30aP06

Characteristics of DC or Pulsed Type High Electric Field Plasma and its Application to Air Cleaning System

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DC or pulsed type High Electric Field Plasma (HEFP) is investigated. Here, HEFP means no discharges take place in atmospheric environment, and strong electric field less than about 3 x10^6 v/m is produced to accelerate free electrons to high energy for decomposition of chemicals, water vapor or killing bacteria. Here, in this presentation, we have applied this HEFP to air cleaning system. In order to produce HEFP, two types of high voltage exciter are used, 1) short rise time pulsed type high voltages or 2) DC high voltages. The phenomena observed using two types of high voltages are slightly different in addition to the consumed electric power. The main purposes of the present researches are to show the typical characteristics of HEFP action, including trapping phenomena of micro-dust particles with diameter 0.3 μm or larger, in addition to the decomposition of chemicals such as NH_3, CH_2O or water vapor, and sterilization. The dust particles are perfectly trapped by adding HEFP with DC voltages. In the case of pulsed HEFP, 100% trapping of dust particles has not been attributed, because voltage height required for selecting the best condition for trapping is not controlled at present. The decomposition of chemicals and bacteria sterilization are also confirmed perfectly.

These phenomena are applied to make new type of air cleaner usable in the rooms for daily life or large rooms for many peoples staying or in moving vehicles. The key phenomena, and most important action, is not use the actions resulted from Ozone, oxygen radicals or UV light produced after plasma discharges in air in order to realize above mentioned phenomena. These gasses or light is very toxic to the surrounding materials, including human bodies and we should not use these materials for realizing above mentioned phenomena.

The model structure is shown in Fig.1.

The applied machine of this system is now on the commercial market.

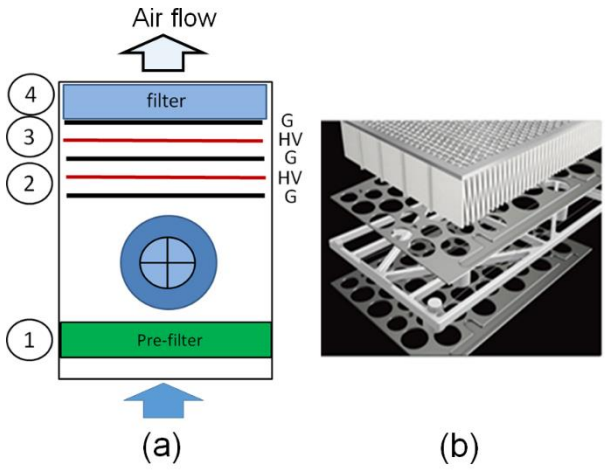

Fig.1 (a) System of air cleaner The air is absorbed from bottom side by a fun and goes out after going through each section. (b) The electrode structure seen in Sections ② or ③ in (a) and filter ④.

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29pB01

Multiple Pulse Effects on Decomposition of Hydrocarbons for Hydrogen Production

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Hydrogen production on vehicle is under development by using plasma discharges working in high pressure condition (> 1.5 atm). In this system, no production of COx is expected. The original fuel for the system is methane (CH_4) or propane (C_3H_8). For those purposes mainly dielectric barrier discharge (DBD) non-thermal plasma system is employed with high voltage pulse of width 5-30 μs and maximum amplitude 13 kV. The decomposition rate depends on the input pulse width. At present 5~30 μsec width square shaped pulse is tried, but each pulse is decomposed into multiples of fundamental 5 μs pulse, because of machine problem. As a result, up to 20 μs width, the decomposition efficiency increases, but over that values it decreases. The physical phenomena of the pulse width dependence are discussed with use of multiple pulse decomposition model.

We consider the ion density continuity equation with a source term $n_i H(t-\tau_i)e^{-\alpha(t-\tau_i)}$ for $i = 0$, 1, 2, etc., where the Heaviside function $H(t)$ is defined by $H(t) = 0$ for $t < 0$ and $H(t) = 1$ for $t \geq 0$. The continuity equation is expressed as follows:

$$\frac{d}{dt}n_i + \nabla\cdot(n_i v) = n_0 H(t-\tau_0)(1+\beta_0 e^{-\alpha(t-\tau_0)}) + H(t-\tau_1)\{n_1 + \beta_1(n_0+n_1)e^{-\alpha(t-\tau_1)}\} + H(t-\tau_2)\{n_2 + \beta_2(n_0+n_1+n_2)e^{-\alpha(t-\tau_2)}\} + \cdots \quad \cdots\cdots\cdots (1)$$

