

An SDBD Plasma-based Source for Efficient Degradation of VOCs in an Enclosed Environment

4.1 Introduction

The presence of volatile organic compounds (VOCs) severely harms both the environment and people. Many items, such as furniture, cars, factories, paints, construction materials, and natural sources, release VOCs into the air [211] [212]. The release of VOCs into the indoor atmosphere is a significant reason for worry due to its detrimental impacts on people [213] [214]. The traditional techniques for degrading VOCs include adsorption [215], absorption [216], photocatalysis [217] [218], incineration and condensation [219] [220], catalytic oxidation [221], and membrane purification [222]. These techniques have a number of drawbacks, chief among them being high energy consumption and low efficiency. In catalytic oxidation, for example, the catalyst must be heated to a higher temperature and sustained at that temperature during the whole process [Hermia et al., 1993]. In the incineration process, combustion of waste materials produces ash residue and air pollutants. Compared to the original raw waste materials, these new forms are significantly more challenging to handle. In the thermal oxidation process, a substantial quantity of energy is used to heat a significant volume of gas with a low VOCs content [Choi et al., 2000]. One of the widely used techniques for removing VOCs is PCO, which has shown better efficiency and stability. However, in this process, traditional photocatalytic materials like TiO_2 can only be activated by UV light, and UV sources are potentially considered as environmentally hazardous [Balk et al., 2011]. The methods mentioned above are not useful in terms of cost-effectiveness for the removal/decomposition of VOCs when the concentration is low, as it is challenging to prolong their specific requirements.

NTP or cold plasma technologies are promising and are being investigated to decompose VOCs into less toxic by-products due to their cost-effectiveness and high decomposition efficiency at ambient conditions [Vandenbroucke et al., 2011b] [Oda, 2003]. The plasma-produced HEEs hit carrier gas molecules and produce RONS. These species disrupt different chemical bonds (e.g., C-H and C-C bonds) and enable the VOCs decomposition into less harmful molecules and other by-products under atmospheric conditions [Chung et al., 2019]. Accordingly, different types of NTP or cold plasma discharges like surface discharge [Norberg, 1992], CD [Huang et al., 2001] [Penetrante et al., 1997], DBD [Oda et al., 1999] [Snyder et al., 1998], packed bed discharge [Chang et al., 2005] [Ding et al., 2005] have been researched as a surrogate method to degrade different types of VOCs. A packed-bed arrangement can provide evenly distributed flows, but at the same time, it can also lead to a higher pressure drop across the discharge region and requires imposing a minimal pressure differential which is the big drawback for this technology right now. On the contrary, we aimed to develop a cold plasma discharge system on a coaxial configuration which can provide dimensional flexibility with better VOCs degradation efficiency. Karatum and Deshusses [Karatum et al., 2016] showed that benzene (58%) is most challenging to decompose when compared with other VOCs like toluene (74%), ethylbenzene (81%) and n-hexane (90%) via using a packed bed reactor. It has been observed that an aromatic compound with an side chain like toluene (C_7H_8) or xylene (C_8H_{10}) will require less energy for complete oxidation than aromatic compounds without an side chain like benzene (C_6H_6) [Chae et al., 1999].

In this chapter, we report a SDBD plasma source in a coaxial configuration in combination with TiO_2 NPs catalyst for the decomposition of VOCs in an enclosed environment [Jangra et al.,

2023b]. To check the performance of the SDBD plasma source, the VOCs removal efficiency has been evaluated and compared between two aromatic compounds, toluene and benzene. The main task of the present study is to show a system that can be effectively used to degrade VOCs without a continuous flow of air and VOCs through the reactor. Instead, VOCs can be treated in an enclosed environment by directly operating the SDBD plasma source. The optimization of the developed SDBD plasma source in terms of operational parameters (i.e., applied voltage and frequency) and removal efficiency of treated VOCs is carried out, and the obtained results are correlated.

4.2 Materials and Characterization Methods

Benzene (C_6H_6) and Toluene ($C_6H_5CH_3$) were procured from Merck, India. An already described SDBD plasma source in the section 2.2.2 has been used for the degradation of toluene and benzene from the enclosed environment of sizes 0.34 m^3 . The SDBD plasma source comprises a coaxial surface DBD arrangement and an original/operational view of the source is shown in Figure 4.1. The detailed experimental set-up is discussed in section 2.3 in chapter 2. The plasma discharge is produced at atmospheric pressure, and ambient air is used as the gas carrier. A variable bipolar pulsed power supply is used to produce SDBD plasma. In this geometry, random local electric field generation is possible through the surface discharge, which is otherwise produced in volume dielectric discharge with much more complexities [Wang et al., 2018b].

Firstly, the SDBD plasma source has been characterized for its electrical and optical properties by means of V-I characteristics and OES. After the optimization of applied voltage, frequency and the parameters associated with them such as discharge power, concentration of reactive species, the developed source has been further used for the degradation of VOCs. For the assessment of VOCs (toluene and benzene) degradation, the SDBD plasma source has been operated in a VOC treatment chamber. The complete experimental setup used for the degradation of toluene and benzene is already depicted in Figure 2.11. A digital VOC monitor {ToxiRAE Pro PID (0.1 – 2,000 ppm range, 0.1 ppm res)} is used to record the real-time concentration of VOCs (in ppmv) before and during the treatment by the plasma reactor.

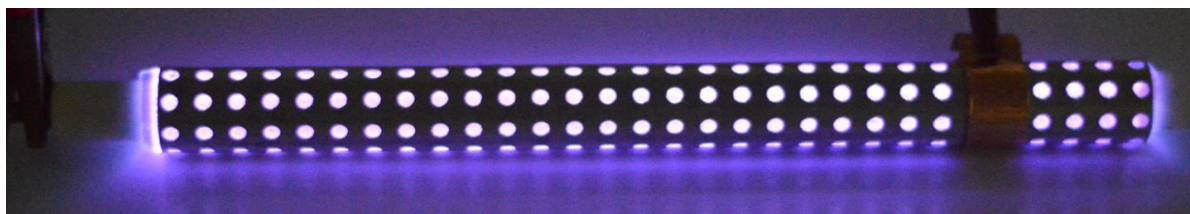


Figure 4.1: Original view of the SDBD plasma source.

