Plasma Medical Science Innovation and Future Prospective
プラズマ医療科学イノベーションと今後の展望

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The nonequilibrium atmospheric pressure plasma has enabled to open the new avenue of plasma medicine, which will create medical innovations. I will overview recent results of plasma medicine and stress on the importance of establishment of its science. Particularly, the fusion of plasma and medical sciences with the molecular biology will be a key strategy to implement this new area.

1. Introduction

Recently, the research of plasma medicine has been expanding in the fundamental and the application around the world. The driving force is the development of nonequilibrium atmospheric pressure plasmas. However, the guideline and concept of the plasma equipment suitable for the plasma medicine has not been yet established. Even so, various kinds of plasma sources have been introduced to applications of the sterilization, the blood coagulation, the cure of cancers and so on in the medical field by try and error methods. We have found out the plasma activated medium was available in the cancer treatment. Usually, the plasma is expose to the liquid containing the cell and the cell is strongly influenced by the plasma treatment but the plasma is only exposed to the medium without cells and the plasma activated medium is introduced to another medium containing the cell, which is named to Plasma activated Medium (PAM). The PAM enabled us to kill cancer cells against normal cells. This fact is expanding the application of plasma processes towards the medicine [1].

Additionally, the excellent application of plasma treatment is the stop of bleeding with high speed, which is attracting attention in the practical use of wound repair towards the clinical trial. In order to precede the fundamental researches in plasma medicine towards the therapeutic testing, we will establish the plasma medical science as soon as possible. The most important way to do it is to diagnose species in the gas phase and liquid phase in the plasma. Such approaches are almost the same as the development of material and device processing have been done in the past 40 years.

Figure 1 shows the scheme of plasma processing. The plasma science consists of diagnostics, generation, control of plasma and simulation (theory). Such a plasma science has been developing the semiconductor in the foundation of industrial sustainable bases. Furthermore, the green innovations of energy devices such as solar cell and fuel cell ones have been also promoted by the plasma processes. Now, life innovations such as the plasma medicine and plasma agriculture have made a sudden rise by the development of the nonequilibrium atmospheric pressure plasma.

However, there is a gap between developments of plasma material science and plasma life science. The most important point to create the plasma life science is how to bridge the gap.

In my study, I will introduce the current status of researches of plasma medicine focusing on the cancer therapy and give you the solution how to bridge the gap.

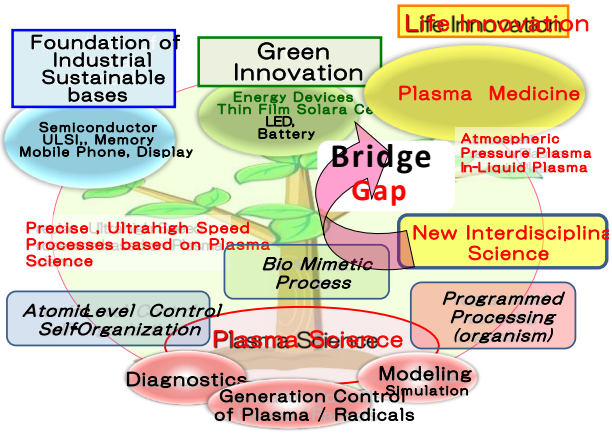

Fig. 1. Scheme of plasma sciences and their applications.

2. Experimental procedure and results

The nonequilibrium atmospheric pressure plasma with a high density around 1016cm-3 employing a pure Ar gas was developed. The plasma was exposed to the conventional medium at a room

temperature as shown in Fig. 2. The plasma activated medium (PAM) was introduced to the ovarian and brain cancers. Surprisingly, the PAM is greatly effective in killing both cancer cells against normal cells. The diagnostics of the species of O, N and NO in the plasma was made by the vacuum ultraviolet absorption spectroscopy and laser induced fluorescence, respectively. Regardless of employing a pure Ar gas, there are many reactive species of O, N and NO together with VUV lights, due to the air engulfment which are incident to the medium.

