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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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O. K. Beysenbayev[1], U. K. Ahmedov[2], A. B. Issa[1],
B. M. Smaylov[1], M. M. Esirkepova[1], Zh. K. Artykova[1]

[1]M. Auezov South Kazakhstan state university, Shymkent, Kazakhstan,
[2]Institute of General and inorganic chemistry, Academy of Sciences of the Republic of Uzbekistan,
Tashkent, Uzbekistan.
E-mail: oral-kb@mail.ru, baha_uppr@mail.ru, isa.aziza@mail.ru

RECEIVING AND RESEARCH OF THE MECHANISM OF CAPSULATION OF SUPERPHOSPHATE AND DOUBLE SUPERPHOSPHATE FOR GIVING OF STRENGTH PROPERTIES

Abstract. In this article process of receiving and a research of the mechanism of capsulation of superphosphate and double superphosphate is considered. Influence of water-soluble polymers depending on concentration and temperature on process of capsulation and granulation of fertilizers, and also on strength characteristics is investigated. It is found out that, the mechanism of process of capsulation of fertilizers consists of several stages: polyelectrolyte adsorption, aggregation of particles of fertilizer, structurization with formation of large units and formations of the thin gel encapsulating layer. At the same time it is shown that carrying out process of capsulation of fertilizers polyelectrolytes leads to receiving the qualitative prolonged fertilizers and improvement of amelioration due to aggregation of soils, agronomical properties saline and damp terrestrial soils.

Keywords: fertilizer, superphosphate, double superphosphate, capsulation process, structurization, polyelectrolytes, statistical durability, fluidized layer, phosphoric slime.

Introduction. Now before the chemical industry, the problem of utilization of large-capacity production wastes of phosphorus – phosphoric slime is particularly acute. Large volumes of this industrial waste not only considerably worsen an ecological situation in regions of Kazakhstan, but also occupy significant floor spaces. In this regard for the cardinal solution of the specified problems, ways of processing of phosphoric slimes, for the purpose of receiving polymer containing complex fertilizers are developed.

It is known that water-soluble polymers (polyelectrolytes) have unique complex properties depending on concentration in system, at low concentration have structure-forming effect, and in more concentrated solutions the pronounced stabilizing effect [1].

Besides, thanks to successful combination of physical and chemical properties of high-molecular connections and surfactants are widely used in various fields of the industry as regulators of stability of disperse systems, stabilizers, structurants, deemulgator, thickeners, frothers, flotoreagent, etc.

Now these polyelectrolytes are widely used in the process of capsulation of various materials (pesticides, fertilizers, medicines, etc.) for protection against the environment, for giving of the strength and prolonged properties.

Slime has smaller density, than pure phosphorus which is 1200 kg/m^3. At his warming up to the temperature of 333-353K there is a division of phases. As pure phosphorus has density of 1720 kg/m^3, it remains in the lower part, and slime – easier gathers above. Slime has low density because of existence of inclusions of water. By production of yellow phosphorus the spherical, shapeless granules less than 20 microns in size similar to sand which it is accepted to call "granulated" can be formed. Such slime is usually formed in sewage or at a slime warming up. The maintenance of a water phase in such slimes reaches 50%.

Under the action of dilute HNO_3 or $K_2Cr_2O_7 + H_2O$, the slime is destroyed with the isolation of pure yellow phosphorus and an insoluble precipitate. Part of the phosphorus is oxidized to H_3PO_4.

Methods. The chemical analysis of phosphoric slime is presented in table 1.

Table 1 – The chemical analysis of the phosphoric slime (calcinated at temperature 1273 K)

Composition ,%										Specific surface, m^2/g	Loss on ignition, %
Composition of slime	P_2O_5	CaO	MgO	SiO_2	Al_2O_3	F	Na_2O K_2O	Fe_2O_3	Σ		
Rich slime	18,5	1,34	3,92	57,4	10,1	2,1	2,72	1,52	97,6	–	7,82
Theore-tical		10,0-29,8	0,7-7,8	5,9-5,1	–	–	2,3-4,2	3,3-9,0	–	>100	12,4-33,0

Phosphoric slime is formed as a result of the silicon fluoride hydrolysis which always is contained in small amounts in oven gases. Then fine surface-active silicon dioxide adsorbs phosphorus. At formation of slime along with phosphorus there is probably also an adsorption silicon dioxide of a part of water. The amount of the slime which is turning out on this or that mechanism depends on the content of fine disperse dust in oven gases and extent of sublimation of compounds of fluorine from phosphorite in the course of melting in the electric furnace. It is established that the probability of formation of slime on the first way makes 90-95%, on the second (through SiF_4) – 5-10%.

