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Research Article

Amperometric and Spectrophotometric Determination of Food Additive Thiabendazole (E-*233*) in Bananas

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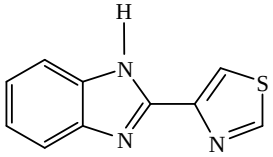
ABSTRACT

We analyzed the interaction of organic cations thiabendazole with heteropoly anions (HPA) of Keggin's structure by methods of UV- spectroscopy and amperometric titration. We studied by UV-spectroscopy the nature of connection organic cation-HPA in the combinations $(TBZH_2)_3(PMo_{12}O_{40})_2$ and we determined the correlation of obtained ionic associates of thiabendazole with HPA by amperometric titration and spectrophotometric method. Defined stoichiometric relation of the reactants by amperometric titration and spectrophotometric methods indicate the formation of ionic associates. Synthesized soluble ionic associates $(TBZH_2)_3(PMo_{12}O_{40})_2$ used as electrode-active substances of plasticized membranes ion-selective electrodes, working in organic cation thiabendazole. The methods of direct potentiometric determination of content thiabendazole in substance food additive (E-233) and bananas that are characterized by sufficient sensitivity, selectivity, simplicity and express.

Keywords: Thiabendazole, Ionic associate, Heteropoly anions, 12-Molybdophosphoric acid, Amperometric titration, UV- spectroscopy.

1. INTRODUCTION

Thiabendazole – 2-(4-thiazolyl) benzimidazole; 2-(4-te Atoll)-1//-benzimidazol belongs to the group of the benzimidazoles ($TBZH_2$). There chelating agent that forms stable complexes with many metals, including iron, but does not bind calcium [1]. The structural formula is as follows:



Empirical formula: $C_{10}H_7N_3S$, the molecular weight of thiabendazole: M=201.3 g/mol. Synonyms: arbotect, mertect, mintezol, tecto, tetusim, trezaderm. Thiabendazole, as a food additive E-233 refers to preservatives, which prevent the development of mold, protecting citrus from damage. E-233 can be used as a surface preservative for fruit and vegetable processing, which improves the appearance of the products during long periods of storage or during transport. Allowable residual content of thiabendazole is 3 to 6 mg per 1kg of fruit. Fruit or vegetable products are processed emulsion with a solution of thiabendazole with the concentration of the latter in the corridor 0.10–0.45%. Part of the rest of Thiabendazole in the range from 5 to 12% is transferred from the surface of citrus peel in the flesh, and the rest (7-14%) gets on the skin. The remains of Thiabendazole well removed in both warm and cold water [2-4].

The most common methods of determining the content of thiabendazole in food products are chromatographic methods [5-9]. The disadvantages of these methods is the complexity and duration of the stages of sample preparation, which increases the time of analysis, the use of toxic and volatile substances, as well as precious equipment. Thus, an urgent problem is development of alternative methods for the quantitative determination of thiabendazole in food products.

The use of electrochemical analysis (amperometric titration and direct potentiometry) is an alternative to the existing methods and gives you the opportunity to develop new simple and rapid methods for the quantitative determination of thiabendazole in food production, which will differ sufficient analytical and metrological parameters (expressly, sensitivity, selectivity), simplicity and low cost of the equipment.

In this paper we propose a new method for the quantitative determination of thiabendazole in substance a food additive E-233 and in food products by the method of direct potentiometry using ion-selective electrodes sensitive to organic cation of thiabendazole. To obtain electrode active material (substance) (EAS) for ion-selective electrodes as counter ions were used heteropoly anions patterns of Keggin's [12]. The study of the reaction between 12-molybdophosphoric acid (MPA) with an organic cation of thiabendazole allowed to use this reaction as an analytical amperometrical during the titration, and the poorly soluble product of this reaction with ion-associative nature of the relationship between heteropoly acid (HPA) and organic cation (OC) – as EAS in the development of ion-selective electrodes (ISE), back to the organic cation of thiabendazole.

2. MATERIALS AND METHODS

2.1. Reagents

In this work, we used the following chemical reagents:

MPA (12- molybdophosphoric acid) $H_3PMo_{12}O_{40}\times 26H_20$, grade "*p.a.*", MPA weight 2.2959 g concentration of 10^{-2} mol/l was dissolved in distilled water in a flask to 100.0 ml. the Solution was heated on a water bath until complete dissolution of the sample.

Thiabendazole, Pharmacopeia purity, a portion of thiabendazole weight 0.0503 g concentration of 10^{-2} mol/l was dissolved in distilled water with 1-3 drops of HCl (2 mol/l) in the flask to 25.0 ml.

