PROPERTIES OF THE PULSED PLASMA-LIQUID SYSTEMS WITH ACOUSTIC WAVES FOCUSING

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The plasma-liquid system with cylindrical geometry and electric pulse discharge less than 10 microseconds duration was created. The influence of plasma treatment to water pH value was investigated. Dependences of the phenol destruction efficiency in its aqueous solution, as a model contaminant, from the solution concentration was obtained and got the best efficiency value: 20 eV per phenol molecule at its water solution with concentration 0.3 M. In obtained absorption spectra remnants of nitric and nitrous acids and other components was not observed, such components was observed after phenol aqueous solution destruction in similar DC plasma-liquid systems.

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INTRODUCTION

The main plasma chemistry issue in our time remains the problem of the high electricity cost used for plasma generation. Due to such fact plasma reactors were trying to use with traditional chemical technologies. In such approach plasma serves as a source of active particles, but devoid of the classical catalysts disadvantages. It is clear that the use of costly electricity should reach maximum efficiency of its application. From the viewpoint of plasma chemistry — it must to increase the selectivity of the plasma-chemical process, that is possible when using non-equilibrium plasma, designed in pulse generation mode, etc [1,2].

Plasma-liquid system has high perspectives in plasma chemistry and in the pulse generating mode very often accompanied by strong acoustic waves. Accumulation (or focusing) of such waves energy will modify the environment`s parameters, and thus obtain a new control mechanism of the plasma-chemical transformations.

1. EXPERIMENTAL SETUP

The experimental setup is shown in Fig. 1. The working part of the system is a cylinder with height H=10 mm and radius R=135 mm. Electrodes are placed perpendicular to the cylinder on the axis of the system. Copper electrodes (1) with a diameter of 10mm are shaped hemispheres with 5 mm curvature radius. Discharge (2) ignited between the electrodes. At the distance of 20 mm from the cylinder lateral surface was placed piezoceramic pressure sensor (3), which recorded acoustic waves caused by the electrical discharge. The internal volume of the chamber was 0,5 liters, as the working liquid was distilled water, and aqueous molar solution of phenol 0,001…0,3 M.

This paper studied the effect of plasma treatment on the pH value water (exposure time to 600 seconds), and the efficiency of phenol molar aqueous solution destruction which was estimated by spectrophotometry (energy exposition 20 and 40 kJ).

Discharge in the cylinder performed by capacity 0,015 μF, which was charged up to 20 kV. Power supply does not exceed 1,5 kW.

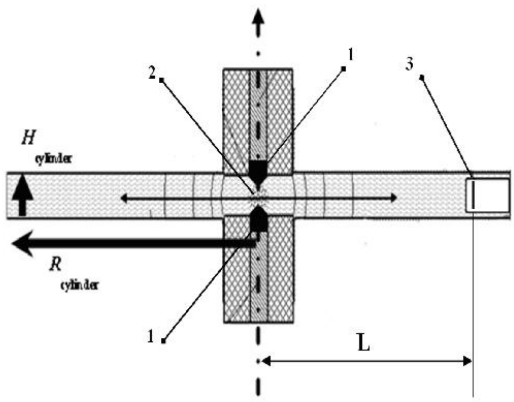

Fig. 1. Pulsed plasma-liquid system with cylindrical geometry

2. RESULTS

It is noticeable that the treatment in pulsed plasma-liquid system previously distilled water from the baseline pH=5 felt alkaline effect of increasing the pH value by 1.9 at the maximum test time of 600 seconds exposure (Fig. 2).

The influence of the inner surface of the plasma reactor can be considered negligible (pH increase of 0.3 at 600 seconds exposure), and the main contribution to the alkaline effect provided by air flow through water and plasma. Although the correct interpretation of this fact requires further research, but most possible explanation for the treatment alkaline effect of the electric pulse discharge in the gas channel with liquid wall was injection of the active particles to the liquid from the plasma.

Injected into the water negative ions and electrons hydrates and in the future may significantly reduce the concentration of positive hydrogen ions due to recombination process [3].

