ROTATING GLIDING DISCHARGE SUBMERGED IN LIQUID

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The plasma-liquid system with rotating gliding discharge submerged in liquid was investigated in work. Electrical parameters of the system under different operating conditions were measured. The dependencies of discharge behavior on the plasma gas and working liquid were researched. Revealed that discharge burns in a gas bubble and is not in contact with the liquid. The possibility of controlling pH by changing the plasma gas was shown.

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INTRODUCTION

In the last years considerable attention has been given to the development of alternative approaches (plasma-chemical, chemistry, supercritical fluids, biological) and complex (plasma-catalytic, activation of plasma chemical processes) to create new technologies of gasification of different hydrocarbons - from fossil (coal, oil) to household waste. Particular interest to this direction presents a combination of traditional chemical technology with non-equilibrium plasma-chemical technologies in hybrid plasma-catalytic systems. The use of non-isothermal plasma, as a catalyst, in these systems is connected with generation of active particles that are injected in chemically active medium gas phase [1, 2] or liquid phase [3-5].

The effectiveness of this approach is obvious if the target products obtained as a result of chain reactions embryos of which are particles generated in the plasma. This direction is the main in the development of perspective plasma power technologies as reforming of hydrocarbons to syngas and obtaining high-quality liquid fuels from liquid-phase hydrocarbon materials in plasma-liquid systems, in which long-chain hydrocarbons are converted into short-chain and oxygen-containing hydrocarbons with a low time of ignition delay [3, 4]. For this purpose used, nontoxic substances as reagents (water, oxygen, carbon dioxide) and the process of chemical transformations in general can be conducted at temperatures much lower than traditional thermochemical technologies [2]. All this points to the compatibility this direction with the concept of sustainable development, which now acquires a priority.

So here we present the plasma-liquid system with submerged in a liquid not studied extensively rotating gliding discharge [6]. We propose an in-liquid fuel reforming approach for the coproduction of a synthetic liquid fuel and a hydrogen rich syngas at atmospheric pressure and moderate temperature conditions using a modified aqueous discharge reactor. Water and ethanol were used as liquids. Air and argon were used as plasma forming gas.

EXPERIMENTAL SETUP

Experimental setup with a rotating gliding discharge submerged in liquid shown on Fig. 1. The plasma generator consists of a central electrode (cathode), the upper flange (anode), and dielectric chamber with holes for tangential supply of working gas. The central part of