2.2. Preparation of reagents for the manufacture of the membranes of ISE

Polyvinyl chloride (PVC), grade C-70 "*puriss.*" – the matrix of the membrane, cyclohexanone (CH), grade "p.a" – the solvent matrix. As membrane solvents – plasticizers used organic solvent: tricresyl phosphate (TCP) brand "*puriss.*". As electrode active substances (EAS) used associates of organic cations thiabendazole ($TBZH_2^{2+}$) heteropoly anions 12- molybdophosphoric of heteropoly acid – $(TBZH_2)_3(PMo_{12}O_{40})_2$.

The plasticized PVC membrane based on the membrane of the solvent-plasticizer – TCP for ISE synthesized by standard methods [10]: 0.45 g of PVC was dissolved in 4.5 ml of CH at low heat on a water bath under stirring until complete dissolution. Separately prepared solution of the sample in the range 0.010 g air with 1.1 ml of membrane solvent plasticizer in a water bath and stirred well until complete dissolution. The resulting solutions in the form of a clear homogeneous liquid mixture was transferred into a Petri dish with a diameter of 50 mm After complete evaporation of the TT from the mixture under a fume hood (3-4 days) gave a clear, slightly orange elastic film of plasticized polyvinyl chloride membrane. Before using ISE was soaked in a solution with a concentration corresponding to the middle of the range of concentrations that is determined.

For registration of the electrode characteristics using an electrochemical cell:

Ag | AgCl, KCl(sat.) | STD. solution ($TBZH_2^{2+}$) | Membrane | Wiesn. solution ($TBZH_2^{2+}$), (10^{-3}M) | KCl (sat.), AgCl | Ag.

2.3. The apparatuses and methods of research

Potentiometric studies were performed on ionomer EV-74 and applied a system of electrodes: indicator – is ISE on the organic cation of Thiabendazole and the reference electrode – electrode chloridine.

<u>The method for quantitative determination of Thiabendazole</u>

Prepare a series of model solutions. For this sample within the content of 5.00–5.50 mg thiabendazole transferred to a volumetric flask 25.0 ml and adjusted to the mark with distilled water. The concentration of the resulting solution of thiabendazole is 0.01 mol/l. then from the prepared solution by the method of dilution prepare a series of model solutions of thiabendazole within concentrations 1×10^{-2}–1×10^{-6} mol/l and record the electrode characterization ISE for this series. After thorough mixing, the working solution is transferred to an electrochemical cell system electrodes: the indicator ion selective electrode reversible to the cation of the organic thiabendazole and chloridine as the reference electrode. By using the ionomer measure electromotive force and gradually schedule define the content of thiabendazole.

The optical density of pure solutions of thiabendazole, and solutions of ionic associates with HPA $PMo_{12}O_{40}^{3-}$ was measured on the spectrophotometer SP – 46.

To establish the possible composition of the associates of thiabendazole with HPA was carried out with the direct saturation of water solution molybdophosphoric acid (MPA) with a concentration of 10^{-5} mol/l 10^{-5} M solution of thiabendazole.

The composition of the associates of thiabendazole with HPA by UV-spectroscopy.

To establish the ratio of reacting components $[TBZH_2^{2+}]$:$[PMo_{12}O_{40}^{3-}]$ 10 volumetric flasks with a

volume of 25.0 ml was injected at 4.0 ml MPA with a concentration of 10^{-5} mol/l was added to each flask different amounts of an aqueous solution of thiabendazole with a concentration of 10^{-5} mol/l at pH=4.0: 1.0; 2.0; 3.0; 4.0; 5.0; 6.0; 7.0; 8.0; 9.0; 10.0 ml, bring the volume of each flask to the mark with water and determined the optical density of the obtained solutions at λ=238 nm, l=1 cm the results of detection of the saturation curve was built and was determined the ratio of the reacting components.

3. RESULTS AND DISCUSSION

To determine many organic dietary supplements that contain basic Nitrogen atom, are widely used as analytical reagent of heteropoly acid (HPA) Keggin's [10-12]. Earlier by us [11] developed a method for quantifying food additives E-233 (thiabendazole) by the method of amperometric titration with 12- molybdophosphoric heteropoly acid using as an analytical reagent-precipitator heteropoly anion of 12-molybdophosphoric heteropoly acid with indication of equivalence point-current electrochemical reduction of HPA. Determined the ratio of the reacting components in the interaction of thiabendazole with IFC according to the results of amperometric titrations (n=5, P=0.95) $[TBZH_2^{2+}]:[PMo_{12}O_{40}^{3-}]=3:2$. Based on the results of amperometric titrations can be concluded about the education slightly soluble in water ion associate general formula $(TBZH_2)_3(PMo_{12}O_{40})_2$. The developed method is characterized by sufficient sensitivity (1×10^{-4} mol/l), selectivity and expressly.

3.1. Study of the reactions of interaction of 12-molybdophosphoric acid HPA with Tiabendazole the method of UV spectroscopy

The method of UV-spectroscopy study of the reaction of interaction HPA of 12-molybdophosphoric acid with Thiabendazole. Absorption spectra of investigated compounds were recorded in the range of 200-340 nm in quartz cuvettes with a layer thickness of 1 cm. As solvent and solution comparison for thiabendazole used distilled water.

