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Synthesis of a novel host molecule of cross-linking-polymeric-β-cyclodextrin-*o*-vanillin furfuralhydrazone and spectrofluorimetric analysis of its identifying cadmium

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Abstract

A novel host inclusion complex of cross-linking-polymeric- β -cyclodextrin-o-vanillin furfuralhydrazone (β -CDP-OVFH) was synthesized and characterized with IR and ¹H NMR spectra to confirm its structure. The coordination reaction of the host reagent with Cd²⁺ was studied and the optimum reacting conditions were observed carefully. A highly selective and sensitive spectrofluorimetric determination of trace amount of cadmium was proposed based on the reaction of Cd²⁺ with β -CDP-OVFH in ammonia water–ammonium acetate buffer medium of pH = 11.0. The molar ratio of β -CDP-OVFH to Cd²⁺ was 1:1. The maximum excitation and emission wavelengths were 393 and 494 nm, respectively. The linear range of this method was from 3.0 to 500 μ g l⁻¹ with a detection limit of 0.80 μ g l⁻¹. The effect of interferences in the determination of cadmium was investigated and the results showed that the host reagent had quite high capacity of identifying Cd²⁺. The proposed method was successfully applied to the determination of trace amount of Cd²⁺ in mussel and tea samples. © 2004 Elsevier B.V. All rights reserved.

Keywords: Synthesis of host inclusion complex; Cross-linking-polymeric-β-cyclodextrin-*o*-vanillin furfuralhydrazone (β-CDP-OVFH); Spectrofluorimetry; Determination of cadmium

1. Introduction

Cadmium is one accumulative metal element and it is harmful to most biology. The harm of cadmium consists of disturbing the metabolism of copper, zinc, and cobalt, inhibiting some systems of enzymes directly and causing ostalgia and disturbance of nephridium. With the aggravation of pollution, cadmium has caused more and more harm on human health [1-3]. Therefore, it becomes more important to find methods detecting trace amount of cadmium in production and environmental protection. At present, determination of Cd²⁺ by atomic absorption spectrometry [4,5], spectrophotometry [6], and ICP-MS [7–9] have been often used while spectrofluorimetry [10,11] has been used scarcely. Compared with these methods, spectrofluorimetry has advantages such as higher sensitivity, better selectivity, less samples, simpler, and faster. So it is very important to quest sensitive and selective fluorescent reagents to determine trace amount of cadmium. In recent years, aroylhydrazones which contain the group of -CONHN=CH- have played more and more important roles in determining metal ions as fluorescent reagents, but their development is restricted because of their low sensitivity and selectivity [12–16]. With the characteristic structure [17,18], β -cyclodextrin (β -CD) has received much attention as a fine natural host reagent nowadays [19-23]. The cross-linking-polymeric-\beta-CD (β-CDP) has advantage over β-CD on including and identifying capacity and has a wide application foreground in the field of molecule identification [24-26]. In this paper, we synthesized the cross-linking-polymeric-β-cyclodextrin-o-vanillin furfuralhydrazone (β-CDP-OVFH), characterized its structure with IR and ¹H NMR spectra and studied the coordination reaction of $\beta\text{-}CDP\text{-}OVFH$ with $Cd^{2+}.$ The $\beta\text{-}CD$ cavities in β-CDP-OVFH protected the single-excited state molecule of the fluorescent complex from being quenched by water and soluble oxygen which improved the quanta yield, so the sensitivity was improved greatly. The steric effect of β-CDP-OVFH made it difficult to include big molecules, so the selectivity was improved. In the determination of

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cadmium with β -CDP-OVFH, the linear range was from 3.0 to 500 μ g l⁻¹ with a detection limit of 0.80 μ g l⁻¹. The effect of interferences in the determination of cadmium was investigated and the results showed that the host reagent had quite high capacity of identifying Cd²⁺. The determination of small guest ion—Cd²⁺ with the host reagent has advantages such as high sensitivity, good selectivity, stability, and so on. To our knowledge, no papers reported dealing with the inclusion complex, so search of new pattern host molecule reagents using β -CDP as matrix has a better application foreground.

