Plasma Assisted Destruction of Volatile Pollutants using Dielectric Barrier Discharge

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Abstract -This work reports the development of atmospheric pressure non thermal plasma reactor with dielectric barrier discharge (DBD) for diagnosis, characterisation and decomposition of VOCs compounds. The DBD discharge has been generated in planar geometry reactor powered by AC voltage transformer. The reactor consisting two electrodes, each electrode plates are covered with 3 mm thick Pyrex dielectric plates. The air discharge gap between the dielectric layers was varied from 3mm to 15mm. The optimization the said reactor has been done by Paschen curve, Townsend breakdown curve. The decomposition of vocs are explained in terms of dissociation energy (I-V curve).

I. INTRODUCTION

The volatile organic compounds released from various industrial and agricultural process is a significant source of air pollution and may cause problem to human health due to their toxicity , some of the VOC's are carcinogenic or responsible for respiratory diseases, hence it has a bad effect on environment[1-2]. So the destruction of VOC by the non thermal plasma process can be done in two methods like corona discharge and dielectric barrier discharge (DBD). Corona discharges have many applications in the industry. But only small concentrations of excited or charged species are needed. But in case of DBD, it is applied for volume plasma chemistry. This is also called silent discharge, having many advantages like electrical discharge is non-equilibrium at atmospheric pressure[3]. This has many applications like ozone generation, pollution control [4] plasma chemical vapour deposition, also excimer lamp excitation and more recently surface modification of adverse materials [5]. In order to optimize the design of a DBD reactor, like some previous studies current-voltage characteristics are verified. Discharging occurs in a parallel plate DBD reactor with two dielectric layers has been measured as a function of the applied voltage and the discharge gap.

II. EXPERIMENTAL ARRANGEMENT

The experimental arrangement used to study DBD discharge at atmospheric pressure condition is sketched below.

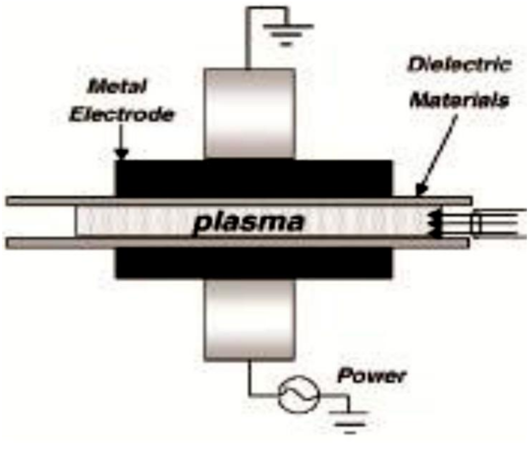

Fig-1 Parallel plate Plasma reactor

The discharge is generated between two plane electrodes and is covered by 3mm thick Pyrex dielectric plates. The high voltage power supply is consisted of a step-up transformer (0-30 kV, 50Hz). The discharging is studied taking two mass flow controller of the range 0-5 lit/min.The breakdown voltage for different voc with an inert gas He and Argon are studied here.

III. RESULTS AND DISCUSSION

The optimization parameters for different gases (argon and He) for voltage and distance were analyzed. Townsend breakdown and Paschen Curve were analyzed for different pressure and distance [6] (Fig 2).

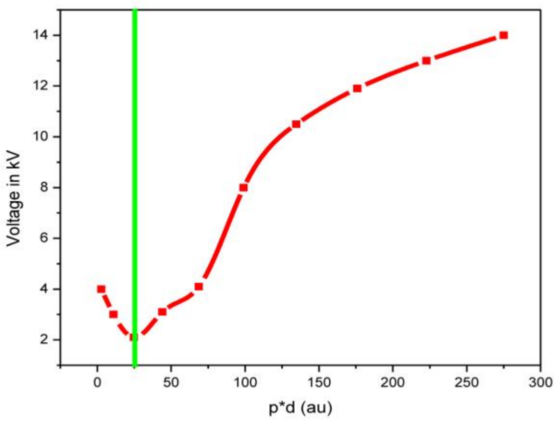

Fig 2. Paschen Curve for Ar.

