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Effective Polymer Reagent for Binding Soil and Sands

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ABSTRACT

The article discusses some of the possibilities for the synthesis and use of new polyol hydrogels based on secondary resources in the Aral Sea region.
It shown that the problem of the drying up of the Aral Sea is a global problem of our time. Highly swellable polyol gels based on lignosulfonates with phosphorus-containing compounds, obtained on the basis of wastes of JSC "Maxam-Ammophos", were obtained. The conducted field and experimental studies showed that the developed polyol hydrogels did not lose their applied properties even after three years of field tests. An important factor is the fact that the technology and method of introducing highly swellable polyol hydrogels is simple, does not require complex technological operations and special training of workers of the agrarian structure and farmers.

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Introduction

The problem of the drying up of the Aral Sea is a global problem of our time. This problem is aggravated by the fact that the mobile sands of the drained bottom of the Aral Sea are highly saline, contain a huge amount of various harmful chemical reagents that are part of various mineral fertilizers and dust. One of the serious factors in the deterioration of the ecological situation in the Aral Sea region is the removal of salts and dust from the territory of these regions [1].

In this context, the problem of fixing saline sands of the drained bottom of the Aral Sea, the creation of strong surface structures that do not interfere with plant growth and protect from weathering due to a strong aerodynamic flow, is the most urgent problem of modern polymer chemistry and ecology in general.

Experimental techniques

The studies used modern physicochemical and analytical methods of analysis, such as IR, PMR and UV spectroscopy, potentiometric, pycnometry to determine density, viscometer to determine the viscosity of polymers, velocity sedimentation to determine the molecular weight and dispersion of polymers, etc [2-3].

Results and its discussion

It is known that the drained bottom of the Aral Sea is covered with a layer of saline mobile sands with an area of more than 2,400 thousand hectares. The content of water-resistant macrostructures in them is more than 0.25 mm, which are important for the cultivation of salt-resistant plants on these sands, is insignificant and often amounts to no more than 5-7% of the total mass of sand, as a result of which their rational use in the agricultural sector of the economy is difficult. In this connection, an important problem is the consolidation of sands from wind erosion through the creation of a strong surface crust, which ensures the fixation of mineral particles and salts in the places of their formation in order to prevent deflation [4].

However, the known complex additives [5] do not provide high physical and mechanical properties of the treated soil, in addition, there is also a decrease in the maximum adsorption of moisture in comparison with the initial 1.5 times, but the specific surface area practically does not change. Known complex fixer, including a 0.5% solution of polymer MPK-1 (a product of incomplete saponification of polyacrylonitrile with alkali in severe conditions) with sawdust. The disadvantage of this method is the complexity of obtaining a polymeric complex fixer - a product of incomplete saponification of polyacrylonitrile with alkali in harsh conditions, the duration of the production process and the toxicity of polyacrylonitrile.

In addition, the known complex fixer does not cause a particular increase in the sorption capacity of soils, and due to the inaccessibility and high cost of MPK-1 and the chemicals used, the unit cost of the final product is high.

In this aspect, the purpose of our recent research work is to protect mobile sands from wind erosion by chemical fixation using high-molecular-weight composite additives obtained based on industrial waste from chemical enterprises of our republic.

In this regard, we have carried out research on the synthesis and development of technology for the production of water-soluble polymers based on methacryloyl chloride (MAC) with phosphorus-containing compounds obtained on the basis of wastes of JSC "Maxam-Ammophos" it is known from the literature that MAC easily enters into an electrophilic substitution reaction with such electropositive centers as nitrogen and phosphorus. The latter predetermined the possibility of investigating the behavior of MAC in electrophilic substitution reactions with the above compounds, in order to obtain high-molecular compounds and polyols, and the possibility of using them as a soil structure former and sand fixer.

It was found that when MAC is mixed with phosphorous acid, both in bulk and in organic solvents in a wide temperature range, high molecular weight substances are formed that do not contain free monomer molecules, i.e. an irreversible polycondensation reaction occurs.

