Spectrophotometric and Fluorescent Determination of Hydrophobic Organic Cations in the Surfactant-modified System Mo(VI) – Bromopyrogallol Red

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The spectrophotometric and fluorescent characteristics of the surfactant-modified molybdenum (VI) – bromopyrogallol red reagent system were studied. The hydrophobic modification was achieved by adding cationic, nonionic surfactants, or, accordingly, mixtures of surfactant modifiers into the metal reagent system. Modification of the metal reagent system with a nonionic surfactant leads to a decrease in the limit of detection of the hydrophobic organic cation in the molybdenum (VI) – bromopyrogallol red system by the fluorescence method and an increase in the contrast of the spectrophotometric reaction. The colloid-chemical state of molybdenum (VI) – bromopyrogallol red solutions in the presence of cationic surfactant, nonionic surfactant, and their mixture was also investigated. An increase in the turbidity of the investigated solutions is registered under the conditions of a decrease in the scattering factor, which, in turn, increases the limit of detection of the spectrophotometric determination of decamethoxine in the surfactant-modified molybdenum (VI) – bromopyrogallol red system. Based on the obtained results, the conditions for controlled modification of the metal reagent system with surfactants for the determination of hydrophobic organic cations by molecular spectroscopy methods were proposed. Fluorescence and spectrophotometric detection of decamethoxine content in medicines was carried out in optimized surfactant-modified molybdenum (VI) – bromopyrogallol red systems.

Keywords: spectrophotometry, fluorescence, molybdenum, bromopyrogallol red, surfactant, cetylpyridinium chloride, Triton X-100, decamethoxine

The actual direction of the use of surfactants in the analysis is the multi-faceted modification of metal reagent systems [1-3]. The complex formation of metals with organic reagents in the presence of surfactants often leads to an increase in the signal intensity of the solution and a shift in the position of the wavelength maxima in the absorption and fluorescence spectra [4, 5]. In some cases, it is possible to improve the metrological characteristics of analyte determination in surfactant-modified metal reagent systems [6, 7]. This effect is generally explained by a change in the hydration of reagents and their chelates from hydrophilic to predominantly hydrophobic under the action of surfactants. Reactivity, protolytic and tautomeric properties, solubility of organic reagents and their complexes with metal ions also change in the presence of surfactants [8, 9]. The variety of forms of hydrophobic properties and, as a result, the solubility of the complexes, stoichiometric and substoichiometric associates of various compositions formed in the system required taking into account the colloid-chemical state of the analyzed analytical systems.

Among the metal reagent systems that are widely used for the determination of hydrophobic organic cations, the system Mo(VI) – bromopyrogallol red (BPR) stands out. The possibilities of analytical use of Mo(VI)-BPR complexes increase significantly in the presence of cationic and nonionic surfactants [10, 11]. At the same time, there is an increase in the contrast of the reaction and an improvement in the visual perception of the color of the complex. This technique is widely used to increase the sensitivity and selectivity of spectrophotometry methods for determining hydrophobic organic cations in Mo(VI)-BPR-surfactant solutions and in other molecular spectroscopy methods [12-14].

The influence of cationic surfactants and a mixture of cationic and nonionic surfactants on the interaction of molybdenum with bromopyrogallol red has been well studied by the spectrophotometry method [12, 13, 15]. The possibility of creating fluorescent reagent systems based on Mo(VI)-BPR complex was investigated in the paper. The expediency of this approach is due to the presence of a rigid structure and πsystem in the bromopyrogallol red molecule, the absence of electrons at the 4d level in Mo^{6+} ions [16], and the formation of stable Mo(VI)-BPR and Mo(VI)-BPR-surfactant complexes in a wide range of acidity.

Hydrophobic organic compounds of an ionic nature in surfactant-modified reagent and metal reagent systems are usually determined by electrochemical [17-18], chromatographic [19-20] and molecular spectroscopy methods [21-25]. Methods of molecular

spectroscopy, among which the most significant methods of fluorescence and spectrophotometry, are dominant in unified and express methods of analysis of organic cations.