Impedance matching resistor was installed between HV power supply and DBD reactor for maximum power transfer at optimized operating condition.

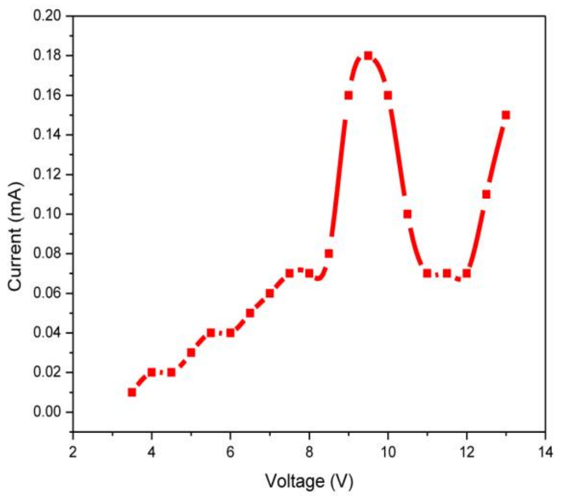

Fig 3. I-V Curve for Benzene-Helium

We have observed that the breakdown starts at 3.0 kV, 2.7 kV, 3.0 kV, and 3.8 kV for benzene, chlorobenzene, toluene, xylene respectively (fig-4). The glow region starts at 14.5 kV, 11.5 kV, 14 kV, 13 kV respectively in the presence of helium plasma. In this glow region large numbers of electrons have been produced by ionization/excitation of helium. Interestingly, the bond dissociation energy of C-H bond in benzene is ~ 390 kCal/mol [7], in toluene is ~ 77.5 kCal/mol, in xylene 77.5 kCal/mol [8] and the bond dissociation energy of C-Cl bond in chlorobenzene is ~ 399.19 kCal/mol [9]. So, it is expected that chlorobenzene should dissociate at higher voltage as benzene and other compounds at lower voltages. But, it is observed that chlorobenzene dissociate at comparatively low voltage i.e.at 2.7 kV and glow discharge starts at ~ 11.5 kV. This may be because, since the electron affinity of Cl is appreciable, as soon as the chamber is filled with helium plasma, Cl get detached from chlorobenzene and becomes neutral recombining with free electron in the plasma. Again, for benzene maximum current is drawn i.e. 0.67 A and for chlorobenzene it is lower than benzene i.e. 0.41 A. This may be because the chlorine ions get detached from chlorobenzene which acts as scavenger of the free electrons. So, less current, destruction of pollutants like chlorobenzene is achieved by using DBD reactor. It is a useful technique to destroy volatile compounds like chlorobenzene etc. The I-V characteristic curve of the volatile aromatic compounds is very interesting features which is reported in this work.

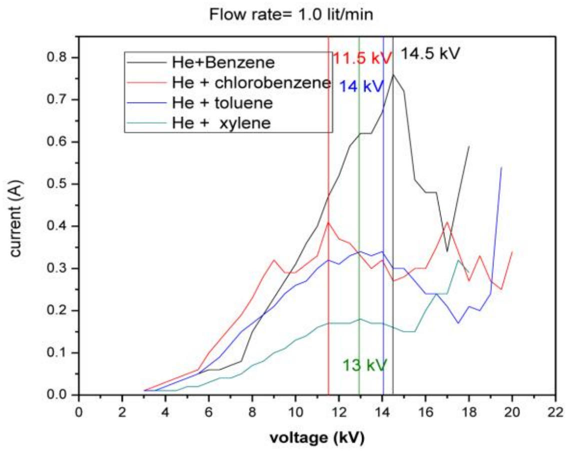

Figure 4. I-V curve for the volatile aromatic compounds (+He) in DBD process

IV. CONCLUSION

Dielectric barrier discharge assisted plasma technique is a novel green technique with high energy evolution. The developed DBD assisted plasma reactor is optimized using various diagnostic methods. The decomposition of Benzene,toluene,Xylene,chlorobenzene is studied in terms of breakdown voltage in i-v curve depending on bond dissociation energy .Due to attachment of electronegative group,chlorobenzene shows breakdown at a lower potential.

V. AKNOWLEDGEMENT

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VI. REFERENCES:

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