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Langmuir aggregation of azocarmine B on cetyl trimethylammonium bromide and application

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Abstract

The microphase adsorption-spectral correction (MPASC) technique was described and applied to the study of the interaction of azocarmine B (ACB) with cetyl trimethylammonium bromide (CTAB). The synergism mechanism of CTAB was analyzed and discussed. The adsorption of ACB on CTAB at pH 9.2 obeys the Langmuir monolayer adsorption. The great electrostatic micellar aggregate (ACB·CTAB₃)₂₆ was formed, on which the Cu–ACB complex was formed rapidly in the aggregate formula (Cu·ACB·CTAB₃)₂₆. The adsorption constant of the CTAB–ACB aggregate and the stability constant of the Cu–ACB complex was determined to be 3.45×10^5 and 7.71×10^5 , respectively. The analysis of the samples gave the satisfactory quantitative results. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: MPASC technique; Microelectrostatic field; Langmuir aggregation; Cetyl trimethylammonium bromide; Azocarmine B

1. Introduction

In present supersensitive analysis of trace component, a surfactant e.g. Triton X-100, cetyl trimethylammonium bromide (CTAB) and so on is often necessary because of the enhancement of sensitivity. The following models were earlier proposed to explain the synergism (e.g. solubilization, stabilization and so on) of surfactant: micelle extraction [1], synergism perturbation [2], electrostatic field aggregate [3], hydrogen bond formation [4], micelle catalysis [5], asymmetric microenvironment [6] and so on. An ion surfactant molecule has usually long chain and various aggregation forms in aqueous solution e.g. spherical, worm-like, tubules and lamellae [7]. Recently, the study of the surfactant molecular aggregation is still very active [8–10]. Understanding the aggregation of micelle and its assembly with other organic ions e.g. stain is very significant to synthesize the new-type efficient detergent.

The interaction of a surfactant with a stain often occurs just like a precipitation-stain adsorption. A surfactant molecule has usually long chain and various aggregation forms in aqueous solution e.g. spherical, worm-like, tubules and lamellae [10]. In a surfactant (S) solution, the

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aggregation of S molecules will form an electrostatic global micelle (Fig. 1 Fig. 2) when S is more than the critical micellar concentration (CMC). So, the electrostatic attraction of stain (L) ions with opposite charge occurs in the micelle until the kinetic equilibrium (Fig. 1-middle). Due to the electrostatic attraction, the solubilization of L occurs in the S solution. The addition of a metal ions (M) will cause the sensitive complexion of M with L adsorbed in micelle phase (Fig. 1- right). Since the concentration of L in micelle phase is much higher than that in aqueous phase, the reaction is very easy and quite rapid. Like a catalyst carrier, the presence of the micelle accelerates the M-L complex reaction. All L molecules are concentrated on S micelle so the complexation between a M and L in the micelle phase becomes rapid and sensitive. This causes the enhancement of the sensitivity. Similarly, the same electrostatic adsorption of L on the S monomer surface can occur when S is less than CMC (Fig. 1-1). The aggregation of L on S surface is in only a monolayer like biomacromolecule [11]. It obeys the Langmuir adsorption [12] and the following equilibrium occurs: L (aqueous phase, C_1) \Leftrightarrow SL_N (surfactant phase, $C_{\rm S}$) in L-S solution. The Langmuir equation is used:

$$\frac{1}{\gamma} = \frac{1}{N} + \frac{1}{KNC_{\rm L}} \tag{1}$$

where K is the equilibrium constant and C_L the concentration of the excess L. N indicates the maximal adsorption ratio of L to S and γ the molar ratio of L adsorbed to S. Within increase in L concentration, γ will approach a maximum, called the adsorption ratio N. Further, we may calculate N and K values by regression of line γ^{-1} versus C_L^{-1} . Both C_L and γ are calculated by the equations [11,13]:

$$\gamma = \eta \, \frac{C_{\rm L0}}{C_{\rm S}} \tag{2}$$

$$C_{\rm L} = (1 - \eta) C_{\rm L0} \tag{3}$$

$$\eta = \frac{A_c - \Delta A}{A_0} \tag{4}$$

where both $C_{\rm S}$ and $C_{\rm L0}$ are the concentration of the S and L added initially and η indicates the effective fraction of L. A_c , A_0 and ΔA are the real absorbance of the S–L aggregate, the measurement absorbance of the reagent blank against water and that of the S–L solution against reagent blank directly measured at the peak wavelength λ_2 . The A_c is calculated by means of [14,15]:



Fig. 1. The adsorption of stain anions (L) on a cationic surfactant surface (1) and micelle (2) and the sensitive complexation of a metal (M') with L adsorbed on M surface.