Again, TiO_2 NPs were prepared using the sol-gel method as described earlier in the section 2.4.1 and coated on the outer grounded electrode via a dip-coating process. This catalyst was chosen because it has advantages over other photocatalysts, including low cost, exceptional optical and electrical characteristics, high chemical stability, non-toxicity, and eco-friendliness [Lazar et al., 2012]. The characterization techniques used for the phase and morphological analysis of TiO_2 NPs are identical as discussed in section 3.3.2 of chapter 3. It is well known that the photocatalytic process is a surface process, and the adhesion of TiO_2 NPs to the aluminium electrode is what matters most. Cleaning the aluminium sheet and performing a scotch tape test to confirm adhesion were done, and it has been observed that coatings are quite stable and do not degrade over time. This further leads to generating $\bullet OH$, as one of the reactive species, for faster VOCs degradation.

The initial concentration of VOCs in an airtight box is estimated using the following relationship [K. et al., 2008],

$$\text{Concentration (ppm)} = 24.45 \times \text{concentration} \left(\frac{\text{mg}}{\text{m}^3} \right) \div \text{molecular weight} \quad (4.1)$$

For the used volume of the test box, the concentrations (mg/m³) of toluene and benzene for 1 ml were 2550 mg/m³ and 2576.5 mg/m³, respectively. This corresponds to the 100 ± 2 ppm optimized concentration from an amount of 148 µl and 124 µl of toluene and benzene used in the experiment.

4.3 Results and Discussion

4.3.1 Characterization of SDBD Plasma Source

To analyse the performance of the pulsed power supply driven SDBD plasma source, the average discharge power (P) has been calculated. In general, the total measured current consists of two components, the conduction current (I_c) and the displacement current (I_d). Only the conduction current is of primary concern since it is an accurate measure of all electric losses and, consequently, the amount of power dissipated in the system. The displacement current can be obtained from the equivalent capacitance of the circuit and $\frac{dV}{dt}$ as,

$$I_t = I_d + I_c \quad (4.2)$$

$$I_d = C \frac{dV}{dt} \quad (4.3)$$

When the discharge is off, I_d is equal to the measured current and the corresponding displacement current is estimated to be about 50 mA for 5.5 kV/25 kHz applied condition.

Figure 4.2 (a) shows the typical V-I characteristic of the developed SDBD plasma source. The average discharge power of the SDBD plasma source has been obtained from the applied voltage and discharge current waveforms as,

$$E_p = \int V(t) [I(t) - C \frac{dV}{dt}] dt \quad (4.4)$$

$$P = E_p \times f \quad (4.5)$$

Where $V(t)$ is the applied pulse voltage, $I(t)$ is the discharge current, E_p is the energy consumed per pulse, f is the pulse repetition frequency, and C the capacitance of the system that is taken into account while calculating the displacement current. Generally, in the power calculation, the displacement current can be neglected, because it does not contribute to the power that is dissipated in the discharge. A more detailed explanation about the displacement current can be found elsewhere [Schücke et al., 2020] [Böddecker et al., 2022].

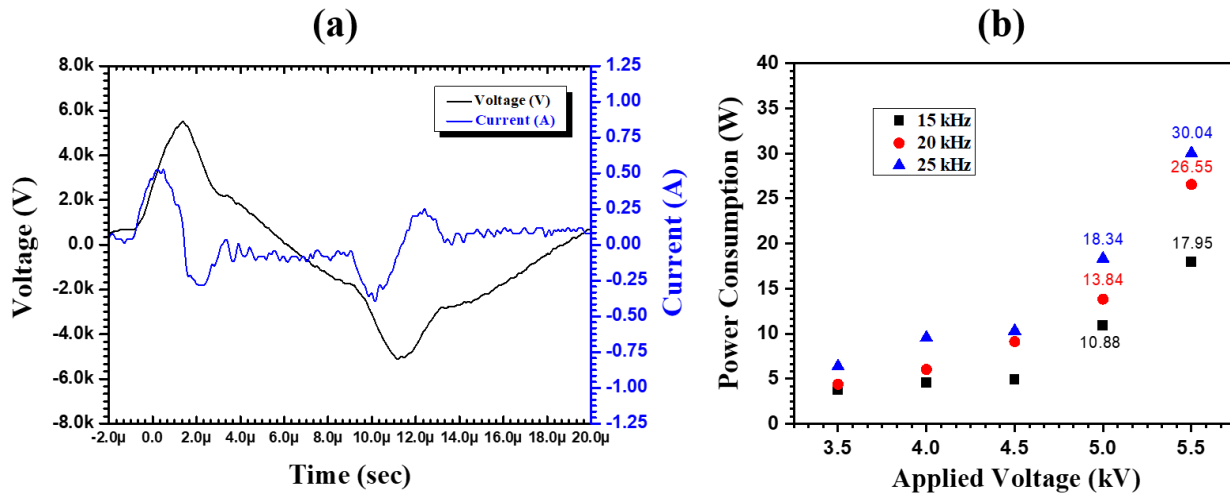


Figure 4.2: (a) Typical VI characteristics of SDBD plasma source at 5.5 kV/25 kHz, (b) Power consumed by the SDBD plasma source v/s supply voltage at different frequencies.

The energy consumed per pulse (in Joule) for each supplied voltage has also been calculated and the consumed energy is then multiplied by the corresponding pulse repetition frequency to determine the power (in Watts) used by the SDBD plasma source. For example, the calculated energy per pulse at 5.5 kV/25 kHz is 12.02×10^{-4} J, which corresponds to 30.04 W consumed power. Figure 4.2 (b) shows the power consumed by the SDBD plasma source at different applied voltages and frequencies. The power consumed by the SDBD plasma source increases from 3.75 W to 17.95 W for the applied pulse voltages from 3.5 kV to 5.5 kV at a fixed applied frequency of 15 kHz.

It was observed that for the combinations of higher supply voltage and frequency (5.5 kV and 25 kHz), the device power consumption reaches a maximum of 30.04 W with a peak discharge current of 532 mA. The used power at higher voltages might be attributed to the creation of many streamers as the supply voltage rises. As a result, there is a threshold voltage and frequency limit beyond which the input energy is not employed to keep the plasma discharge alive. Rather the input energy is wasted due to thermal dissipation, resulting in dielectric (glass) heating. Therefore, it can be argued that the device operation can be fixed for a supply voltage and applied frequency which should be relatively lower but above discharge initiation. The average electron density is also calculated for the SDBD plasma source at the different applied voltages using V-I curves and the method described by El-Zein et al. [El-Zein et al., 2016], and the electron density turns out to be $\sim 4.5 \times 10^{14} \text{ cm}^{-3}$ at 5.5 kV/25 kHz. The obtained electron density is well within the non-thermal non-equilibrium plasma range and in good agreement with previous reporting [Zhou et al., 2009] [Tabaie et al., 2020b].