Therefore, the work aimed to develop optimal conditions for the determination of hydrophobic organic compounds of a cationic nature, in particular decamethoxine, using Mo(VI)-BPR-Triton X-100 and Mo(VI)-BPR-cetylpyridinium chloride-Triton X-100 systems by spectrophotometry and fluorescence methods.

Experimental sections

Bromopyrogallol red was obtained from Aldrich. 1hexadecylpyridin-1-ium chloride (cetylpyridinium chloride, CPC) from Sigma-Aldrich (Germany) of ≥99% purity was used as a cationic surfactant (c-Surf). 2-[4-(2,4,4-Trimethylpentan-2-yl)phenoxy]ethanol (Triton X-100, TX-100) of laboratory grade (Merck, USA) was used as a nonionic surfactant (n-Surf). Solutions of the dye and surfactants (Surf) were prepared by dissolving the exact samples in distilled water. A molybdenum (Mo) solution was prepared by dissolving sodium molybdate in distilled water.

Fluorescence measurements were performed with a Perkin Elmer LS55 fluorescence spectrometer. The absorption spectra of the solutions were measured with a UV-2401PC UV-Vis-spectrophotometer (Shimadzu). The pH was controlled by the pH 340-meter with an ESL-43-07 glass electrode.

Parameters calculated

The colloid-chemical state of the solutions was studied by the turbidity-spectrum method [26]. Based on the absorption spectra, the turbidity (τ) of the solutions was calculated by the ratio $\tau=2.3A/l$ [27], where A is the optical density, l is the width of the light-absorbing layer, cm. The scattering factor (F_r) is used as a quantitative characteristic for estimating the size of colloidal particles present in the system in the spectrophotometric study of colloidal systems. The value of the scattering factor was calculated as the tangent of the slope of the auxiliary function $\ln A=f(\ln\lambda)$ for the long-wavelength region of the spectrum. The wavelength interval was chosen by the criterion of at least 80 nm toward longer wavelengths from the position of the maximum absorption and for which the dependence $\ln A=f(\ln\lambda)$ is linear. The value of scattering factor $F_r<4$ corresponds to the colloidal degree of dispersion and $F_r>4$ corresponds to the molecular or pseudomolecular state of the system. The average size of colloidal aggregates can be calculated for $2<F_r<4$ [28].

The parameters ΔA, ΔI, and Δλ were selected as the most significant quality parameters of the analyte (surfactant) analytical signal. Where ΔA and ΔI are the difference in the intensity of the spectrophotometric and fluorescent signals, respectively, of the analytical system in the absence and presence of the analyte; Δλ is the change in the λ_{max} position of the analytical system in the absence and presence of the analyte.

Results and discussion

The absorption spectra of Mo(VI)-BPR solutions in the presence of a cationic surfactant were recorded in the paper (Fig. 1). It is known [29, 30] that the optical density of Mo(VI)-BPR-CPC complex is maximal and constant at pH≤4.0. The addition of cetylpyridinium chloride to the studied solution contributes to the formation of a poorly soluble electroneutral complex of the ion associate type with an intense blue color, where the cetylpyridinium cation binds to the anionic component of the reagent Mo(VI):BPR:CP=1:2:2 and 1:2:4 complex [31], curves 3 and 4 in Fig. 1.