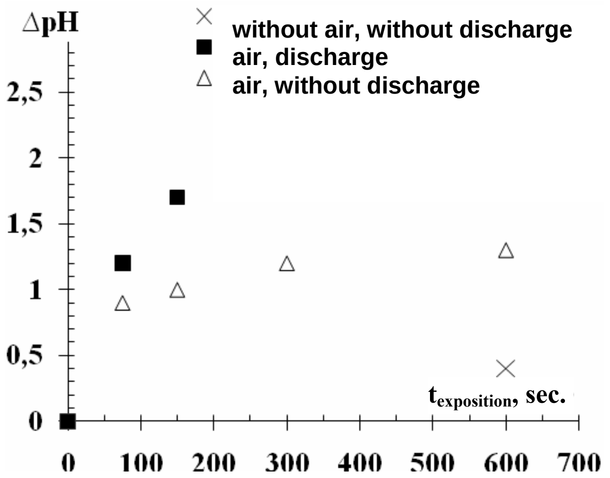

Fig. 2. Changing the pH at different modes of treatment in pulsed plasma-liquid system

In the absorption spectra of treated in the pulsed plasma-liquid system phenol-water solutions has no background signal wich corresponds to other organic hydrocarbon components observed after phenol destruction in DC plasma-liquid system [4] (Fig. 3).

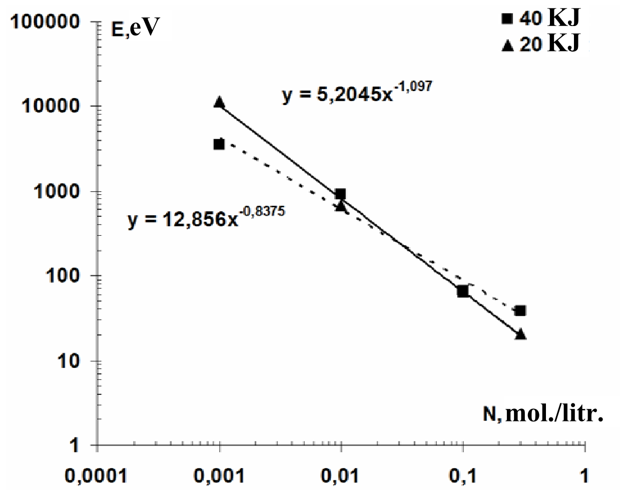

Fig. 4. Dependence of the phenol molecules destruction energy from phenol concentration in its aqueous solution

In plasma liquid systems with transverse arc and secondary discharge usually observed remnants of nitric and nitrous acids [5], but this components wasn`t observed after phenol molar solutions destruction in pulsed plasma-liquid system.

Using the calibrated solution with the given phenol concentration and difference in absorption intensity area of phenol at absorption spectra for untreated and treated water solutions was calculated destruction energy degradation of one phenol molecule. The results are illustrated in Fig. 4. Destruction performance increased with increasing phenol concentration in its aqueous solution and moving to the phenol dissociation energy of 4.75 eV at the highest investigated concentration — 0.3 M.