Results. Phosphoric slime is cheap raw materials, however at his use as fertilizer is ineffective that is connected mainly with small contents the assimilable forms of phosphoric anhydride (figure 1, table 2). Results of researches have shown that the content of phosphoric anhydride in phosphoric slime has made

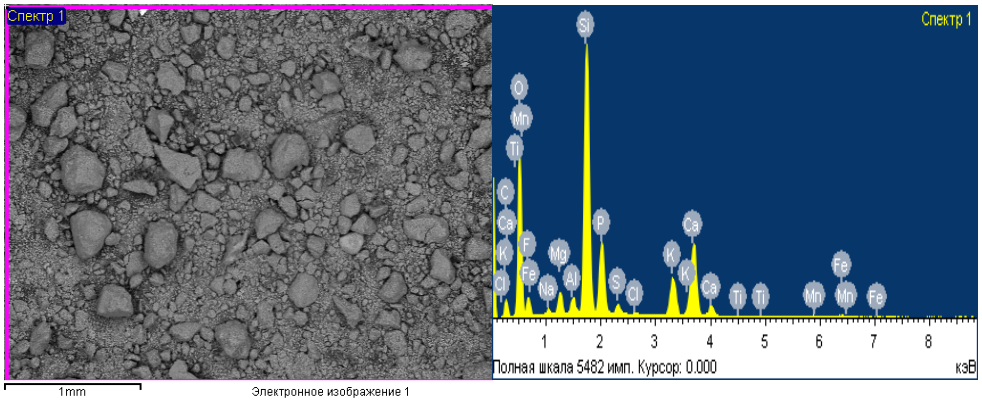


Figure 1 – Mineralogical composition and microstructure of phosphoric slime

Table 2 – Mineralogical structure of a sample of phosphoric slime

Element	Weight, %	Chemical composition of oxides, %	%
F	3.74	–	–
Na	0.77	NaO	1,04
Mg	1.86	MgO	3,08
Al	0.97	Al_2O_3	1,83
Si	17.58	SiO_2	37,60
P	7.02	P_2O_5	16,08
S	0.87	–	–
Cl	0.13	–	–
K	4.16	K_2O	5,01
Ca	8.86	CaO	12,4
Ti	0.02	TiO_2	0,033
Mn	0.24	MnO	0,31
Fe	0.52	Fe_2O_3	0,67

18,5%. Nevertheless on sour soils fine phosphoric slime of some fields is successfully applied as slowly operating fertilizer. From phosphoric slime of such fields it is possible to receive a number of qualitative fertilizers: superphosphate, double superphosphate, ammophos, monoammonium phosphate.

In this regard the mechanism of decomposition of phosphoric slime by sulfuric acid or phosphoric acid in the presence of water-soluble polyelectrolytes is considered, and also for establishment of structure complex the polymer-containing fertilizers - superphosphate and double superphosphate and interaction of the components which are contained in them researches by the x-ray power dispersive INCAEnergy (OxfordINSTRUMENTS) microanalyzer ISM-6490LV(IED) established on a raster electronic microscope are conducted. Shooting at the SEM was carried out at an increase of 1000 and 10,000 times (figure 1, 2, table 2, 4).

The way of receiving complex the polymer-containing fertilizers of superphosphate and double superphosphate by method of decomposition of phosphoric slime sulfuric or phosphoric acid in the presence of polyelectrolytes [2, 3] is developed.

From stainless steel with a mixer and a shirt load a certain amount of phosphoric slime, sulfuric or phosphoric acids into the reactor. Process of decomposition of phosphoric slime is carried out at 60 °C at continuous hashing within 60 minutes. At the same time there is a decomposition of phosphoric slime to formation of a monokaltsiyfosfat and sulfate of calcium according to the total equation:

$$2Ca_5(PO_4)_3F + 7H_2SO_4 + 3H_2O = 3Ca(H_2P0_4)_2 \cdot H_2O + 7CaSO_4 + 2HF$$

For improvement of qualitative characteristics and giving of strength properties are added esterifies derivatives of the hydrolyzed polyacrylonitrile (EPPAN) or polyacrylamide (EPPAA), i.e. water-soluble polyelectrolytes to complex fertilizers. Increase in strength characteristics and prolongation is explained by capsulation complex fertilizer of water-soluble polyelectrolytes.

15 minutes before the end of thermostating, 0.2-0.4 ml of EPPAN and EPPAA are added to the mixture. The resulting pastes were granulated and dried for 120 minutes at temperature of 100°C.

The resulting complex polymer-containing fertilizer - superphosphate has the following composition, presented in table 3.

Table 3 – The content of phosphorus pentoxide in the final product

Name	Thermostating, t °C	H_2O, ml	ВРПЭ, ml	P_2O_5 total	P_2O_5 assimilable	P_2O_5 water-soluble	N	Weight of finished product, g
100 g of slime thermo-stated within 1 hour	60	70	0,2	13,12	12,75	9,12	2,0	70

In the figure 2 and the microscopic picture and mineralogical structure of samples complex the polymer-containing fertilizer of superphosphate are presented in table 4. From the obtained data it is visible that samples have generally amorphous structure with small inclusion of metals.