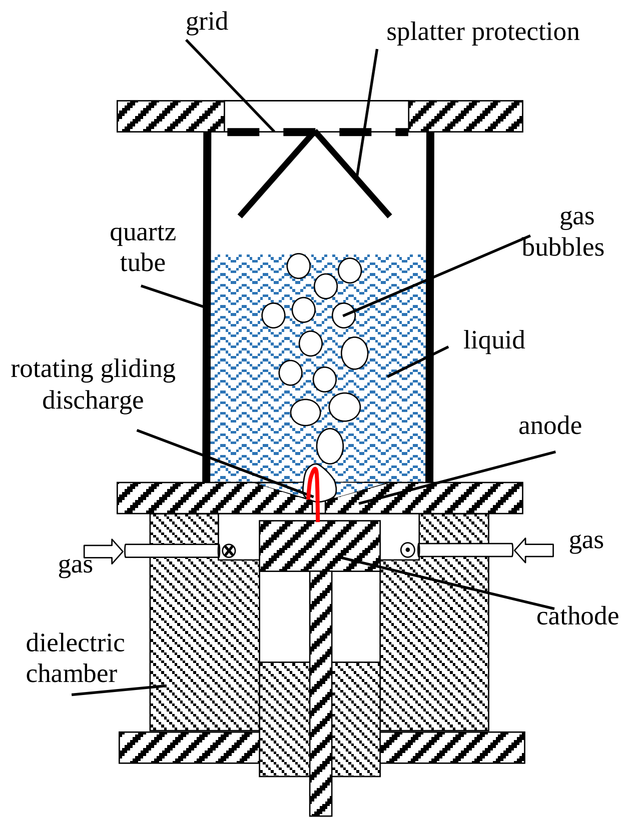

Fig. 1. Experimental setup with rotating gliding discharge submerged in liquid

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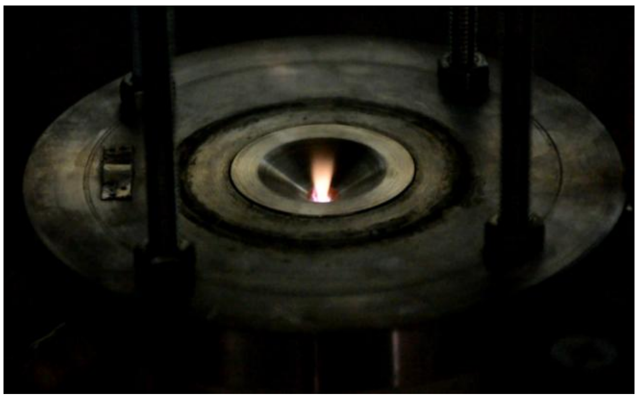
the anode has a conical shape with a hole in the center. The diameter of the hole is 3 mm. Rotating gliding discharge burns between the cathode and anode. The quartz tube which is filled with tested liquid placing on the anode. Distillate and ethanol were used as test liquid. Air and argon is used as working gas. To trap liquid splashes mesh with cone was located above the liquid. The volume of treated liquid was 100 ml.

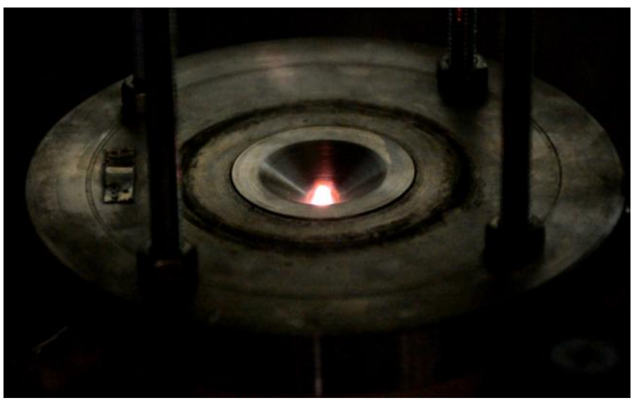
The electrical parameters of the system such as current-voltage characteristics were investigated. Research were conducted for the different modes of the system. The influence of the discharge on processed liquid was, investigated by measuring the pH of water before and after treatment.

Photo of the discharge for different modes of setup presented on Figs. 2 and 3.

The current channel and plasma torch in open system (without liquid) have a larger length in airflow than in a argon flow. Diameter of the current channel is larger when using air as the working gas.



a



b

Fig. 2. Rotating gliding discharge in open system (without liquid) at different plasma gases. I=100 mA, G=10 l/min: in Air (a); in Argon (b)

a

b

Fig. 3. Rotating gliding discharge submerged in distillate at different plasma gases. I=100 mA, G=10 l/min: in distillate + Air (a); in distillate + Argon (b)

RESULTS AND DISCUSSION

Electrical characteristics of the system were studied in a range of discharge currents from 50 to 200 mA. Plasma gas flow rate (G) was changed from 5 to 25 l/min.

Current-voltage characteristics of the rotating gliding discharge in open system (without liquid) are presented in Fig. 4.

Current-voltage characteristics of the discharge in the airflow in open system have descending character (see Fig. 4,a). Discharge voltage in 4 times smaller and within the studied range of currents and flows the voltage does not change in the case of burning discharge in the argon flow (see Fig. 4,b). The current-voltage characteristics of the rotating gliding discharge submerged in liquid shown on Fig. 5. Distillate and ethanol were used as working liquid.