UV spectra of aqueous solutions of thiabendazole in a wide range of pH are characterized by the presence of intense absorption bands in the range of 200-340 nm (Fig.1).

According to the literature data [12], aqueous solutions of thiabendazole have two maximum absorption at a wavelength of 243 nm and 302 nm. As can be seen from Fig. 1 most closely corresponds with the literature absorption spectrum of thiabendazole obtained at pH=4.0, absorption bands of solutions at other pH values shifted due to changes in medium acidity.

Band with a maximum absorption at 200-215 nm, corresponds to the presence in the molecule of thiabendazole group NH has a medium intensity and appears due to the free pair electrons in the Nitrogen atom (there is a transition $n\rightarrow\sigma^*$). In the interval 224-238 and 300 nm for aqueous solutions of thiabendazole observed absorption band, which can be attributed to $\pi\rightarrow\pi^*$ and $n\rightarrow\pi^*$ transitions due to the presence in the molecule of thiabendazole C=N.

Absorption spectra of 12-molybdophosphoric acid characterized by the presence of intense absorption bands in the range 207-220 nm, which belongs to the electron transfer from the orbitals localized on the Oxygen atoms, the metal atom of the end links O=Me (Me–Mo) [12], and less intensive bands of charge transfer through bridged connections Me–O–Me (260-280 and 320-330 nm).

UV spectra of an aqueous solution of compounds associate $(TBZH_2)_3(PMo_{12}O_{40})_2$ (Fig. 2) contains absorption bands, characteristic of the interacting substances (HPA, TBZ), which testifies to the immutability of their structure and confirms the associative nature of the interaction. In addition, in the spectrum of the observed deviation from additivity of absorption. This can be explained by the fact that during the formation of ionic associates of HPA and an organic cation of thiabendazole, which has several nitrogen atoms of the optical density of the ion associate is somewhat reduced in comparison with the organic cation of thiabendazole due to compaction of the molecular structure of organic cations in ionic associate

In table 1. provides a generalized basic absorption bands of UV spectra of HPA, the organic cation of thiabendazole and their compounds.

It was also found the ratio of the obtained ionic associates of thiabendazole with HPA spectrophotometric method and amperometric titration.

To establish the possible correlation of the associates of thiabendazole HPA was carried out with the direct saturation of water solution of molybdophosphoric acid with a concentration of 10^{-5} mol/l 10^{-5} M solution of thiabendazole. According to the results of measurements build the curve of saturation (Fig.3) and determined the ratio of the reacting components.

The ratio of components in combination with the results of determination amounted to $[TBZH_2^{2+}]:[PMo_{12}O_{40}^{3-}] = 3:2$ thus formed associate composition $(TBZH_2)_3(PMo_{12}O_{40})_2$.

For a more detailed study of the composition of the associate and confirm the obtained data, the ratio of components in the formation of associates of thiabendazole with $PMo_{12}O_{40}^{3-}$ were also determined [11] by the method of amperometric titration. The results of amperometric titrations established that the ratio of

the reacting components at P=0.95 and n=7 is $[TBZH_2^{2+}]:[PMo_{12}O_{40}^{3-}]$ =3:2, which confirms the formation of poorly soluble compound with ion-associative nature of the relationship between the composition $(TBZH_2)_3(PMo_{12}O_{40})_2$.

The results of UV - spectroscopic studies of reactions of the interaction of HPA with an organic cation of thiabendazole as well as information on the stoichiometric ratios of the reacting components has allowed us to synthesize soluble, persistent HPA associates with OC thiabendazole.

Thanks to this we have developed ionselective electrodes (ISE), sensitive to organic cation of thiabendazole ($TBZH_2^{2+}$) with plasticized polyvinylchloride membrane, in which EAS are used as ion associates $(TBZH_2)_3(PMo_{12}O_{40})_2$.

3.2. The electrode characteristics of the ISE

To construct a calibration graph (E, mV-pC) prepared a series of standard aqueous solutions of thiabendazole with concentrations ranging from 10^{-2} to 10^{-6} mol/l.

In table 2 shows characteristics of the electrode ISE, convertible to organic cation of thiabendazole with EAS on the basis of thiabendazole OC and heteropoly anions $PMo_{12}O_{40}^{3-}$.

As can be seen from the table 2 the quantitative content of EAS in the membrane does not significantly affect the basic characteristics of the developed electrode ISE. When comparing membrane solvent-plasticizers the best electrode characteristics are observed when using membranes on the basis of the Tricresyl phosphate, the linearity is in the concentration range of thiabendazole from 10^{-2} to 10^{-5} mol/l.