Fig. 2. Absorption spectra of ACB, ACB–CTAB and Cu–ACB–CTAB solutions at pH 9.2: (1) ACB (1.00 μ mol)–CTAB (2.00 μ mol) solution at pH 7.5; (2), (3), (4), (5) same as (1) but at pH 8.4, 9.2, 10.4 and 11.4; (6) ACB (1.00 μ mol) solution; (7) ACB (1.00 μ mol)–CTAB (10 μ mol) solution. (8) ACB–CTAB product (1.00 μ mol)–Cu (20 μ g) solution and (9) Cu (320 μ g)–ACB–CTAB product (1.0 μ mol) solution. Curves 6, 7 and 9 against water and the others against the reagent blank. b- Effect of molar ratio of CTAB to ACB on the absorbance ratio.

$$A_{\rm c} = \frac{\Delta A - \beta \,\Delta A'}{1 - \alpha \beta} \tag{5}$$

where $\Delta A'$ indicates the absorbance of the S–L solution measured, respectively, at the valley absorption wavelength λ_1 . In general, α and β are the correction constants and they are calculated by measuring directly SL and L solutions. In addition, the absorptivity (real $\varepsilon_r^{\lambda_2}$ not apparent $\varepsilon_a^{\lambda_2}$) of the adsorption product SL_N at λ_2 is also directly calculated by the relation:

$$\varepsilon_r^{\lambda_2} = \frac{mNA_c}{\delta\gamma C_S} \tag{6}$$

where *m* is the aggregation number of micelle, δ the cell thickness (cm) and the others have the same meanings as in the equations above.

The combination of both the Langmuir adsorption and the spectral correction technique provides a very helpful experimental strategy for study of aggregation of chromophore on surfactant micelle. The method is called microphase adsorption-spectral correction technique (MPASC). In the present article, we have studied the aggregation of azocarmine B (ACB) on CTAB and its application to sensitive determination of trace amounts of copper(I). The reagent was earlier used in the volumetric determination and its structure is given below:



It forms negative ions (3 - 1 +) at pH 9.2 and is adsorbed on cationic surfactant surface. The imino group and the adjacent sulfonic group can coordinate Cu(I) by two teeth at pH 9.2. Results showed that the aggregation of ACB on CTAB obeys the Langmuir isothermal adsorption in only a monolayer. The maximal adsorption ratio of CTAB to ACB is 3:1 at pH 9.2 and its adsorption constant $K_{\text{CTAB-ACB}} = 1.02 \times 10^5$. The analysis of the samples showed that the recovery of CTAB is between 99.2 and 108% with the relative standard deviation (R.S.D.) 1.83% and the recovery of copper between 92.0 and 103.5% with R.S.D. 2.57%.

2. Experimental

2.1. Materials

Absorption spectra were recorded on a UV/VIS 265 Spectrophotometer (Shimadzu, Japan) with 1

cm and the individual absorbance was measured on a Model 722 spectrophotometer (Shanghai Fenxi Instruments) with 2 cm cells. The conductivity meter, Model DDS-11A (Tianjin Sec. Anal. Instrument.) was used to measure conductivity together with Model DJS-1 conductivity immersion electrode (electrode constant 0.98. Shanghai Tienkuang Device Works) in production of deionized water between 0.5 and 1 $\mu\Omega$ cm⁻¹. pH of solution was measured on pHS-2C acidity meter (Leici Instrument, Shanghai) and Model 630D pH Pen (Shanghai Ren's Electronic). The temperature was adjusted and remained constant in electric heated thermostat bath, Model 116R (Changjiang Test Instruments of Tongjiang, China).