In order to select the most effective operating parameters for the developed source, the surface temperature of the dielectric material has been measured. Figure 4.3 shows the surface temperature of the plasma source at different applied voltages and at a fixed frequency of 25 kHz. The surface temperature of the dielectric material increases with increases in the applied voltage, which shows that an increase in supplied power causes heating of the glass tube, and at higher supplied powers, the plasma discharge is also not sustained sometimes. As can be seen from Figure 4.3, an increase in applied voltage from 5.0 kV to 5.5 kV increases the dielectric temperature around two folds.

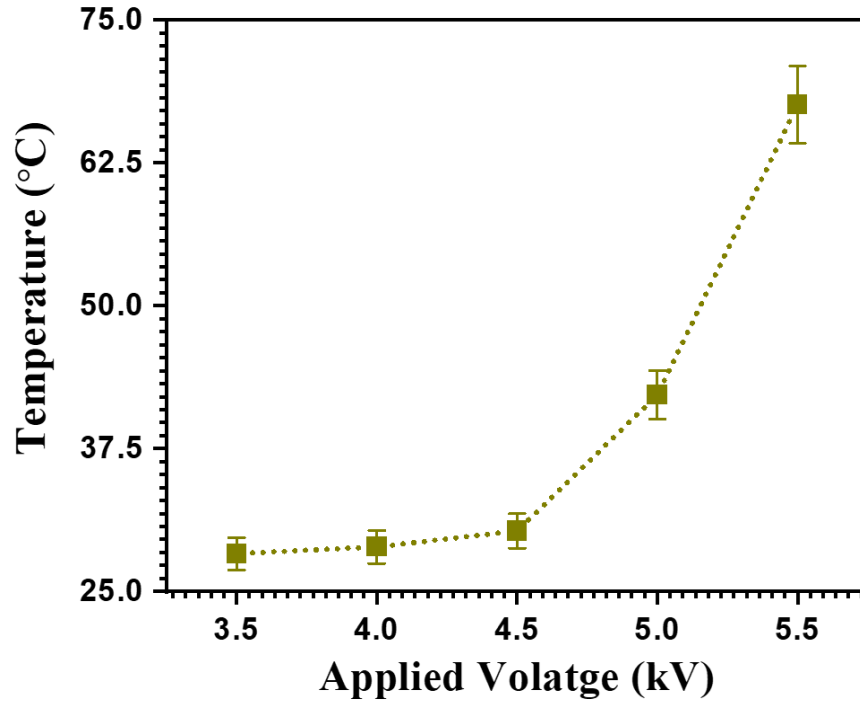


Figure 4.3: Applied voltage v/s SDBD source surface temperature profile at a fixed frequency of 25 kHz.

4.3.2 Optical Emission Spectroscopy and Plasma Characteristics

For the gas phase characterization of the SDBD plasma source, a widely recognized Optical Emission Spectroscopy (OES) technique is employed. Spectra are recorded over the wavelength range of 275 nm to 500 nm, enabling the analysis of excited active species generated by the SDBD plasma source. Figure 4.4 (a) shows the OES of the SDBD plasma source operated at applied parameters 5.0 kV/25 kHz. The spectra were dominated by the peaks related to N_2 second positive system (SPS, C-B) emissions at 316.1, 337.3, 353.6, 357.6, 375.0, and 380.4 nm wavelengths as well as N_2^* first negative system (FNS) at 391.4, 399.8 and 405.3 nm [Misra et al., 2013]. This is because of the very high concentration of molecular nitrogen in the atmospheric air and their direct and stepwise electron impact excitations. Figure 4.4 (a) (inset) shows the OES in the wavelength range of 275 nm to 315 nm and most of the emission peaks lies in the 280–310 nm wavelength range are recognized from the de-excitation of hydroxyl radicals [Feizollahi et al., 2021].

The electron temperature represents the average energy of the electrons in the plasma and is a crucial parameter, as it significantly influences the overall behavior and characteristics of the plasma. In the non-LTE (local thermodynamic equilibrium) or partial-LTE plasmas, the electron temperature can be calculated from the emission spectra by measuring the two lines of an existing atomic/molecular species with same degree of ionization [Tabaie et al., 2020a; Taghizadeh et al., 2014] as depicted in equation 2.5. We have used two spectral lines, one from the first negative system (FNS) and another from the second positive system (SPS) of excited nitrogen molecules having wavelengths 380.4 nm and 391.2 nm, respectively for electron temperature estimation. The values of transition probabilities and statistical weights for different energy levels are taken from NIST database [“NIST Standard Reference Database 78,” 2024] [Tabaie et al., 2020a]. The estimated electron temperature at different applied voltage and at a fixed frequency of 25 kHz is shown in Figure 4.4 (b). At low voltages, the temperature of the electrons may typically increase as the voltage rises. This is due to the fact that a higher applied voltage may result in stronger electric fields, which in turn may accelerate electrons and increase their energy and temperature.