The turnover of the synthesized membrane to the organic cation of Tiabendazole is observed in the concentration range of thiabendazole from 10^{-2} to 10^{-5} mol/l (Fig. 4)

Thus, the slope of the electrode function S developed ISE is equal to the slope of the straight-line dependence and makes 30.0 mV/p*c*, which suggests that the slope is close to theoretical for doubly charged ions, which is typical for an aqueous solution of thiabendazole in an acidic medium.

3.3. The influence of acidic environment

The influence of pH on the slope of the electrode function of ISE, convertible to organic cation of thiabendazole (Fig. 5). For construction of calibration graphs (E, mV-p*c*) prepared a series of aqueous solutions of thiabendazole with concentrations from 10^{-6} to 10^{-2} mol/l. pH value was maintained with solutions of H_2SO_4 and NaOH.

To study the dependence of electrochemical properties of ISE from pH values showed that the slope of the calibration graphs retains a constant value at pH=3.0–4.0. If you increase the acidity of the solution is observed narrowing of the range of linearity and reduction of the slope of the electrode function. (Fig.5). Therefore, further research used a series of solutions at pH 4.0.

3.4. Selectivity

One of the most important electrode characteristics of ion-selective electrode is the potentiometric selectivity coefficient $K_{i/j}$. The selectivity coefficient shows the possibility of potentiometric determination of the ion investigated (i) in the presence of ions interfering (j). The smaller the selectivity coefficient, the greater the selectivity in relation to ions, which are investigated in the presence of interfering ions, the ISE. If the selectivity coefficient $K_{i/i}$ is greater than one, in this case, the electrode is more sensitive to the interfering ion j is compared with the ion and that is determined. If $K_{i/j}<1$, the electrode is selective to ions that is defined.

Selectivity coefficients of the developed ISE is relatively interfering inorganic ions Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+ were determined by the method of mixed solutions, which is based on the measurement of mixed potentials in solutions with constant content of interfering ion with variable ion concentration and that determined [12]. The coefficients are calculated according to the formula $K^{pot}_{i|i}=a_i/a_i$. The value of a_i was found at the point on the experimental curve (Fig.6), the calculated selectivity coefficients of the developed ISE, are given in Table 3.

Thus, the selectivity of the ISE on the organic cation of thiabendazole on the background of interfering ions Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+ is 10^{-2}, which allows for direct potentiometric measurements of thiabendazole in the presence of a hundredfold excess of Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+ ions.

Response time developed ISE determined by changes in the concentration of the ion potential is determined at low concentrations 2-3 min., and at high concentrations (10^{-3}–10^{-2} mol/l) decreases up to 40-50 sec. The stability and reproducibility of the ISE indices over time does not change more than ± (1.5–2.5) mV/day. Life time of ISE depends on how you store them the longest (60-65 days) he was at the electrodes, which are kept in a dry condition and for 10-15 min before the measurement was soaked in a solution with a concentration corresponding to the middle of the range of analyte concentrations (10^{-3}–10^{-4} mol/l).

3.5. Quantification of thiabendazole in substance a food additive (E-233) and bananas

Developed methods direct potentiometric determination of thiabendazole in substance a food additive (E-

233) and food products using the developed ISE. The developed methods were tested on samples of substances and food additives (E-233) and food products. For the analysis of food products was selected peel and banana pulp.

Prepare a series of model solutions. For this sample within the content of 5.0–5.5 mg of thiabendazole transferred to a volumetric flask 25.0 ml and adjusted to the mark with distilled water. The concentration of the resulting solution of thiabendazole is 0.01 mol/l. then from the prepared solution by the method of dilution prepare a series of model solutions of thiabendazole within concentrations $1 \cdot 10^{-2}$–$1 \cdot 10^{-6}$ mol/l and record the electrode characterization ISE for this series.

After thorough mixing, the working solution is transferred to an electrochemical cell system electrodes: the indicator ion selective electrode reversible to the cation of the organic thiabendazole and saturated silver chloride electrode – reference electrode. By using the ionomer measure electromotive force and gradually schedule define the content of thiabendazole. The linearity of functions is observed from 10^{-2}–10^{-5} mol/L. Membrane with the content of EAS 0,010 g; MP – TCP, pH=4,0). The results of the direct potentiometric detection of organic cation of thiabendazole in substance a food additive E-233 using the developed ion-selective electrode are given in Table. 4. For the sample containing 5.00 mg of tiabendazole found 5.07±0.04 mg (P=0.95; n=7). In Table 4 shows the results of quantitative determination of thiabendazole method straight potentiometry. The correctness of the results of the determination of OC thiabendazole was checked by a method of additives. Aliquot to 25 ml of the analyzed solution was added to 1 ml of a standard solution of OK with a concentration of 1 mg/ml and measured the electrode potential after each supplement.

