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Treatment of HCHO Using Corona Discharge and Pellet Catalysts†

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Possibilities of formaldehyde (HCHO) treatment in dry air and nitrogen using discharge plasma of streamer corona discharge was investigated and its treatment efficiency in various conditions was evaluated. The effect of combination of plasma and pellet catalysts for formaldehyde treatment was examined too.

The reactor of multi-point-to-mesh geometry was used. The distance between electrodes was 16 mm. Initial concentration of formaldehyde was 200 - 1000 ppm in dry air or nitrogen, and the gas flow was 0.25, 0.5 or 1.0 lpm. The analysis of gas composition was performed by FTIR and UV-VIS spectrometry.

Formaldehyde treatment efficiency of more than 80% using discharge only was obtained. The efficiency was better for smaller initial concentrations of formaldehyde and smaller gas flow rates, although decrease of gas flow especially resulted in rapid increase of energy consumption. Formaldehyde decomposition resulted in formation of CO and HCOOH. The formation of CO occurs most probably by photolytic reactions e.g. $HCHO+h\nu \rightarrow CO+H_2$. In air CO can be formed also via $HCHO+h\nu \rightarrow H+HCO$ followed by $HCO+O_2 \rightarrow CO+HO_2$. Oxygen also supports formaldehyde oxidation to formic acid by $HCHO+O \rightarrow HCOOH$. On contrary, a reaction with ozone appeared not to be effective. Due to existing oxidation process HCHO treatment is better in dry air, however also produces more CO_2, NO_2 and N_2O compared with nitrogen mixtures. Transformation of streamer into spark resulted in decrease of HCHO treatment and CO production and increase of CO_2 and NO_2 productions.

Combined effect of catalyst and plasma was investigated too. An 8 mm thick layer of catalytic pellets of various materials (TiO_2, Pt/Al_2O_3, MnO_2, NaY, molecular sieves) was placed on the mesh electrode. At small discharge power the treatment efficiency was relatively small due to desorption of formaldehyde adsorbed by pellets before application of the discharge. Treatment efficiency however rapidly increased with discharge power as removal of formaldehyde dominated its desorption. Increase of formaldehyde concentration, however, can also be attributed to interaction of the discharge with pellets and or formaldehyde generation from methanol and formic acid. A combination of plasma and catalysts indicated surface process plays important role and affects formaldehyde decomposition.

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3PA09

Acetaldehyde treatment in Foaming Column

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AOT (Advanced Oxidation Technologies) are known as safe and effectual in disinfection, and treatment of many organic compounds. Acetaldehyde (CH3CHO) is a flammable, volatile, colorless liquid with a nice fruity odor if diluted. It is miscible in water and common organic solvents as acetone, toluene, etc. It might be a primary or secondary pollutant as it is widely used in production of many chemical compounds, and in the dye, cosmetics, leather, rubber and food industries. It is anticipated to be a human carcinogen.

In this paper the application of electrical discharge in the foaming system for the ethanal removal was presented. Foam was formed with mixtures of oxygen, acetaldehyde and pure water in the special flow regime of media, using the diffusers [1]. To decrease the pressure drop on the diffuser, the metal grid replaced the diffuser and small amount of common surfactant was dosed in some experiments.

The main reactor was a cylindrical column with a ceramic diffuser, which was placed perpendicularly to the flow direction of media. Gas was added in the lowest part of the apparatus using gas inlet. The outlet was located in the upper part of the reactor. The electrodes of stainless steel consisted of the inner tube electrode and the outer tube electrode. The pulse power source was operated at 250 Hz.

Hydrogen peroxide, OH radicals, small amounts of gaseous and dissolved ozone were generated in foam due to the electrical discharge [2]. The concentration of hydrogen peroxide was measured using HACH Hydrogen Peroxide Test Kit. The amount of H2O2 ranged 55 mg/l and was highest for the limits of gas flow, when foam was most stable and uniform. The small amount of gaseous ozone was also detected. The concentration of acetaldehyde decreased in the tested samples due to the superposition effect of simultaneous application of various oxidants formed in foam by the electrical discharge.

Generally, with the low gas flow rate and the higher applied voltage concentration of oxidants increased as expected. For the high gas flow rate with the same total power arcing phenomena took place.

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