The standard stock solution of CTAB (10.00 mmol 1^{-1}) was prepared by dissolving CTAB (Shanghai Chemical Reagents Center) in deionized water and then 1.00 mmol 1⁻¹ CTAB was prepared daily by diluting the stock solution. ACB solution $(1.000 \text{ mmol } 1^{-1})$ was prepared by dissolving 0.4260 g of ACB (ACB, content 80%, purchased from Shanghai Chemical Reagents Supply Center) in 500 ml of deionized water. The borax-boric acid buffer solutions (between pH 7.5 and 11.4) and 1.0 mol 1^{-1} NaOH were used to control the acidity of the solution. The CTAB-ACB adsorption product solution (containing 0.500 mmol 1^{-1} ACB) was prepared by mixing 100 ml of 1.00 mmol 1^{-1} ACB, 90.0 ml of 10.0 mmol 1^{-1} CTAB and 10 ml of pH 9.2 buffer solution. 2.0 mol 1^{-1} NaCl was used to adjust the ionic strength of the aqueous solutions. Standard copper solution (1.00 mg ml⁻¹) was prepared by dissolving high purity metal copper in nitric acid and its diluted solution $(10.0 \text{ mg} \text{ l}^{-1})$ was further prepared and used. The hydroxylamine hydrochloride solution (2%) was prepared for reducing Cu(II) to Cu(I). The masking reagent solution, 2% (v/v) thioglycolic acid was prepared for complexing other metals in the determination of cationic surfactant in wastewater. All reagents were of analytical grade and used without further purification.

2.2. Methods

2.2.1. Aggregation of ACB on CTAB

Into a 25 ml calibrated flask were added an

appropriate working solution of CTAB, 2.5 ml of buffer solution (pH 9.2) and 2.00 ml of 1.00 mmol 1^{-1} ACB. The mixture was diluted to 25 ml with deionized water and mixed thoroughly. After 10 min, absorbances were measured at 465 and 570 nm, respectively, against the blank treated in the same way without CTAB.

2.2.2. Determination of copper

Ten ml of a sample was taken in a 25 ml flask. Added 2.5 ml of pH 9.2 buffer solution and 2.0 ml of 0.500 mmol 1^{-1} CTAB-ACB aggregate. After mixed, added 1.0 ml of 2% hydroxylamine hydrochloride. Diluted to 25 ml and mixed well. After 15 min, measured absorbances at 500 and 595 nm, respectively, against reagent blank without Cu and calculated A_c of the ternary complex.

3. Results and discussion

3.1. Spectral analysis

The absorption spectra of the CTAB-ACB solutions are shown in Fig. 2(a), where 2.00 µmol of CTAB and 1.000 umol of ACB were added. From curves 1-5, the peak and valley are all located at near 570 and 465 nm but curves 2-4 give higher absorbances. Curve 6 indicates the spectrum of ACB solution at pH 9.2 and its peak is located at 510 nm. Fig. 2(b) shows the absorbances ratio of the ACB solutions at 465 and 570 nm containing various CTAB concentrations. We see that the ratio reaches minimum and remains almost constant when CTAB is over five times ACB in molarity. Therefore, the solution containing 9.0 µmol of CTAB and 1.00 µmol of ACB is regarded as containing none of free ACB. Curve 7 gives its spectrum and its peak is located at 520 nm. By comparing curves 6 and 7, the spectral red shift of the adsorption product is only 10 nm. From curves 6 and 7, the correction coefficients were calculated to be $\beta_{ACB} = 0.464$ and $\alpha_{CTAB-ACB} =$ 0.894. So the real absorption of the CTAB - ACB

aggregate was calculated by $A_c = 1.71(\Delta A - 0.464\Delta A')$.

In the presence of hydroxylamine hydrochloride, the absorption spectrum of the CTAB– ACB–Cu(I) ternary complex is shown in Fig. 1, too. The absorption peak of the ternary complex is located at 550 nm. By comparing spectra 6 and 9, the spectral red shift is only 40 nm. From curve 8, the peak and valley of the CTAB–ACB–Cu(I) solution are located at 595 and 500 nm, respectively. So the two wavelengths were used in this work. From curves 9 and 10, the correction coefficients were calculated to be $\beta_{CTAB-ACB} = 0.130$ and $\alpha_{CTAB-ACB-Cu(I)} = 1.04$. The real absorption of the CTAB–ACB–Cu(I) ternary complex was calculated by $A_c = 1.16(\Delta A - 0.130\Delta A')$.

