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OBTAINING UREA COMPLEX FERTILIZER WITH PHYSIOLOGICALLY ACTIVE SUBSTANCES

Ibrohimjon Abidov
Ph.D., Associate Professor, Namangan Institute of Engineering and Technology
E-mail: ib56abidov@gmail.com
Farhod Fayzullaevich Hoshimov
Ph.D., Associate Professor, Namangan Institute of Engineering and Technology
E-mail: farhod@inbox.ru

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Abstract: The possibility of obtaining urea with physiologically active substances (PAS) has been studied. The studies used spectrophotometric methods of determination and statistical processing of results. A method for monitoring PAS in the composition of modified urea, as well as a technology for producing fertilizer, has been developed. A developed method for determining PAS in modified urea with an accuracy of at least 0.026%, which makes it possible to control the technological process of large-scale production of modified urea.

Keywords: physiologically active substances, urea, N-oxide-2,6-dimethylpyridine, benzimidazolin-2-one and 5-chlorobenzimidazolin-2-one, spectrophotometer, method, spectra, statistical processing of results, peak, maximum, bathochromic shift, compound.

ПОЛУЧЕНИЕ КАРБАМИДНОГО КОМПЛЕКСНОГО УДОБРЕНИЯ С ФИЗИОЛОГИЧЕСКИ АКТИВНЫМИ ВЕЩЕСТВАМИ

Аннотация: Изучена возможность получения мочевины с физиологически активными веществами (ПАВ). В исследованиях использовались спектрофотометрические методы определения и статистической обработки результатов. Разработан метод мониторинга ПАВ в составе модифицированного карбамида, а также технология получения удобрения. Разработан метод определения ПАС в модифицированном карбамиде с точностью не менее 0,026 %, позволяющий контролировать технологический процесс крупнотоннажного производства модифицированного карбамида.

Ключевые слова: физиологически активные вещества, мочевина, N-оксид-2,6-диметилпиридин, бензимидазолин-2-он и 5-хлорбензимидазолин-2-он, спектрофотометр, метод, спектры, статистическая обработка результатов, пик, максимум, батохромный сдвиг, сложный.

INTRODUCTION

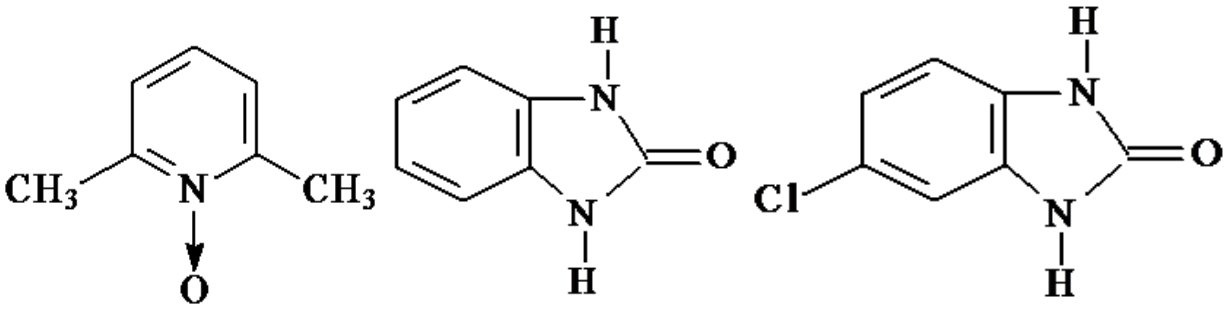
The introduction of physiologically active substances into fertilizers, despite their relatively high cost, gives a positive effect at their low (from 0.03 to 0.05 wt.%) concentrations in a complex fertilizer. Based on the studies carried out, it was shown that a number of stable compositions were obtained, the study of which showed their effectiveness in agriculture as plant growth stimulants, in addition to the main function [1, 2].

