MEASUREMENT OF NO\textsubscript{x} PRODUCTION IN AN ATMOSPHERIC CORONA DISCHARGE

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Abstract

Nitrogen oxides (NO\textsubscript{x}) are one of the main noxious pollutants in flue gases from thermal power plants and from other economic activities and in exhaust gases and are the cause of acid rain and photochemical smog. Many chemical components have been identified in urban air pollution. These pollutants include nitrogen oxides NO\textsubscript{x} (NO, NO\textsubscript{2}, N\textsubscript{2}O), sulphur dioxide SO\textsubscript{2}, carbon monoxide CO and many volatile organic compounds [1].

1. Introduction

Formation of O\textsubscript{3} is photochemically related

\[ O_2 + hv \rightarrow O + O \]

and

\[ O + O_2 \rightarrow O_3 \]

Nitrogen oxides are also produced from corona and spark discharges. Thus, the same processes take place in atmospheric point corona discharges during the conditions of increased geoelectric field [2].

Production of NO\textsubscript{x} in the examined discharges can also compared with the nitrogen oxides production in the single point (or multipoint) corona discharges on the points of trees. These discharges are responsible for the electric charge transfer from the atmosphere to the Earth and for the ozone and various hydrocarbons (terpenes) generation and destruction in the forest during suitable geoelectric field conditions [3].

Nitrogen fixation is a significant source of nitrogen for plants and trees. However, the only organism able to fix atmospheric nitrogen are certain algae and bacteria. The deposition of NO\textsubscript{x} into vegetation is one sink in the atmospheric nitrogen cycle. The adaptation of plants to the uptake of NO\textsubscript{2} also shows in the extra sensitivity of these plants and trees to gaseous air pollutants. Appropriate enzymes have evolved for the assimilation of NO\textsubscript{2} in leaves and needles and probably can be used as pollution indicators.
The reactions which could produce NO, NO$_2$ and N$_2$O are [6]

\[
\begin{align*}
O + N_2 & \rightarrow NO + N, \\
N + O_2 & \rightarrow NO + O, \\
O_3 + NO & \rightarrow NO_2 + O_2, \\
O + N_2 & \rightarrow N_2O, \\
O_2 + N_2 & \rightarrow N_2O + O.
\end{align*}
\]

The reaction of NO$_2$ with OH (hydroxyl radical) yields HNO$_3$, which is one component of acid rain

\[
NO_2 + OH \rightarrow HNO_3.
\]

2. Experimental results

In this work we present experimental results with several types of atmospheric pressure discharges: single point-to-plane corona, multipoint-to-plane corona, both with metal electrodes [2] and multineedle corona discharge with electrodes from the natural living material, mainly from needles of pine and spruce [3] (see Fig. 1 and 2). The gas products were lead away to the NO$_x$ analyser. We used analysers working with the chemiluminiscence reaction of ozone or NO$_2$ with selective reagents in the aerosol of the luminol. The minimum measurable density was 0.0188 µg/m$^3$ for NO$_2$.

![Fig. 1. Schematic view of the experimental set-up for measurement of corona on small tree of pine and spruce.](image-url)
In order to compare our results with other measurement, the yields of NO\textsubscript{2} and NO were also compared with each other. The comparison shows that mainly NO\textsubscript{2} was formed in the discharge chamber, which is in agreement with previous measurement [4].

The yield of NO\textsubscript{2} by a DC atmospheric positive corona discharge was about \(5 \times 10^{12}\) molecules /s/\(\mu\)A. This value agrees well with the results of Punkkinen and Aurela [4].

It can be seen that multineedle configurations yield more NO\textsubscript{2} than a single point with the same corona current. This fact suggests that the density and number of needles could probably have adapted to the electric nitrogen fixation. Fig. 3 shows the some results for the positive corona discharge in multipoint configuration with electrodes made from brass. On fig. 4 we present the preliminary results obtained for positive (streamer) corona discharge on coniferous tree – pine.

![Electrode systems for single – and multi – needle configuration.](image)

![Graph showing NO\textsubscript{2} production as a function of discharge current.](image)

Fig. 2. Electrode systems for single – and multi – needle configuration.

Fig. 3. NO\textsubscript{2} production as a function of discharge current for positive corona discharge with one-, three- and seven point metal (brass) electrodes.
Fig. 4. NO\(_x\) production as a function of discharge current for positive corona discharge on small tree of pine (Picea abies).

3. Other applications

We present also the measurement of NO\(_x\) and NO\(_3\) produced during the running of the common electrical appliances (drilling machines, other electric motors, breakers, air cleaners, ionizers etc.) in which small electrical discharges, such as corona and short arcs, arise. The results of measurement are shown in Tab. 1. We state that besides the combustion processes, representing the main source of nitrogen oxides, and other production activities the entirely common electrical appliances in which some types of electrical discharges occur are also generators of these undesirable gases. Such appliances can be met nowadays at the majority of workplaces.

4. Conclusion

We present some preliminary results concerning the NO\(_x\) production by atmospheric corona discharge. The difference between normal and plant corona may be caused by the presence of complex hydrocarbons, volatile aromatic compound (terpenes, isoprene, toluene [5]) released from the plants and subsequent changes in surrounded atmosphere.
Tab. I. Measurement of NO$_2$ and O$_3$ production by common electrical appliances

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>Current [mA]</th>
<th>Contact voltage [V]</th>
<th>Production of NO$_2$ [ppb]</th>
<th>Production of O$_3$ [ppb]</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling machine</td>
<td>330</td>
<td>223</td>
<td>125.5</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>Blower motor (collector, series)</td>
<td>330</td>
<td>12</td>
<td>37</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>Blower motor (collector, shunt)</td>
<td>420</td>
<td>24</td>
<td>54</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>Wiper motor (collector, shunt)</td>
<td>1460</td>
<td>6</td>
<td>6.4</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>Collector motor for instruments</td>
<td>156</td>
<td>24</td>
<td>6.7</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>Circuit breaker I</td>
<td>34</td>
<td>12</td>
<td>35.3</td>
<td></td>
<td>$\leq$1</td>
</tr>
<tr>
<td>Circuit breaker I</td>
<td>60</td>
<td>24</td>
<td>92</td>
<td></td>
<td>$\leq$2</td>
</tr>
<tr>
<td>Circuit breaker II</td>
<td>16</td>
<td>12</td>
<td>22</td>
<td></td>
<td>background</td>
</tr>
<tr>
<td>Circuit breaker II</td>
<td>28.5</td>
<td>24</td>
<td>48.1</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Vibrator</td>
<td>60</td>
<td>3.5</td>
<td>4</td>
<td></td>
<td>6.5</td>
</tr>
<tr>
<td>Vacuum tester</td>
<td>265</td>
<td>80 / 6 kV</td>
<td>$\leq$1000</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Home ionizer</td>
<td></td>
<td>4.6 kV</td>
<td>15.3</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Home ionizer with carbon fibre I</td>
<td></td>
<td>4.8 kV</td>
<td>16.6</td>
<td></td>
<td>17.5</td>
</tr>
<tr>
<td>Home ionizer with carbon fibre II</td>
<td></td>
<td>4.7 kV</td>
<td>13.2</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Blanched rice shacked in polyethylene vessel</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

This work has been supported by the research program No. J04/98.212300016 "Pollution Control and Monitoring of Environment" of the Czech Technical University in Prague (sponsored by the Ministry of Education, Youth and Sports of the Czech Republic).

References