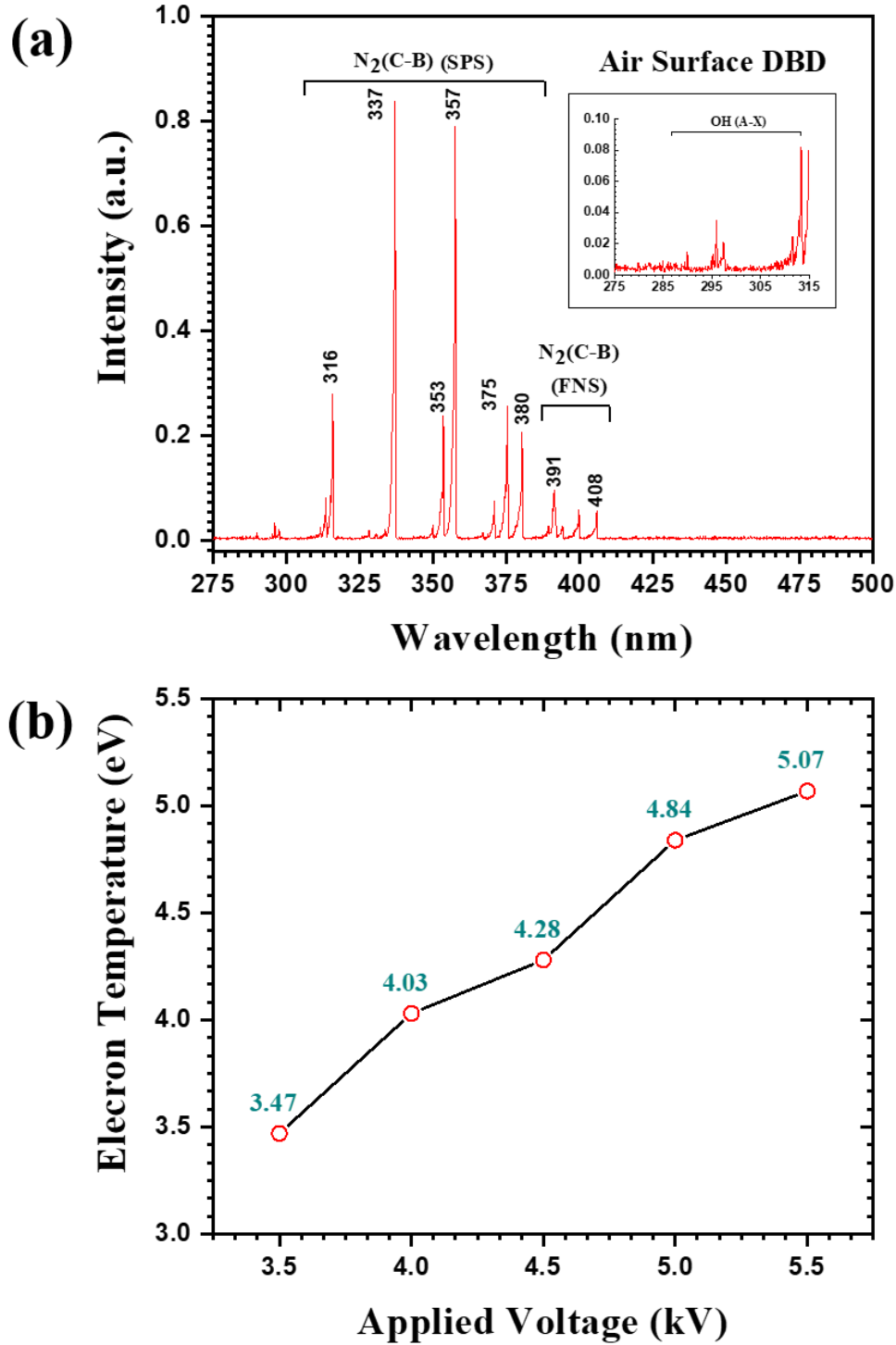


Figure 4.4: Optical emission spectra (OES) of atmospheric air SDBD plasma source operated at 5.0 kV/25 kHz, and (b) electron temperature profile at different applied voltage and at a fixed frequency of 25 kHz.

The potential use of thermocouple readings for the gas temperature in the atmospheric pressure cold plasma discharge is limited. The optical emission spectra can also be used for the gas temperature measurement in the discharge region. For this, the rotational temperature (T_{rot}) of molecules can be obtained by fitting the experimental molecular bands of N_2 with the simulated spectrum by minimizing the mismatch between the two spectra. The estimated T_{rot} can provide a good indication of the T_{gas} if the rotational population of N_2 gas molecules is under equilibrium conditions. A more detailed explanation of this method can be found elsewhere [Sahu et al., 2016b, 2016a]. Given that accurately analysing gas temperature necessitates significant computational efforts to ensure precise measurements and verify equilibrium conditions, this study opts for simplicity by using a conventional thermocouple to measure the

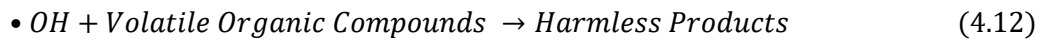
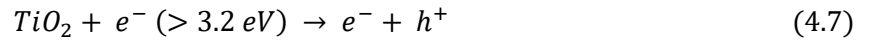
temperature of the plasma source and dielectric. The measured gas temperature for the developed SDBD plasma source can be seen from Figure 4.3.

4.3.3 Quantification of •OH and O₃

The relative concentration of the numerous reactive species produced during the discharge is the major factor influencing the plasma source's effectiveness. As already discussed, for the higher production of reactive species, the outer electrode of the SDBD plasma source is coated with TiO₂ NPs. It is generally known that photocatalysts may be activated by exposing them to UV light with enough photonic energy ($h\nu$) to overcome the gap between the conduction and valence bands, causing the formation of electron-hole pairs.



In previous studies, it has been investigated that UV intensity produced by DBD plasma discharges is not necessarily the determining factor to activate photocatalysts because of their much lower UV intensity in comparison to UV lamp emissions [Mei et al., 2016b] [Guaitella et al., 2008]. Plasma discharges can generate UV radiation; however, in this study, we have measured the UV intensity generated by the SDBD plasma source, by using a calibrated UV power meter. Due to the surface discharge produced, almost negligible UV intensity is recorded in this study. What we prompted here is that the HEEs (3 – 5 eV) generated by the SDBD plasma are considered to be the primary factor in activating TiO₂ photocatalyst for electron-hole pair generation, formation of hydroxyl groups, and consequently VOCs degradation. Hydroxyl radicals with strong oxidising properties (oxidation potential: 2.8 V) could react with VOCs and their intermediates for faster degradation. The following principal reactions mainly describe the formation of •OH via the TiO₂ coated surface as well as from the positive and negative ions produced by subsequent processes;



Accordingly, we have quantified the concentration of •OH generated by the SDBD plasma source in the reaction chamber along with O₃ that might have produced due to surface DBD discharge. •OH and O₃ were quantitatively analysed at different voltages (3.5 kV to 5.5 kV) and a fixed frequency of 25 kHz. Figure 4.5 (a) shows the concentration of •OH at different applied voltages and fixed frequency of 25 kHz. It clearly shows that the concentration of •OH increases with increasing voltage at fixed pulse repetition frequency. It is observed that at a maximum concentration of ~ 70 µM of •OH were generated in the gas phase at 5.5 kV/25 kHz and the yield of •OH is proportional to the applied voltage. Similar to •OH, the O₃ concentration is increased with applied voltages [(see Figure 4.5 (b))], and it reaches a maximum value of 0.8 ppm at the applied voltage of 5.5 kV. The concentration of O₃ reported in this study is significantly lower than previous reporting [Vaze et al., 2010].