2. Experimental

2.1. Apparatus

All fluorescence measurements were carried out on a Perkin-Elmer (Norwalk, CT, USA) LS-50 spectrofluorimeter equipped with a xenon lamp and 1.0 cm quartz cells. The slit of excitation and emission were 5 and 4 nm, respectively. All pH measurements were made with a pH-3C digital pH-meter (Shanghai Lei Ci Device Works Shanghai, China) with a combined glass–calomel electrode. The IR spectra were recorded on a PE-983 IR spectrometer (KBr discs (cm⁻¹), Perkin-Elmer, Norwalk, CT, USA). Elemental analysis measurements were performed with a PE-240 CHN elementary analytical meter (Perkin-Elmer, Norwalk, CT, USA). The ¹H NMR spectra were recorded on a FX-90Q Nuclear Magnetic Resonance Spectrometer (DMSO as solvent, JEOL, Japan).

2.2. Reagents

β-Cyclodextrin was purified by recrystallization, the 0.10 mg ml⁻¹ of standard stock solution of cadmium was diluted to work solution, a buffer solution (pH = 11.0, 0.20 mol1⁻¹) of ammonia water–ammonium acetate was prepared, β-CDP-OVFH ($5.0 \times 10^{-4} \text{ mol1}^{-1}$) and OVFH ($1.0 \times 10^{-3} \text{ mol1}^{-1}$) solution was prepared in 100 ml of ethanol. All chemicals used were of analytical reagent or higher grade and doubly distilled water was used throughout.

2.3. Synthesis of host molecule reagent

2.3.1. Synthesis of formacylhydrazine

2.70 ml of methyl-furoate (about 0.025 mol) and 3.00 ml of 85% hydrationhydrazine (about 0.025 mol) were added into a 50 ml of flask then 25.0 ml of 95% ethanol was added. The mixture was refluxed for 5 h in a water bath of 80–90 °C then distilled by decompression to eliminate ethanol and residual hydrationhydrazine. The red-brown and ropy liquid was obtained and cooled in ice-water, then the white and wax solid was obtained with a yield of 75%. The melting point of the solid was 75–76 °C.

2.3.2. Synthesis of OVFH

1.26 g (0.010 mol) of formacylhydrazine were added into 40.0 ml of 95% ethanol and the mixture was heated to dissolve completely. 1.52 g (0.010 mol) of *o*-vanillin was added into 20.0 ml of 95% ethanol and the mixture was heated to dissolve. The solution of *o*-vanillin was added into the formacylhydrazine solution dropwise, then the mixture was refluxed for 2 h in a water bath of 90–100 °C, cooled and pumped out. The precipitate was recrystallized from ethanol and washed with 10.0 ml of 95% ethanol three times then 2.10 g of yellowish powder was obtained with a yield of 81%. The melting point of the powder was 147–148 °C. Elemental analysis gave a composition of: C 59.92%, H 4.61%, and N 10.81%, which was in good agreement with the theoretical composition of OVFH: C 59.97%, H 4.65%, and N 10.77%.

2.3.3. Synthesis of β -CDP

10.5 g of β -CD was dissolved in 25.0 ml of NaOH (35%) and 8.50 ml of epichlorohydrin was added dropwise. The reaction mixture was kept at 90 °C for 5 min with stirring. After the solution was cooled to room temperature and neutralized with 6.0 mol 1⁻¹ of HCl, it turned into a transparent yellowish solution. This solution was dialyzed with a dialysis bag (molecular weight less than 3500) in order to eliminate NaCl and remnant material. The solution was concentrated to 50.0 ml. 25.0 ml of the concentrated solution was freeze-dried under low pressure, then 4.30 g of β -CDP was obtained. The product decomposed at 240 °C. The average molecular weight of the complex was 5300, which was measured by gelatin chromatogram. It could be concluded that there were four β -CD units in one complex molecule [27].

