-19.

“The disinfection efficiency of our chip is on a par with conventional mercury lamps, and we are excited about the potential applications of the device in consumer products, including food containers, refrigerators, and medical technology applications, to name a few," said Prof Hilmi Volkan Demir of NTU's School of Electrical and Electronic Engineering, School of Physical and Mathematical Sciences and School of Materials Science and Engineering, and the Director of LUMINOUS!, who led the research and was the senior author of the study.

The chip has been incorporated into a commercially available handheld device called EcoLoc. EcoLoc is designed to be used with a specially developed food container lid to help consumers keep food safe and fresh. The lid, manufactured by PureFize subsidiary EcoLoc, fits the IKEA series of 365+ food storage containers.

UV treatment using the EcoLoc device eliminates pathogens and spoilage microorganisms on the surface of the food, slowing their proliferation during storage. Users can switch on EcoLoc for a few minutes before storing food in the refrigerator or use the device daily to keep refrigerated food safer and fresher.

Using the chip, the shelf-life of various perishable foods, including bread, fruits, vegetables and meats, was extended to almost a week with minimal changes in taste and odour.

“Our chip is a significant breakthrough in health and safety as it has the potential to eradicate harmful food spoilage microorganisms as well as reduce the spread of infectious diseases such as COVID-19,” said senior research fellow Dr Vijay Kumar Sharma of NTU’s School of Electrical and Electronic Engineering and LUMINOUS!, who was the first author of the study.

“The innovation will also contribute to a greener tomorrow by reducing the amount of food waste generated.”

“The unique broad-spectrum UV technology that we have developed can combat biofilm formation and we have shown that the chip can be operated in small, confined spaces without the need for cooling. As such, this technology that we have developed together with NTU complements the range of available UV technologies on the market very well.” said Mr. Rune Torbjörnsen, CEO of PureFize Technologies.

In the future, the researchers aim to integrate the technology into other applications that prolong shelf-life and improve the safety and quality of foods. They are also expanding the applications of this innovative UV technology in different sectors, including medical equipment sterilisation, home sanitation and packaging.

Read more about the innovation:

“On-Chip Mercury-Free Deep-UV Light-Emitting Sources with Ultrahigh Germicidal Efficiency”. Advanced Optical Materials (2021), DOI: 10.1002/adom.202100072

Validation of the water disinfecting efficacy of PureFize® UV chip “*Escherichia coli*”, Bespoke Microbiology Services, ALS Laboratories UK Ltd. 2023, VAL00096 (1-2).

Validation of the water disinfecting efficacy of PureFize® UV chip “*Pseudomonas aeruginosa*”, Bespoke Microbiology Services, ALS Laboratories UK Ltd. 2023, VAL00096 (1-2).

Validation of the water disinfecting efficacy of PureFize® UV chip “*Legionella pneumophila*”, Bespoke Microbiology Services, ALS Laboratories UK Ltd. 2023, VAL00096 (1-2).

Validation of the water disinfecting efficacy of PureFize® UV chip “*Legionella pneumophila*”, Bespoke Microbiology Services, ALS Laboratories UK Ltd. 2023, VAL00096 (1-2).

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