3.2. Effect of pH on aggregation of ACB

In various pH solutions, the absorption of CTAB-ACB solutions was measured and the effect of pH on the adsorption ratio of ACB to CTAB is shown in Fig. 3. We observe that the increase of acidity of solution causes the ratio decrease. Between pH 8.4 and 10.4, the adsorption ratio approaches a maximum in spite of the pK_a value of ACB is predicted to be much lower than neutral pH. This is attributed to the fact that ACB²⁻ monomers were formed and it was adsorbed closely on CTAB surface. However, the adsorption of hydroxyl ions is notable on CTAB in strongly basic solution. On the contrary, the



Fig. 3. Effect of pH on the adsorption ratio (γ) of ACB to CTAB in solution initially containing 1.00 µmol of ACB and 2.00 µmol of CTAB.



Fig. 4. Effect of temperature on real absorbance (A_c) of the ACB–CTAB adsorption product in solutions initially containing 1.00 µmol of ACB and: (1) 2.00 µmol of CTAB, (2) 5.00 µmol of CTAB, (3) 7.50 µmol of CTAB, (4) 10.0 µmol of CTAB and (5) 12.5 µmol of CTAB.

intermolecular interaction, self-assembly of ACB results in the formation of the large aggregates in acidic solution. It is possible for such self-aggregates hard to be attracted on CTAB surface by electrostatic force because of its weight and big volume. In addition, the protonation or dihydrogenization of the imino group (-NH-) will not occur and the adjacent sulfonic group forms negative oxygen ($-O^-$) in such a pH scope. They will coordinate Cu(I) by double teeth in high sensitivity. Therefore, pH 9.2 buffer solution was added in this work.

3.3. Effect of ionic strength and temperature on aggregation of ACB

In order to inquire the effect of total ionic concentration in solution, the addition of NaCl was carried out. The adsorption ratio of ACB to CTAB almost remains constant between ionic strength 0 and 2 mol 1^{-1} . So the increase of ionic strength has hardly affected the aggregation of ACB on CTAB. This is attributed to the fact that ACB has much stronger adsorption on CTAB surface than Cl⁻.

The effect of temperature on the adsorption ratio of ACB to CTAB is shown in Fig. 4. The ratio always decreases with increase in temperature. This accords with the common nature of a surface adsorption. In addition, we observe that



Fig. 5. Effect of time on the composition ratio (γ): (1) adsorption ratio of ACB to CTAB in solution initially containing ACB (1.00 µmol) and CTAB (2.00 µmol) and (2) complex ratio of Cu to ACB in solution initially containing ACB–CTAB (1.00 µmol) and Cu (20 µg).

curves 1-5 all give the same decrease trend. The adsorption ratio of ACB to CTAB decreases about 10% per increasing 10 °C.

3.4. Effect of time on adsorption of ACB and complex reaction between Cu(I) and ACB

At room temperature (25 °C), the effect of the interaction time on the adsorption interaction be-

tween CTAB and ACB and the complexation between the CTAB-ACB aggregate and Cu(I) is shown in Fig. 5. Curve 1 reaches maximum in 2 min and curve 2 approaches to maximum in 15 min. So the aggregation of ACB on CTAB is much rapider than the chemical reaction between Cu(I) and ACB. The absorbance measurement of the adsorption solution was made after 2 min and that of the ternary complex solution after 15 min.

3.5. Variation of ACB concentration and determination of characteristic constant of aggregate

3.5.1. The aggregation of ACB on CTAB

By varying the addition of ACB, the absorption of the solutions was measured and their A_c and adsorption ratios are shown in Fig. 6. From curve 1, we observe that the absorbance approaches a maximum and remain constant when the addition of 1.00 mmol 1⁻¹ ACB is more than 0.7 ml. So 2 ml of the ACB solution was added in the quantitative determination of cationic surfactant. From curve 2, the adsorption ratio remains constant at 0.34 when the addition of the ACB solution is over 1.0 ml. Measured the absorbance of the



Fig. 6. Effect of ACB on adsorption ratio (γ) in solution initially containing 2.00 µmol of CTAB.



Fig. 7. γ^{-1} vs. $C_{\rm L}^{-1}$.

