Organic compound destruction in dynamic plasma–liquid systems

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Résumé

The processes of organic compound (phenol and cation-active surfactants) destruction and inactivation of cultures (*Escherichia coli*) in water solutions, which occurs under the influence of plasma, and growth of cultures (spore culture of *Bacillus cereus* B4368 and the Gram-negative culture *Pseudomonas fluorescens* B5040) in water after plasma treatment was investigated to different dynamic plasma-liquid systems (PLS). The breakdown products of phenol and cation-active surfactants detected with absorption spectroscopy. The bacteria destruction was analysed with application of ultraviolet absorption and luminescence spectroscopy. It was shown that the sterilisation of water with *Escherichia coli* under influence of plasma secondary discharge with "liquid" electrode at atmospheric pressure may amount to 100%. Gram-negative culture more intensively cultivates in water after low-pressure plasma treatment, spore culture - after plasma treatment of atmospheric pressure. At plasma sterilisation the bacteriostatic effect is observe. The most effective system for phenol plasmolytic destruction in water solutions are the secondary discharge with a liquid electrode at atmospheric pressure and PLS, based on the impulse discharge in the gas channel with liquid wall.

Introduction

The problem of complete cleaning for the industrial wastewaters from organic high active and toxic substances (HATS) is important enough and simultaneously difficult decided. However this problem can not be considered decided. Apparently, radiochemical and plasmachemical technologies are represented by most perspective, as allow to achieve the greatest speed destruction of substances at the expense of high-energy concentration. However, it is necessary to take into account, that toxic substances are, frequently, the complex high-molecular compounds. Therefore destruction of HATS results in occurrence not only products of disintegration, but also wide spectrum more complex high molecular of compounds [1]. The chemical reactions both in radiochemical and in plasmachemical systems can proceed with participation of the electronic-exited particles, which practically are not investigated today. It is specified that by high probability of occurrence unknown ealier substances at the data technologies. Therefore now the transition to complex technologies on a basis of plasmachemical processes begin. The opportunities of plasma-bio technology were considered at water clearing from chlorophenols in work [1] and were shown, that the transition to complex technology of water clearing results to synergism.

However, the destruction of toxic components by microorganisms can result in occurrence the mutants. It means that after biochemical destruction of high active products of preliminary plasma water clearing from initial toxic pollution it is necessary to provide inactivation of microorganisms in water. This work is devoted to development of similar multistage technology on base of plasma-bio-plasmachemical processes. The base scheme of the proposed technology includes the plasma module for the preliminary treatment of initial wastewater, the biochemical modules (biodestruction, biosorption and biosedimentation) and the modules for plasma inactivation of microorganisms in water.

2. Experimental technique

The process of organic compound destruction in water solutions, which occurs under the influence of plasma, was investigated to different plasma-liquid systems (PLS) in this work. The organic solutions in distillated water was treated by plasma of secondary discharge with a liquid electrode at low pressure [2] of secondary discharge stimulated by transverse arc at atmospheric pressure [3] of DC discharge in the gas channel with liquid wall and the additional excitation of ultrasonic field in liquid [4, 5], Pulse discharge in gas channel with liquid wall [4] and the discharge in reverse-vortex gas flow of "tornado" type [6].

2.1. The surfactant and phenol destruction in water solutions by plasma treatment. The plasma influence on the molecular structure of the surfactants in water solution was studied. The alcylpiridinium salts (pentadecyl piridinium bromide, cetyl piridinium bromide, tetradecyl piridinium bromide) and quaternary ammonium salts (tetradecyl three ethyl ammonium bromide, cetyl threemethyl ammonium bromide) have used as cationic surfactant models in the present work. The reference solutions with 10-3 M concentration were prepared by distillate water solution of the purity crystal matters. Other solutions were prepared by water diluting. The sensitive and selective sorption-photometric method have been using for surfactant detection in solutions after plasma treatment. This method permits to determine less than 1 μg/l cationic surfactants for all types of it. Phenol destruction in water solutions was investigated in a range of concentration 10-6 - 5 10-1 M with use the spectrophotometer analysis in UF area of a spectrum (200 - 500 nm).

2.2. Plasma inactivation of microorganisms. *Escherichia coli* was used as test culture at study of decontamination action of plasma processing. The plasma processing was carried out in the experimental module with the secondary discharge with a liquid electrode at low pressure ~ 10 torr [2] and in the plasmachemical reactor on the base of secondary discharge with the "liquid" electrode at atmospheric pressure [3].

2.3. Growth of cultures in water after plasma treatment. The various secondary discharges of low and high pressure with a liquid electrode used at plasma treatment. The spore culture of *Bacillus cereus* B4368 and the Gram-negative culture *Pseudomonas fluorescens* B5040 were used as test cultures. Cultures cultivated within 18 hours on nutritious environment no. 284 containing 5 g/l gluconate. Then these cultures accommodated in distillate water past plasma processing and investigated intensity of their growth.

3. Basic results

The results of work indicate the efficiency of plasma destruction of phenol and surfactants, inactivation of micro-organisms at plasma of water and allow to make a choice of cultures for designing of biodestructeres of products of preliminary plasma treatment in complex plasma-bio-plasmachemical technology of waste water treatment. The most effective system for phenol plasmolytic destruction in water solutions are the secondary discharge with a liquid electrode at atmospheric pressure and PLS, based on the pulse discharge in the gas channel with liquid wall. The complete inactivation of *Escherichia coli* can occur at low enough power inputs ~ 6 kW hour $м^{-3}$ by the plasma inactivation with use of the secondary discharge at low pressure with a liquid electrode in optimum modes: at negative polarity of a liquid electrode. The degassing of a solution as a result of an exposition it at the lowered pressure (10-30 torr), the burning of the auxiliary independent discharge above a surface of a solution did not influence on vital functions of *Escherichia coli* culture. The essential influence of thickness of a solution above an electrode in a solution was not noticed also on vital functions of *Escherichia coli* culture. The water treatment by plasma of secondary discharge with "liquid" electrode at atmospheric pressure can be reduced to 100 % of water with *Escherichia coli* sterilization also. The plasma sterilization of water at atmospheric pressure is accompanied by bacteriostatic effect. Appearance of luminescence in a water solution is observed after completely sterilization. Gram-negative culture more intensively cultivate in water after low-pressure plasma treatment, spore culture - after plasma treatment of atmospheric pressure.

Acknowledgement

This work was supported by National Taras Shevchenko University of Kyiv, Institute of Biocolloidal Chemistry of Ukrainian National Academy of Science, Ministry of Education and Science of Ukraine.

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