§32. Study of Removal of Volatile Organic Compound (VOC) and Related Atomic and Molecular Processes in Plasma Reactors

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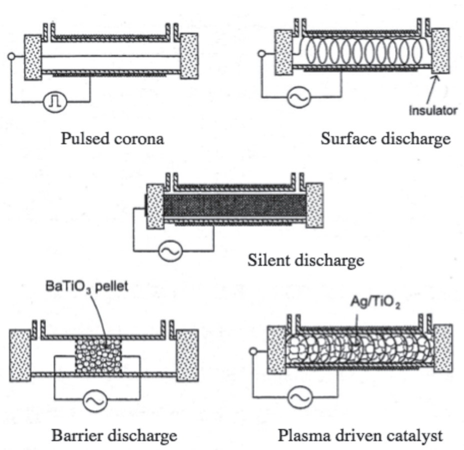
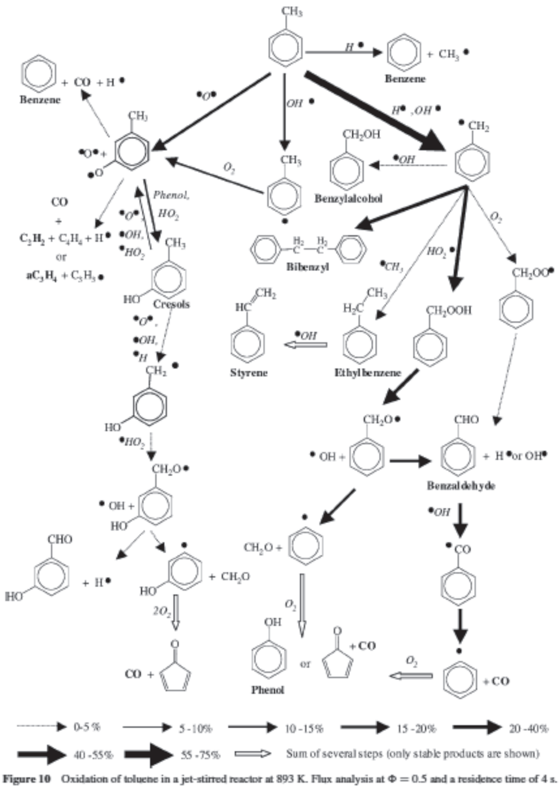
We study atomic and molecular processes concerning to the removal of Volatile Organic Compound (VOC). VOCs such as toluene and benzene used in the printing industry may cause health hazards and recent regulations demand new removal technologies.

Decomposition of VOCs using non-thermal plasmas, is expected to be more efficient and more cost effective than present technologies. Fig.1 shows various kinds of plasma reactors, which are used in the study of decomposition of VOCs [1]. In the non-thermal plasmas, the electron temperature is high enough to excite and ionize VOCs molecules such as toluene and benzene, while the gas temperature remains room temperature. However, present experiments need input power density of more than 1kJ/*l*, which implies improvement of the efficiency is required, based on the better understanding of the chemical and physical processes in the plasma.



(Fig.1) Plasma reactors for the decomposition of VOCs[1].

We had a working group meeting on 20-Apr-2007 to discuss the present status of theoretical and experimental studies of the decomposition of VOCs. The modeling consists of atomic and molecular processes coupled with spatially and temporally non-equilibrium state of plasmas. Chemical kinetics concerning to the oxidation of VOCs are being investigated as a part of studies of combustion and soot formation. VOCs are also interested as a precursor of tropsphiric ozone in the environmental science. However, even database of the atomic and molecular processes has been developed in these studies [3], evaluation and validation of atomic and molecular data are necessary before applying the data to the non-thermal plasmas, because plasma parameters are different from those in combustion and atmospheric chemistry. For example, formation of free radicals after interaction of energetic electrons (>1eV) with gas molecules and subsequent reaction processes should be investigated.



(Fig.2) Chemical kinetics of oxidation of toluene [2].

Modeling of discharge is also indispensible. The formation of a streamer is stochastic and highly non-uniform, which requires new modeling methods, because it is beyond the capacity of present fluid as well as particle approach.

We have started the development of a comprehensive model of the dry air discharge to find an appropriate method to couple complex discharge and atomic and molecular processes. Experimental studies have also been initiated with respect to the decomposition of PFCs using the electron beam irradiation.

In 2008 we will continue the activity to collect and evaluate the atomic and molecular data for the decomposition of VOCs, and we will investigate the plasma condition to improve efficiency using simulation models.

[1] “Recent Develoment of Air Purification Technology; Effective Solution to VOCs control policy”, edited by K. Takeuchi, CMC press, 2007 (in Japanese).
[2] R. Bounaceur, et al., Int. J. Chem. Kin. 37, 25(2005).
[3] http://www.ametsoc.org/chapters/renotahoe/EUPHORE/Slide1.html