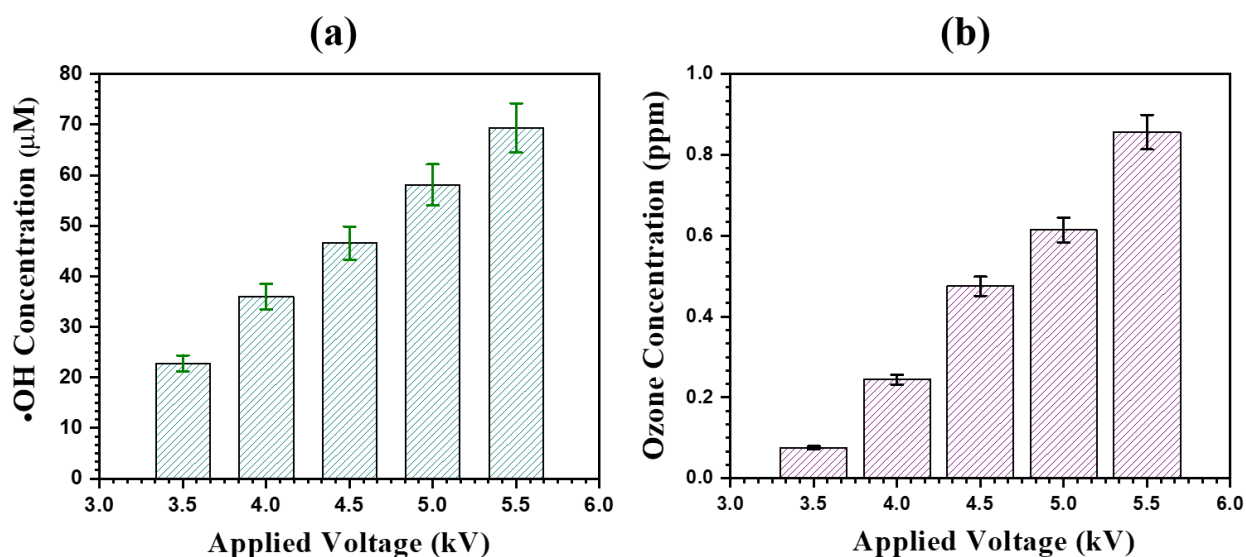


Figure 4.5: Concentration of (a) •OH and (b) O₃ measured at different applied voltages at a fixed frequency of 25 kHz.

4.4 Characteristics of VOCs decomposition

Toluene (C₇H₈) and benzene (C₆H₆) were selected as the target VOC pollutants so as to analyse the decomposition efficacy of the SDBD plasma system. The initial and during experiment concentrations of both the selected pollutants were recorded at an interval of 5 minutes, up to 60 minutes. After monitoring the constant initial concentration for 60 minutes, the decomposition of toluene and benzene by the SDBD plasma source has been further monitored for up to 60 minutes. Figure 4.6 (a), 4.6 (b), and 4.6 (c) shows the trends of toluene decomposition at a frequency of 15 kHz, 20 kHz, and 25 kHz, respectively, with different applied voltages. It is found that the concentration of toluene is decreasing continuously in all combinations of applied voltages and frequencies. However, the maximum decomposition of toluene occurred at 5.5 kV/25 kHz. Figure 4.6 (d) shows the removal efficiency of toluene at different applied parameters and it was observed that the removal efficiency is increased with increasing pulse repetition frequency. This is due to the fact that at higher frequencies the discharge power increases in the SDBD plasma that may lead to a higher number of reactive species generation.

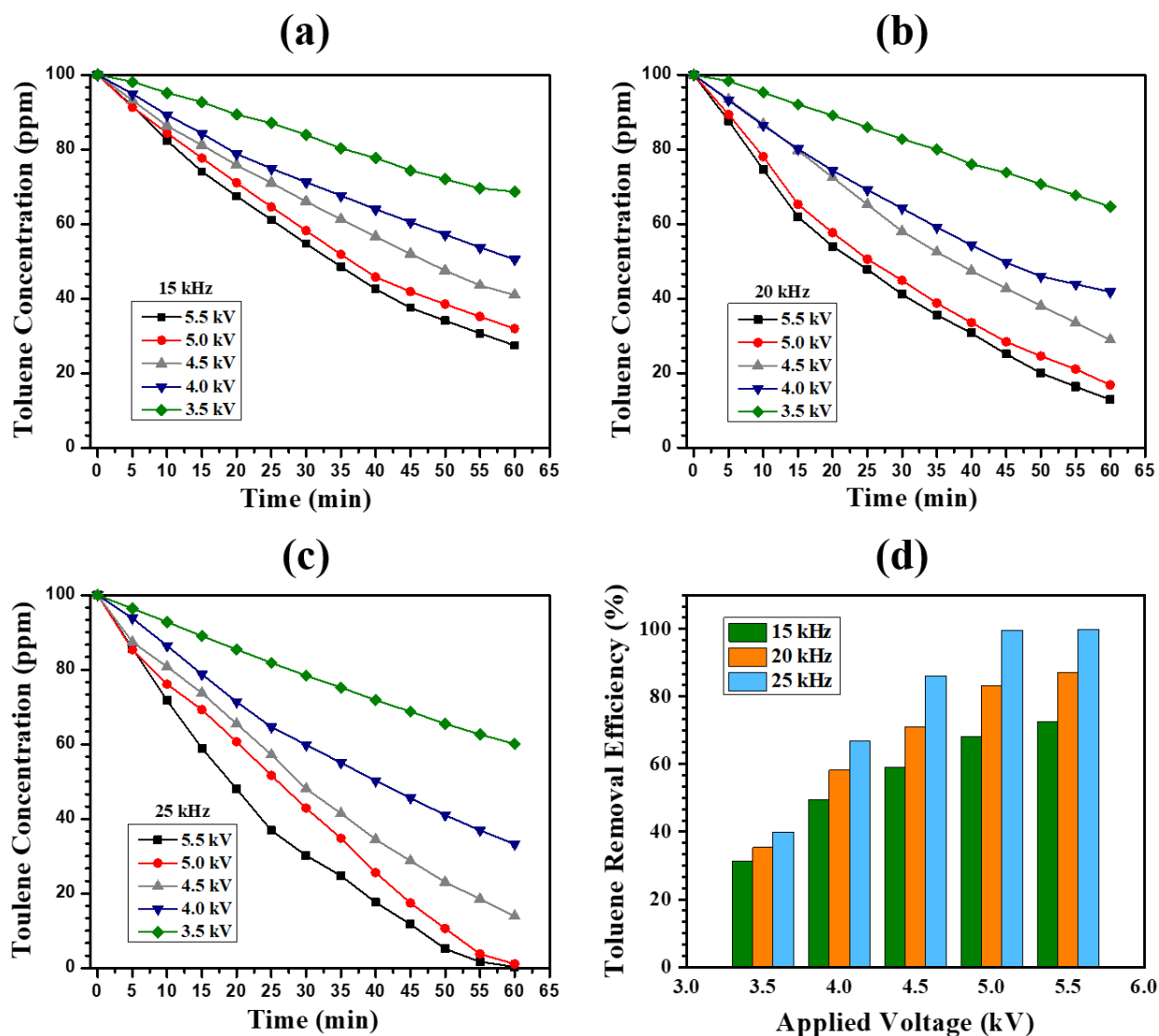


Figure 4.6: Toluene degradation performance by SBDB plasma source (a) at 15 kHz, (b) at 20 kHz, (c) at 25 kHz at different applied voltages, and (d) removal efficiency of toluene at different applied parameters.