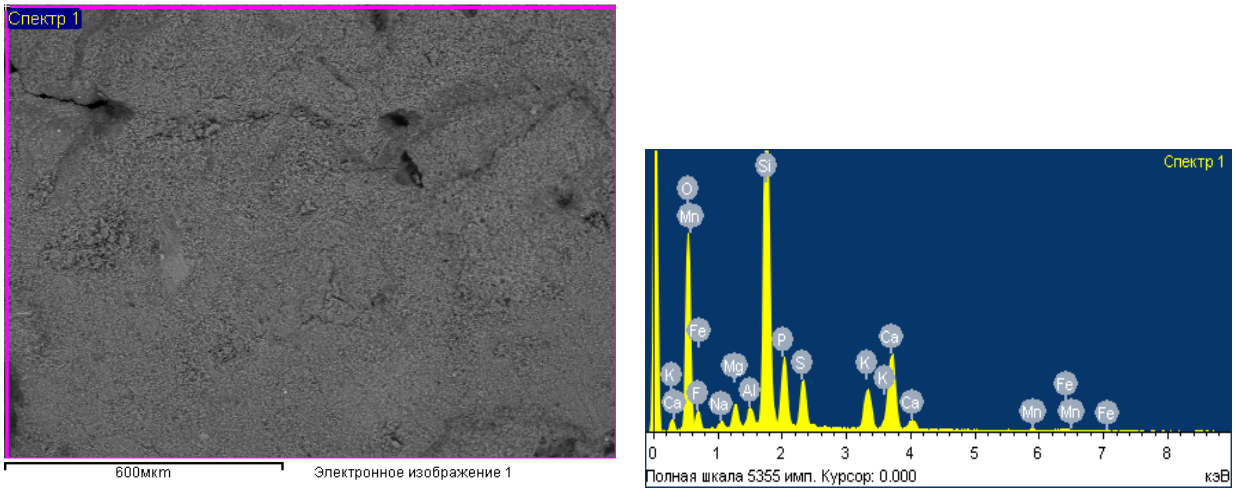


Figure 2 – Mineralogical composition and microstructure of sample of the polymer-containing fertilizer of superphosphate

Table 4 – Mineralogical structure of a sample of the polymer-containing fertilizer of superphosphate

Element	Weight, %	Chemical composition of oxides	%
O	44.86	–	–
F	6.55	–	–
Na	0.62	Na_2O	0,84
Mg	1.79	MgO	2,97
Al	1.11	Al_2O_3	2,1
Si	20.42	SiO_2	43,68
P	6.46	P_2O_5	14,8
S	4.24	SO_3	10,6
K	4.05	K_2O	4,88
Ca	9.02	CaO	12,62
Mn	0.25	MnO	0,32
Fe	0.61	Fe_2O_3	0,87

From figure 2 and table 4 are shows that the obtained complex polymer-containing fertilizer - superphosphate incorporates all trace elements - Mg, Al, Si, K, Ca, Mn, Fe, and phosphorus for normal growth and crop yield.

Method for the preparation of a complex polymer-containing organomineral fertilizer, double superphosphate [3] was developed, which is carried out as follows, in 100 g of sifted finely dispersed phosphorus slurry 70 ml of evaporated 43.37% H_3PO_4 are added.

The process of decomposition of phosphoric acid by phosphoric acid proceeds according to the following basic reactions:

$$Ca_5(PO_4)_3F + 7H_3PO_4 + 5H_2O = 5Ca(H_2PO_4)_2 \cdot H_2O + HF,$$

$$CaMg(CO_3)_2 + 4H_3PO_4 = Ca(H2PO_4)_2 \cdot H_2O + Mg(H_2PO_4)_2 \cdot H_2O + 2CO_2,$$

$$R_2O_3 + 2H_3PO_4 + H_2O = 2[RPO_4 \cdot 2H_2O].$$

The resulting mixture is incubated at 60°C for 60 minutes, 0.2 ml of hydrolysed polyelectrolyte derivatives based on PAN are added to the end of the thermostatting [3]. This produces a thick mass which is granulated and the finished granules are dried for 120 minutes at temperature of 100°C.

In the process of obtaining double superphosphate on the basis of phosphorus slime, two main stages can be distinguished. In the first stage, with continuous mixing of phosphorus slime and phosphoric acid, the reaction proceeds in mobile suspension, the liquid phase of which contains phosphoric acid, monocalcium phosphate, and other soluble reaction products.

In the second stage, the decomposition of phosphate is accompanied by the crystallization of monocalcium phosphate, as a result of which the compositions of the liquid and solid phases of the reaction mass gradually change. The isolation of crystals deposited in part on the phosphate grains makes it difficult for H^+ ions to access them, and the decomposition process slows down sharply. When the liquid phase of the suspension becomes saturated with both monocalcium phosphate and dicalcium phosphate, the decomposition reaction ceases.

The rate of dissolution of phosphates in unsaturated solutions of solutions containing phosphoric acid is limited by the diffusion of the least mobile calcium ion from the disintegrating surface of the phosphate grain into the liquid phase. The quality of double superphosphate is estimated by the content of the assimilable P2O5 in it, which is present in the form of various compounds: H_3PO_4, $Ca(H_2PO_4)_2$, $Mg(H_2PO_4)_2$, $CaHPO_4$, $MgHPO_4$, iron and aluminum phosphates.

The resulting polymer-containing double superphosphate fertilizer is a light gray granule that is very soluble in water, 3-5 mm in diameter, with high strength characteristics, which is necessary for the operation.

In the figure 3 and the microscopic picture and the element analysis of double superphosphate are presented in table 5. It can be seen that samples have, generally amorphous structure with small inclusion of metals. In the figure 5 presence of elementary phosphorus is shown. In terms of phosphoric anhydride the maintenance of P_2O_5 is generally 24.08%.