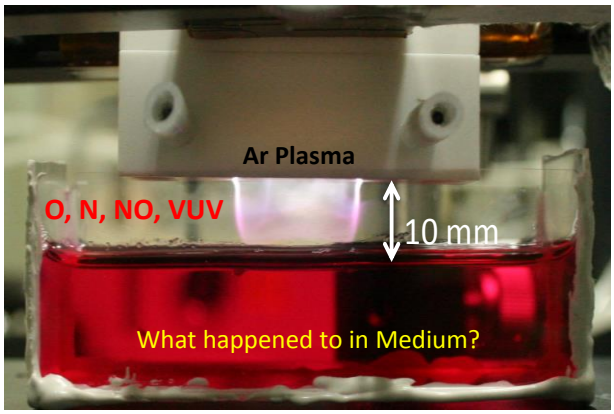

Fig. 2. The photograph of plasma treatment of medium. The atmospheric pressure Ar plasma was exposed to the medium with a distance of 10mm.

The medium exposed by the plasma was investigated by the electron spin resonance spectroscopy with various kinds of spin traps. The chemical elements of OH and H2O2 were monitored. On the basis of comprehensive results of diagnostics in the gas phase and medium, the important factors to kill the cancer cells will be the organic peroxide compound synthesized by the reaction of O atoms with medium. The mechanism of the killing cancers has been done by the molecular biologic approach.

Figure 3 shows the scheme of the signal transmission in the cell by the PAM stimulation. The PAM delivers the signal in the cell through proteins. Such an analysis has been just established in the molecular biology. From these analysis of signal transmission, we have found out that the PAM has down-regulated the AKT, which is a growth factor of cancers together with the caspase activation, which is led to the apoptosis. I will put emphasis on the introduction of the molecular biology to the plasma material science, which will be leading to the creation of a real new interdisciplinary science established by the plasma community.

Finally, the PAM was injected to mice with ovarian cancers. The volume of the cancer of mice with PAM injection was successfully decreased [2].

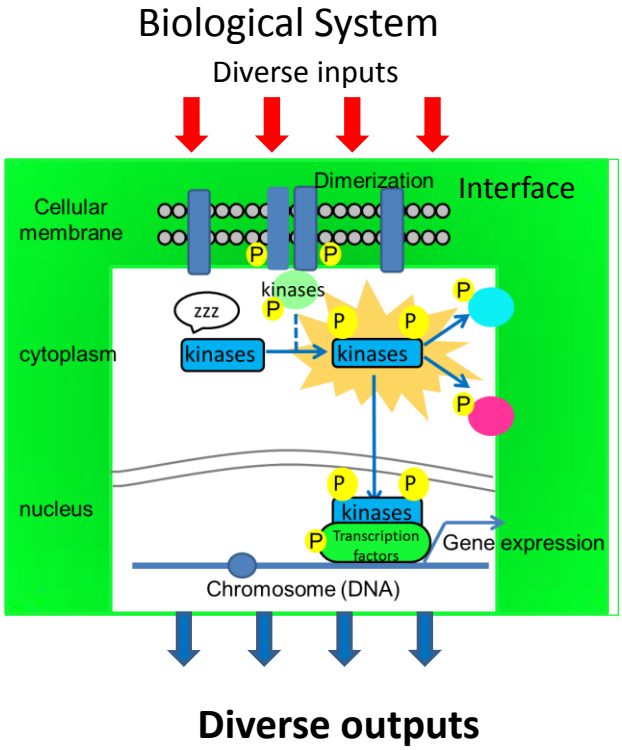

Fig. 3. The scheme of the signal transmission in a cell stimulated by PAM.

3. Conclusion

The plasma medicine will advance the plasma material science and eventually establish the new interdisciplinary science. The most important approach by the plasma scientists is still better understanding of kinetics of species and lights not only in the gas phase but also solid and liquid surfaces. Additionally, the introduction of the molecular biology to the plasma science is crucial of importance.

Acknowledgements

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References

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