CAN PLASMA GUNS SAVE THE WORLD?

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WHO recommends hand sanitizers which are 80-96% ethanol and 3% hydrogen peroxide. The problem with hydrogen peroxide is its short shelf life and its cost to transport. This makes it a logistical nightmare to procure in large doses. A research team from the University of Malta has found a way to create hydrogen peroxide with a technique that seems like science fiction. ***Antónia Ribeiro*** *gets in touch.*

Hand sanitizers have inserted themselves in our everyday language. In response to a global pandemic, disinfection has become the cardinal rule.

At the Department of Food Safety and Nutrition and the Metamaterials Unit of the University of Malta, researchers have been playing with plasma, the most common state of matter in the known universe. Dr Dmytro Kozak (Division BioTeC+, Department of Chemical Engineering at KU Leuven, Belgium) was working at the Metamaterials Unit, trying to develop a technology using atmospheric plasma. He brought the technology to the attention of Dr Jefferson de Oliveira Mallia (Research Support Officer within the Faculty of Health Sciences), as a way to disinfect seeds for human consumption. But when COVID-19 hit and hand sanitizer became scarce, they realised they may have been tinkering with a novel way to produce disinfectant.

This is how project SANITAS was born, out of the hard work and personal care of researcher Dr Sholeem Griffin (Centre for Biomedical Cybernetics, University of Malta) and Mallia. SANITAS is developing novel techniques to produce disinfectants that protect against disease. The project's most infamous target is SARS-CoV2, but the final disinfectant should work on any pathogen, be it virus, bacteria, or fungi. To make this possible quickly and inexpensively, SANITAS proposes using atmospheric plasma.

PLASMA-ACTIVATED WATER

Besides solid, liquid, and gas, there is a fourth state of matter: plasma. Its particles rarely collide, so it can be described as similar to a gas. However, the particles' movements are synchronised, making it behave as a fluid, much like a body of water. Plus, plasma is so electrically charged that it can create its own magnetic field. It is also the most common type of matter in the universe, even if rare on Earth. You can find it in lighnting storms, in the aurora borealis (Northern Lights) or in light sabers.

The SANITAS team makes their disinfectant with a bit of water, a sprinkle of air, and a lot of energy. But don't go microwaving water just yet – plasma is the key ingredient, and it is very hard to stabilise. Before researchers were able to produce and manipulate plasma at our normal atmospheric pressure, they needed very strict conditions, which meant a painfully expensive process.

Plasma is key because of its high electric charge. Plasma can strip away electrons from particles, leaving them ionised. Point plasma at water, and when it hits,

Left and right: Appartus used during the SANITAS Project
Photos by James Moffett

Dr Jefferson de Oliveira Mallia
Photo by James Moffett

it energises the hydrogen atoms in the water molecules, making it possible for the water molecules to join and form H_2O_2, or hydrogen peroxide. Hydrogen peroxide is one example of many reactive oxygen species (ROS) created through this process. In high amounts, these charged particles cause damage to cells' components, affecting their equilibrium and potentially causing death — that is why plasma guns are so popular in sci-fi movies.

The chemical works by destabilising the protective coatings around viral particles as well as bacterial and fungal cells. The microbes end up dying when what keeps them together just comes apart. Disrupting these structures is what makes disinfectant so powerful and useful, an essential sanitiser during the COVID-19 pandemic.