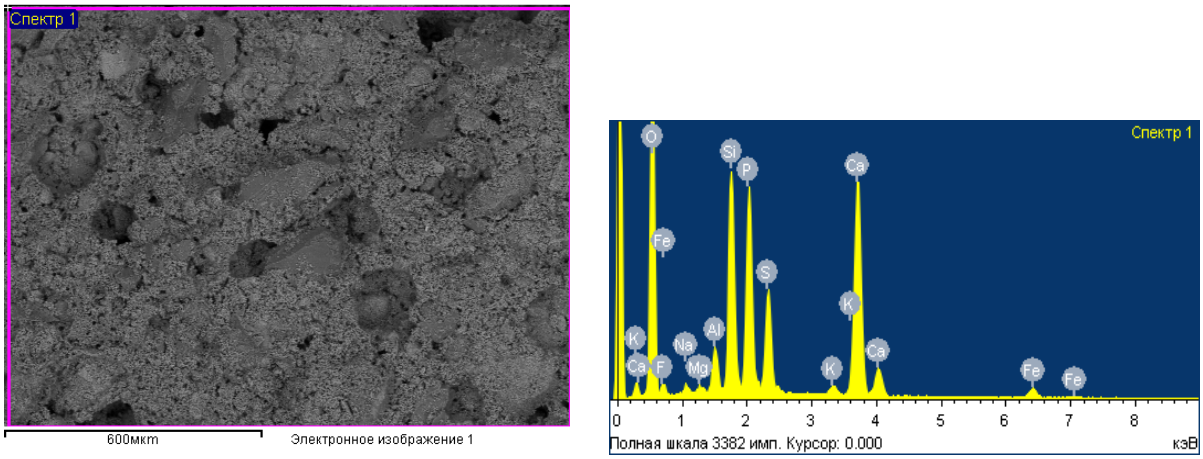


Figure 3 – Microscopic snapshot and elemental analysis
of the complex polymer-containing organomineral fertilizer – double superphosphate (based on phosphate flour)

Table 5 – Elemental analysis of the complex polymer-containing organomineral fertilizer – double superphosphate (based on phosphate flour)

Element	Weight, %	Chemical composition of oxides	%
O	53.67	–	–
F	2.05	–	–
Na	0.68	Na_2O	0,92
Mg	0.33	MgO	0,55
Al	1.67	Al_2O_3	3,16
Si	7.79	SiO_2	16,66
P	10.51	P_2O_5	24,08
S	5.26	SO_3	13,15
K	0.51	K_2O	0,61
Ca	15.86	CaO	22,19
Fe	1.69	Fe_2O_3	2,42

It can be seen from figure 3 and table 5 that the obtained complex polymer fertilizer - double superphosphate has in its composition all trace elements - Mg, Al, Si, K, Ca, Fe and phosphorus for normal growth and increase of crop yields.

This increases water retention in soil aggregates due to the structure-forming properties of the polymer, which positively affects crop yields.

Double superphosphate has the same agrochemical efficiency, as well as simple superphosphate at introduction of equal quantities of assimilable P_2O_5. His main advantage consists in rather smaller quantity of ballast. It reduces costs of transportation and storage of nutrient (P_2O_5), reduces a container expense, reduces costs of entering of fertilizer into the soil. Therefore use of double superphosphate is economically more effective, than simple superphosphate of the received product which is well influencing strength characteristics.

The processes underlying the action of modified polyelectrolyte derivatives based on PAN, PAA as structurants are in many respects similar to those occurring when they are used as a soil-forming agent for soil and soil aggregates [4, 5]. The shape of the molecules of polyelectrolytes in solution is determined by the ionic strength and pH of the solution. The polyelectrolytes of amphoteric character containing ionogenic - carboxyl, amide, imidny and radio groups [4] are effective. Obviously, for an effective action of an ionogenic polymer on the structure of fertilizer granules, some optimal content of charged groups in the molecule is necessary.

Addition of polyelectrolyte to mineral fertilizers contributes to the formation of the structure in the system and the formation of the polymer-fertilizer complex, to the retention of the assimilable P_2O_5 in the fertilizer composition, and subsequently, when used, leads to the aggregation of soil aggregates, these aggregates retain moisture, which has a beneficial effect on the preservation of soil moisture for a long time. Thus, these polyelectrolytes contribute to improvement of melioration due to aggregation of soils, but also agronomic properties of solonchakous and damp soils.

Application by production of superphosphate and double superphosphate of the modified derivative polyelectrolytes on a basis the PAN, PAA promotes not only improvement of operational properties of mineral fertilizers, but also increase in productivity of crops.

The relative maintenance of water-soluble P_2O_5 is influenced significantly by presence of the modified derivative polyelectrolytes on a basis the PAN, PAA, fiber waste Nitron which considerably improve this indicator, thereby increasing enrichment of the soil useful elements.

Capsulation of the received superphosphate is carried out in two ways:

The first is method of soaking, the received complex polymer-containing fertilizer 0.2% solution of polyelectrolyte and further drying at 105^0C and granulation. As polyelectrolyte esterified derivatives of the hydrolyzed polyacrylonitrile are used.

