Plasma reforming of ethanol/water mixture in the plasma-liquid system with reverse vortex air/CO_2 flow of "tornado" type with liquid electrode

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Plasma reforming of ethanol/water mixture in the plasma-liquid system with the discharge in a reverse vortex gas flow of "tornado" type with a liquid electrode, and CO_2 addition researches represented in this work. Population temperatures of electron, vibration and rotation levels in the plasma components and the relative concentrations of these components in plasma are defined. The influence of the presence of CO_2 in the reforming system on yield gas products is defined too.

Technologies with syngas usage are very relevant now. Syngas is mixture of H_2 and CO. It is an important raw material for the synthesis of various materials and synthetic fuels, such as ammonia, methanol, acetic acid, methyl formiate, dimethyl ether, synthetic gasoline, diesel fuel, nanostructures, etc. We also know that fuel adding to syngas improves the efficiency of its combustion: burning less time, propagation of combustion wave is rapid, the stabilization of combustion, more complete combustion of the mixture and reduces the amount of hazardous emissions (NO_x).

The most promising for syngas production are renewable hydrocarbon sources. Great interest in reforming of liquid hydrocarbons represent plasma-liquid systems, because they do not require further gasification. These systems include discharge in reverse vortex flow of "tornado" type with liquid electrode (TORNADO-LE) [1]. It is known that synthesis or catalysis of different products need the various H_2/CO ratio in syngas. It is therefore an important task, but creating the syngas is the ability to control the ratio of H_2 to CO in original mixture. The standard approach to changing and control for syngas ratio in reforming process is CO_2 adding to the reforming system [2].

Scheme of the experimental setup is shown on Fig. 1.