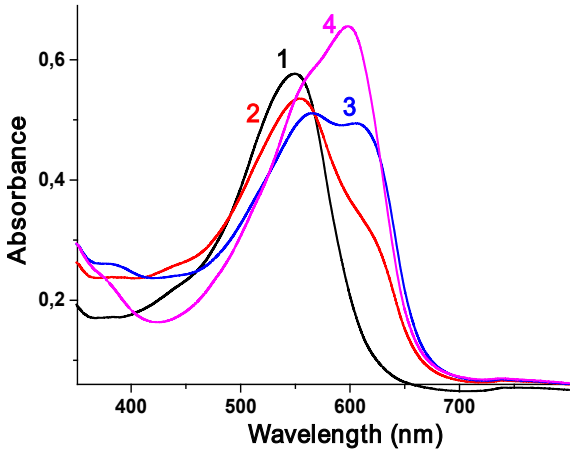

Figure 1. Absorption spectra of Mo(VI)-BPR aqueous solutions in the presence of cetylpyridinium chloride. $C_{Mo}=1.0\cdot10^{-5}$ M, $C_{BPR}=2.0\cdot10^{-5}$ M, C_{CPC}, M: 0 (1), $1.0\cdot10^{-5}$ (2), $2.0\cdot10^{-5}$ (3), $4.0\cdot10^{-5}$ (4), pH=4.0.

Fluorescence spectra of Mo(VI)-BPR solutions in the presence of cationic surfactant were also studied. Thus, the positions of the emission wavelength maxima of aqueous solutions of the three-component Mo(VI)-BPR-CPC system in the $0\text{-}2.0\cdot10^{-4}$ M range of cationic surfactant concentrations change little. The fluorescence intensity increases when the cationic surfactant is added to Mo(VI)-BPR aqueous solution at $C_{CPC}\leq4.0\cdot10^{-5}$ M (Fig. 2). The maximum intensity of the fluorescent signal was registered under the conditions of Mo(VI)-BPR-CPC complex formation with a composition of 1:2:4. The signal intensity of Mo(VI)-BPR-CPC system decreases when $C_{CPC}>4.0\cdot10^{-5}$ M.

The addition of nonionic Triton X-100 to Mo(VI)-BPR-CPC solution leads to significant changes in the intensity of the fluorescent and spectrophotometric signal of the cationic surfactant. Thus, the n-Surf-concentration dependence is characterized by the presence of the maximum analytical signal of CPC at $C_{TX\text{-}100}=4.0\cdot10^{-5}$ M, i.e. at Mo(VI):BPR:CP:TX-100=1:2:1:4 ratio of system components. Modification of Mo(VI):BPR:CPC system with a nonionic surfactant was further carried out at a given concentration of Triton X-100.

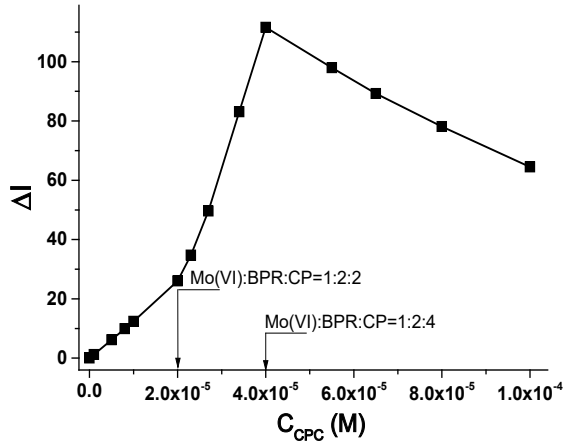

Figure 2. Dependence of the fluorescent signal of CPC in Mo(VI)-BPR solutions on the cationic surfactant concentration.

Determination of CPC in the n-Surf-modified Mo(VI)-BPR system was carried out by spectrophotometry and fluorescence methods (Table 1). It is noteworthy that the fluorescent signal of the cationic surfactant is less stable compared to the spectrophotometric one, which is caused by the small quantum yields of the metal reagent system. The n-Surf-modified Mo(VI)-BPR system, in contrast to such an unmodified system, leads to improved metrological characteristics of fluorescent determination of cationic surfactant. Along with this, the limit of detection (LOD) and the coefficient of determination (r^2) of spectrophotometric determination of CPC in Mo(VI)-BPR-TX-100 system increase and decrease, respectively.