solutions containing 0.012 mmol 1⁻¹ CTAB and various ACB concentrations for the determination of adsorption characteristics of the ACB-CTAB product. Calculated both $C_{\rm L}$ and γ of each solution and their relationship is shown in Fig. 7. We find that $C_{\rm L}^{-1}$ versus γ^{-1} is linear and the linear regression equation is $\gamma^{-1} = 3.03 + 8.79 \times$ $10^{-6}C_{\rm L}^{-1}$ (correlation coefficient R = 0.9922). Therefore, the aggregation of ACB on CTAB accords with the Langmuir isothermal adsorption in only a monolayer. From the line intercept, the adsorption ratio of ACB to CTAB is calculated to be 0.33. We find that this figure is identical with the remaining maximum of curve 2 in Fig. 6. Therefore, ACB·CTAB₃ was formed when CTAB is less than CMC. The great aggregate (ACB·CTAB₃)₂₆ will be produced when CTAB is more than CMC. From the line slope, the equilibrium constant of the adsorption product was computed to be $K = 3.45 \times 10^5$. Additionally, from Eq. (6) the real (not apparent) molar absorptivity of the aggregate was calculated to be $\varepsilon_r^{570 \text{ nm}} =$ 4.32×10^5 l mol⁻¹ cm⁻¹.

3.5.2. The coordination between ACB-CTAB product and Cu(I)

In fact, 0.0192 mmol 1^{-1} (ACB·CTAB₃)₂₆ aggregate was formed in the solution initially containing 0.50 mmol 1^{-1} ACB and 4.50 mmol 1^{-1} CTAB because CTAB concentration is more than CMC. About 200 ml of such a solution was prepared for

sensitively complexing copper and this is described in Section 2.1. We found that only Cu(I) can be attracted in the aggregate product to complex ACB. So the hydroxylamine hydrochloride was added to change Cu(II) into Cu(I) in aqueous solution. By varying the addition of 0.0192 mmol 1^{-1} (ACB·CTAB₃)₂₆ aggregate in Cu(I) solution, measured the absorbance of solutions and calculated η of (ACB·CTAB₃)₂₆ and γ of ACB to Cu of each solution. Their curves are shown in Fig. 8. From curve 2, the complex ratio γ reaches maximum and then remains constant at 1.0 when the addition of 0.0192 mmol 1^{-1} (ACB·CTAB₃)₂₆ is more than 1.0 ml. Therefore, the final ternary complex is (Cu·ACB·CTAB₃)₂₆. The possible structure of the Cu-ACB complex is suggested below:



In the quantitative determination of copper in samples, 0.0192 mmol 1^{-1} (ACB·CTAB₃)₂₆ was added. From curve 1, the effective (ACB·CTAB₃)₂₆ is only 0.33 at 1.0 ml of the addition. So 67% of (ACB·CTAB₃)₂₆ aggregate is free



Fig. 8. Effect of addition of the ACB–CTAB aggregate solution on η and γ in solution initially containing 20 µg of Cu.



Fig. 9. Standard curves for the determination of cationic surfactant (both 1 and 2 at 570 nm) and that of copper (both 3 and 4 at 595 nm). both (1) and (3): real absorbance (A_c) , both (2) and (4) measured absorbance (ΔA) .

and excessive in the solution. Surely, it affects the absorbance measurement of the ternary complex.

The six replicate determinations of the solutions all containing 20.0 μg of Cu(II) and 9.62 nmol of $(ACB \times CTAB_3)_{26}$ aggregate were made for the real absorptivity (ε) of the ternary complex. Results are followed $A_c = 0.153 \pm 0.008$ and $\gamma = 0.629 \pm 0.030$. The real absorptivity of $(Cu \times ACB \times CTAB_3)_{26}$ product was calculated to be $\varepsilon = 5.10 \times 10^5 \text{ l} \text{ mol}^{-1} \text{ cm}^{-1}$ at 595 nm. Additionally, we can calculate the equilibrium constant [15] of complex $(ACB \times Cu)$ to be 7.71×10^5 . In the determination of the adsorption or complex ratio and equilibrium constant, the spectral correction technique is advanced in operation and principle by comparing with the classical methods such as Scatchard model [16], molar ratios [17], continuous variations [18] and equilibrium movements [19].

3.6. Calibration graph and precision for determination of cationic surfactant and copper

3.6.1. Determination of CTAB

The adsorption of ACB in CTAB micelle may also be used for the quantitative determination of cationic surfactant in the presence of thioglycolic acid. The standard series of CTAB solutions were prepared and measured at pH 9.2 containing 1 ml of 2% thioglycolic acid. The standard curves are shown in Fig. 9. Curve 1 is more linear with higher slope than curve 2. Therefore, the spectral correction method gives the better accuracy and higher sensitivity than ordinary spectrophotometry. The regression equation of curve 1 is: $A_c = 0.214x + 0.004$ (x µmol of CTAB). The detection limit was only 0.05 µmol in 25 ml of solution. Six replicated determinations of 1.00 µmol of CTAB were carried out and the mean was $0.971 + 0.015 \mu mol$.