A similar trend has been obtained in the case of benzene degradation, as can be seen from Figure 4.7. Figure 4.7 (d) shows the benzene removal efficiency at different combinations of applied voltages and frequencies. The benzene removal efficiency has been observed to have increased with increasing frequency, which is evident due to the higher number of reactive species at higher discharge powers. The comparative data of the highest and lowest removal efficiency of toluene and benzene attained are shown in Table 4.1.

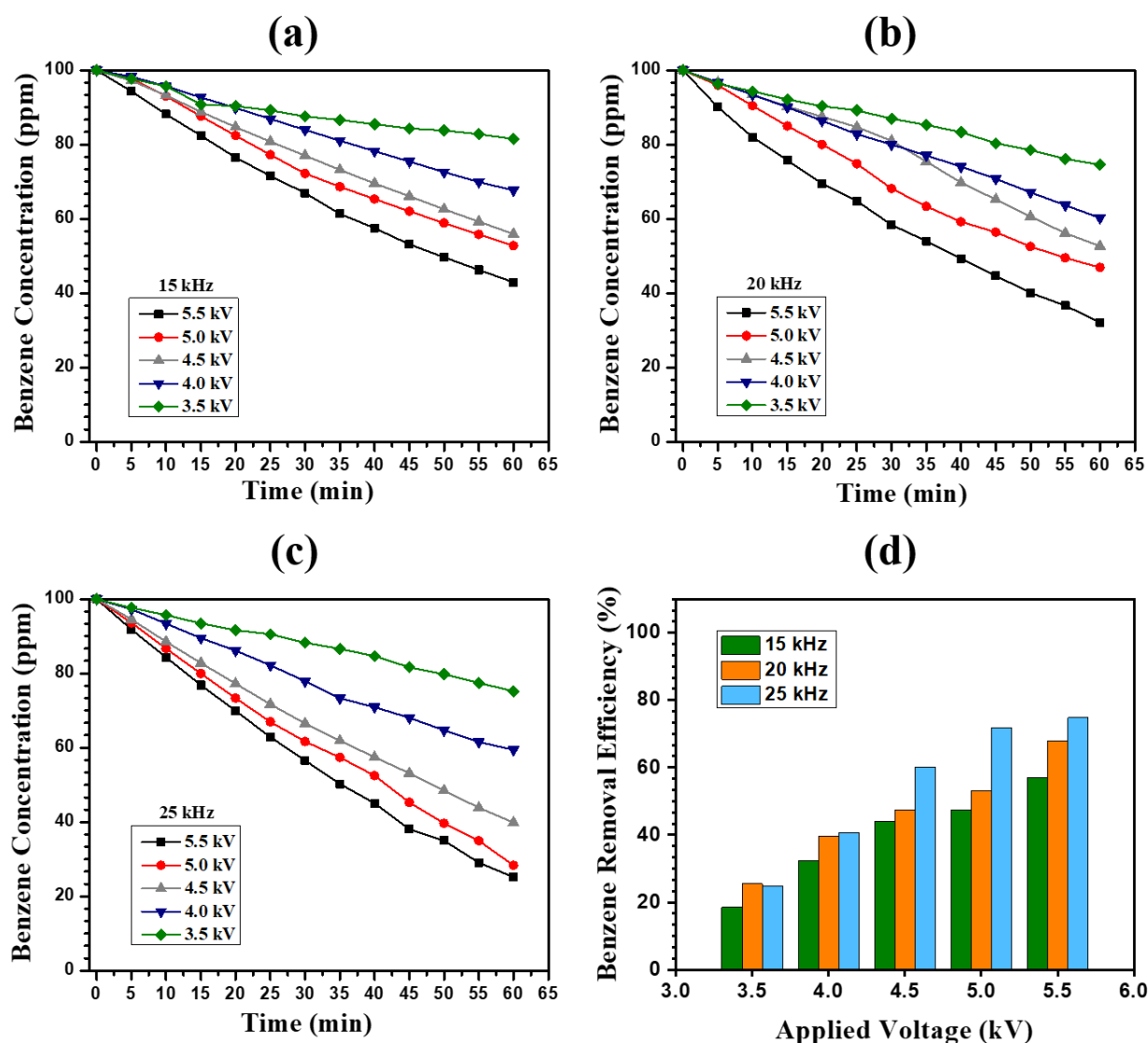


Figure 4.7: Benzene degradation performance by SBDB plasma source (a) at 15 kHz, (b) at 20 kHz, (c) at 25 kHz at different applied voltages, and (d) removal efficiency of benzene at different applied parameters.

Table 4.1: Removal efficiency of toluene and benzene at different applied conditions

Applied Voltage (kV)	3.5	5.5	3.5	5.5
Pulse Repetition Frequency (kHz)	% Removal Efficiency (Toluene)		% Removal Efficiency (Benzene)	
15	31.3	72.6	18.5	57.1
20	35.4	87.1	25.4	67.9
25	39.9	99.7	24.8	74.8

As shown in Figure 4.8 (a) and 4.8 (b), the degradation of toluene and benzene is best fitting in the pseudo first order kinetic model. The rate constant for the toluene and benzene degradation at 5.5 kV/20 kHz is 0.033 min^{-1} ($R^2 > 0.99$) and 0.0183 min^{-1} ($R^2 > 0.99$), respectively. The toluene degraded nearly 2 times faster than the benzene. Furthermore, aromatic compounds with side chains (like toluene) would require less energy for complete oxidation than aromatic

compounds without an aside chain (like benzene). This behaviour is attributed to their bond dissociation energy (BDE). To understand it more clearly, the BDE of C-C in toluene and benzene are compared. The BDE of C-C in benzene is 5.5 eV, while the BDE of C-C in the methyl (CH_3) and benzene (C_6H_6) ring is roughly 3.6 eV. Also, the BDE of the C-H bond in the benzene ring is 4.3 eV. So, plasma-produced HEEs, having an energy of more than 5.5 eV, may easily destroy the C-C bond in benzene and toluene.