Shifts in the position of wavelength maxima (Δλ) in the absorption spectra of complex solutions upon the addition of surfactants were considered as an analytical signal (Fig. 3). The Δλ value is competitive in comparison with the traditional ΔA indicator when determining organic cations. Thus, the addition of a cationic surfactant to Mo(VI)-BPR system leads to a red shift in the position of the absorption maxima (Δλ≈45 nm) of the formed Mo(VI)-BPR-CPC three-component complex (curve 1 in Fig. 3). An increase in the contrast (Δλ≈70 nm) of the reaction of Mo(VI)-BPR-CPC system formation is recorded in the presence of nonionic surfactant (curve 2 in Fig. 3). At the same time, the addition of a nonionic surfactant leads to an increase in the sensitivity of the spectrophotometric determination of CPC in Mo(VI)-BPR-TX-100 system based on estimates of the bathochromic shifts in the position of the absorption maxima of the solutions. Thus, the analytical capabilities of surfactant-modified metal reagent systems can be fully used to enhance the contrast of colorimetric reactions.

The obtained data showed the expediency of using the surfactant-modified Mo(VI)-BPR system in the design of analytical systems for the determination of hydrophobic organic cations by molecular spectroscopy methods. Decamethoxine was chosen as the object of the study. Decamethoxine is a widely used antimicrobial agent that belongs to the group of bis-quaternary ammonium compounds and is an analog of a cationic surfactant.

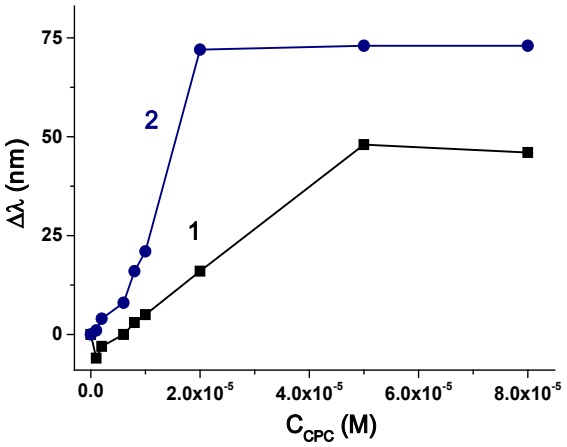

Figure 3. Dependence of the change in the position of the maximum absorption wavelength of Mo(VI) BPR (1) and Mo(VI)-BPR-TX100 (2) systems on the concentration of CPC. $C_{Mo}=1.0\cdot10^{-5}$ M, $C_{BPR}=2.0\cdot10^{-5}$ M, $C_{TX\text{-}100}=4.0\cdot10^{-5}$ M, pH=4.0.

The determination of decamethoxine in the surfactant-modified Mo(VI)-BPR system was carried out by fluorescence and spectrophotometry methods. The best metrological characteristics of the fluorescent determination of the analyte were recorded for Mo(VI)-BPR-CPC and Mo(VI)-BPR-CPC-TX-100 systems (Table 2).

Table 1. Parameters of CPC determination in Mo(VI)-BPR system in the presence of Triton X-100 by spectrophotometry and fluorescence methods. $C_{Mo}=1.0\cdot10^{-5}$ M, $C_{BPR}=2.0\cdot10^{-5}$ M, pH=4.0.

Detection	Spectrophotometry		Fluorescence	
$C_{TX\text{-}100}$, M	0	$4.0\cdot10^{-5}$	0	$4.0\cdot10^{-5}$
Equation, C_{CPC}, M	$\Delta A=(0.001\pm0.004)+(1.27\pm0.04)\cdot10^{4}\cdot C$	$\Delta A=(0.01\pm0.01)+(2.0\pm0.1)\cdot10^{4}\cdot C$	$\Delta I=(0.8\pm0.9)+(1.1\pm0.2)\cdot10^{6}\cdot C$	$\Delta I=(0.9\pm4.4)+(3.3\pm0.4)\cdot10^{6}\cdot C$
Linearity, 10^{-6}, M	1.0-20	2.0-20	5.0-20	5.0-20
r^2	0.99	0.98	0.90	0.91
LOD, 10^{-6}, M	0.9	1.5	4.9	4.0

Table 2. Parameters of fluorescent determination of decamethoxine in Mo(VI)-BPR-CPC-TX-100 system. C_{Mo}=1.0·10^{-5} M, C_{BPR}=2.0·10^{-5} M, pH=4.0.