The second is a capsulation method, at the same time capsulation and drying of complex polymer-containing fertilizer it is carried out by a dusting method polyelectrolyte in a fluidized layer. Capsulation is carried out by a dusting method fertilizer polyelectrolyte in the mounted multisection device in fluidized layer.

Results of a research of the influence of the drying temperature on durability of granules complex the polymer-containing fertilizers in the process of capsulation by EPPAN polyelectrolyte are presented in table 6.

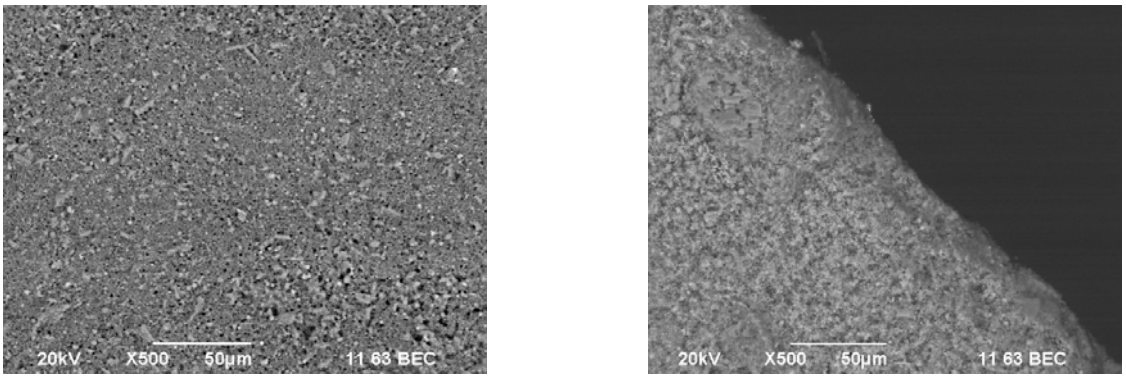
Table 6 – Influence of temperature on durability of granules

Capsulation mode	Temperature, ^{0}C			
	25	50	75	100
Before capsulation				
Static durability of granules, kg	0	0	1,0	1,87
Capsulation with 0.25% solution of EPPAN				
Static durability of granules, kg	2,75	1,87	15,8	2,86
Capsulation with 0.5% solution of EPPAN				
Static durability of granules, kg	2,98	7,10	18,27	2,10
Capsulation with 1.0% solution of EPPAN				
Static durability of granules, kg	8,50	4,75	13,78	3,78

As can be seen from the table the statistical durability of the granules of fertilizers which aren't encapsulated by polyelectrolyte (before capsulation) is in limits of 0–1.87 kg, and at capsulation durability of granules increases up to 18.27 kg. Statistical durability of granules depends not only on concentration of polyelectrolyte, but also on capsulation process temperature. The optimal condition for the process of mineral fertilizer encapsulation corresponds to the content of a 0.25-0.5% solution of EPPAN at a temperature of 75°C, as evidenced by micrographs (figure 4–7).

To establish the mechanism of the encapsulation process, the microstructure of fertilizers – superphosphate and double superphosphate (figures 4–7) in the process of drying and granulation depending on the concentration of EPPAN was studied (0,25, 0,50, 0,75, 1,0%) at temperature of 75^0C.

In figure 4a the microstructure of the encapsulated and granulated double superphosphate at 75^0C in the presence of 0.25% of water solution of the hydrolyzed polyacrylonitrile is presented. At this concentration there is the structure formation of a system - double superphosphate, i.e. it turns into fine-grained amorphous structure. The microstructure of cut of the capsule is presented in figure 4b from which it is visible that concentration of polyelectrolyte is insufficient for formation of protective layer of the capsule. But at the same time the static durability of granules increases from 1.0 to 15.8 kg.



(a) (b)

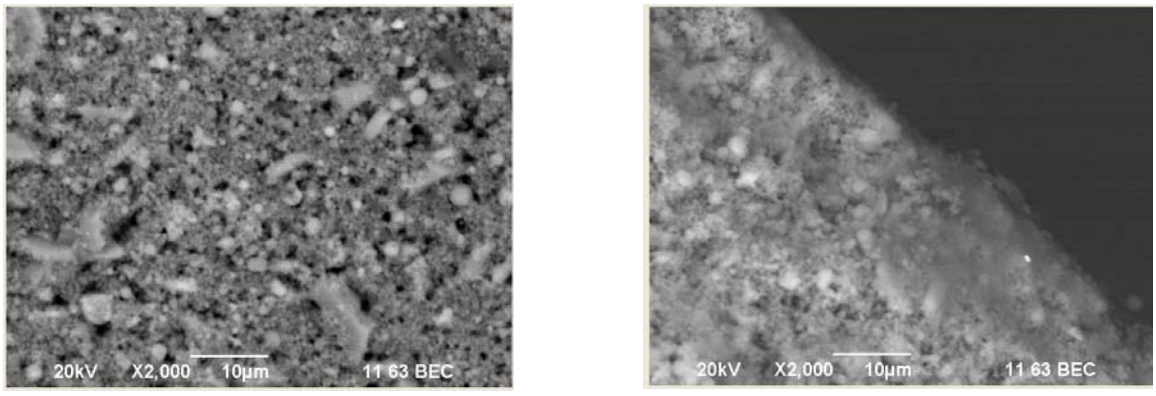
Figure 4 – Microstructure (a) and a cut of sample (b) of the encapsulated and granulated double superphosphate at 75^0C in the presence of 0.25% of water solution of the hydrolyzed polyacrylonitrile