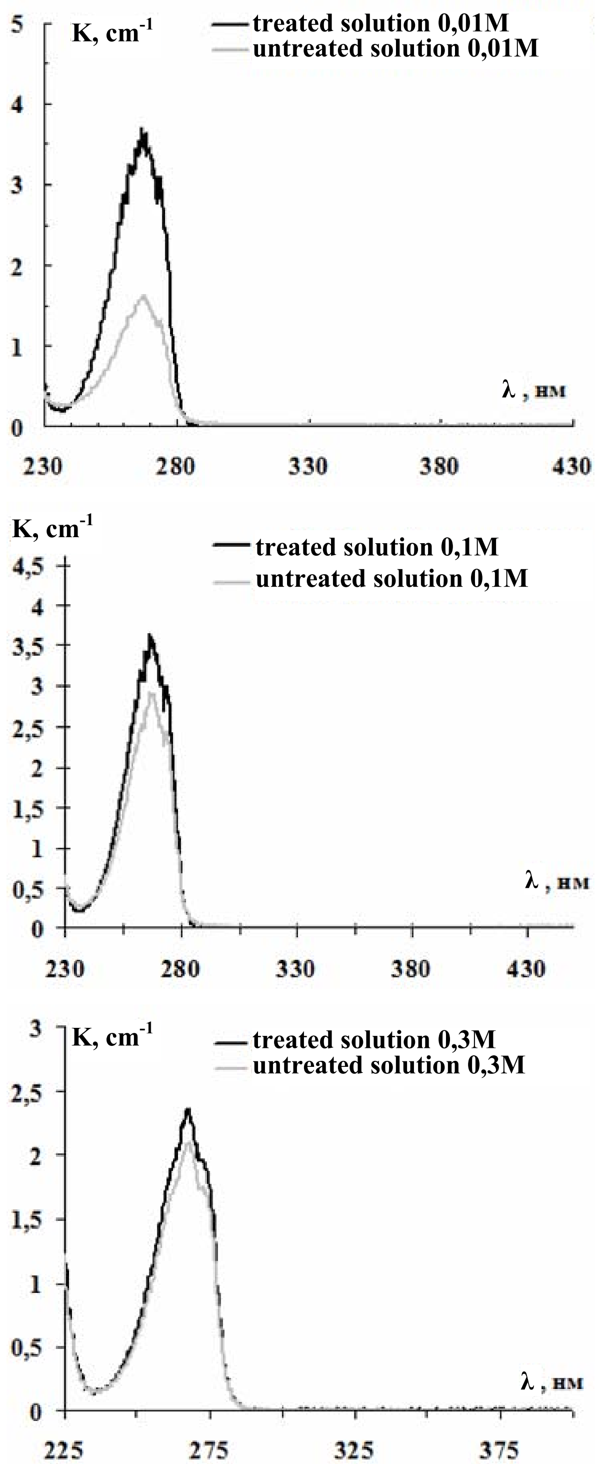

Fig. 3. The absorption spectra of untreated and treated phenol aqueous solution in pulsed plasma-liquid system at different molar concentrations. Energy costs – 20 kJ

CONCLUSIONS

1. During the research of creating convergent acoustic waves in cylindrical plasma-liquid system with axial single pulsed discharge was shown generation of convergent acoustic wave energy with comparable energy of the primary divergent wave energy.
2. Air addition into the liquid reduces the intensity of the continuous spectrum area and Shtark broadening of

hydrogen line Hα, that indicates decrease of plasma non-ideality.

3. In single pulse mode revealed decreasing amplitude of acoustic signal splashes during measurements using a series of pulses at the frequency of 15 Hz compared to measurements in single pulses mode , which may be due to changes in the parameters of wave propagation.

4. For the first time in pulsed plasma-liquid systems with cylindrical geometry and axial discharge showed decrease of the H^+ ions concentration in water due to plasma treatment, almost two orders of magnitude.

5. Remnants of nitric and nitrous acids wasn`t observed after phenol molar solutions destruction in pulsed plasma-liquid system.

6. Destruction efficiency increases with the concentration of phenol in its solution and destruction energy of phenol molecule reaches 20 eV. The result indicates a promising application for the treatment of concentrated waste (municipal) water.

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СВОЙСТВА ИМПУЛЬСНЫХ ПЛАЗМЕННО-ЖИДКОСТНЫХ СИСТЕМ С ФОКУСИРОВАНИЕМ АКУСТИЧЕСКИХ ВОЛН

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Разработана плазменно-жидкостная система цилиндрической геометрии с электрическим импульсным разрядом длительностью не более 10 мкс. Исследовано влияние плазмохимической обработки воды на ее водородный показатель pH. Получены зависимости эффективности деструкции фенола в водном растворе, в качестве модельного загрязнителя, от концентрации раствора, и получен наилучший уровень эффективности: 20 эВ на молекулу фенола при концентрации раствора 0,3 М. На полученных спектрах поглощения отсутствуют остатки азотной и азотистой кислот, а также других соединений, которые наблюдаются при деструкции фенола в его водных растворах в подобных плазменно-жидкостных системах постоянного тока.

ВЛАСТИВОСТІ ІМПУЛЬСНИХ ПЛАЗМОВО-РІДИННИХ СИСТЕМ З ФОКУСУВАННЯМ АКУСТИЧНИХ ХВИЛЬ

С.М. Сидорук, В.В. Юхименко, В.Я. Черняк, В.Е. Марчук, Е.Ю. Гаврилюк, Е.В. Мартиш, О.А. Федорович

Розроблено плазмово-рідинну систему циліндричної геометрії з електричним імпульсним розрядом тривалістю менш ніж 10 мкс. Досліджено вплив плазмохімічної обробки води на її водневий показник pH. Отримані залежності ефективності деструкції фенолу у водяному розчині, в якості модельного забруднювача, від концентрації розчину, та отримано найкращий рівень ефективності: 20 еВ на молекулу фенолу при концентрації розчину 0,3 М. На отриманих спектрах поглинання відсутні залишки азотної та азотистої кислот, а також інші сполуки, що спостерігаються при деструкції фенолу в його водяних розчинах в подібних плазмово-рідинних системах постійного струму.