Based on urea, modification of prilled magnesium-containing urea granules was obtained and a technology for producing complex NK and NMg-fertilizers based on it was developed, and the possibility of modifying urea with formaldehyde for use in light industry was shown [3, 4].

Using a solid-phase method, polymer complexes containing physiologically active substances are obtained [5-9].

The production of fertilizers containing physiologically active substances (PAS) is not associated with significant specific capital investments for the reconstruction of existing technological schemes, however, it is necessary to solve a number of technological problems associated with the organization of PAS dosage units, mixing PAS with large fertilizer flow, analytical quality control of the finished product. In this regard, issues were considered and research was carried out on the development of methods for introducing PAS into fertilizers and obtaining urea modified with PAS. To develop technical conditions and put products into production, reliable methods for monitoring and determining the content of the studied PAS in the finished product are required. We have developed methods for determining PAS in urea using the spectrophotometric method [10-14].

The following compounds were selected as the active substances - N-oxide-2,6-dimethylpyridine (IVIN), benzimidazolin-2-one (BION) and 5-chlorobenzimidazolin-2-one (5 CBIONE) whose structural formula is as follows:



METHODS

In laboratory conditions, samples of fertilizers were obtained by evaporating urea solutions containing various amounts of IVIN at 100°C. When carrying out the research, recrystallized salts of analytical grade were used. and "h.ch." and laboratory-synthesized BION, 5-CBION, IVIN.

UV spectra were recorded using a Hitachi-EPS-3T spectrometer (solvent - ethanol) and an SF-4A spectrometer (solvent - methanol).

The essence of the method is that the optical densities of the standard PAS solution (Ast) and the test solution of the composition (Ax) are determined. Taking into account the dilution of the studied solutions and the weighed portions of the studied composition samples according to the well-known formula:

$$Cx=(Cst*Ax)/Ast$$

We find the percentage of PAS in the compositions, where: Cx is the desired concentration of the PAS, mg/ml, AX is the optical density of the test solution of the composition, Cst - concentration of standard solution of PAS, mg/ml, Ast is the optical density of the standard PAS solution.

RESULTS

The UV spectra of IVIN and urea were studied (Fig. 1). It can be seen from the figure that at λ = 260 nm the influence of urea on the absorption band of IVIN is practically absent and therefore this band was chosen as characteristic for the quantitative determination of IVIN in IVIN containing urea.

The study of polythermal systems and spectrophotometric analysis showed that IVIN is not subject to physical and chemical changes. The IVIN content in the samples was at the same level as similar “dry compositions”.

DISCUSSIONS

When fusing urea and IVIN for 10 - 15 minutes at a temperature 135°C and stirring followed by cooling, it was found that in the selected range of variation of parameters IVIN did not undergo changes and retains all the properties of a physiologically active compound (Fig. 1 and 2, Table 1).

The IVIN content in IVIN-containing urea is determined with an accuracy of 0.003%.