2.3.4. Synthesis of host molecule (β -CDP-OVFH)

0.200 g of *o*-vanillin furfuralhydrazone was dissolved in 5.00 ml of methanol and 6.00 ml of concentrated β -CDP solution was added. The color of solution changed from yellowish to brown and precipitation was observed simultaneously. The mixture solution was kept at 50 °C with stirring for 30 min, cooled and filtered under reduced pressure, then the precipitation was recrystallized from ethanol and washed with 10 ml of doubly distilled water for three times. After dried, 0.290 g of brown crystal was obtained with a yield of 13%. The melting point was 181–182 °C.

2.4. Spectrofluorimetric determination of cadmium

Into a 10 ml color comparison tube were added 1.50 ml of NH₃·H₂O–NH₄Ac buffer solution (pH = 11.0, 0.20 mol l⁻¹), certain amount of 5.0 µg ml⁻¹ cadmium standard solution, 2.50 ml of ethanol and 0.30 ml of 5.0×10^{-4} mol l⁻¹ β-CDP-OVFH (or 1.0×10^{-3} mol l⁻¹ OVFH, or 5.0×10^{-4} mol l⁻¹ β-CDP and 1.0×10^{-3} mol l⁻¹ OVFH), then it was diluted to volume. The solution was mixed thoroughly and equilibrated for 10 min at room temperature, then the fluorescence intensity was measured at λ

(ex/em) = 393/494 nm against a reagent blank. A calibration graph was prepared under the same conditions for the determination of cadmium. The excitation and emission slit both set to 5 nm.

2.5. Sample treatment

0.2500 g of tea sample (GBW08505) was put into a 100 ml of beaker and 2.50 ml of nitric acid was added, the solution was marinated for one night, then 0.25 ml of perchloricacid was added. The mixture was heated slowly until copious white fumes disappeared. After being cooled, 20 ml doubly distilled water was used to wash the precipitation for three times. The solution was adjusted to neutrality with NaOH and transferred to a 100 ml of measuring flask and fixed to volume.

0.2000 g of dry mussel sample (GBW08571) was incinerated in porcelain crucible after cleaned, then it was charred at 550 °C in a muffle for 2 h. After being cooled, 4.00 ml of HNO₃ and 0.50 ml of HClO₄ were added. The mixture was heated slowly until copious white fumes disappeared. After being cooled, 20 ml doubly distilled water was used to wash the precipitation for three times. The solution was adjusted to neutrality with NaOH and transferred to a 100 ml of measuring flask and fixed to volume.

10.00 ml of the two above solutions was put into 100 ml of separating funnel, respectively, then 2.00 ml of H_2SO_4 (1 + 1), 2.00 ml of KBr solution (2.5 mol l⁻¹) and 6.00 ml of water were added in turn. The equilibrized mixture was extracted twice with 10.00 and 5.00 ml of diantipyrylmethane–chloroform (DAM–CHCl₃) solution (2.5%), respectively. The aqueous layer was discarded and the extract was washed with 20.00 ml of H_2SO_4 –KBr lotion. The organic phase was combined, then Cd^{2+} was extracted with 10.00 ml of $NH_3 \cdot H_2O$ (2 + 98). The aqueous phase was collected and diluted 10-fold, then determined by the method developed.

3. Results and discussion

3.1. Confirmation of host molecule

3.1.1. Physical properties

The physical properties such as melting point, crystal shape, and color of OVFH and β -CDP-OVFH were listed in Table 1, which indicated a new reagent had formed.