The regularities of the polycondensation of MAC with phosphorous acid were studied at equimolar ratios of the starting components in the temperature range 333-373K for 300 minutes. The course of the polycondensation process was monitored by potentiometric titration of acid groups. Since the change in the reduced viscosity and the evolution of hydrogen chloride are a direct result of the described processes, it was a quantitative assessment of these two factors that served as a method for determining the rate of polycondensation of MAC and PC.

To clarify the nature of the interaction of phosphorous acid with the above monomer, the UV and IR spectra of the starting and final products, as well as the PMR spectra of the starting compounds were studied.

Infrared spectroscopic studies established the presence of absorption at frequencies of 760-730, 1100, 1400, 1500, 1965 cm-1, which is characteristic of C-O-P bonds, as well as the stretching vibration of hydroxyl groups at frequencies of 2500, 3020 cm-1. It was also revealed that in the IR spectrum of the polymer obtained on the basis of the interaction of phosphorous acid with MAC, the band corresponding to stretching vibrations of the C-Cl-bond, is shifted to the low-frequency region up to 1350 cm-1, in comparison with that in the waste spectrum. The stretching vibration of the C-CI bond (850-800 cm-1), belonging to the MAC group, disappears due to the formation of a new chemical OH-bond in the region of 2500 and 3020 cm-1. At the same time, new intense absorption bands in the range of 1050-1100 cm-1 are also formed, which refer to asymmetric vibrations of the ether bond (-C-O-P-) (1250, 930 cm-1) during the interaction of MAC with phosphorous acid. The results of IR, PMR and UV spectroscopic studies, elemental analysis, and potentiometric titration indicate that the resulting product is a linear polymer.

The reaction product is a very viscous uncolored or amber colored liquid with a specific odor, their physicochemical characteristics are fully identified [6].

Further, the applied properties of the developed polymer as a structurant of soils and sands were investigated. Samples of saline mobile sands of the drained bottom of the Aral Sea were used as an object. Research on the consolidation of saline mobile sands of the dried bottom of the Aral Sea with high molecular weight additives using sand-binding polymers was studied at a solution concentration of 0.1, 0.3, 0.5 and 1.0%. The sand surface was treated by spraying it with polymer solutions (Table 1).

Table 1
Influence of polymer solution concentration on sediment volume, filtration rate and viscosity of soil suspension filtrates

№	Concentration of polymers in suspension,%	pH suspensions	Volume draft, $см^3$	Speed filtration, ml / min	Specific filtrate viscosity g / dl
1.	0	7,8	2,40	2,50	-
2	Lignin -0,1	7,5	2,80	1,45	0,055
3	Lignin -0,2	7,4	2,75	0,60	0,094
4	Lignin - 0,5	7,0	2,60	0,32	0,18
5	SHM-0,1	7,4	2,45	1,18	0,04
6	SHM-0,2	7,2	2,85	4,60	0,05
7	SHM-0,5	6,8	3,00	12,00	0,08

In the course of the study, it was found that the interaction of the water-soluble polymer "SHM" developed by us with dispersed particles depends on many factors: the concentration of the polymer "SHM" and the mineral suspension, the presence of electrolytes, temperature, salinity, etc. Among the mineral suspensions, soil and clay suspensions imported from the Aral Sea region.

Thus, the influence of the polymer of the SHM series developed by us by analogy with polyacrylamide (PAA) showed that polyacrylamide preparations interact with soil particles, as a result of which a structure appears in the suspension. The pH of the soil suspension in the presence of these polymers does not change in the same way as in suspensions with lignin, which is apparently associated with the buffer effect of the soil on the change in the concentration of hydrogen ions in the mixture. An exception in this respect is Ca-PAA, where an increase in the polymer content leads to an increase in pH.

The relative volume of the sediment of the soil suspension under the influence of the polymers synthesized by us changes in the same way.