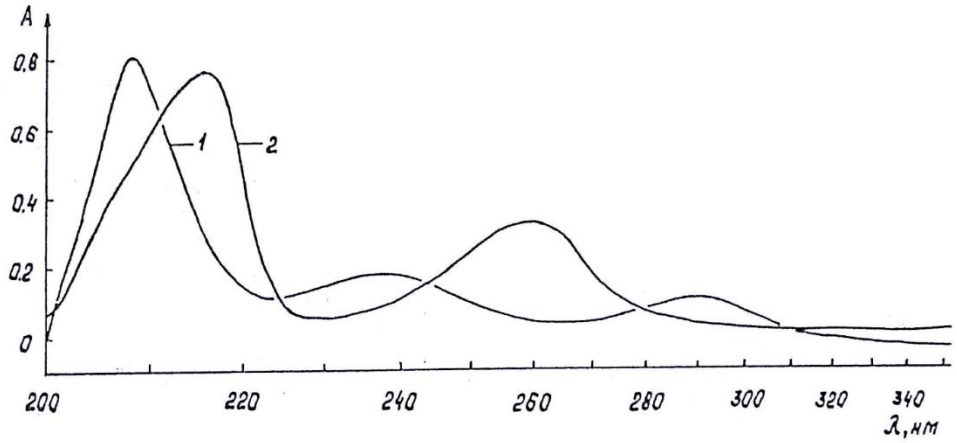


Fig. 1. UV spectra: 1-urea, 2-C7H9NO

Due to the fact that BION and 5-CBION are insoluble in aqueous solutions of urea, they were introduced into a hot melt of urea having a temperature of 135°C.

A method for monitoring the content of PAS in urea has been developed.

Table 1. Statistical processing of IVIN analysis results in IVIN-containing urea

№	Taken, %	Found,%	ΔX	$\Delta X_i-\Delta X^+$	$(\Delta X_i-\Delta X^+)^2$	S	S_x	ξ,%
1	0.050	0.049	0.001	-0.0054	$2.916*10^{-5}$			
2	0.070	0.071	0.001	-0.0054	$2.916*10^{-5}$			
3	0.100	0.105	0.005	-0.0014	$0.20*10^{-5}$			
4	0.300	0.298	0.002	-0.0044	$1.94*10^{-5}$			
5	0.500	0.503	0.003	-0.0034	$1.16*10^{-5}$			
6	0.700	0.702	0.002	-0.0044	$1.94*10^{-5}$	$4.64*10^{-3}$	$1.4*10^{-5}$	0.003
7	1.0	0.989	0.011	0.0046	$2.12*10^{-5}$			
8	2.0	2.013	0.013	0.0066	$4.36*10^{-5}$			
9	3.0	2.988	0.012	0.0056	$3.14*10^{-5}$			
10	4.0	3.989	0.011	0.0046	$2.12*10^{-5}$			
11	5.0	5.009	0.009	0.0026	$0.68*10^{-5}$			

We have studied the UV spectra of urea, BION (1) and 5-CBION (2). Spectra (1) and (2) are characterized by the corresponding three maxima.

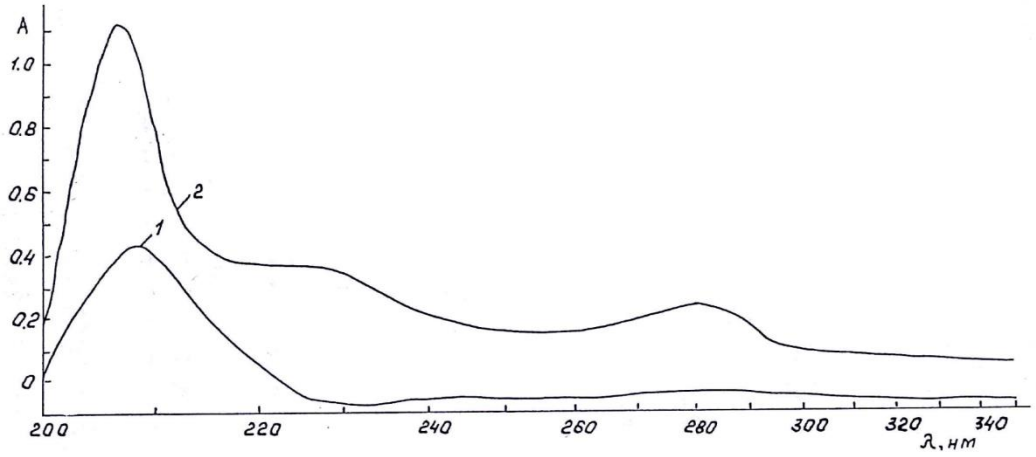


Fig.2. UV spectra: 1-urea; 2-$C_7H_6N_2O$

Analysis of the absorption curves clearly shows the bathochromic shift of all three bands (2) compared to (1), which is explained by the presence of a substituent for the electronegative chlorine atom in position "5" of compound (2).

