Corona-discharge treatment of gaseous benzene, toluene and xylene at atmospheric pressure

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1. Introduction
Recently, various kinds of VOCs (volatile organic compounds) contained in exhaust gas from factories, automobiles, etc., cause major environmental issues.

- Toluene (C₆H₅CH₃) and xylene (C₆H₄(CH₃)₂) are emitted to the environment in the largest volume.
- The emission volume of benzene (C₆H₆) is less than those of toluene and xylene, but it has carcinogenicity and teratogenicity.

2. Experimental apparatus and conditions

- Electrodes
  A multi-nozzle electrode, which consists of thorium, uranium-coated needles (25 mm length and 4 mm diameter), and a plane electrode made of stainless steel (30 mm diameter), are placed in a cylindrical discharge chamber.
- The distance between the multi-nozzle electrode and the plane electrode is fixed at 35 mm.

- Discharge chamber
  The cylindrical discharge chamber is made of stainless-steel, with 100 mm inner diameter and 300 mm height.

- Applied voltage
  A positive DC high voltage (20–25 kV) is applied to the multi-nozzle electrode, generating a corona discharge.

- Gas conditions
  Nitrogen-oxygen mixture is used as background gas, and the mixture ratio is N₂/O₂ = 80/20.
  Initial gas pressure in the chamber is 1013.25 kPa (atmospheric pressure), and initial concentrations of benzene, toluene and xylene are 300 ppm.

- Concentration measurement
  Concentrations of benzene, toluene, xylene and by-products are measured by a Fourier Transform Infrared Spectrometer (Shimadzu, FTIR-8900) equipped with a gas cell (Infrared Analysis, 1000 ppm), which has optical path length of 10 m.

- Measurement of voltage and current
  Applied voltage is measured by a high-voltage probe (Tektronix P6015A).
  Discharge current is calculated by voltage drop across a non-inductive resistance (1 kΩ), which is connected between the plane electrode and the earth.

3. Results and discussion

(1) Infrared absorbance spectra

- CO₂, CO, HCOOH and formic anhydride are produced from benzene.
- O₃ and NOₓ are produced from the background gas.

- CO₂, CO, HCOOH, formic anhydride and acetic formic anhydride are produced from toluene.
- By-products from xylene are the same as those from toluene.

4. Conclusions

Decomposition processes of benzene, toluene and xylene in nitrogen-oxygen mixture gas in an atmospheric DC corona discharge are investigated.

- CO₂, CO, HCOOH, formic anhydride (FAH), CH₃CN, maleic anhydride and glyoxal are produced from benzene in the atmospheric DC corona discharge.
- Maleic anhydride (FAH), peroxyacetyl nitrate, CH₃HCOOH and methyl glyoxal are produced from xylene.
- Concentrations of benzene, toluene and xylene decrease linearly with the increase of input energy.
- Benzene, toluene and xylene are chiefly converted to CO₂ via CO, HCOOH, FAH and FAH by the atmospheric DC corona discharge.
- The total number of carbon atoms, which is presented as the top line of stacked graph, decreases monotonously with the increase of input energy, and then becomes constant.
- This leads to the fact that the same number of carbon atoms contained in benzene, toluene and xylene are deposited on the electrodes and the wall of the discharge chamber.