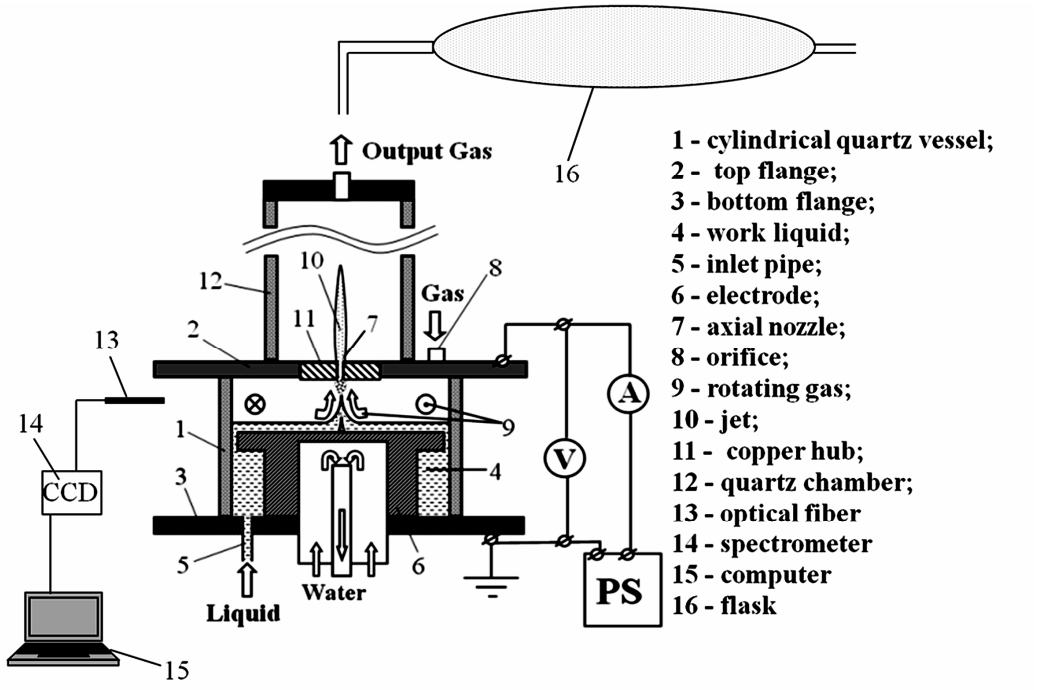

Fig. 1: Scheme of plasma-liquid system TORNADO-LE

Distilled water and ethanol/distilled water mixture (C_2H_5OH/H_2O = 1/9) was used as a working liquid in plasma-liquid system TORNADO-LE (regime - "solid" cathode). Air/CO_2 mixture was used as a working gas. Value changed in the range: Air/CO_2 = 20/1 ÷ 3/1 – for C_2H_5OH/H_2O mixture, Air/CO_2 = 20/1 ÷ 0/1 – for distilled water.

We investigated emission spectra of plasma between electrodes, current voltage characteristics and entering gas chromatography under reforming of hydrocarbons in the system, mentioned above. It was found that the increase of CO_2 in the working gas leads to an increase in discharge voltage. In the case when working gas was pure CO_2 current-voltage characteristic become decreasing.

The typical emission spectrum plasma between electrode gap in case when distilled water were used like a working liquid is shown on Fig. 2. The following components exist in plasma the molecule OH and H, O atoms, but in cases when the amount of CO_2 in the working gas exceeds the amount of air, atomic carbon appears. In case when C_2H_5OH/H_2O mixture was used as a working liquid in plasma are present such component as molecules OH, NH and CN, the atoms H, O.

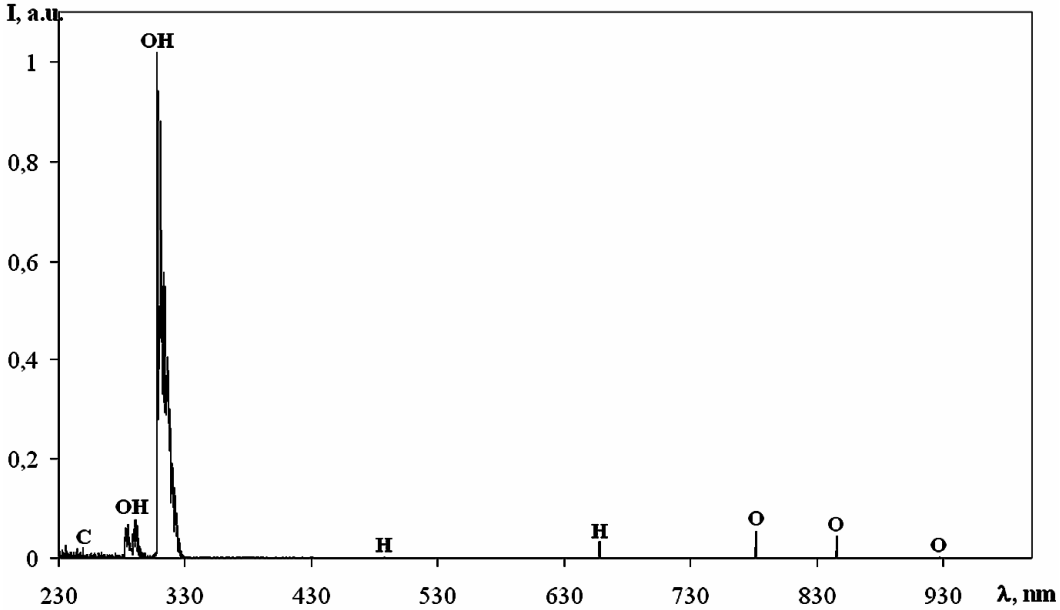

Fig. 2: The typical emission spectrum plasma between electrode gap in case when distilled water were used like a working liquid. Discharge current 250 mA, voltage – 2.4 kV. CO_2 was used as a working gas.

Population temperatures of electron T^*_e, vibration T^*_v and rotation T^*_r levels in the plasma components and the relative concentrations of these components in plasma were measured. The electron temperature T_e was measured. Temperatures were determined by using methods represented in papers [3,4]. The influence of the presence of CO_2 in the reforming system on yield gas products is defined too.

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