where $\alpha = 1/\tau_d$, τ_d is the plasma decay time of about 10 - 50 μs, β_i is the ionization rate of hydrogen molecules, n_i is the hydrogen density determined by the plasma source, and thus $n_0, n_1, n_2 \cdots$ due to production rate of H_2 after decomposition from a hydrocarbon, and τ_n corresponds to the birth time of hydrogen. Here, we can assume that the produced H_2 molecule density is almost constant during the pulse decay time, but a small amount of which, β_i %, may be ionized by accelerated electrons to higher energies. The ionized hydrogen atom H_2^+ will decay into neutral H_2 after some decay time, say, about 10~50 μs. Through these process, however, total amount of H_2 molecules does not change. In other words, each pulse decomposes hydrocarbon to make H_2 molecules, but once H_2 molecules are produced, the total number of which is kept constant even if some of H_2 was ionized.

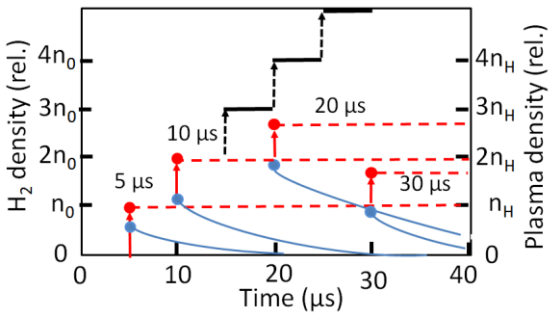

Fig. 1. The dependence of decomposition rate on pulse width calculated with using Eq.(1) at different pulse width .Black solid lines correspond to expected production amount of H_2.

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29pB02.

New type of hydrogen purifying filter

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Hydrogen production system working on vehicle is under development. This system will be expected to produce H_2 gas about 1-2 L/min. This amount is expected required for H_2 fuel cell working on vehicle for producing electricity in order to drive vehicles. In this process, the key problem is the filtering system. In the present hydrogen production, original fuels are mainly hydrocarbons, such as natural gases. These gases are decomposed with chemical processes in the plant. In this process, they have to use filters for separating pure H_2 from mixed gases. The popular filter system, however, mainly based on the diffusion through the thin chemical films, and separation speed is less than 0.01 L/min. and it is not useful.

We are developing two kinds of new filter, which are introduced herewith:

1. Using liquid propane for separation such as shown in Fig.1. The mixed gases go through the liquid propane gas area and propane gas from the mixed gases will be liquefied to be separated from H2. Fine structure of the liquid filter uses thermos bottle. The cooled mesh in the filter must be installed, because of the vaporized propane will exist all the times even near the liquid propane surface and this vapor must be liquefied not going out from filter area.

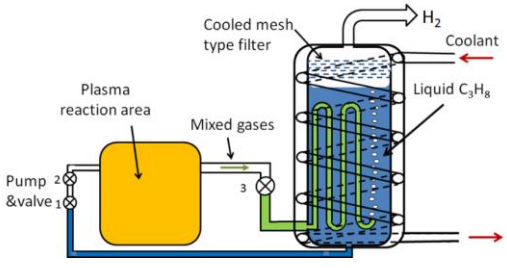

Fig. 1. Liquid type filter.

The pipe connected to the gas decomposition area from where the mixed gas will be produced, will be very narrow about o.5~1.0 mm in diameter and the location of the exit in the liquid propane area must be close to the bottom of the bottle. It is better that this pipe will be bent a couple of turns for obtaining the better cooling effect of the mixed gases.

2. Another new filter can produce pure hydrogen. A key structure is shown in Fig.2. This idea is even similar to our old idea (Ref.2). The present system will be driven by electric motor to drive the circulating inner fins. Therefore, this is stably working and enough amount of hydrogen will be produced easily. In order to control the inside fin, we have two types:

(1) A driving motor will be set up inside the fin area.

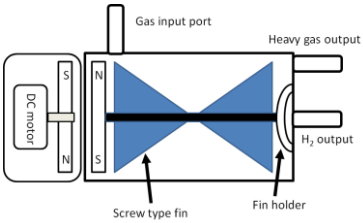

Fig. 2. Rotation type filter.

(2) A driving motor is set up separately in the outside area and connected to the inside fin through magnetic field. (Fig.2).

Here, the number of screw type fin will be 3-4 pieces. The rotation speed of the fin will be around 20,000 rpm.

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