Decomposition of VOCs by gliding discharge plasma

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Decomposition of volatile pollutants emission is a very important problem, especially for the industrial profile countries. The aim of the investigations was to develop a plasma-catalytic system for removal of volatile chlorinated hydrocarbons from waste industrial gases and exhaust gases from incineration plants. Plasma - catalyst with stationary bed systems were investigated. Measurements were performed for determining the optimal process conditions for removal of the model pollutant CCl₄. High temperature or catalytic processes is being the most commonly used. In recent years an attempts have been made for decomposition of volatile organic compounds by the use of non-equilibrium plasma.

Experimental

The homogeneous system (GD) and the reactor with stationary bed (GDS) of vanadium oxide catalysts were used for decomposition of CCl₄. Reactor was provided with a conic reaction chamber with ceramic lining and two vertical diverging stainless steel electrodes. The reactor was powered by a 50 Hz system. The discharge power was 150 - 460 W. The gas temperatures was 250 - 500 °C. The gas mixture composition was oxygen and argon (1:2) and the gas flow rate was 200 or 300 Nl/h controlled by mass flow controllers. The initial concentration of CCl₄ in the gas was 0.1 or 0.5 vol.%. The CCl₄ concentration was controlled by CEM system by Bronkhorst.

The vanadium oxide catalysts containing about 7 wt.% of V₂O₅ was supported on ceramic carrier. The catalysts, were obtained by impregnation of ceramic carrier with aqueous solutions of VOSO₄ and K₂SO₄, dried and calcined in ambient air at 600°C for 4 h. Two kinds of catalysts were prepared. First V₂O₅ + K₂O supported on diatomite, second V₂O₅ + K₂O/diatomite catalysts were packed into the reactor without additional pretreatment. The BET absorption isotherm was used for carrier and catalysts surface determination.

The main product of CCl₄ decomposition was chlorine. However chlorine present in the outlet gas caused corrosion of the electrodes and elements of the reactor made of brass. That might be the reason of losses in chlorine balance. In homogeneous system when 0.1 initial CCl₄ concentration was used traces of fosgen were observed. In outlet gas any other chlorohydrocarbons than nonreacted CCl₄, had not been detected.

Conclusions

CCl₄ can be effectively decomposed in gliding discharge reactor. The highest overall CCl₄ conversion (0.97) was achieved when 200 Nl/h gas flow was used in plasma catalytic system. The chlorinated hydrocarbons compounds were not produced by gliding discharge from CCl₄ in gas mixtures with argon and oxygen. In plasma catalytic system fosgen was not observed.

Effect of catalysts on overall CCl₄ conversion. Gas flow 300 Nl/h, CCl₄ concentration 0.5 %.

Effect of catalysts on CCl₄ decomposition. Gas flow 300 Nl/h, discharge power 300W.