However, in the case of industrial polymer PAA, the soil suspension is larger (Figs. 1 and 2). For a suspension with lignin, the volume of the sediment passes through a maximum with an increase in the polymer concentration. An increase in the sediment volume with an increase in the content of the considered polymers does not change symbatically with the filtration rate. The latter passes through a minimum at a polymer concentration of 0.05%. This may be due to the fact that at low polymer concentrations, not all particles aggregate, the remaining particles clog the pores, and thus the rate of fluid passage through the sediment layer decreases.

This is due to the fact that under the influence of the polyelectrolyte, firstly, peptization of soil particles can occur, and, consequently, clogging of pores with smaller particles, and secondly, the screening of the particle surface with a polymer. As a result, favorable conditions are created for the sliding of particles relative to each other and the appearance of a dense packing, which inhibits the passage of the liquid phase through the sediment layer. However, if peptization occurred, the volume of the sediment would have to continuously decrease, the dispersion medium would be turbid, but this is not observed. The observed decrease in specific viscosity Soil filtrate in comparison with the initial lignin solutions confirms the correctness of the second assumption - there is an enveloping of the surface of soil polymer particles. By calculation, the maximum adsorption of lignin on soil particles was determined at 8.2%, which is significantly higher than for PAA.

Thus, polyacrylamide polymers and lignin interact with soil particles. Depending on the nature of the polymer, this leads either to an increase in the sliding of the soil particles enveloped by it relative to each other, or to the structuring of soil particles. When studying the soil brought from the bottom of the drained Aral Sea, it was found that the filtration rate in the presence of the polymer of the SHM series developed by us in all the indicated concentrations increases, but not proportionally to the increase in its dosage, since in the process of interaction of soil particles with the polymer, aggregates of different sizes are obtained. On light soil, the increase in the filtration rate is even more pronounced than on non-saline light soil. For comparison

with the developed by us polymer of the "SHM" series, the PAA polymer was investigated on light inhabited soil, which in the same sequence increased the rate of water filtration through the soil.

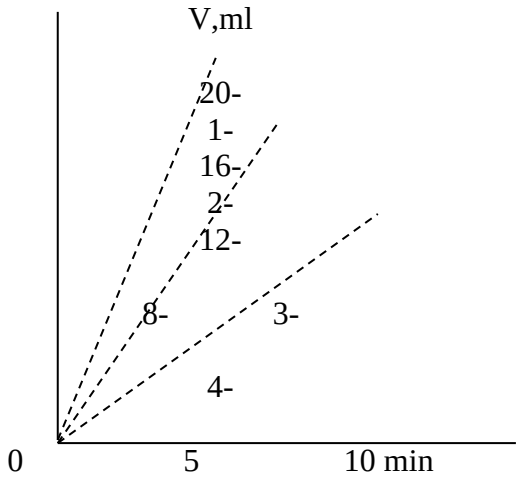

Fig. 1. Change in the rate of filtration of soil suspension on the concentration of lignin: 1-original soil, 2-0.2% lignin, 3-0.5% lignin.

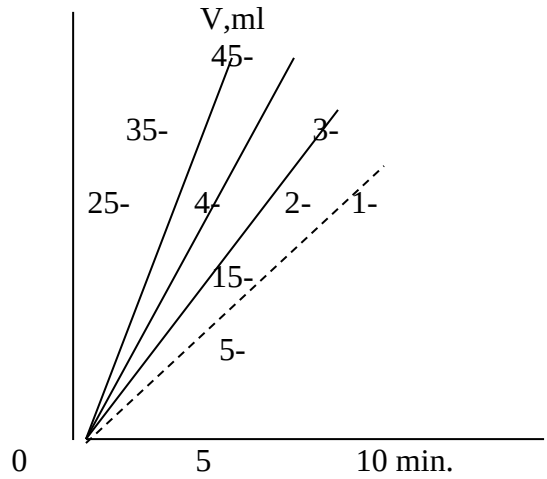

Fig. 2. Change in the rate of filtration of soil suspension on the concentration of SHM: 1-original soil, 2 - 0.05% SHM, 3 - 0.1% SHM, 4 - 0.3% SHM.

