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Optical-Mechanical Method for Determining the Hydrodynamics of Impurities in Liquids

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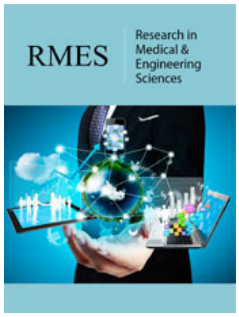

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Abstract

The article discusses ways to improve the optical methods for determining the characteristics of pollution particles in water, in order to increase the efficiency of wastewater treatment. The use of measurement systems based on digital processing of Doppler signals from laser systems provides high-precision simultaneous measurement of the velocity and effective diameter of colloidal and dispersed particles. The integration of optical systems for automated measurement and adaptive control of pollution parameters opens up opportunities for significant intensification of wastewater treatment and purification processes.

Keywords: Pollution; Wastewater; Dispersed particle; Measurements; Laser system; Doppler signal

Introduction

The laser Doppler interferometry methods are used in many fields of physics, medicine, telecommunications, biology, and chemistry. They allow for the study of materials and processes that were previously difficult or impossible to investigate using traditional physical and chemical methods.

The use of laser light sources with high coherence, high power in a narrow spectral range, and high directivity has made it possible to develop and implement new interferometry methods for various objects and processes. In addition to traditional measurements of linear movements, including ultra-small movements, measurements of distances, velocities, and vibrations, as well as measurements of sizes and surface shapes, new methods are being developed based on the use of quantum dots in the photodetectors of optical systems for laser Doppler interferometry [1].

Analysis of the physical and chemical processes of colloidal and dispersed particles coagulation during the treatment of electroplating production wastewater has shown that the value of electrokinetic zeta potential (ξ - potential) of the double electric layer (DEL) of particles is of significant importance. At sufficiently large values of zeta potential (ξ > 30mV), colloidal systems are stable, since the repulsive forces arising between particles due to the deformation of diffuse electric layers prevent the enlargement of the dispersed phase as a result of particle coagulation [2,3].

The theoretical justification of the use of the optical method for determining the hydro-mechanical and physical parameters of suspended matter particles in wastewater has created the preconditions for the development and testing of a laboratory-based measuring device for determining the electrophoretic velocity, diameter, and electrokinetic potential during electrophoresis.

Using the Doppler effect and the Dove prism, a combined block diagram (Figure 1) has been developed for determining the electrokinetic zeta potential, effective diameter, electrophoretic velocity, and the number of impurity particles in aqueous solutions, etc.

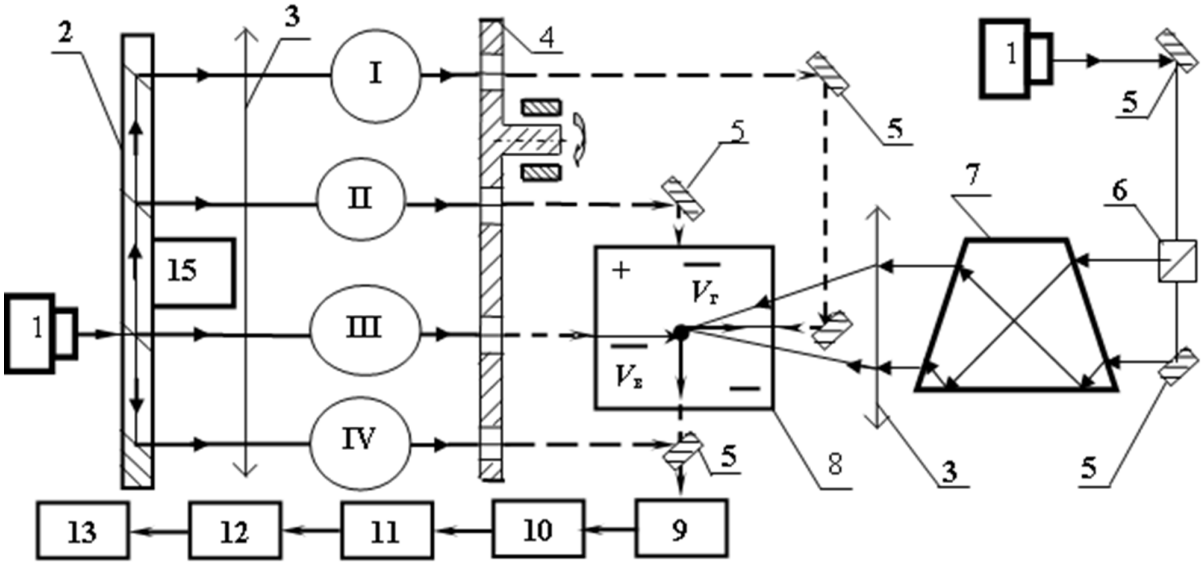

Figure 1: Combined block diagram of the optical-mechanical system for determining the hydro-mechanical parameters of particles in aqueous solutions, technical fluids, and industrial wastewater: 1-coherent radiation source (helium-neon laser); 2-beam splitter; 3-optical lens; 4-electromechanical modulator; 5-mirror system; 6-world stream divider; 7-Dove prism; 8-electrophoretic cell; 9-photoelectric multiplier; 10-photodetector; 11-oscilloscope; 12-pulse counter; 13-personal computer; I, II, III, IV-measuring channels.

A detailed analysis of the dependence of the Doppler signal magnitude on time is the basis for the developed optical methods of laser interferometry for simultaneous measurement of the velocity and effective diameter of a particle during electrophoresis and/or another combination of various hydrodynamic parameters of impurity particles in liquid media [4,5].

Conclusion

A. Experimental measurements of the rate in the processes of electrophoresis and sedimentation allow to determine the values of electrokinetic zeta - potential of the double electric layer and the size (effective diameter) of particles, which is used in the study of reagent coagulation in the purification and neutralization of chromium-containing wastewater of galvanic production.

B. An optical method of laser Doppler interferometry has been developed and proposed in laboratory conditions, which allows remote, high-precision, real-time measurement of the electrophoretic velocity of particles in the processes of electrophoresis and sedimentation in a wide range of velocities of 10-5 ...102m/s and diameters of 1...500 microns.

C. The theoretical justification of the application of the optical method allows us to create the preconditions for the development of an algorithm and a program for mathematical modeling of the Doppler signal shape when measuring the hydrodynamic and physical parameters of particles in a fluid flow using laser Doppler interferometry, which allow us to estimate the relative errors in determining the size of impurity particles in aqueous solutions and the sensitivity of the developed method.

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