Thus, in Table 4 shows the data, confirming the correctness of the results of thiabendazole determination in substance and the absence of systematic errors

3.6. Quantification of thiabendazole in cork banana

Chopped with a knife, peel banana (100g) was placed in a glass and fill with water to 300 ml, then settles for 12 hours. Then the obtained solution was filtered through cheesecloth and transferred quantitatively into a measuring flask of 250 ml. the resulting solution was acidified with diluted HCl solution to pH=4.0.

Measure the potential of the ISE, reversible to the cation of thiabendazole in standard solutions of thiabendazole in a concentration range from 10^{-6} to 10^{-2} mol/l. Then measure the potential of the investigated solution, quantitatively transferred into the electrochemical cell with the electrode system: ISE, back to OC thiabendazole, as an indicator, and chlorobi as the reference electrode. By using the ionomer EV-74 measured electromotive force and gradually schedule determine the concentration of tiabendazole. The linearity of functions is observed from 10^{-2}–10^{-5} mol/l. Membrane with the content of EAS 0.010 g; membrane solvent – TCP, pH=4.0). The results of the direct potentiometric determination of thiabendazole in the peel of banana with use of the developed ion-selective electrode are given in Table 5.

For the sample that contains 5.03 mg Tiabendazole found 5.01±0.07 mg (P=0.95; n=7).

According to the results of potentiometric determination it was calculated that the content of thiabendazole in the peel of banana is 5.03 mg / 100 g of the product (or 0.0503 mg tiabendazole in 1g of banana peel).

The results of quantitative determination of the content of thiabendazole in the peel of the banana by the method of direct potentiometry is characterized by high sensitivity (10^{-5} mol/l) and good repeatability.

3.7. Quantification of thiabendazole in the pulp of banana

Finely chopped with a knife and suppressed the pulp of banana (100 g) was placed in a glass and fill with water to 250 ml, then settles for 12 hours. Then the obtained solution was filtered through cheesecloth and transferred quantitatively into a measuring flask of 200 ml, the resulting solution is acidified with a solution of HCl solution to pH=4.0.

Measure the potential of the ISE, reversible to the cation of thiabendazole in standard solutions of thiabendazole in a concentration range from 10^{-6} to 10^{-2} mol/l. Then measure the potential of the investigated solution, quantitatively transferred into the electrochemical cell with the electrode system: ISE, back to OC thiabendazole, as an indicator, and saturated silver chloride electrode as the reference electrode. By using the ionomer EV-74 measured electromotive force and gradually schedule determine the concentration of tiabendazole in the sample. The linearity of functions is observed from 10^{-2}–10^{-5} mol/l. Membrane with the content of EAS 0.010 g, membrane solvent – TCP, pH=4.0). The results of the direct potentiometric determination of thiabendazole in the pulp of banana with use of the developed ion-selective electrode are given in table. 6.

For the sample that contains 4.02 mg Tiabendazole found 3.98±0.07 mg (P=0.95; n=7).

According to the results of potentiometric determination it was calculated that the content of thiabendazole in the pulp of the banana is 4.02 mg in 100 g of this product.

4. CONCLUSIONS

Thus, the study of the electrochemical characteristics of the developed ion-selective electrode reversible to the cation of the organic thiabendazole allowed to determine the optimal parameters and conditions of functioning of the ISE, to consider the peculiarities of the chemical behaviour of the substances under study and to develop simple and rapid (5-7 min) methodology amperometric titration and direct potentiometric determination of thiabendazole in substance a food additive (E-233) and bananas.

Table 1
UV absorption spectra of the organic cation of thiabendazole and associate it with HPA $PMo_{12}O_{40}^{3-}$

Compound	λ_{max}, nm	features of UV-spectra
$H_3PMo_{12}O_4$	215	208 – 217 intensive
	235	222 – 232 shoulder
	320	weak
Thiabendazole	238	224 – 240 intense in a wide range of pH
	300	294 – 302 intensive
$(TBZH_2)_3(PMo_{12}O_{40})_2$	215	204–215 intensive
	235	222 – 232 shoulder
	238	224 – 240 intense in a wide range of pH
	300	294 – 302 intense in a wide range of pH
	320	weak

Table 2
Electrode characteristics of ISE, back to OC thiabendazole depending on various factors

Plasticizer	The content of EAS in the membrane, g	S, mV	The linearity interval, mol/l
EAS – $(TBZH_2)_3(PMo_{12}O_{40})_2$			
DBP	m=0.010	43	$2.0\cdot10^{-4} – 1.0\cdot10^{-2}$
	m=0.001	39	$1.1\cdot10^{-4} – 1.0\cdot10^{-2}$
	m=0.005	41	$1.0\cdot10^{-4} – 1.0\cdot10^{-2}$
DOP	m=0.010	43	$2.5\cdot10^{-4} – 1.0\cdot10^{-2}$
	m=0.001	33	$3.0\cdot10^{-5} – 1.0\cdot10^{-2}$
	m=0.005	44	$1.1\cdot10^{-4} – 1.0\cdot10^{-2}$
TCP	m=0.010	30	$1.0\cdot10^{-5} – 1.0\cdot10^{-2}$
	m=0.001	33	$1.1\cdot10^{-5} – 1.0\cdot10^{-2}$
	m=0.005	26	$1.0\cdot10^{-5} – 1.0\cdot10^{-2}$