Table 1 Changes of physical properties

Compound	Melting point	Crystal shape	Color
OVFH	147–148 °C	Pine needle shape	Yellowish
β-CDP	Decomposed at 240 °C	Powder	White
β-CDP-OVFH	181–182 °C	Stick shape	Brown

Table 2				
The ¹ H NM	MR spectra of	OVFH and	$\beta\text{-}CDP\text{-}OVFH$	(δ (ppm))

Compound	Function group									
	Ar–OH	N–H	Phenyl and furan	Ar–OCH ₃	CH=N					
δ _{OVFH}	12.00	10.80	6.40–7.95	3.83	8.65					
$\delta_{\beta-CDP-OVFH}$	11.98	10.79	6.32-7.92	3.82	8.64					
$\Delta \delta^{a}$	-0.02	-0.01	-0.03 to	-0.01	-0.01					
			-0.08							

^a $\Delta \delta = \delta_{\beta\text{-CDP-OVFH}} - \delta_{\text{OVFH}}.$

3.1.2. The ¹H NMR spectra of OVFH and β -CDP-OVFH

In order to confirm if OVFH entered into the β -CDP cavities, the ¹H NMR spectra of OVFH and β -CDP-OVFH were obtained. The results were listed in Table 2. It was easy to see that the chemical shifts (δ) of all hydrogen atoms moved to higher field to different extents. The changes of Ar–OH, N–H, CH=N, and Ar–OCH₃ were not obvious while the changes of phenyl and furan were prominent. The results showed that the phenyl and furan rings of OVFH entered into the β -CD cavities. The rich electron β -CD cavities improved the electron cloud density of the hydrogen included, so the shield effect was increased. This made the chemical shifts of hydrogen atoms included move to higher field. Because Ar–OH, N–H, CH=N, and Ar–OCH₃ were located outside the cavities, their changes were not obvious.

3.1.3. The IR spectra of OVFH and β -CDP-OVFH

The peak shape of OVFH did not change after included by β -CDP, but the wave locations of hydroxybenzene–OH, C=O, Ar-O and C=N all shifted to different extents. The IR spectra showed that the wave locations of the function group increased 30 cm^{-1} (–OH), 19 cm^{-1} (–OH), 5 cm^{-1} (C=O), 5 cm^{-1} (Ar–O), 5 cm^{-1} (Ar–O) and 3 cm^{-1} (C=N), respectively (Table 3). Because hydroxybenzene-OH and Ar-O jointed with benzene ring, C=O jointed with furfuran ring directly and benzene and furfuran rings entered into the cavities, the rich-electron cavities of β -CDP increased the density of electron cloud and led to the increment of frequency. Although C=N did not joint with benzene or furfuran directly, they formed a conjugated system with benzene and furfuran rings, which led to the increment of the density of electron cloud but not too much. The results of IR spectra showed that the new host reagent had formed.

Table 3 The IR spectra of OVFH and $\beta\text{-}\text{CDP-}\text{OVFH}~(\text{cm}^{-1})$

Compound	Band and group						
	–OH	C=O	Ar–O	C=N			
OVBH	3420, 3250	1660	1250, 1305	1612			
β-CDP-OVFH	3450, 3269	1665	1255, 1310	1615			
Δ	+30, +19	+5	+5, +5	+3			



Fig. 1. The structure of β-CDP-OVFH.

3.1.4. The structure of β -CDP-OVFH

The reaction molar ratio of β -CDP and OVFH was tested as 1:1, 1:2, 1:4, 2:1, and 4:1, respectively. The results showed that when the ratio was 1:2, both yield and crystal shape were the best, so we presumed that each molecule of β -CDP-OVFH consisted one β -CDP and two OVFH. This conclusion was agreement with the structure of Fig. 1.