C_{TX-100}, M	C_{CPC}, M	Detection parameters	
0	0	r^2	0.76
		LOD, M	3.3·10^{-6}
0	2.0·10^{-5}	r^2	0.99
		LOD, M	5.4·10^{-7}
4.0·10^{-5}	1.0·10^{-5}	r^2	0.99
		LOD, M	7.1·10^{-7}

The obtained results confirm the expediency of the controlled rational modification of the reagent system taking into account the stoichiometry of the formed supramolecular complexes. The first cation of the surfactant is coordinated to BPR by the sulfo group, which is isolated from the π-system of the dye, in the absence of a nonionic surfactant. Controlled n-Surf-modification removes this limitation and already the first surfactant cation in the n-Surf-modified system is active.

Spectrophotometric determination of decamethoxine in surfactant-modified Mo(VI)-BPR system is less sensitive. This can be explained by the fact that the interaction of the organic dication of decamethoxine with Mo(VI)-BPR complex, which under the experimental conditions has a charge of 2$^-$, proceeds with the possible formation of colloidal aggregates at the stoichiometric ratio of the system components. As a result, this leads to a deterioration of the photometric signal of decamethoxine. Therefore, it was considered appropriate to investigate the colloid-chemical state of Mo(VI)-BPR solutions in the presence of cationic surfactant, nonionic surfactant, and their mixture (Fig. 4). It is noteworthy that the conditions for registering the maximum turbidity in the studied system coincide with the conditions for registering the minimum value of the scattering factor.

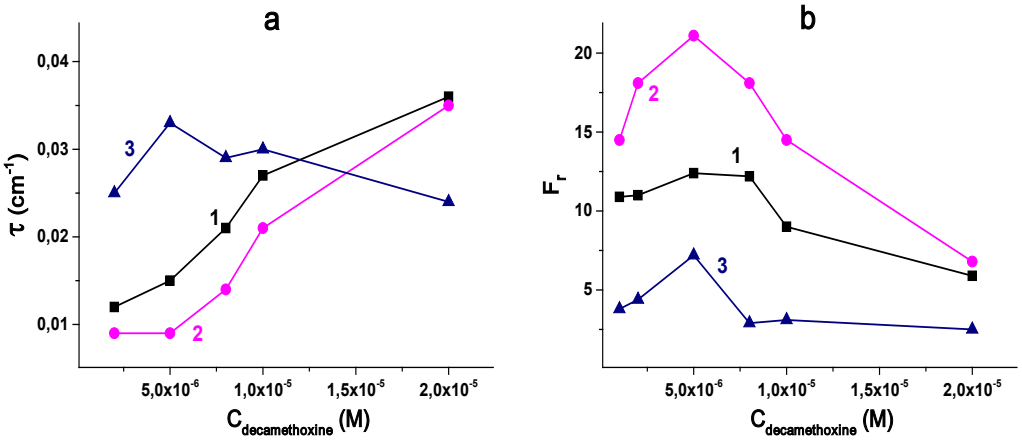

Figure 4. Dependence of turbidity τ (a) and scattering factor F_r (b) of Mo(VI)-BPR (1), Mo(VI)-BPR-TX-100 (2), and Mo(VI)-BPR-CPC-TX-100 (3) solutions on decamethoxine concentration. C_{Mo}=1.0·10^{-5} M, C_{BPR}=2.0·10^{-5} M, C_{CPC}=2.0·10^{-5} M, C_{TX-100}=4.0·10^{-5} M, pH=4.0.

An increase in the turbidity of the investigated solutions is predictably recorded under the conditions of a decrease in the scattering factor (Fig. 5). At the same time, the system maintains a pseudomolecular degree of dispersion and the value of F_r is greater than 4 in the decamethoxine investigated concentration range.