3.6.2. Determination of copper

According to the recommended procedures, the standard series of copper solutions were prepared and measured. The standard curves 3 and 4 are shown in Fig. 9. Curve 3 is more linear with higher slope than curve 4. The regression equation of curve 3 is: $A_c = 0.0125x - 0.002$ (x µg of copper,) and it was used in the quantitative determination of copper (I, II) in samples. The detection limit was only 1.0 µg in 25 ml of solution. Six replicated determinations of 10.0 µg of copper gave the mean 10.3 ± 0.5 µg.

3.7. Effect of foreign ions in determination of cationic surfactant and copper

By adding 2% thioglycolic acid in the determination of cationic surfactant, the influence of foreign substances including ions, organic compounds and other surfactants, on the determination of CTAB by the spectral correction technique was tested at pH 9.2. None of the following ions affected the direct determination of 1.00 µmol of CTAB (less than 10% error): 2 mg of K⁺, Cl⁻, SO₄²⁻, Ac⁻, 1 mg of SO₃²⁻, C₂O₄²⁻, Triton X-100, glucose, humic acid, amino acid, Ca(II), Mg(II), SDBS; 0.5 mg of F⁻,

Table 1

Determination of cationic surfactant and copper in samples

Sample number	Added	Found	
		Cationic surfactant (µmol)	Cu (µg)
1	10 ml of sample	0.404 ± 0.007	2.18 ± 0.06
	0.500 μmol of CTAB or 2.00 μg of Cu(II)+10 ml of sample	$\begin{array}{c} \text{R.S.D.: } 1.85\% \\ 0.900 \pm 0.006 \\ \text{D} \end{array}$	$\begin{array}{c} \text{R.S.D.: } 2.57\% \\ 4.25 \pm 0.07 \\ 102.5\% \end{array}$
2	10 ml of sample 1.00 μmol of CTAB or 1.00 μg of Cu(II)+10 ml of sample	Rec.: 99.2% 1.02 ± 0.04 2.10 ± 0.06	Rec.: 103.5% 1.27 ± 0.06 2.19 ± 0.06
3	10 ml of sample 0.200 μmol of CTAB or 5.00 μg of Cu(II)+10 ml of sample	Rec.: 108% 0.199 ± 0.006 0.414 ± 0.005 Rec.: 107.5%	Rec.: 92.0% 5.20 ± 0.09 10.2 ± 0.3 Rec.: 100%

Al(III), Mn(II), Ni(II), Zn(II), Pb(II); 0.2 mg of acetone, Cu(II), Co(II), Cd(II), Fe(III) and Hg(II).

In the presence of hydroxylamine hydrochloride, none of the following ions affected the direct determination of 10.0 μ g of copper: 2 mg of alkaline metals, alkaline earths, common anions e.g. Cl⁻, SO₄²⁻, F⁻, NH₄⁺, Ac⁻ and NO₃⁻; 0.5 mg of rare earths, Zn(II), Mn(II), Al(III), Fe(II), anionic detergent, 0.3 mg of Ni(II), Co(II) and 0.1 mg of heavy metals e.g. Cd(II), Hg(II), Pb(II). This complexation is highly selective.

3.8. Determination of cationic surfactant and copper in samples

Three samples were determined. Sample 1 was sampled from Huaihe River and sample 2 from local sewage pipe. Sample 3 was prepared by adding Ca(II), Cl⁻, glucose, PO_4^{3-} , Ge(IV), V(V), acetate, Mn(II), Zn(II), Pb(II) and Hg(II) in drinking water background solution. The analytical results of samples are given in Table 1. The recovery of standard CTAB is between 99.2 and 108% and the R.S.D. is 1.83%. The recovery of standard copper is between 92.0 and 103.5% with R.S.D. 2.57%.

4. Conclusion

The investigation to the interaction of ACB with

CTAB supports the monolayer aggregation of ACB in CTAB micelles and the formation hypothesis of microelectrostatic field. Though MPASC technique has not given the higher sensitivity than other methods such as RLS [20]. However, it may meet precision and accuracy criteria and offers the additional benefits of simplicity and versatility. We describe the basic physics behind MPASC technique, survey some ongoing research on application to different micellar and macromolecular solution. We understand the classical method can still play important role in studying the synergism mechanism of surfactant micelle.

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