

# Werkstoffe

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# Subject: Plasma for disaster relief

## Plasma for biological disaster relief

The three-year MoPlasDekon (mobile plasma decontamination) project funded by the German Federal Ministry of Education and Research (BMBF) as part of its "Research for Civil Security" program came to an end in August this year. A newly developed, mobile plasma technology should make it possible for the first time to perform the necessary disinfection of contaminated surfaces anywhere in the world without using harmful and polluting chemicals.

Against a background of rising globalization characterized by mass flows of people and goods between the countries and continents of the world and a constantly rising global population, epidemics now have the potential to spread far more rapidly than before, according to the German Federal Office of Civil Protection and Disaster Assistance (BBK). Climate change too with its unforeseen consequences in terms of new biological threats – such as the spread of previously unknown infectious diseases by plants and animals, for example – represents a major challenge for disaster relief organizations in the future. In addition, there is the real threat of terrorist attacks with biological warfare agents. The effectiveness of these weapons of mass destruction which make targeted use of pathogenic biological agents such as microorganisms (bacteria, viruses and fungi) and toxins can be further enhanced through gene manipulation and chemical processes.

### The project

When the three project partners Plasmatrete GmbH from Steinhagen, the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising and M-U-T GmbH from Wedel joined forces to work on the MoPlasDekon research project in September 2016, their aim was to develop an innovative, mobile plasma system for the rapid, chemical-free disinfection of contaminated objects and to investigate the effectiveness and practical applications of such a device. In contrast to chemical methods, the plasma technology they developed provides an extremely rapid and environmentally friendly means of eliminating dangerous pathogens on diverse surfaces. Once developed to a marketable product, the plasma disinfectant should be able to clean the plastic protective suits worn by emergency teams just as rapidly and effectively as the interiors of entire ambulances (Fig. 1). The innovative process will protect emergen-



Fig. 1.: The newly developed mobile plasma decontamination system (MoPlasDekon) can disinfect the interior of the entire ambulance during emergency situations without using chemicals.

Photo Plasmatrete

cy workers and prevent the spread of disease without relying on the use of harmful chemicals.

### Combined expert knowledge

The job of developing and designing the plasma unit itself fell to project partner Plasmatrete. The microbiological evaluation of the plasma system demonstrator (Fig. 2) developed during the project was performed at the Fraunhofer IVV.

The researchers there used bacteria, fungi and viruses to test the effectiveness of the plasma in decontaminating and disinfecting the surfaces of different materials contaminated with biological pathogens. The third project partner, North German sensor and control systems specialist m-u-t developed special gas analyzers. Two of these sensors send their data directly to the plasma system's mobile power generator. One of them measures the plasma at the nozzle outlet at the start of the decontamination phase, while the other is located inside the contaminated ambulance and signals to the generator the point when the concentration of the disinfecting plasma gas inside is sufficient. The MoPlasDekon partners received expert advice from four associated project partners working in the field: the Analytical Task Force (ATF B) of the Essen Fire Service that specializes in biological threats, the rescue and disaster management specialists at the Bavarian Red Cross

(BRK) and specialist tent and equipment supplier Inhag Zelte und Zubehör based in Hesse. The fourth practical advisor was the German government's center for the monitoring and prevention of diseases, the Robert Koch Institute (RKI) in Berlin, which itself operates a task force for biological threats.



Fig. 2: Plasmatrete was tasked with engineering and designing the new plasma decontamination system. Pictured: Prof. Dr. Thomas Schmitt-John, director of Plasma Live Science at the company. Photo Plasmatrete

### Chemical decontamination

Contaminated objects are generally decontaminated and disinfected using chemicals. When rescue teams in infected areas remove their special protective suits after use, they are at great risk of exposure to pathogens adhering to these suits. So before removing their contaminated clothing, they enter a decontamination tent where they are sluiced down or showered with chemical solutions. Then they are brushed from top to bottom with a soft brush to ensure that the solution is evenly applied. The aim is to remove all pathogenic microorganisms.

Substances such as peracetic acid (PES) or hydrogen peroxide are mainly used to kill the vegetative bacteria, fungi and sporicidal pathogens and to inactivate viruses. Not only are these chemicals harmful to human health and extremely harmful to the environment, transportation to contaminated areas and subsequent storage frequently involves significant logistical efforts. Furthermore, they must be carefully disposed of after use.