Colloidal aggregation of the analytical form can lead to a decrease in the accuracy of analytical measurements [32, 33], and sometimes can lead to the complete impossibility of quantitative determinations. Previous studies [33] showed that turbidity and scattering factor affect the standard deviation (S_r) parameter of absorption measurements of the reagent-c-Surf solutions. The highest value of S_r is recorded at the point of stoichiometry, under the conditions of the formation of the most hydrophobic stoichiometric associates, and this corresponds to the maximum value of τ and the minimum value of F_r. It is noteworthy that the studied system maintained a pseudomolecular degree of dispersion (Fr>4) even under these conditions.

A negative effect of the aggregation of the metal reagent system on the metrological characteristics of the spectrophotometric determination of decamethoxine in the surfactant-modified Mo(VI)-BPR system was registered. Thus, an increase in turbidity and a decrease in the scattering factor of the investigated solutions increase the LOD parameter (Table 3).

Modification of the metal reagent system with a nonionic surfactant is the most appropriate since such a system is characterized by a pseudomolecular degree of dispersion (the best from the point of view of reproducibility) and the highest sensitivity (lowest LOD value) of analyte determination. Therefore, Mo(VI)-BPR-TX-100 system was chosen as optimal for the development of a spectrophotometric method

for the determination of decamethoxine based on estimates of the bathochromic shifts in the position of the absorption maxima of the solutions. Determination of decamethoxine was carried out in the medicines.

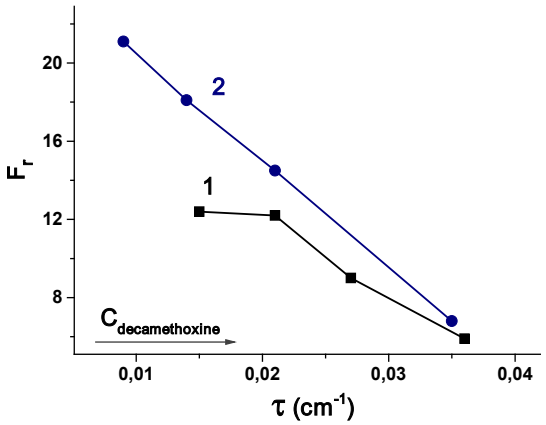

Figure 5. Dependence of the scattering factor F_r on the turbidity τ of Mo(VI)-BPR-decamethoxine solutions in the absence (1) and the presence (2) of Triton X-100.

Table 3. The LOD parameter of the spectrophotometric determination of decamethoxine in the surfactant-modified Mo(VI)-BPR system based on estimates of the bathochromic shifts in the position of the absorption maxima of the solutions depending on the τ and F_r of the solutions. $C_{Mo}=1.0\cdot10^{-5}$ M, $C_{BPR}=2.0\cdot10^{-5}$ M, $C_{CPC}=2.0\cdot10^{-5}$ M (3), $C_{CPC}=1.0\cdot10^{-5}$ M (4), $C_{TX\text{-}100}=4.0\cdot10^{-5}$ M, $C_{decamethoxine}=1.0\cdot10^{-5}$ M, pH=4.0.

№	System	τ, cm^{-1}	F_r	LOD, 10^{-7} M
1	Mo(VI)-BPR	0.027	9.0	7.5
2	Mo(VI)-BPR-TX-100	0.021	14	7.9
3	Mo(VI)-BPR-CPC	0.032	1.3	27
4	Mo(VI)-BPR-CPC-TX-100	0.030	3.1	85

Spectrophotometric determination of decamethoxine in Mo(VI)-BPR-TX-100 system. The linearity of the spectrophotometric determination of decamethoxine in Mo(VI)-BPR-TX-100 system is 0-6.9 mg/L. The calculated LOD and LOQ values were 0.5 mg/L and 1.8 mg/L, respectively. The accuracy and precision of the method in the area of low analyte content (0.2 mg/L) was 100.8% (RSD=1.9%). The accuracy and precision of the method in the medium (3.2 mg/L) and high (6.4 mg/L) content of the substance to be determined were 100.2 and 100.4% (RSD 1.2% and 0.7%), respectively. Recovery values are in the range of 100.2-100.5%.

