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Flocculation With Prolongation Properties of Sulfur Microparticles by Anionic Polyacrylamide in a Flow

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Abstract

The possibility of using rheological approaches for flocculation of sulfur microparticles with anionic polyacrylamide in a longitudinal field in a free jet mode and a shear field generated in a sphere-plane system cell has been studied. It is shown that in a free jet, the "jet-aerosol" transition of a suspension based on S:PAA:water (1:0.1:100) and flocculated particles are realized with the prolongation property of the insecticide. When shear flow of a suspension based on S:PAA:water (1:1:50) in a "sphere-plane" cell, the rotating sphere transformed the gel-like suspension from the rheometer reservoir onto the surface in a thin layer. The formed layer with a thickness of about 0.5mm had a gel-like appearance, which turned into a solid phase layer within 3 months as a result of the evaporation of water from the gel composition under normal condition.

Keywords: Microparticles; Polyacrylamides; Molecular weight; Suspension; Rheometer

Introduction

Anionic Polyacrylamides (PAA) highly efficiently interact with particulate matter in liquids and are widely used as flocculants in wastewater treatment, precipitation of fine particles of expensive metals, non-metals, etc., [1,2]. PAA samples are characterized by a high molecular weight (from 2 million to 15 million), and the efficiency of flocculation of such polymers, along with ionogenic activities, largely depends on the propensity for the conformational rearrangement of their long macromolecules around particles [3,4]. Such conformational transformations of macromolecules are possible in a laminar flow of longitudinal and shear fields [5,6]. In the longitudinal field, the transition "coil - unfolded chain" took place and the contact areas of the unfolded chains with a number of moving particles increase. The folding of the extended chains outside the longitudinal field ended with high flocculation of the particles. Usually, the longitudinal field is generated under the action of converging streamlines of liquids, for example, in the inlet (or outlet) zone of the opening of the short-capillary viscometer of the Kuvshinsky (VK) dilute flow [7]. Such a viscometer most effectively, studied the behavior of macromolecules in a longitudinal flow of dilute and moderately concentrated solutions and mixtures.

In the shear field, the rotational-translational motion of macromolecules surrounded by a number of moving particles under the action of shear stress was realized and a favorable condition for the velocity gradient that was created for the effective implementation of flocculation in the flow. The shear flow was generated by rotating one of the planes in the rheometer cells of the "cylinder-cylinder", "cone-plane", "plane-plane", etc. types [7-9]. By means of such cells, the features of the shear flow of moderately concentrated, concentrated solutions and mixtures, gel-like systems and other types were studied. As flocculated particles, bioactive substances were of great interest, for example, sulfur microparticles (S) used as insecticides against insects. The duration (prolongation} of the bioactive action of these microparticles could be adjusted depending on the degree of flocculation with polyacrylamide. This work was carried out in this aspect, in which the possibility of flocculation of sulfur microparticles with anionic polyacrylamide in a longitudinal field in a free jet mode and a shear field, implemented in the original cell of the "sphere-plane" type, was studied.

Objects and Methods

Anionic PAA obtained by alkaline hydrolysis of nonionic PAA (manufactured by Navoiazot, Uzbekistan) was used as a flocculant. This water-soluble anionic PAA was characterized with the degree of hydrolysis DH=30% and molecular weight M=3675000. Sulfur microparticles were obtained by mechanical grinding of sulfur lumps isolated during natural gas processing (manufactured by Mubarek, Uzbekistan). The insolubility of sulfur in water led to the formation of a suspension when S microparticles were added to PAA"s aqueous solutions and gels. The flocculation property of PAA was studied in a dilute suspension (mass ratio S:PAA:water=1:0.1:100) in a longitudinal field, as well as in a concentrated suspension (S:PAA:water=1:1:100) and a gel-like suspension (S:PAA:water=1:1:50) in a shear field. The longitudinal field in the "free jet" flow regime was generated by squeezing a diluted suspension through a short capillary (diameter d=0.05cm) of a VK viscometer. The transition from a laminar suspension flow to a turbulent one was estimated by the Reynolds criterion Re≥2300 [10]. The shear flow of a concentrated (or gel-like) suspension was implemented in a specially assembled cell of a sphere-plane rheometer. In this cell, the sphere (a ball with a diameter of 3cm) is located inside a spherical body, in which the gap between the body and the sphere is 0.1cm. From the bottom of the case, 1/4 of the sphere is outside and is in contact with the surface of the plane. The shear flow of the suspension (S:PAA:water=1:1:50) was generated in a cell of the "sphere-plane" type, by means of which the gel-like mass of the suspension was deposited on the surface of the plane.

Jet-Aerosol Transformation

In the free jet mode of the longitudinal field, it was found that an increase in the volumetric flow rate $Q^* \geq 36 cm^3/s$ of a suspension through a short capillary VC promotes the transformation of a laminar flow into a turbulent flow and a dynamic "jet–aerosol" phase transition. The formed aerosol particles were flocculated microparticles S which are deposited on the surface of various materials and could be applied to plant leaves and the like. Flocculated microparticles S were retained on the surface for more than 50 days, which is 5 times longer than the time when S powders without PAA were applied to the surface [11,12].

Application of the Suspension

In the case of shear flow in a "sphere-plane" cell, the rotating sphere transformed the gel-like suspension from the rheometer reservoir onto the surface in a thin layer. The formed layer with a thickness of about 0.5mm had a gel-like appearance, which turned into a solid phase layer within 3 months as a result of the evaporation of water from the gel composition under normal condition. Physicochemical analysis of the gel-like and solid-phase layers showed that the samples retain biological activity, i.e., insecticidal properties.

Conclusion

Thus, the conducted studies showed the possibility of using rheological approaches for the formation of flocculated sulfur microparticles by polyacrylamide with a long-term prolongation action.

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