3.2. Excitation and emission spectra

Under the selected conditions, the maximum excitation and emission wavelengths were 393 and 494 nm, respectively (Fig. 2). We found that the complex of β -CDP-OVFH–Cd²⁺ had very strong fluorescence intensity while the reagent blank had low signal, which indicated that β-CDP-OVFH had a higher signal-to-noise than OVFH in the determination of cadmium. With the driving force of hydrophobic interaction, van der Waals force and hydrogen bond, the OVFH molecule entered into the β -CDP cavities and formed a supermolecule host reagent- β -CDP-OVFH. Two β -CD units of the β -CDP cooperated to include phenyl and furan rings of OVFH, which improved the rigidity of the host reagent. The β -CD cavities in β -CDP-OVFH offered a non-polar microenvironment, the movement freedom of the formed fluorescent complex molecule and the relaxation effect of the water molecule were both greatly depressed, which reduced the mutual collision of molecules and the non-radiative transition. The complexometric effect of Cd²⁺ with OVFH made the rigidity and plane of β -CDP-OVFH improved. Furthermore, the β -CD cavity could also protect the fluorescent single state molecule of β -CDP-OVFH–Cd²⁺ from the quenching of water and soluble oxygen.

If we simply added the same dosage of β -CDP and OVFH into the reaction system rather than β -CDP-OVFH, β -CDP could still offer a feasible microenvironment of weaker polarity and stronger rigidity, so the quenching effect of water and soluble oxygen on the fluorescent single state molecule of OVFH–Cd²⁺ was reduced and the fluorescence intensity was improved, compared to the system without β -CDP. However, the steric effect of β -CDP restrained OVFH–Cd²⁺ from entering into the cavities of β -CDP, so the rigidity and plane of OVFH–Cd²⁺ could not be improved further. In β -CDP-OVFH, the steric effect made it easy to include with appropriate guest (for example Cd²⁺) [28], so the selectivity was improved greatly.

3.3. Effect of pH

The pH of the medium could change the existent conformation of reagent and metal ion, which affected directly the formation and stability of the complex. So it



Fig. 2. Excitation (a) and emission spectra (b). 1 and 1' were the fluorescent spectra of β -CDP-OVFH–Cd²⁺ and blank, respectively; 2 and 2' were the fluorescent spectra of β -CDP + OVFH + Cd²⁺ and blank, respectively. The concentration of reagents were: $5.0 \times 10^{-5} \text{ mol} 1^{-1}$ of β -CDP-OVFH; $1.0 \times 10^{-4} \text{ mol} 1^{-1}$ of Ω -CDP; $500 \,\mu\text{g} 1^{-1}$ of Cd²⁺.



Fig. 3. Effect of pH on the relative fluorescent intensity of the β -CDP-OVFH–Cd²⁺ C (β -CDP-OVFH): $5.0 \times 10^{-5} \text{ mol } l^{-1}$; C (Cd²⁺): $500 \,\mu g \, l^{-1}$.

made a great effect on the fluorescence intensity of the β -CDP-OVFH–Cd²⁺ complex. According to the experimental method, 1.50 ml of different pH value buffer solution was added and fluorescence intensity was determined. The experimental results showed that the relative fluorescence intensity reached the highest value and remained constant between 10.6 and 11.3 (Fig. 3), so the optimum pH of 11.0 for the complex formation was selected. Among Tris–HCl, Na₂B₄O₇–NaOH, KH₂PO₄–K₂HPO₄ and NH₃·H₂O–NH₄Ac buffer solution systems, it was more sensitive for the reaction system in NH₃·H₂O–NH₄Ac buffer solution (0.20 mol1⁻¹).

3.4. Effect of amount of buffer solution

The influence of the amount of buffer solution on the relative fluorescence intensity of the solution containing $500 \ \mu g \ l^{-1}$ of $\ Cd^{2+}$ and $1.0 \times 10^{-5} \ mol \ l^{-1}$ of β -CDP-OVFH was studied. The fluorescence intensity remained constant between 1.00 and 2.00 ml and decreased slowly thereafter. Thus, 1.50 ml was selected throughout the experimental work.