In figure 5a the microstructure of the encapsulated and granulated double superphosphate at 75^0C in the presence of 0.5% water solution of the hydrolyzed polyacrylonitrile is presented. Increase in concentration of polyelectrolyte in a system leads to change of structure of fertilizer, i.e. in structure of fertilizers needle and uneven rhombic forms appear. Besides, in structure light barrel-shaped forms on properties characteristic of aluminosilicates are found. It demonstrates that emergence of these fragments in structure of fertilizer, probably, is connected with aggregation of particles of fertilizers and further forming of the large interconnected units due to adsorptive properties and functional groups of the polyelectrolytes responsible for strength properties of structure of all system. With increasing concentration the polymolecular sorption occurs, accompanied by hydrophilization of the particle surface [7, 8]. According to some scientists at such concentration the secondary adsorptive layer in which molecules are guided a hydrophilic part outside that promotes coagulative coupling of particles [5] is formed. Perhaps also are forming of superficial connection or fertilizers of a polymeric complex.

All this, probably, leads to formation of amorphous structure with the advent of crystal.

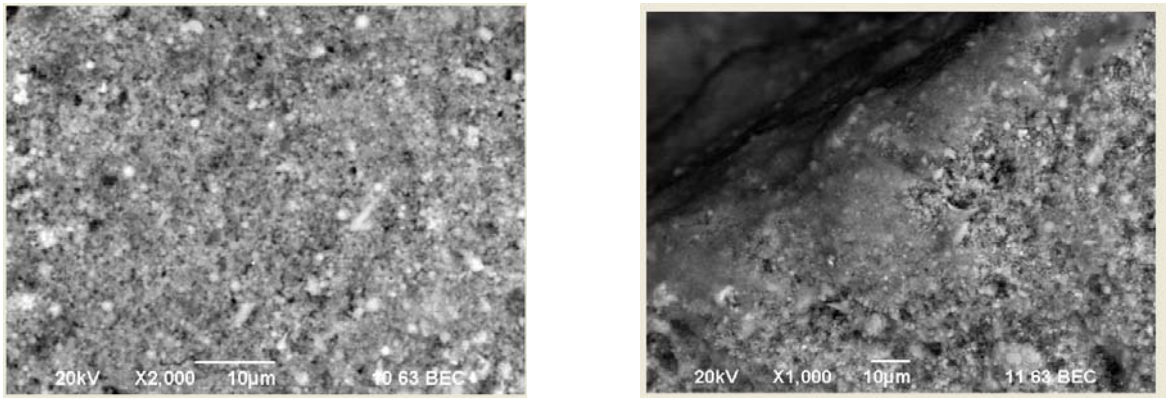
In figure 5b the cut of the top part of the encapsulated granule from which it is visible that polyelectrolyte not only has the binding and structuring properties of an internal part of structure of a granule, but also the encapsulating action of the top layer is presented. At the same time accumulation of binding components in the top part of granules (figure 5b), probably, increase in concentration of structural polyelectrolyte is observed that leads to primary education of a thin film on a surface of granules and provides increase in durability up to 18.27 kg.

At concentration of 0.75% of polyelectrolyte (figure 6a) insignificant reduction of quantity of needle and uneven rhombic forms is observed. Increase in concentration of polyelectrolyte in a system leads to further increase in binding components in the top part of granules (figure 6b) and there is a spatial and



(a) (b)

Figure 5 – Microstructure (a) and a cut of sample (b) of the encapsulated and granulated double superphosphate at 75^0C in the presence of 0.5% water solution of the hydrolyzed polyacrylonitrile



(a) (b)

Figure 6 – Microstructure (a) and a cut of sample (b) of the encapsulated and granulated double superphosphate at 75^0C in the presence of 0.75% water solution of the hydrolyzed polyacrylonitrile

mesh structure consisting of small flocculants and separate particles with adsorbed on them molecules of polyelectrolyte connected among themselves by rather strong filamentary bridges from molecular chains of polyelectrolyte [7, 8] (figures 2, 3, 8).

Thus, increase in concentration of structural polyelectrolyte leads to formation of gel structure (in the form of the encapsulating layer) in the top part of granules and to formation of thin films that provides strength properties to granules.

In process of capsulation 1% water solution of polyelectrolyte (figure 7a) also observes reduction of quantities of needle and uneven rhombic forms. More structured part is observed on a surface of granules (figure 7b) and at the same time are formed the encapsulating polyelectrolyte layer due to interaction of the active centers of mineral fertilizers and active functional groups of polyelectrolyte with formation of thin films.