With MoPlasDekon it's quite a different matter. Use of the mobile plasma decontamination system would eliminate all the above-mentioned problems. The new system requires only electrical energy and air as process gas.

### Chemical-free decontamination with plasma

Although the MoPlasDekon technology involves a plasma gas generated under normal pressure, unlike the manufacturer's Openair-Plasma used in industry to clean and activate material surfaces, this plasma is not generated using an arc-like discharge. "The newly developed CD-40 sterilization nozzle generates the plasma by means of dielectric barrier discharge (DBD)", explains Dr. Alexander Knospe, Director of Innovation Management at Plasmatreat and joint coordinator of MoPlasDekon. "In contrast to conventional atmospheric pressure plasma, this technology produces a reactive plasma gas with a long life which is suitable for disinfecting and even sterilizing larger areas up to 5 m<sup>3</sup> in volume." This corresponds approximately to the volume of an ambulance, which can be decontaminated using the DBD process in around one to two hours without the need for chemicals.

The entire plasma process is monitored spectroscopically to ensure continuous and reproducible operation (Fig. 3). When asked which materials had so far been treated during testing, Prof. Dr. Thomas Schmitt-John, director of the Plasma Life



Fig. 3.: MoPlasDekon coordinator and director of Innovation Management at Plasmatreat Dr. Alexander Knospe (left) inspects the spectroscopic monitoring of the plasma process with project engineer Sebastian Guist (right).  
Photo Plasmatreat



Fig. 4: The new developed nozzle can reduce the bacterial load by a factor of one million, which meets the requirements for sterilization.  
Photo Plasmatreat

Science department at the systems engineer replies: "We have tested it on glass, plastic and metal surfaces and so far found no difference in disinfection performance. Since the DBD plasma gas is relatively cold and the distance between the nozzle and the substrate is large anyway, thermally sensitive plastics can also be decontaminated."

The newly developed nozzle (Fig. 4) achieved a 6-log microbial reduction rate. This equates to a reduction in the bacterial load by a factor of one million, which meets the requirements for sterilization.

According to Schmitt-Johns, the decontamination tests conducted to date have successfully demonstrated the bactericidal and fungicidal effect as well as the antiviral and sporicidal effect of the MoPlasDekon technology.

### Practical solution

Rescue services have their own emergency power generators in case there is no power supply at the point of deployment and no other means of connecting to the mains. In a power cut, the plasma unit would be connected to one of these gene-

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rators. But if for any reason this generator was to fail, it would still be possible to carry out the necessary disinfection with the plasma system developed for MoPlasDekon. Schmitt-John: "Plasma power generators are normally powered by the mains supply. But the CD-40 unit has a special feature: it is equipped with a built-in lithium-ion battery as a backup supply. It can be recharged from any power socket or even from the rescue workers' vehicle battery in an emergency at any time."

Dealing with biological hazards – regardless of whether they are in remote areas or a city, a third world country or a Western state – requires rescue teams to be deployed as quickly as possible and all the rescue equipment to be transported to the hazardous area as quickly as possible. In view of the volume and weight of the items of equipment, every gram saved naturally counts. The declared technical goal of the research project was that the plasma disinfectant should be mobile, compact and light enough for one person to carry. No such device currently exists. The plasma systems used for disinfection purposes in industry are permanently installed due to their weight and the fact that they are connected to a stationary

power supply. In contrast, the future MoPlasDekon product, weighing only 25 kg, will be rapidly deployable anywhere and the integrated rechargeable battery ensures the power supply in emergencies. The fully developed generator will be far more user-friendly than the demonstration model. It will have fully automated preprogramming and the control panel will have only two switches for the operator to deal with: on and off (Fig. 5).

### Summary

When the BMBF-funded project comes to an end, the plasma decontamination system will be advanced to the production stage. Investors interested in the end product will find it has promising potential: The first mobile battery-powered high-tech plasma system, monitored by gas sensors, that is capable of eliminating harmful pathogens on objects at disaster zones anywhere in the world – rapidly, safely and entirely without chemicals.

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Fig. 5.: Easy to use today, even easier in the future: The control panel of the mass-produced version of the MoPlasDekon will have only two switches: on and off. Photo Plasmatreat

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