3.5. Effect of organic solvent

The effect of organic solvent on the fluorescence intensity of the β -CDP-OVFH–Cd²⁺ complex was studied. Table 4 showed that the complex has higher fluorescence intensity in ethanol than in any other organic solvents. The fluorescence intensity of the complex remained constant between 2.00 and 3.00 ml of ethanol. Therefore, 2.50 ml of ethanol was selected.

3.6. Effect of amount of β -CDP-OVFH

The influence of the amount of β -CDP-OVFH on the fluorescence intensity of the complex was studied under the conditions established above. The fluorescence intensity increased with the amount of β -CDP-OVFH up to 0.20 ml, remained constant between 0.20 and 0.40 ml and decreased slowly thereafter. A suitable amount of β -CDP-OVFH was advantageous to form fluorescent complex, while superfluous β -CDP-OVFH could decrease the fluorescence intensity of β -CDP-OVFH -Cd²⁺. Thus, 0.30 ml of β -CDP-OVFH was selected throughout the experiment.

3.7. Effect of temperature and reaction time

The influence of temperature was tested. The experimental results showed that high temperature increased the collision of molecules, which made the collision probability of excited molecules and solvent molecules increase and resulted in the declination of fluorescence intensity. So the room temperature was selected. The relative fluorescence intensity reached a maximum after 10 min and remained constant for at least 1 h, then decreased slowly. Therefore, all coordination reactions were kept for 10 min at the room temperature.

3.8. Stoichiometry of the complex

The stoichiometry of the complex was studied under the established experimental conditions by the molar ratio and continuous variation methods. Both methods showed that the composition of the complex was 1:1 (Cd²⁺: β -CDP-OVFH). For the β -CD cavity was hydrophobic, it would reduce the stability of the complex if the guest had a greater polarity or electric charge, so the neutral host molecule was the best matching to the β -CD cavity [29]. As described above, there were four β -CD units in one β -CDP molecule, so there were two OVFH molecules in one host reagent molecule. It was easy to see that the complex was neutral and suitable for the composition of the complex, which was 1:1 (Cd²⁺: β -CDP-OVFH). So we presume the model structure of the complex was as shown in Fig. 4.

Table 4

Effect of organic solvent on fluorescence intensity (F) of the β -CDP-OVFH-Cd²⁺ complex and the reagent blank

F O M	Organic solve	Organic solvent ^a									
	Methanol	Ethanol	Isopropanol	Acetonitrile	Ether	Acetone	N,N-Dimethylformamide				
Blank	24	22	32.3	35.7	15.1	47.8	59.9				
Complex	82.5	96	77.1	92.4	75.5	102.7	113				

^a The amount of every organic solvent was 2.50 ml.

Table 5

Characteristics of fluorimetric methods for cadmium	
Reagent	Linear rar
	$(\mu g l^{-1})$

Reagent	Linear range	Detection	Major interference	Ref.
	$(\mu g l^{-1})$	limit ($\mu g l^{-1}$)		
8-Hydroxyquinoline-5-sulfonic acid and bromo-cetyltrimethylamine	5-100	4.2	Fe ³⁺ , Cu ²⁺ , Co ²⁺ , Ni ²⁺	[10]
Luminol-8-hydroxyquinoline-5-sulfonic acid-H2O2	20-1000	10	Zn^{2+} , Al^{3+}	[11]
9-(1',4',7',10',13'-Pentaazacyclo-pentadecyl)methylanthracene	10-60	4.5	Cu ⁺ , Cu ²⁺ , Hg ²⁺ , Cr ³⁺	[31]
Rhodamine S-polyrinylalcohol-124	4–20	0.88	Bi ³⁺ , Pd ²⁺ , Hg ²⁺	[32]
β-CDP-OVFH	3.0-500	0.80	Al ³⁺ , Fe ³⁺ , Zn ²⁺ , Ni ²⁺	This work