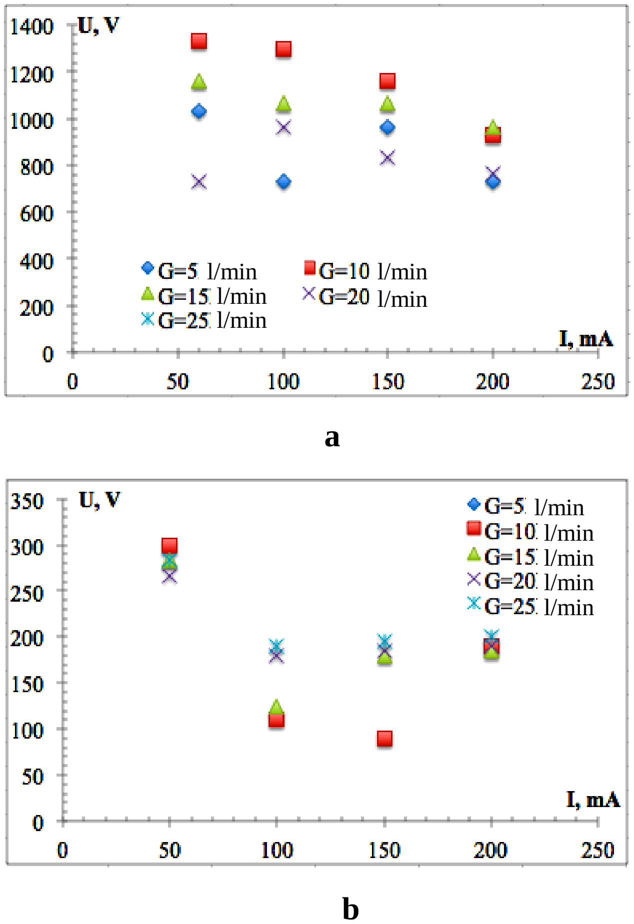


Fig. 4. Current-voltage characteristics of rotating gliding discharge in open system (without liquid) at different plasma gases: Air (a); Argon (b)

From the results presented on Fig. 5 we can see that in submerged discharge current-voltage characteristics behavior, for different type of plasma gases (see Fig. 5,a and b), the same as in the open system without liquid (see Fig. 4). The voltage value of discharge is same. This indicates that in the plasma-liquid system with rotating gliding discharge submerged in liquid current channel and plasma torch are in the gas bubble and the liquid does not get into the area where the discharge is burning.

If ethanol used as a working liquid within the studied parameters of current and argon flows, the current-voltage characteristics behave in the same way as in the case of distillate (see Fig. 5,b).

In a system with a rotating gliding discharge submerged in liquid plasma torch and current channel blowing outside of discharge gap inside the gas cavities at low gas flows. Beginning from flow > 15 l / min current channel length decreases and plasma torch significantly reduced. The discharge burns only in the interelectrode space. Besides electro physical characteristics the discharge influence on liquid at different plasma gases was researched. The influence of the discharge on processed liquid was, investigated by measuring the pH of