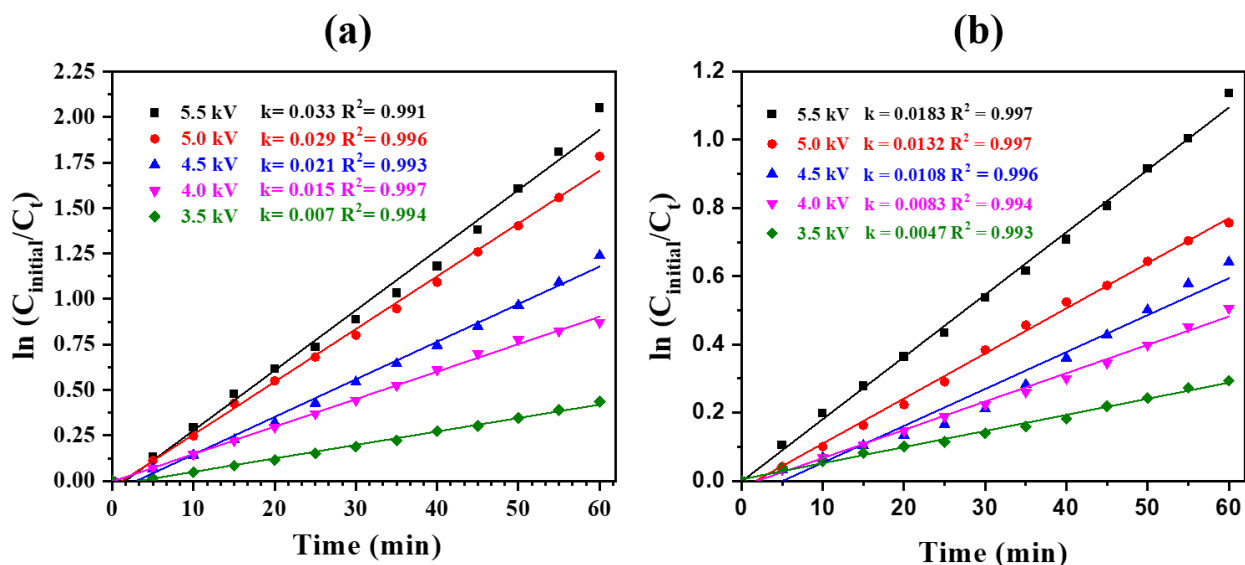


Figure 4.8: Pseudo-first order kinetics for (a) degradation of toluene, and (b) degradation of benzene under SDBD plasma source.

The removal efficiency of toluene at each applied voltage (at a fixed frequency) is more than the removal efficiency of the benzene because of its lower BDE. Figure 4.9 (a) depicts the comparison of toluene and benzene removal efficiency at a fixed frequency of 25 kHz with varying voltages. The corresponding rate constants for toluene and benzene degradation can be seen from Figure 4.9 (b), which again revealed that the degradation rate of toluene is much faster than that of benzene. The reaction rate of toluene and benzene has been calculated using equation 2.10 as described in section 2.5 of chapter 2. The obtained results in this study are consistent with the previous reporting [Liang et al., 2022a]. It is seen that when the applied voltage increases beyond 5.0 kV, it does not contribute to the decomposition process rather increases the power consumption in the SDBD plasma itself. This can be further attributed from Figure 4.9 (a) that, when the toluene and benzene removal efficiency has increased from 98.9% to 99.7% and 71.7% to 74.8%, respectively, the power consumption of the SDBD plasma source has increased by approximately two folds [see Figure 4.2 (b)]. It means power consumed by the device is lost in the thermal dissipation of the dielectric material rather than the decomposition process. The optimized power for the developed SDBD source is much lower compared to other conventional methods like catalytic oxidation, thermal oxidation and photocatalytic decomposition which provides a better scope of VOCs reduction effectively. Table 4.2 depicts the reaction rate constant for the decomposition of toluene and benzene and it is worth noticing that the reaction rate constant of toluene is approximately halve the reaction rate of benzene.

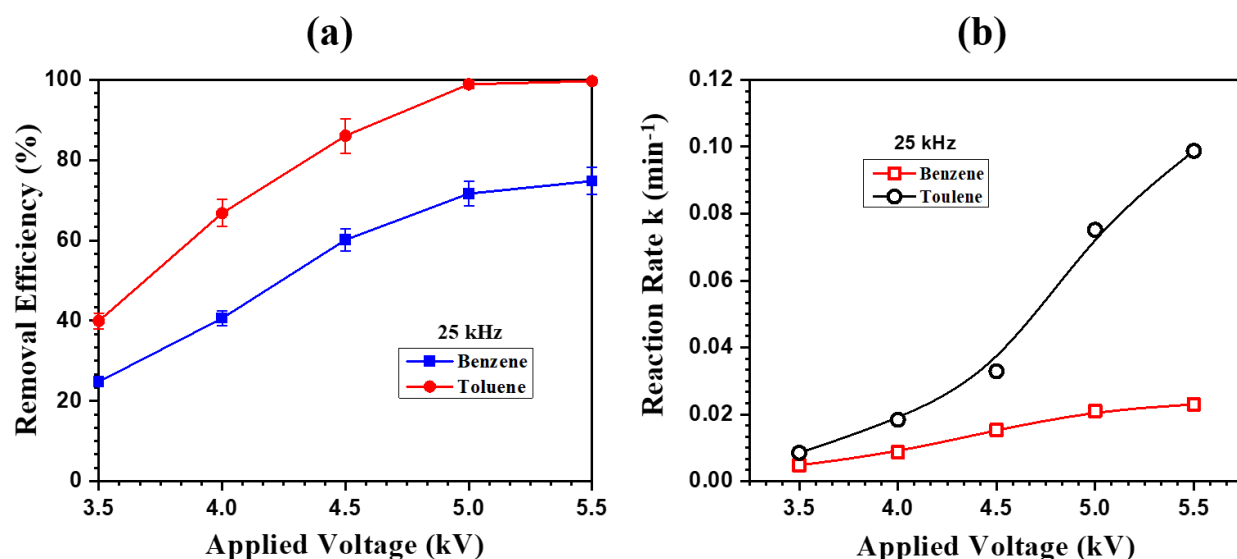


Figure 4.9: (a) Comparison of benzene and toluene removal efficiency and, (d) degradation reaction rate constant of toluene and benzene as a function of applied voltage at fixed frequency of 25 kHz.

Table 4.2: Reaction rate constants of toluene and benzene at different applied voltage at fixed frequency of 25 kHz.

