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CARBON DIOXIDE REFORMING OF METHANE IN A GLOW DISCHARGE AT ATMOSPHERIC PRESSURE *)

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Environmental and energy applications of low-temperature plasma are of increasing interest worldwide. The main question is whether plasma-based solutions can provide a good alternative to existing thermal processes and whether they can compete with other new gas conversion technologies. Currently, the conversion of CO_2 into chemicals and fuels is a hot topic. One of the areas is carbon dioxide (dry) reforming of methane [1, 2]. This reaction is highly endothermic (ΔH_{298} = 247 kJ*mol^{-1}), since both CO_2 and CH_4 are stable molecules. To obtain significant conversions, temperatures of at least 1000 °C are required. Low temperatures can be achieved with catalysts, but then the problem is their deactivation by carbon deposition. Therefore, an attractive possibility is to consider the nonequilibrium properties of gas electrical discharges to direct the energy into molecular dissociation rather than into gas heating.

To perform the research, a setup for obtaining a discharge in methane and carbon dioxide mixtures at atmospheric pressure was developed and manufactured. A stabilized Spellman SL1200 source with a voltage of up to 10 kV was used as a constant voltage source (measurements were performed using different polarities of the applied voltage), as well as a high-voltage transformer with an output voltage of up to 10 kV (50 Hz). The discharge voltage and current shapes were recorded by a Tektronix TDS 2012B oscilloscope. The power absorbed in the discharge was determined from the measured current and voltage oscillograms. The discharge emission spectra were recorded by an AvaSpec 2048 spectrometer.

The gas flow at the discharge input was controlled by RRG-20 electronic flow meters, and the flow of gas product mixture at the output was controlled by a mechanical flow meter. The methane flow at the input was constant and equal to 25 ml/min, the carbon dioxide flow varied in the range of 25-74 ml/min. The composition of the main gas products of the discharge was studied on a portable gas chromatograph PIA with reverse purging with a katharometer and gas chromatographic columns with molecular sieves 13A and Hayesep S.

The main discharge products are H_2 and CO. The degree of methane decomposition is in the range of 68-99 %, the degree of carbon dioxide decomposition is in the range of 52-97 %. The dependences of the rates of hydrogen and carbon monoxide formation at the reactor output are shown in cases of using a power source with a frequency of 50 Hz, a DC source at different polarities and different ratios of CO_2 with CH_4 flows.

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References

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