Table 2. Statistical processing of the results of the analysis of BION in BION-containing urea

№	Taken,%	Found,%	ΔX	$\Delta X_i-\Delta X^+$	$(\Delta X_i-\Delta X^+)^2$	S	S_x	ξ,%
1	0.010	0.013	0.003	-0.005	0.000025	0.0065	0.0025	0.0061
2	0.030	0.028	0.002	-0.006	0.000036			
3	0.050	0.048	0.002	-0.006	0.000036			
4	0.10	0.083	0.017	0.009	0.000081			
5	0.30	0.314	0.014	0.006	0.000036			
6	1.0	1.076	0.0014	0.006	0.000036			
7	2.0	2.010	0.010	0.002	0.000004			

Content (1) has the following absorption bands: λ=206nm (logξ=3.57), λ=225nm (logξ=2.08) and λ=280nm (logξ=1.89), while (2): λ=208 nm (logξ=2.43), λ=227nm (logξ=1.83) and λ=288nm (logξ=1.68).

The most optimal for spectrophotometric determination (1) and (2) in the composition of urea are for (1) λ=280 nm (Table 2, Fig. 2) and for (2) λ=288 nm (Fig. 3, Table 3), where the influence of urea absorption is minimal.

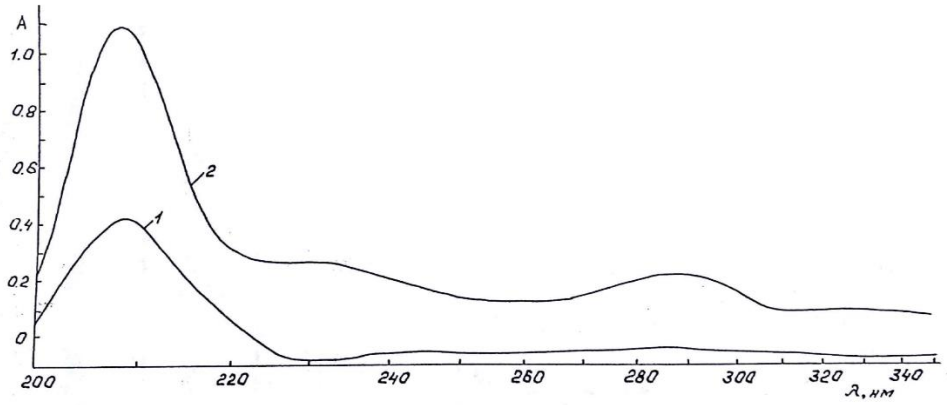


Fig. 3. UV spectra: 1-urea; 2-$C_7H_5N_2OCl$

Table 3. Statistical processing of the results of the analysis of 5-CBION and 5-CBION-containing urea

№	Taken,%	Found,%	ΔX	$\Delta X_i-\Delta X^+$	$(\Delta X_i-\Delta X^+)^2$	S	S_x	ξ,%
1	0.010	0.013	0.003	-0.0055	0.003025	0.072	0.026	0.026
2	0.030	0.032	0.002	-0.0060	0.003600			
3	0.050	0.056	0.006	-0.0025	0.000625			
4	0.10	0.099	0.001	0.0075	0.005625			
5	0.30	0.314	0.014	0.0055	0.003025			
6	0.50	0.515	0.015	0.0065	0.004225			
7	1.0	1.018	0.018	0.0950	0.009025			
8	2.0	1.983	0.017	0.0085	0.007225			

CONCLUSIONS

Thus, the developed method for determining PAS in modified urea makes it possible to control the technological process. The content of BION and 5-CBION in the compositions “urea-1” and “urea-2” was determined with an accuracy of 0.0061 and 0.026%, respectively. The conducted studies show that organizing large-scale production of urea containing IVIN, BION, 5-CBION does not present any particular difficulties.

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