"Auridexan**"** ear drops, GNCLS Research Plant, Ltd. (Ukraine), used as a pharmaceutical form containing decamethoxine. 1 mL of **"**Auridexan**"** solution contains 0.5 mg of decamethoxine (excipients: ethanol).

1 mL of **"**Auridexan**"** drops (which corresponds to the content of decamethoxine in the solution of ≈0.5 mg) are placed in 5 flasks with a volume of 10.0 mL, which contain 1.0 mL of a $1.0\cdot10^{-4}$ M solution of molybdenum (VI), 2.0 mL of $1.0\cdot10^{-4}$ M solution of bromopyrogallol red and 4.0 mL of $1.0\cdot10^{-4}$ M solution of Triton X-100. Distilled water was made to the final volume. The contents of the flasks are mixed and the pH is set to 4.0 using HNO_3 solution. The content of decamethoxine in the medicinal product was determined using the appropriate calibration dependence. The results of the spectrophotometric determination of decamethoxine in **"**Auridexan**"** ear drops are shown in Table 4.

The data presented in Table 4 indicate that the content of decamethoxine in **"**Auridexan**"** ear drops meets the requirements of the European Pharmacopoeia.

The influence of the colloid-chemical state of the investigated solutions on the quality and intensity of the analytical signal of the analyte in fluorescence, compared with spectrophotometry, turned out to be smaller, which can be explained by the different nature of the signal. It is quite logical that the hydrophobically modified Mo(VI)-BPR-CPC-TX-100 system turned out to be optimal for the development of a fluorescent technique for the determination of decamethoxine.

Fluorescent determination of decamethoxine in Mo(VI)-BPR-CPC-TX-100 system. The linearity of the fluorescent determination of decamethoxine in Mo(VI)-BPR-CPC-TX-100 system is 0-6.9 mg/L. The calculated LOD and LOQ values were 0.5 mg/L and 1.7 mg/L, respectively. The accuracy and precision of the method in the area of low analyte content (0.2 mg/L) was 100.6% (RSD=1.6%). The accuracy and precision of the method in the medium (3.2 mg/L) and high (6.4 mg/L) content of the substance to be determined were 100.3 and 100.1% (RSD 0.9% and 0.7%), respectively. Recovery values are in the range of 99.9-100.5%.

Table 4. Results of spectrophotometric (1) and fluorescent (2) determination of decamethoxine in pharmaceuticals. $C_{Mo}=1.0\cdot10^{-5}$ M, $C_{BPR}=2.0\cdot10^{-5}$ M, $C_{CPC}=1.0\cdot10^{-5}$ M, $C_{TX\text{-}100}=4.0\cdot10^{-5}$ M, pH=4.0, n=5, p=0.95.

No	Pharmaceutical	Reagent system	Decamethoxine content, mg/mL		RSD
			Declared by the manufacturer	Found according to the developed method	
1	«Auridexan»	Mo(VI)-BPR-TX-100	0.50±0.03[a]	0.501±0.007	0.011
2	«Ophtalmodek»	Mo(VI)-BPR-CPC-TX-100	0.20±0.01[a]	0.200±0.004	0.017

"Ophtalmodek" eye drops, GNCLS Research Plant, Ltd. (Ukraine), were used as a pharmaceutical form containing decamethoxine. 1 ml of "Ophtalmodek" solution contains 0.2 mg of decamethoxine (excipients: sodium chloride, purified water).