3.9. Effect of interferences

A systematic study of the interferences in the determination of cadmium $(100 \ \mu g \ 1^{-1})$ was carried out under the conditions established above. The criterion for interference was defined as an tolerable error not exceeding $\pm 5.0\%$ in the determination. No interference was encountered from (tolerance ratio in mass): NH₄⁺, I⁻, NO₃⁻, NO₂⁻, Br⁻ (over 1000); CO₃²⁻, CH₃COO⁻, F⁻, SO₄²⁻ (500); PO₄³⁻, SO₃²⁻, C₂O₄²⁻ (300); tartaric acid (200); Mo(VI) (150); Ba²⁺ (100); citric acid (80); B³⁺ (50); Ca²⁺ (10); Cu²⁺, Co²⁺, Mn²⁺, Pb²⁺, Cr₂O₇²⁻, Be²⁺ (5); Al³⁺, Fe³⁺, Zn²⁺, Ni²⁺ (1). From the results, we could see that the host reagent (β-CDP-OVFH) had a better selectivity and finer identifying capacity on the small guest—Cd²⁺.

3.10. Analytical characteristics

Under the optimum experimental conditions, there was a linear relationship between the relative fluorescence intensity and the concentration of Cd^{2+} in the range of 3.0–500 µg1⁻¹ with a correlation coefficient (*r*) of 0.9996. The regression equation was $\Delta F = 0.643 + 13.11C$ (µg/10 ml). The detection limit, as defined by IUPAC [30], was determined to be 0.80 µg1⁻¹. The relative standard deviation (R.S.D.) was 2.2% obtained from a series of 11 standards each containing 250 µg1⁻¹ of Cd²⁺. The proposed method was compared with other common fluorimetric procedures (Table 5). As we could see, the proposed method had higher sensitivity than other fluorimetric meth-



Fig. 4. Model structure of the complex.

Table 6										
Determination	of	cadmium	in	mussel	and	tea	samples	(P)	= 0.95)	

Standard value ($\mu g g^{-1}$)	Measured value $(\mu g g^{-1}) (n = 6)$	R.S.D. (%)
$ 4.5 \pm 0.3 \\ 0.032 \pm 0.005 $	$\frac{4.43 \pm 0.09}{0.030 \pm 0.001}$	2.4 5.6
	Standard value ($\mu g g^{-1}$) 4.5 ± 0.3 0.032 ± 0.005	Standard value ($\mu g g^{-1}$)Measured value ($\mu g g^{-1}$) ($n = 6$)4.5 ± 0.3 0.032 ± 0.0054.43 ± 0.09 0.030 ± 0.001

ods and very wide linear range as well, which composed the distinctive merits of it.

3.11. Determination of cadmium in tea and mussel samples

The determination results were shown in Table 6. The measured value was in good agreement with the standard value, which indicated that the proposed method was reliable to determine trace amount of cadmium.

4. Conclusion

We consider the reaction of host and guest is the dual identifying action through the studies. At first, β -CDP has a special identifying action and the driving force is hydrophobic, hydrogen bond interaction and the release of high-energy water. Secondly, β -CDP-OVFH also has identifying action with the driving force of electrostatic interaction. Because the fluorescent structure of plane, rigidity and large conjugation of π bond are formed and the fluidness of electron is improved due to the rich-electron cavities of β -CDP increasing the density of electron cloud of the complex. At the same time, the coordinated action of poly cavities makes the plane and rigidity improved further, which leads to higher quanta efficiency and sensitivity.

In this paper, we applied β -CDP-OVFH as a host molecule to determine Cd²⁺ successfully, presented dual identification theory, and provide a wonderful host reagent for analysis of trace amount cadmium. The use of β -CDP-OVFH as a host molecule to determine small guest has the advantage of high sensitivity, good selectivity, and stability. In addition, the novel host molecule is excellent fluorescent reagent, which can be applied to the identification and determination of cadmium. Therefore, the search of new pattern of host molecule reagent using β -CDP as matrix has a widely applying foreground.

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