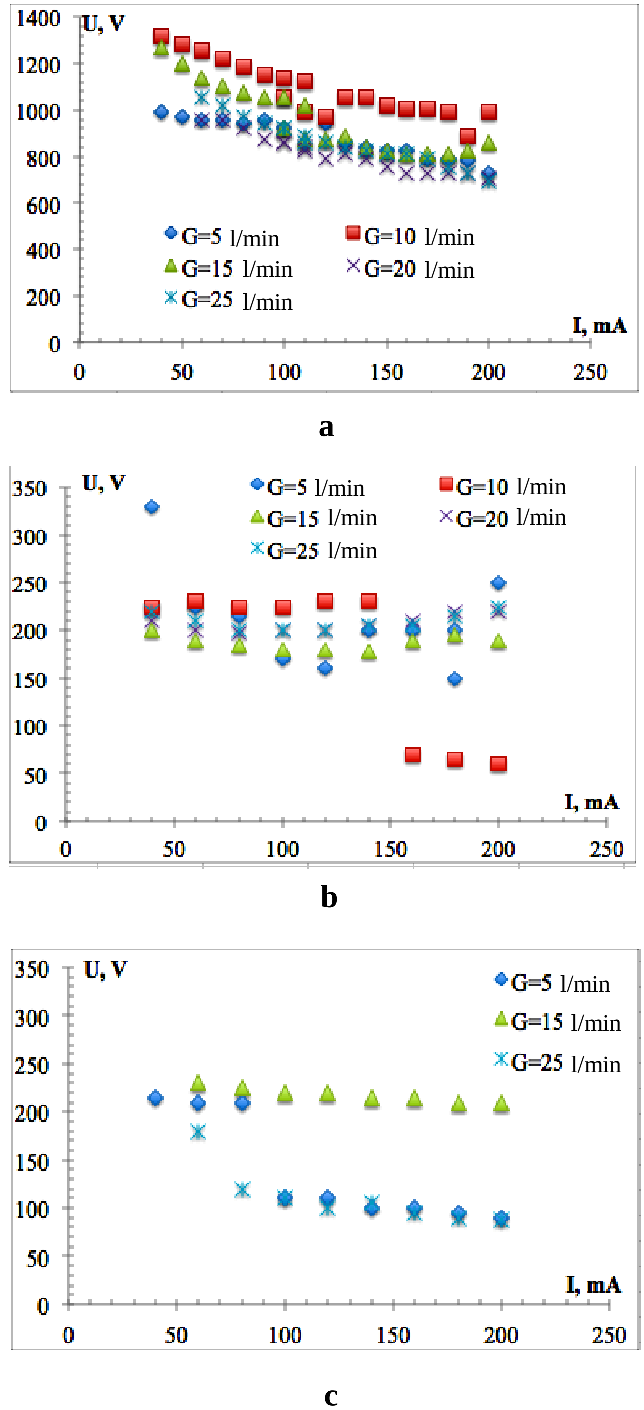


Fig. 5. Current-voltage characteristics of rotating gliding discharge submerged in liquid (in distillate and ethanol) at different plasma gases: water + Air (a); water + Argon (b); ethanol + Argon (c)

water before and after treatment. The results of these measurements are presented on Fig. 6.

Results shown that in the plasma-liquid system with rotating gliding discharge submerged in liquid by changing the plasma gases can change the pH of the liquid towards reduction and toward increasing from the initial value. The pH of the treated distillate, in both cases,

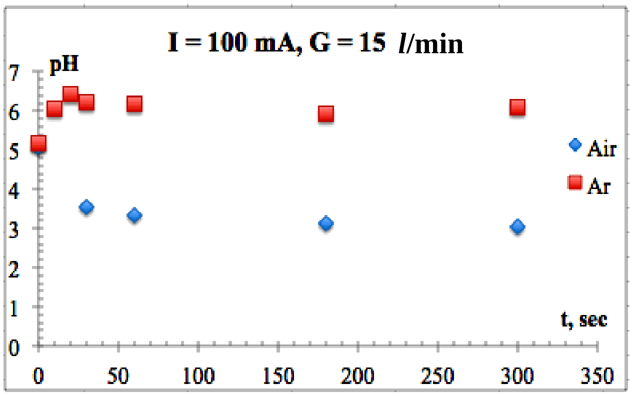


Fig. 6. The dependence of distillate pH on the processing time in a system with a rotating gliding discharge submerged in distillate at different plasma gases. I = 100 mA, G = 15 l/min

quickly it reaches saturation. At studying of the distillate pH with using argon as the plasma gas was verified whether the argon purging through distillate, without discharge, on distillate pH. Argon purged through distillate, with the initial pH = 5.24 during 30 s and distillate pH was increased to 6.28. This may be due to the fact that argon might take out dissolved gases from liquids.

CONCLUSIONS

In the plasma-liquid system with rotating gliding discharge submerged in liquid current channel and plasma torch are in the gas bubble and the liquid does not get into the area where the discharge is burning.

The plasma torch and current channel blowing outside the discharge gap inside the gas cavities at low gas flows. Beginning from flow > 15 l / min current channel length decreases and plasma torch significantly reduced.

In the plasma-liquid system with rotating gliding discharge submerged in liquid by changing the plasma gases can change the pH of the liquid towards reduction and toward increasing from the initial value.

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ВРАЩАЮЩИЙСЯ СКОЛЬЗЯЩИЙ РАЗРЯД, ПОГРУЖЁННЫЙ В ЖИДКОСТЬ

В.В. Юхименко, В.Я. Черняк, Д.К. Гамазин, Д.С. Левко, В.А. Бортышевский, Р.В. Корж

Исследовалась плазменно-жидкостная система с вращающимся скользящим разрядом, погружённым в жидкость. Измерены электрофизические параметры системы при различных режимах работы. Исследовано поведение разряда в зависимости от плазмообразующего газа и рабочей жидкости. Выявлено, что разряд горит в газовом пузыре и не контактирует с жидкостью. Показана возможность управления уровнем pH посредством изменения плазмообразующего газа.

ОБЕРТОВИЙ КОВЗНИЙ РОЗРЯД, ЗАНУРЕНИЙ В РІДИНУ

В.В. Юхименко, В.Я. Черняк, Д.К. Гамазін, Д.С. Левко, В.А. Бортишевський, Р.В. Корж

Досліджувалась плазмово-рідинна система з обертовим ковзним розрядом, зануреним у рідину. Виміряно електрофізичні параметри системи при різних режимах роботи. Досліджено поведінку розряду в залежності від плазмоутворюючого газу та робочої рідини. Виявлено, що розряд горить у газовій бульбашці і не контактує з рідиною. Показано можливість керування рівнем pH за допомогою зміни плазмоутворюючого газу.