The granulometric composition of the soil affects the bonding process of microaggregates. Against the background of calcium chloride, soil particles of different sizes form the most loose sediments in the presence of SHM.

Analyzing the obtained experimental data, the efficiency of SCM was calculated by their effect on soil suspensions. It turned out that in a typical soil, the effectiveness of "SHM" at a dose of 0.05% to the weight of the soil is 11, and PAA is 9.

From what has been said it follows that under the influence of the SHM developed by us from waste and local raw materials, structure formation occurs in 10% soil suspensions, as a result of which larger aggregates are formed that contribute to an increase in the rate of passage of the liquid phase through the sediment layer. Structural formation leads to a decrease taken together stability of the suspension, which, in turn, is associated with a decrease in the degree of dispersion of the system.

By the method of sedimentation analysis, the effect of the polymer of the SHM series synthesized by us on the dispersity of various mineral suspensions was studied. The experiments were carried out with 0.2% suspensions, to which, 24 hours after preparation, polymer solutions were added in appropriate dosages.

The effect was studied in kinetics after 5, 10, 15, etc. minutes. It was revealed that under the influence of "SHM" the degree of dispersion and other values associated with the size of the suspension particles change. Equilibrium is established after 5 minutes of contact of the suspension with the polymer. Regardless of the type of mineral system, the radius of the most probable particles increases, which indicates the aggregation of particles of the dispersed phase under the influence of a polymer additive. Aggregation of the dispersed phase occurs within the optimal dosage of the polymer. A further increase in the concentration of "SHM" contributes to an increase in dispersion and, accordingly, a decrease in the value of the most probable radius of particles, which may be a consequence of the disintegration of the formed aggregates under the influence of the polyelectrolyte and the stabilization of the particles of the suspension.

Analysis of the known polymer compositions [4,5] showed that the addition of methacryloylchloride and orthophosphoric acid in combination with other components significantly increases the strength and adsorption capacity of soils, as well as due to the presence of phosphates, amines and other microelements, positively affects the growth of seeds, the presence of phosphogypsum in combination with sawdust contributes to a strong fixation of the sand, which leads to a greater retention of moisture under a newly formed crust of sand, like mulch, from drying out, at the same time fixing its surface and thereby preventing wind erosion. This ultimately leads to a simplification of the technology for producing polymer compositions at

lower material and energy costs, which significantly reduces the cost of a unit of production, thus, this composition of components gives the composition new properties.

We have experimentally found that the use of the developed polymer reagent allows:

-reduce wind erosion and soil deflation,

-increases the strength of the crust due to the formation of a water-soluble polymer of strong chemical compounds with salt ions in the sand,

-increase the productivity of plant seeds by increasing soil moisture.

In addition, the use of the developed polymer composition significantly reduces the water consumption during irrigation, due to the formation of polymer gel structures in the soil, which leads to a decrease in the cost of production in general.

Conclusion

Thus, structure formation in mineral suspensions under the influence of the SHM polymer is in a complex dependence on the polymer concentration.

The study of the change in the filtration properties of a typical irrigated gray soil, light gray soil under the influence of the polymers developed by us, showed that on a typical irrigated gray soil, with the addition of polymer in doses of 0.005 to 0.3% to the soil sample, the filtration rate increases with an increase in the polymer concentration. The polymer, both in pasty state and in the form of a dry powder, accelerates filtration, but to a lesser extent than PAA.

The results of studies of the influence of high-molecular-weight compositions on the formation of wind- and water-resistant aggregates, as well as on the mechanical strength of the crust showed that the polymer compositions developed by us are largely

To a certain extent, they create favorable conditions for the cultivation of salt-resistant plants on the fixed sands of the drained bottom of the Aral Sea.

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