Table 3
Potentiometric selectivity coefficients $K^{pot}_{i/i}$ ISE, back to the organic cation of thiabendazole (i – defined cation, j –interfering cation)

Interfering ion	Ki/j
K^+	0.010
Na^+	0.013
NH_4^+	0.105
Ca^{2+}	0.013
Mg^{2+}	0.013
TBZH	–

Table 4
The results of the determination of thiabendazole in substance a food additive (E-233) and checking the correctness of the method of the direct potentiometry (n=7, P=0.95)

Entered thiabendazole, mg	Added thiabendazole, mg	Found thiabendazole, (x ± δ) mg	S_r
5.00	–	5.07±0.04	0.01
	1.00	5.88±0.05	0.01
	2.00	6.95±0.05	0.01
	3.00	7.89±0.15	0.02

Table 5
The results of the determination of thiabendazole in the peel of the banana by the method of direct potentiometry (n = 7, P =0.95)

Investigated sample	Entered thiabendazole, mg	Found thiabendazole, (x ± δ) mg	S_r
Cork banana	5.03	5.01±0.07	0.017

Table 6
The results of the determination of thiabendazole in the pulp of banana by the method of direct potentiometry (n = 7, P = 0.95)

Investigated sample	Entered thiabendazole, mg	Found thiabendazole, (x ± δ) mg	S_r
The flesh banana	4.02	3.98±0.07	0.02

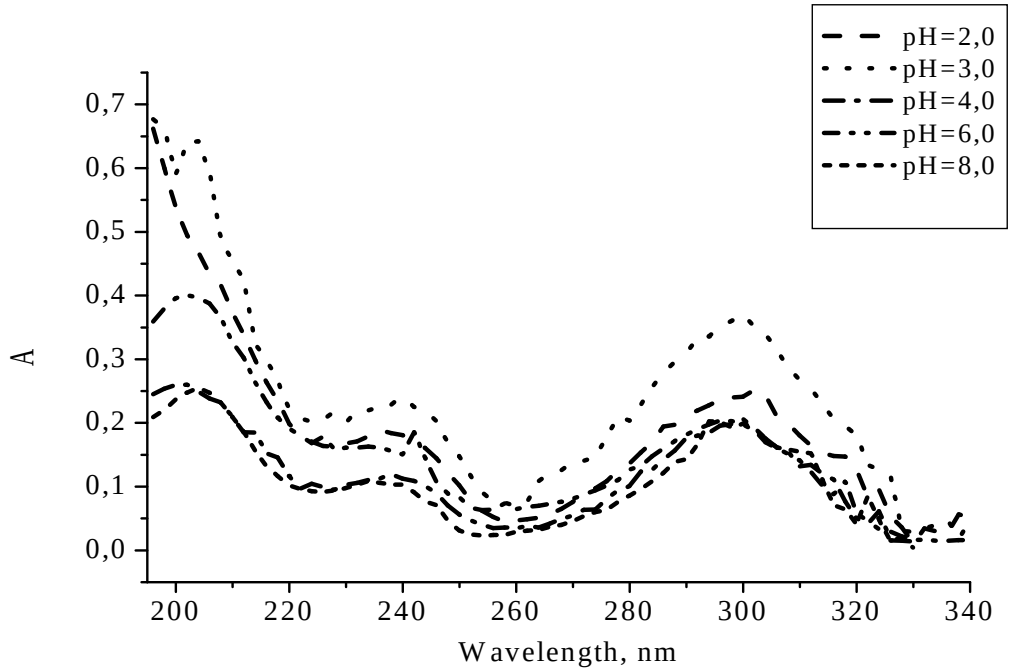


Figure 1
UV absorption spectra of solutions of thiabendazole depending on the solution pH (*c* (TBZH) =10^{-5} mol/l, l=1 cm)