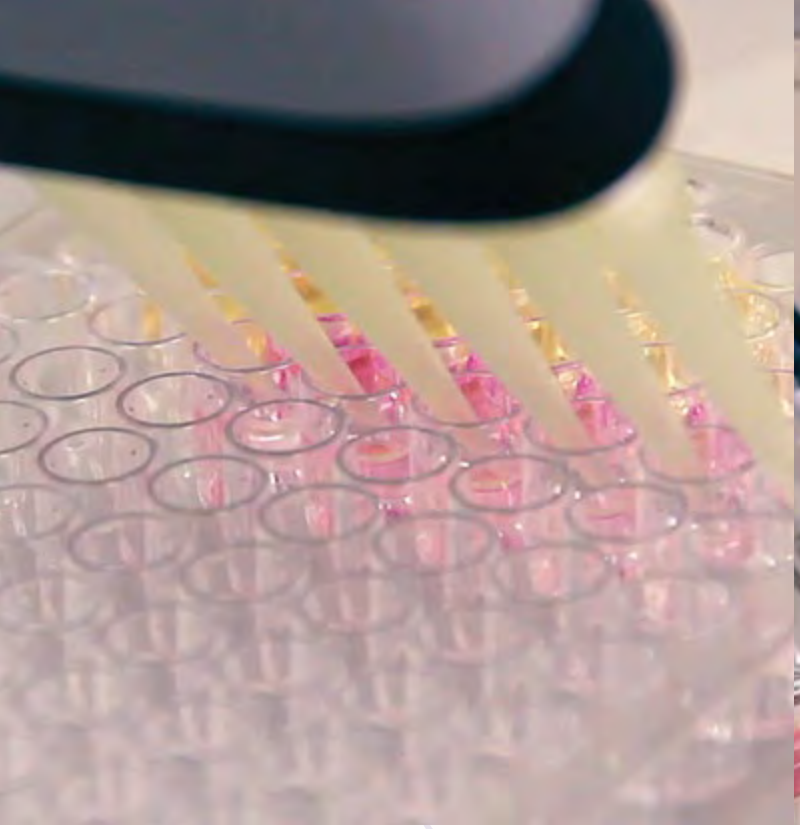
FROM WATER TO DISINFECTANT

What started as a way to clean seeds has become a new way to protect against COVID-19. The base technology may be the same, but it still needs some adaptation to become usable. The team doesn't just want to produce ROS, they want to create a medical grade disinfectant. This means the product has to be effective and safe for human use.

According to legislation from the European Parliament, the approval of any biocidal product,

Dr Sholeem Griffin
Photo by James Moffett

stuff that can kill microorganisms or viruses chemically, has to follow a set of conditions. The purity of the substance has to be within strict parameters, and the substance cannot harm the environment or other beings that are not the target of the product being developed. Testing is key to make sure a new product is safe.



Due to the tight regulations, the project is evaluating the efficacy and safety of the disinfectant. For example, they conducted tests to see their product's efficiency. To comply with regulations, it has to kill a myriad of bacteria, fungi, yeast, and virus strains. If it doesn't pass the tests, it won't be fit for medical use.

Besides being effective, it is important for the product to be safe for human use. The team has to test the liquid formulation to guarantee it doesn't lead to gene mutations or toxicity in skin cells. Similarly, sensitivity tests are being conducted to guarantee the disinfectant doesn't cause skin irritations. No one wants to harm themselves using disinfectant.

A PHYSICIST, A BIOLOGIST, AND A CHEMIST ENTER A BAR

Producing a medical grade disinfectant proved to be a truly transdisciplinary endeavour. Prof. Vasilis Valdramidis (Faculty of Health Sciences) and Prof. Ruben Gatt (Metamaterials Unit at the Faculty of Science) introduced the plasma technology to Kozak, who refined the methodology; Griffin ran the efficacy and safety tests; and Mallia idealised the chemical composition of the disinfectant. Take one member out of this equation, and the project would have become impossible.

Kozak developed the plasma technology, which injects plasma into water. The intensity and duration of the plasma discharge, the chemical characteristics of the water, and even the gas that transports the current (for this particular case, air) were initially decided by him. Griffin and Mallia took his initial set-up and started tweaking it to try to produce their disinfectant. Every detail had to be tested – each step in production affects the next. Was the plasma discharge too intense? Was it too long? Was the water pure enough? Was it too pure? Did it need more salts? Each change results in a slightly different final composition, with different effects on animal cells, viruses, bacteria, and fungi.

> *Producing a medical grade disinfectant proved to be a truly transdisciplinary endeavour.*

The team is currently still testing the protocol to efficiently produce the disinfectant. In the near future, they plan to commercialise the machine to companies and services in health-related departments. They believe that this will prevent shortages of disinfectant during periods of high demand, especially in essential services like hospitals and healthcare facilities.

SANITAS is an unexpected product of a very particular period in our history. Yet, the project is leading to new innovations that will benefit humanity for decades.

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