Atmospheric Plasma for Medicine and Hygiene

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ABSTRACT

"Plasma Health Care" is an emerging research topic. With cold atmospheric plasmas living tissues can be treated and the plasmas can have a bactericidal property. This research topic requires many investigations from different fields like physics, chemistry, medicine, microbiology, etc since it is interdisciplinary. In this paper we briefly demonstrate our activity in hygiene and medicine with cold atmospheric plasma technology.

1. Introduction

Cold atmospheric plasmas can play an important role in different areas of Health Care, e.g. hygiene and medicine because they have a bactericidal/fungicidal property [1-4]. This is an interdisciplinary topic and combines plasma physics, chemistry, fluid dynamics, and life sciences.

In hygiene, the most important plasma contribution is decontamination, disinfection, and sterilization. The main aim is to prevent diseases and their containment. For instance, in the US alone, 2 million hospital induced infections each year are estimated. The most effective method of containment is disinfection of instruments, especially hospital staff and visitors. For this purpose cold atmospheric plasmas could be used as a tool to avoid the spread of infectious diseases.

In medicine active agents produced by plasmas can have an effect at the cellular level. The plasmas can and must be designed depending on the purpose. In case of wound disinfection, there are requirements that the plasmas should reduce bacteria density on wounds without producing any harmful effect on human cell viability and genetic stability. It is essential to understand the action of different plasma components on human cells, prokaryotic cells, viruses, etc.

In this paper we briefly describe our study in hygiene and medicine using cold atmospheric plasmas. In the field of hygiene, an atmospheric plasma dispenser for large area disinfection is introduced and for medicine we discuss the current status of our clinical study in wound care.

2. Plasma hygiene

In or group, a large area scalable and robust electrode design for plasma production in the ambient air has been developed and tested [5]. One example is shown in fig. 1. This device has two "surface micro discharge" (SMD) electrode. The electrodes consist of an insulator plate sandwiched by metal plate and wire mesh. For the plasma production in the surrounding air, a voltage of 18 kV at a frequency of 12.5 kHz is applied. The power consumption is ~0.5 W/cm^2. Advantages of using plasma over normal fluid or ointment applications would be effective killing of bacteria and penetration of plasma and gas into small openings, e.g. pores in the skin. By the plasma dispenser, it is seen that more than five orders of magnitude in bacterial load is obtained in a few seconds of plasma treatments for both gram positive and negative bacteria including MRSA.

By this plasma dispenser, plasma was produced on and around the electrode surface. The plasma produces charged particles (electrons, positive and negative ions), reactive species (NO, O_3, OH, etc.) and UV light. According to our observation, at least the UV radiation alone doesn't play a big role in killing bacteria. Therefore, a transport mechanism of charged particles and reactive species to bacteria as well as plasma chemistry are the key point to optimize the plasma conditions for bactericidal property and satisfying the health requirements against toxic gas and UV light.

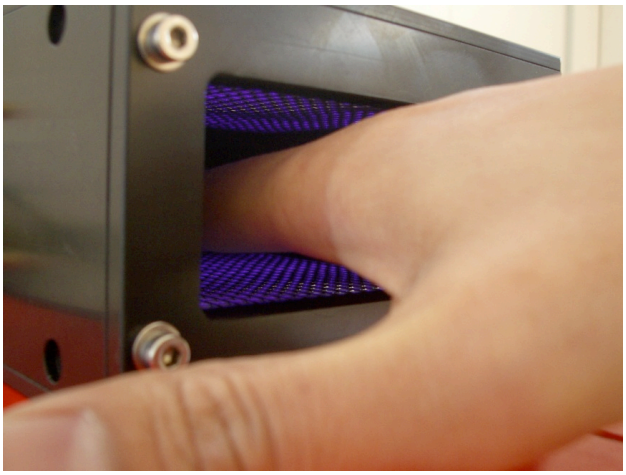

Fig. 1. Plasma dispenser. The plasma was produced on both electrodes with a voltage of 18 kV.

3. Plasma medicine

Since a few years, a clinical study has been carried out in collaboration with Department of Dermatology, Allergology and Environmental Medicine, Hospital Munich Schwabing and Adtec Plasma Technology Co. Ltd. [6,7] A microwave plasma torch with argon gas is used in this study. Figure 2 shows the clinical device used in the clinic. At the end of the flexible arm, the plasma torch is placed. Inside the plasma torch, microwave plasma is generated with ~80 W of microwave power and ~2 slm of argon flow and this plasma flow is applied on wounds. Patients received standard wound care besides a two to five minutes argon

plasma treatment on randomized wound(s). The bacteria load was detected by nitrocellulosis filters. A highly significant ($p<10^{-6}$) higher bactericidal effect of 34 % in plasma treated wounds compared to control wounds (n=291, 36 patients) is observed with five minutes treatment. Even with two minutes treatment resulted in a significant higher reduction rate in bacterial load(40 %, $p<0.016$, n=70, 14 patients). This reduction is found in all kinds of germs including multiresistant one like MRSA. Until now, the treatment is very well tolerated and no side effects occurred.

The responsible agents for bactericidal effect in this study are mainly reactive species and UV light. The reactive species are produced through mixing between the argon plasma flow from the torch and the ambient air. Again, it is quite important to understand the transport of the plasma as well as reactive species as well as plasma physics and chemistry.

Fig. 2. The clinical device for wound treatment. At the end of the flexible arm the plasma torch is placed.

4. Conclusion

Cold atmospheric plasma technology is promising in different areas of health care. Since these research topics are interdisciplinary, many studies in different fields like plasma physics, chemistry, fluid dynamics, biology, etc. are required in order to have the full potential of the new technology and to open new fields.

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