1 mL of "Ophtalmodek" drops (which corresponds to the content of decamethoxine in the solution of ≈0.2 mg) are placed in 5 flasks with a volume of 10.0 mL, which contain 1.0 mL of a $1.0 \cdot 10^{-4}$ M solution of molybdenum (VI), 2.0 mL of $1.0 \cdot 10^{-4}$ M solution of bromopyrogallol red, 1.0 mL of $1.0 \cdot 10^{-4}$ M solution of CPC and 4.0 mL of $1.0 \cdot 10^{-4}$ M solution of Triton X-100. Distilled water was made to the final volume. The contents of the flasks are mixed and the pH is set to 4.0 using HNO_3 solution. The content of decamethoxine in the medicinal product was determined using the appropriate calibration dependence and the method of standard addition. The results of the fluorescent determination of decamethoxine in "Ophthalmodek" eye drops are shown in Table 4.

The content of the active substance in "Ophtalmodek" eye drops meets the requirements of the European Pharmacopoeia.

Electrochemical [35-37], chromatographic [38-42], and molecular spectroscopy methods [43-46] are the most widely used methods for determining organic cations in pharmaceuticals in general laboratory practice. The methods proposed in the work, in comparison with alternative procedures (Table 5), are characterized by simplicity, expressivity, and improved metrological parameters for the determination of organic compounds of cationic nature.

Improved metrology for the determination of organic cations is achieved by hydrophobization of Mo(VI)-BPR system with cationic surfactant and stabilization of solutions with nonionic Triton X-100.

Table 5. Comparison of fluorescent and spectrophotometric procedures of organic cation determination in pharmaceuticals with other literature studies.

Technique Used	Analyte	Reagent system	Definition object	LOD, mg/L	Ref.
Potentiometry	CPC	-	"Ezafluor" mouth wash	1.4	37
Liquid chromatography	Organic cation	-	Eye drops	6.0	42
Spectrophotometry	CPC	Sr(II)-BPR	Antiseptic for the oral cavity "ALODONT"	3.3	43
Solid-phase spectrophotometry	Cationic surfactant	Silica-Titania Xerogel-Pyro-catechol Violet	Disinfectants Alaminol and Catamine AB	1.2	46
Fluorescence	Decamethoxine	Mo(VI)-BPR-CPC-TX-100	"Ophtalmodek" eye drops	0.5	This work
Spectrophotometry	Decamethoxine	Mo(VI)-BPR-TX-100	"Auridexan" ear drops	0.5	This work

Conclusions

Purposeful modification of Mo(VI) – bromopyrogallol red complex with nonionic, cationic surfactants and their mixture was carried out in the work to improve the quality of fluorescent and spectrophotometric signals. The maximum signal of the hydrophobic organic cation in Mo(VI)-BPR and Mo(VI)-BPR-TX-100 systems was registered when three- and four-component stoichiometric complexes were formed. Modification of Mo(VI)-BPR reagent system with a nonionic surfactant leads to an increase in the contrast of the spectrophotometric reaction for the determination of the organic cation, which is implemented in the developed methods. Modification of Mo(VI)-BPR and Mo(VI)-BPR-CPC reagent systems with nonionic surfactants leads to a decrease in the limit of detection of organic cations by molecular spectroscopy methods. The colloid-chemical state of Mo(VI)-BPR solutions in the presence of surfactant modifiers was also investigated. The conditions for registering the maximum turbidity in the studied system coincide with the conditions for registering the minimum value of the scattering factor. Mo(VI)-BPR-TX-100 and Mo(VI)-BPR-CPC-TX-100 systems are characterized by a pseudomolecular degree of dispersion, which ensures acceptable reproducibility and the highest sensitivity of analyte determination. The revealed effects were used in the development of methods for determining decamethoxine in pharmaceuticals by molecular spectroscopy methods. The conditions for the spectrophotometric determination of the decamethoxine content in Mo(VI)-BPR-TX-100 system are proposed based on estimates of the bathochromic shifts of the positions of the absorption maxima of the solutions in «Auridexan» ear drops (LOD=0.5 mg/L). The method of fluorescent determination of the content of decamethoxine in Mo(VI)-BPR-CPC-TX-100 system in «Ophtalmodek» eye drops (LOD=0.5 mg/L) has been developed.

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