Applied Voltage (kV)	Reaction rate k (min^{-1})	
	Toluene	Benzene
3.5	0.00475	0.0005
4.0	0.00868	0.01838
4.5	0.01523	0.03285
5.0	0.02102	0.05516
5.5	0.02297	0.06876

The key difference between benzene and toluene is their molecular structure; toluene has a methyl group attached to the benzene ring, while benzene has no methyl groups attached. Benzene is a closed ring of six carbon atoms, so the decomposition of benzene becomes extra difficult [Chae et al., 1999] [Ogata et al., 2002]. This difference of decomposition has also been observed from their possible degradation pathway. The possible degradation pathways of toluene and benzene are depicted in Figure 4.10 (a) and 4.10 (b), and it is observed that benzene's degradation pathway is significantly more complex than toluene's because of its aromatic structure. The obtained performance of toluene and benzene decomposition is due to the synergistic effect of TiO_2 NPs catalysts with surface DBD discharge. In case of benzene, the destruction process is not only dominated by HEEs but also by a large number of radicals such as N , O , $\bullet\text{OH}$, $\bullet\text{H}$, and $\bullet\text{HO}_2$ [Hu et al., 2016] [Ogata et al., 1999]. Since the energy range of electrons in cold plasma can be from 3.2 eV to 10 eV, it would be much suitable for chemical bond breakage as well as the excitation of atomic and molecular species. As soon as the benzene ring is ruptured by using HEEs and active radicals, a series of possible reactions happen subsequently between toluene and HEEs [Evuti et al., 2016]. According to Kim et al. [Kim et al., 2005], HCOOH can also be generated as a frequent intermediate during the degradation of aromatic compounds that is a major intermediate in the formation of CO_2 . Ultimately the energetic electrons and active radicals will attack the formic acid, resulting in the creation of innocuous CO_2 and H_2O . These possible reaction mechanisms can be found elsewhere [Liang et al., 2022b] [Ma et al., 2016].

The developed source is easily scalable in length and diameter according to the requirement, only the power consumed to initiate the discharge would change. If we consider a closed room then the efficiency of the SBDB source will depend on whether the used room is completely closed (without ventilation) or there is some ventilation from the windows or gates. If the room is completely closed, then the efficiency of the system may remain the same depending on the concentration of VOCs to be treated. Otherwise, if the room is ventilated, then the efficiency of the system may drop due to the continuous involvement of contaminated air from the outer environment.

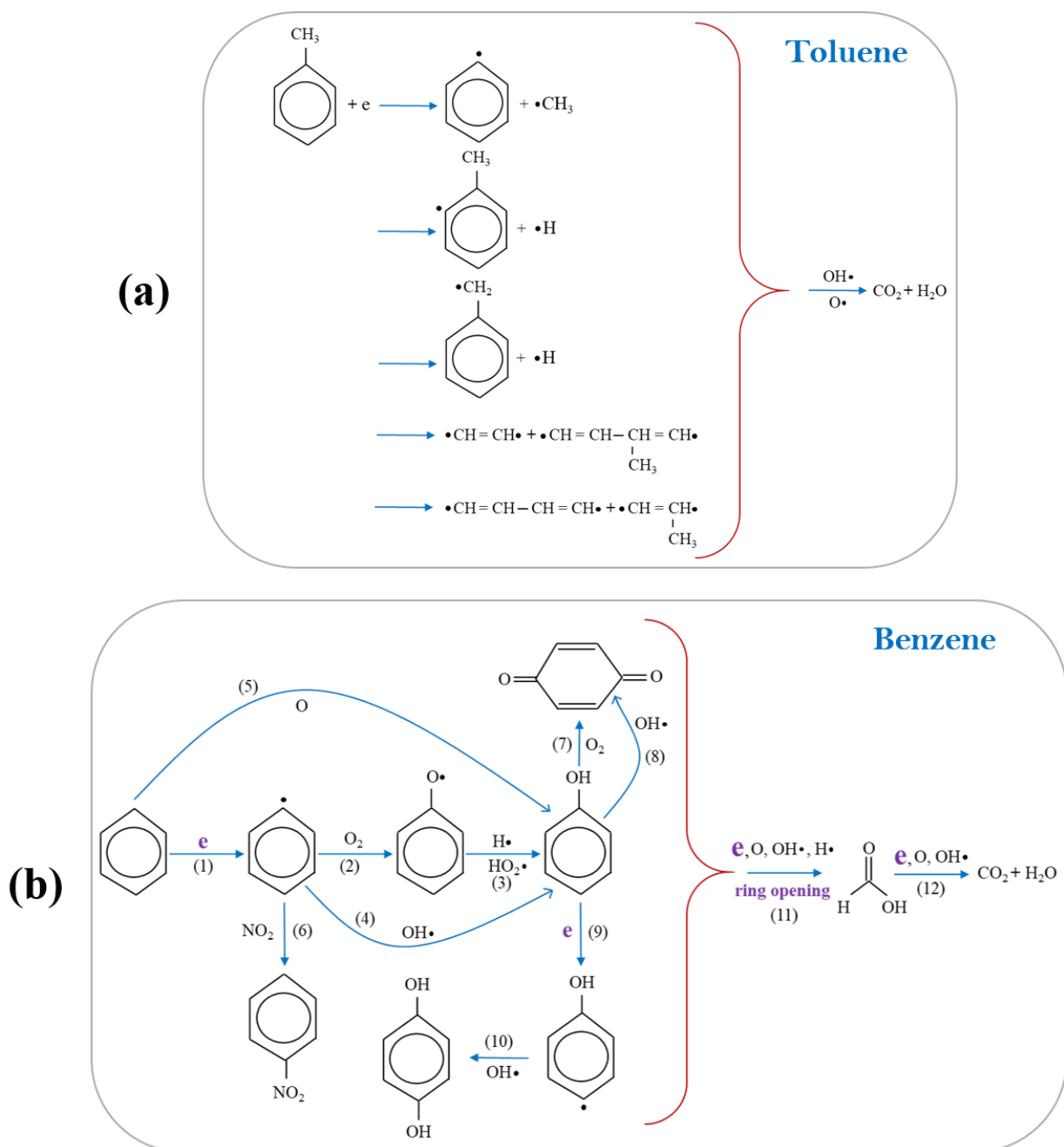


Figure 4.10: Possible degradation pathway of (a) toluene and (b) benzene decomposition via SDBD plasma source.

4.5 Conclusion

A SDBD plasma source combined with TiO_2 nanoparticles catalyst has been designed and developed and it is analysed for the decomposition efficiency of VOCs. The removal efficiency of

toluene and benzene is reported around 99.7% and 74.8%, respectively, in 60 minutes of continuous operation of the SDBD plasma source. The high energetic electrons and reactive species produced by the SDBD plasma are considered as the main driving source for the decomposition process. A bipolar pulsed power source has been used to create cold plasma, which has produced intense discharges and energetic electrons in the coaxial SDBD configuration. The electron temperature in the plasma discharge is measured using OES diagnostic, which is found to be in the range of 3-6 eV at different applied conditions. The energetic electrons produced in the plasma discharge are good enough to activate the TiO_2 nanoparticles catalyst instead of UV light. The developed SDBD is an easily scalable source and can be extended according to the application for VOCs degradation. This investigation opens the way for decoupling the more sophisticated NTP-catalysis process for surface DBDs in the near future.