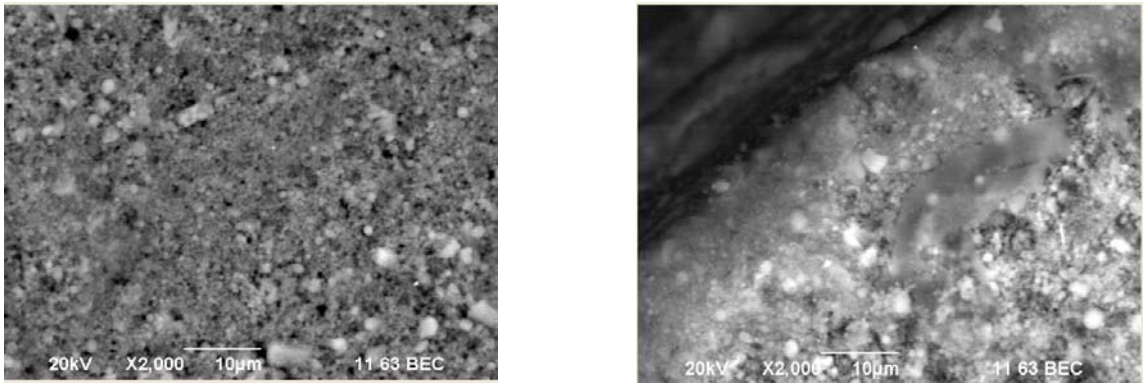
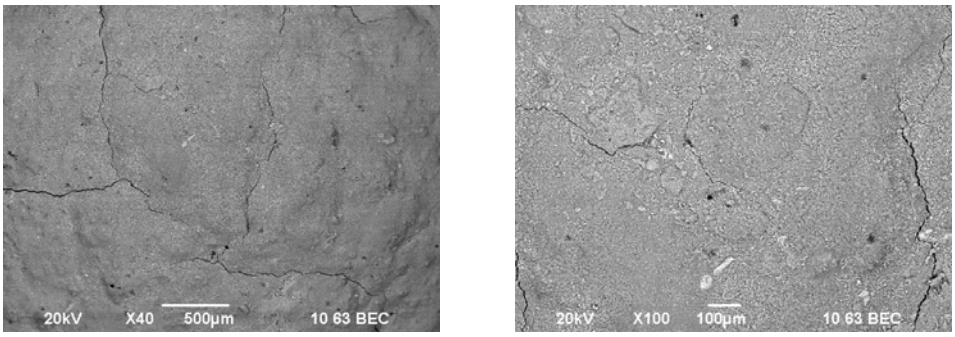


Figure 7 – Microstructure (a) and cut of a sample (b) of the encapsulated and granulated double superphosphate at 75^0C in the presence of 1% water solution of the hydrolyzed polyacrylonitrile

Thus, the mechanism of capsulation of double superphosphate polyelectrolyte consists in aggregation of small particles as a result of which there is a formation of the units leading to structuring in the form of amorphous and crystal structures with formation of the encapsulating layer on surface of granules.

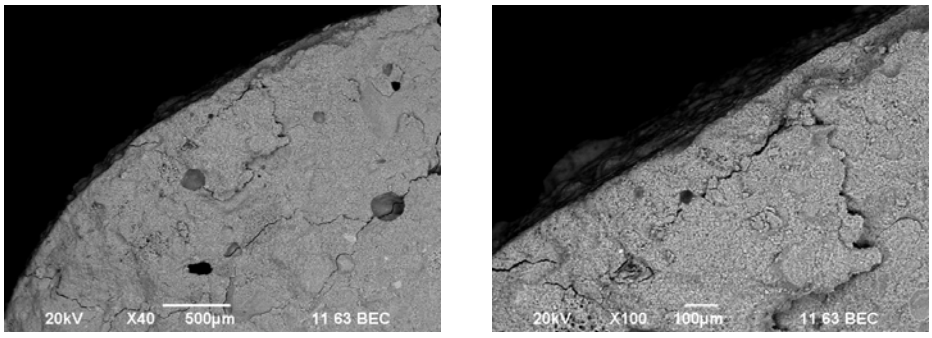
For reliability of the received results on the mechanism of capsulation and for comparative analysis are given below (figure 8, 9) a microstructure of a sample of complex polymer containing fertilizer – superphosphate on the basis of the phosphoric slime encapsulated 0.5% EPPAN solution at 75^0C.

The figures show that the complex polymer – containing fertilizer-superphosphate also strengthens the structure of the complex fertilizer. Apparently, the aggregation of small particles occurs, as a result of which the formation in the form of aggregates occurs due to the interaction of functional groups with the active centers of mineral fertilizer. In addition, on the surface of the particles of complex fertilizers, they form a thin film (figures 8, 9).



(a) (b)

Figure 8 – Microstructure of sample of complex polymer containing fertilizer of the superphosphate which is dried up at 75 ^{0}C (a) - superficial, (b) - a reverse side



(a) (b)

Figure 9 – Microstructure of sample of complex polymer containig fertilizer of the superphosphate which is dried up at 75 ^{0}C (a) - a cut 1, (b) - a cut 2

Conclusions. Methods of receiving the polymer-containing complex mineral fertilizers – superphosphate and double superphosphate are developed. Influence of water-soluble polymers depending on concentration and temperature on process of capsulation and granulation of fertilizers is investigated. It has been established that the mechanism of process of capsulation of fertilizers consists of several stages: polyelectrolyte adsorption, aggregation of particles of fertilizers, structurization with formation of large units and formation of the thin gel encapsulating layer. It has been established that the process of encapsulating mineral fertilizers with polyelectrolyte EPPAN leads to complex properties such as an increase in strength characteristics (18 kg) and elongation, as well as improvement of reclamation through aggregation of soils and soil aggregates.