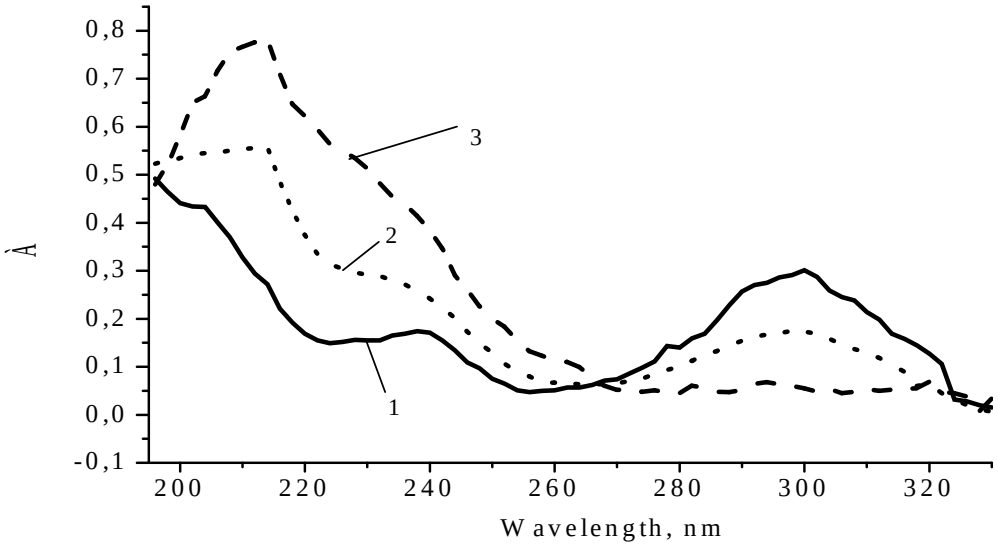


Figure 2
UV absorption spectra of thiabendazole (1), associate $(TBZH_2)_3(PMo_{12}O_{40})_2$ (2), MPA (3) at pH=4.0 (*c* (TBZH) =10^{-5} mol/l, l=1 cm)

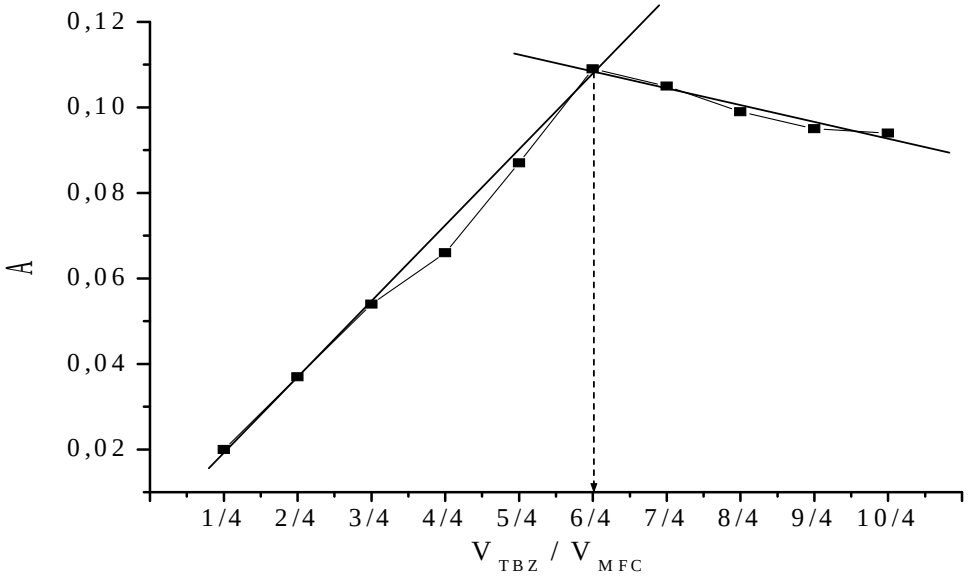


Figure 3
The dependence of the absorption system TBZ–MFC on the concentration of Thiabendazole (V_{MFC}=4 ml, *c*(MPA)=*c*(TBZH) =10^{-5} mol/l, λ=238 nm, l=1 cm

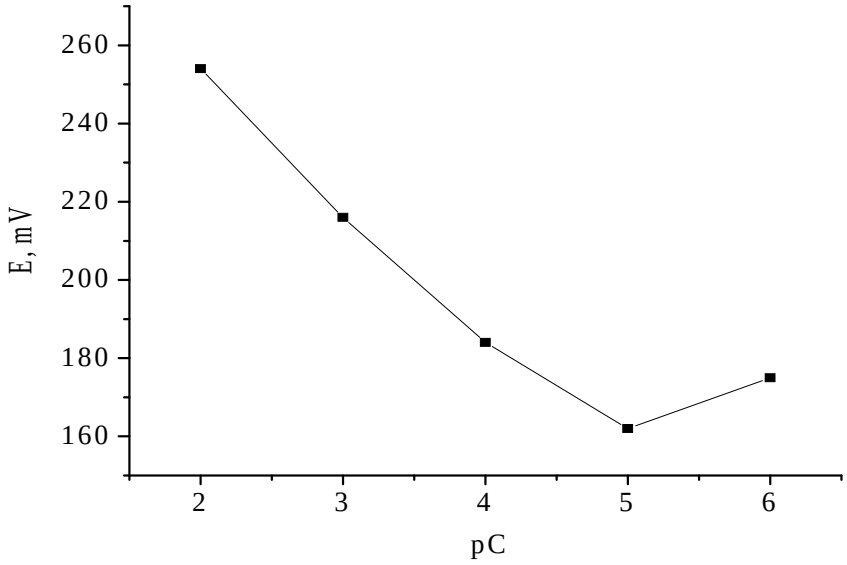


Figure 4
The potential of the ISE from p*c*(TBZH) (the membrane with the content of EAS 0.010 g; membrane solvent (MS)-TCP, pH=4.0)

