Low-energy X-rays surprisingly effective at killing bacterial spores, offering improved sterilization techniques

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Precision Measurements Group members (Derrick Yong in front row, fourth from left and co-first author Ha Thi Mai Hoa in front row fifth from right). Credit: A*STAR Singapore Institute of Manufacturing Technology

Low-energy X-rays are able to sterilize materials, offering a potentially cheap and effective alternative to current techniques, A*STAR researchers have shown.

The effect of the X-rays on bacteria when they are in a spore state, a dormant condition in which they are able to survive harsh conditions, was examined by Derrick Yong and colleagues at the Singapore Institute

of Manufacturing Technology, in collaboration with researchers from other Singapore universities.

They showed that surprisingly low doses of X-rays can kill spores: but that the X-rays can also activate spores. Fine-tuning the procedure is key. "If the exposure is long enough we can kill all of the spores, including those that we unintentionally wake up," says Yong.

Yong explains that the investigations were prompted by conversations with local manufacturers, who seek improved sterilization processes during the production and use of medical equipment and in the food industry.

"We typically picture sterilization as involving extreme conditions such as high temperatures, toxic chemicals or deadly radiation sources," says Yong. An alternative, the research suggests, is that a small and low-hazard tabletop X-ray source could do the job more conveniently and at lower cost.

The researchers began by firing X-ray beams of different energies at the bacterium Bacillus pumilus, a spore-forming bacterium common in soil.

The first results threw up a troubling surprise. "When we looked at the data we couldn't understand why we ended up with more bacteria than we started with," says Yong. The researchers assumed there must have been some error in the experiment, but when they repeated the process, the same thing happened.

"This got us excited," adds Yong.

Further investigation revealed that short duration exposure was 'waking up' the spores rather than killing them. But then came a second and much more useful surprise. In runs of longer duration the lower energy

X-rays were more effective at killing the spores than higher energy rays. This was the crucial breakthrough that allows the new, safer and more convenient sterilization system.

More work is needed to learn how to keep the X-ray energies as low as possible, while adjusting the length of exposure to ensure that all bacterial spores and free-living bacteria are killed. Yong reports that they have already run trials of the system on dried food products and small medical devices. "We are also working on new ways to generate the X-rays and methods to accelerate and scale up the whole process," he adds.

More information: Thi Mai Hoa Ha et al. Activation and inactivation of Bacillus pumilus spores by kiloelectron volt X-ray irradiation, *PLOS ONE* (2017). DOI: 10.1371/journal.pone.0177571

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