О. К. Бейсенбаев[1], У. К. Ахмедов[2], А. Б. Иса[1], Б. М. Смайлов[1], М. М. Есиркепова[1], Ж. К. Артыкова[1]

[1]М. Әуезов атындағы Оңтүстік Қазақстан мемлекеттік университеті, Шымкент, Қазақстан,
[2]Өзбекстан Республикасы ҒА жалпы және бейорганикалық химия институты, Ташкент, Өзбекстан

БЕРІК ҚАСИЕТТЕРДІ БЕРУ ҮШІН СУПЕРФОСФАТТЫ ЖӘНЕ ҚОС СУПЕРФОСФАТТЫ КАПСУЛАЛАУ МЕХАНИЗМІН ЗЕРТТЕУ ЖӘНЕ АЛУ

Аннотация. Мақалада суперфосфатты және қос суперфосфатты капсулалау механизмін зерттеу және алу процесі қарастырылады. Концентрациясы мен температурасына байланысты СЕП-дің тыңайтқыштарды капсулалау және түйіршіктеу процесіне, сондай-ақ беріктік сипаттамаларға әсері зерттелді. Тыңайтқыштарды капсулалау процесінің механизмі бірнеше сатыдан тұрады: полиэлектролитті адсорбциялау, тыңайтқыш бөлшектерін агрегаттау, ірі агрегаттарды құрумен құрылым түзу және жұқа гель тәрізді капсулаланған қабаттың пайда болуы. Бұл ретте, тыңайтқыштарды полиэлектролиттермен капсулалау процесін жүргізу сапалы ұзартылған тыңайтқыштарды алуға және топырақты агрегаттау есебінен мелиорациялықты

жақсартуға, сортаң және шикі топырақты топырақтың агрономиялық қасиеттеріне әкеп соқтыратыны көрсетілген.

Түйін сөздер: тыңайтқыш, суперфосфат, қос суперфосфат, капсулалау процесі, құрылым түзу, полиэлектролиттер, статистикалық беріктілік, жалған күйдірілген қабат, фосфорлы шлам.

О. К. Бейсенбаев[1], У. К. Ахмедов[2], А. Б. Иса[1], Б. М. Смайлов[1], М. М. Есиркепова[1], Ж. К. Артыкова[1]

[1]Южно-Казахстанский государственный университет им. М. Ауэзова, Шымкент, Казахстан,
[2]Институт общей и неорганической химии АН РУз, Ташкент, Узбекистан

ПОЛУЧЕНИЕ И ИССЛЕДОВАНИЕ МЕХАНИЗМА КАПСУЛИРОВАНИЯ СУПЕРФОСФАТА И ДВОЙНОГО СУПЕРФОСФАТА ДЛЯ ПРИДАНИЯ ПРОЧНОСТНЫХ СВОЙСТВ

Аннотация. В статье рассматривается процесс получения и исследования механизма капсулирования суперфосфата и двойного суперфосфата. Исследовано влияние ВРП в зависимости от концентрации и температуры на процесс капсулирования и грануляции удобрений, а также на прочностные характеристики. Выяснено, что механизм процесса капсулирования удобрений состоит из нескольких стадий: адсорбции полиэлектролита, агрегирования частиц удобрения, структурообразования с образованием крупных агрегатов и образования тонкого гелеобразного капсулирующего слоя. При этом показано, что проведение процесса капсулирования удобрений полиэлектролитами приводит к получению качественных пролонгированных удобрений и улучшению мелиоративности за счет агрегирования почв, агрономических свойств солончаковых и сыроземных почв.

Ключевые слова: удобрение, суперфосфат, двойной суперфосфат, процесс капсулирования, структурообразование, полиэлектролиты, статистическая прочность, псевдоожиженный слой, фосфорный шлам.

Information about authors:

Beysenbayev Oral Kurganbekovich, M. Auezov South Kazakhstan state university, Shymkent, Kazakhstan; oral-kb@mail.ru; https://orcid.org/0000-0001-9442-213X

Akhmedov Ulugbek Karimovich, Institute of General and inorganic chemistry, Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan; oral-kb@mail.ru; https://orcid.org/0000-0001-8373-0188

Issa Aziza Bakytzhankyzy, M. Auezov South Kazakhstan state university, Shymkent, Kazakhstan; isa.aziza@mail.ru

Smaylov Bakyt Matkarimovich, M. Auezov South Kazakhstan state university, Shymkent, Kazakhstan; baha_uppr@mail.ru; https://orcid.org/0000-0001-7976-9776

Artykova Zhadyra Kuanyshovna, M. Auezov South Kazakhstan state university, Shymkent, Kazakhstan; articova@mail.ru; https://orcid.org/0000-0002-6466-6317

Maral Makhmudovna Esirkepova, M. Auezov South Kazakhstan state university, Shymkent, Kazakhstan; esirkepova_maral@mail.ru; https://orcid.org/0000-0002-0519-1542

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