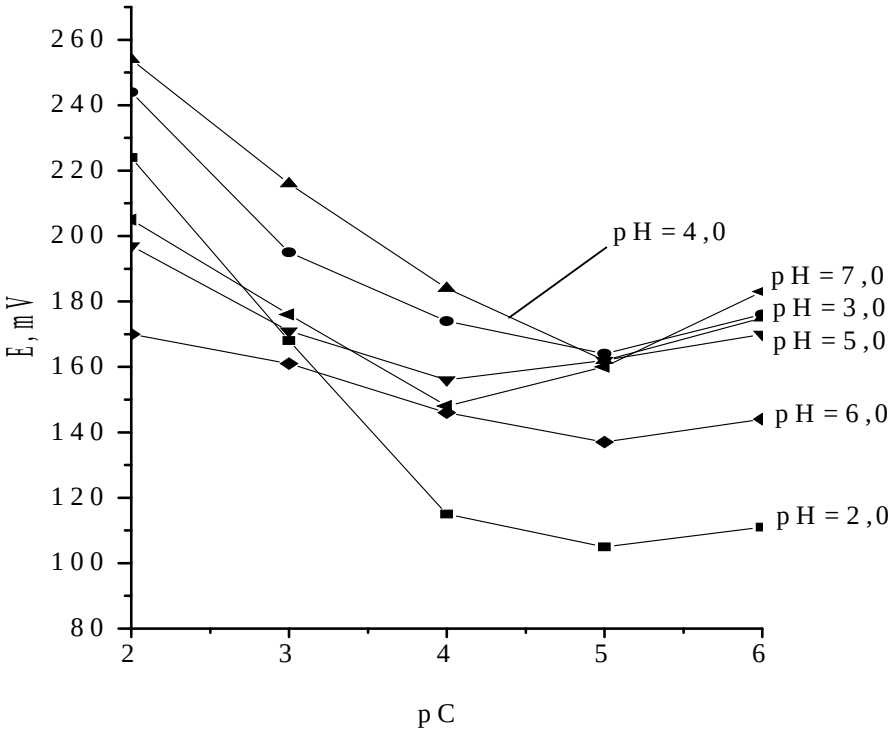


Figure 5
The potential of the ISE concentration thiabendazole at different pH values (the membrane with the content of EAS 0.010 g; MS – TCP)

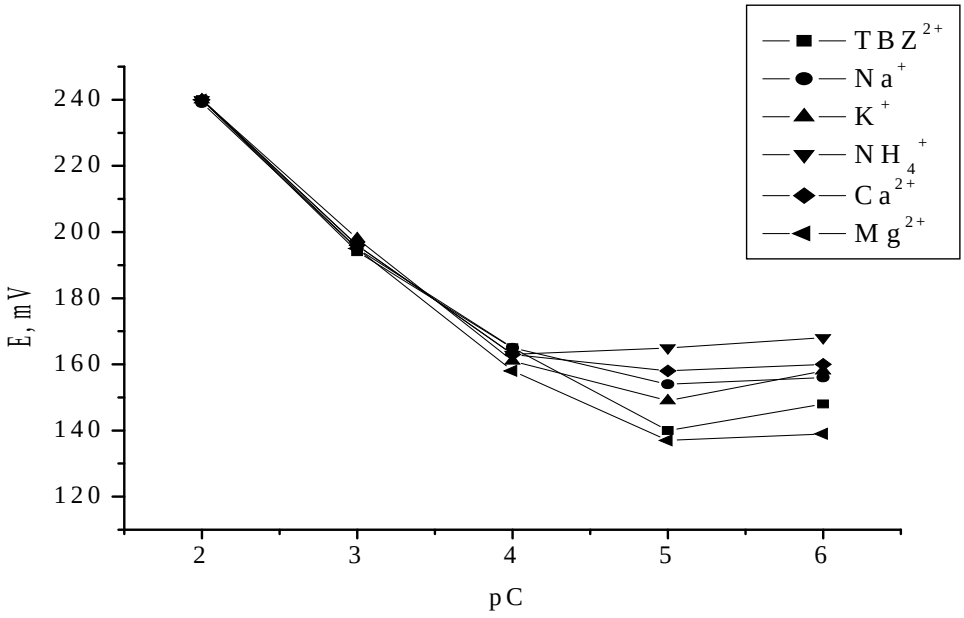


Figure 6
Determination of potentiometric selectivity coefficient $K^{pot}_{i/i}$ is ICE on thiabendazole by the method of mixed solutions in the absence and in the presence of interfering ions

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