



A selective and sensitive optode for determination of Hg^{2+} ion based on covalent immobilization of thiazole yellow on triacetyl cellulose films



M. Salmani G.K., G.H. Rounaghi*, M. Chamsaz

Department of Chemistry, Faculty of Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

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ABSTRACT

A novel optical chemical sensor was constructed for measurement the concentration of Hg^{2+} ion in solutions by covalent immobilization of thiazole yellow dye on a triacetyl cellulose film via epichlorohydrin as a linker. The chemical interaction between the Hg^{2+} ion and immobilized thiazole yellow molecules was studied by UV–vis spectrophotometry at 420 nm. The effect of influencing parameters on immobilization of the dye molecules on the surface of the film and also for improving the sensitivity of the constructed optode was studied. The optode showed a dynamic range from 1×10^{-7} to 3.2×10^{-5} M with respect to concentration of Hg^{2+} ion at pH 9 and its limit of detection was found to be: 1×10^{-8} M. The fabricated optical chemical sensor has good analytical performance such as good selectivity and sensitivity, adequate short term and long term stability and a good reproducibility and repeatability. The response of the fabricated sensor to Hg^{2+} ion is completely reversible and it can be regenerated easily at pH 5 buffer solution in about 2 min. Its response time is 12 min. The constructed optode was successfully applied for determination of Hg^{2+} ion in real samples.

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1. Introduction

Heavy metals are generally defined as metals with relatively high densities, atomic weights or atomic numbers. Among these elements, chromium, arsenic, cadmium, mercury and lead have the greatest potential to cause harm on account of their extensive use, toxicity of some of their compounds or elemental forms and their widespread distribution in the environment [1]. Mercury and most of its compounds are extremely toxic and in fact, mercury ranks sixth among the most toxic chemicals in the list of hazardous compounds [2]. Because of these potential hazards, it is essential to control and measure the mercury and its compounds for protection of environment and health. There are different methods such as, atomic absorption spectroscopy (AAS), inductively coupled plasma–atomic emission spectroscopy (ICP–AES), electrochemical methods, ion chromatography and etc. [3–7] for determination of Hg^{2+} ion in solutions. Although, these methods are usually sensitive, precise and accurate but, they are expensive, time consuming, and sophisticated in most cases.

One of the attractive alternatives for measurement of heavy metal ions and especially Hg^{2+} ion which has considered in recent decades is using the optical chemical sensors. Using of optodes have some advantages such as simplicity, good selectivity, easiness of construction, low cost in construction process and usability for several times and also easiness of use [8]. Numerous research works have been reported for determination of Hg^{2+} ion with optodes. In some of these works, a dye compound or ligand is immobilized on a bed by impregnation or doping [9–17]. These immobilization methods have some advantages such as, easiness of construction and also possibility of using of a wide range of dyes and ligands. But they have some disadvantages such as, swelling, dye leaching, hysteresis and inhomogeneity of the bulk [18]. In some research works, the dye compounds or ligands are immobilized on the bed by covalent bonds [8,19–23]. Although, a few dyes or ligands can be immobilized by covalent bonding, but the constructed sensors usually don't have the above-mentioned disadvantages and usually they have a long lifetime and repeatable response.

Thiazole yellow (TY) with the structural formula of $\text{C}_{28}\text{H}_{19}\text{N}_5\text{Na}_2\text{O}_6\text{S}_4$, is a triazene dye which is used as a stain and fluorescent indicator in microscopy [24], as well as, an albumin detector [25] and also for determination of proteins [26]. Furthermore, it is used as a reagent for the determination of magnesium [27,28] and also as an acid–base indicator that its color

* Corresponding author.

E-mail addresses: ghrounaghi@yahoo.com, ronaghi@um.ac.ir (G.H. Rounaghi).

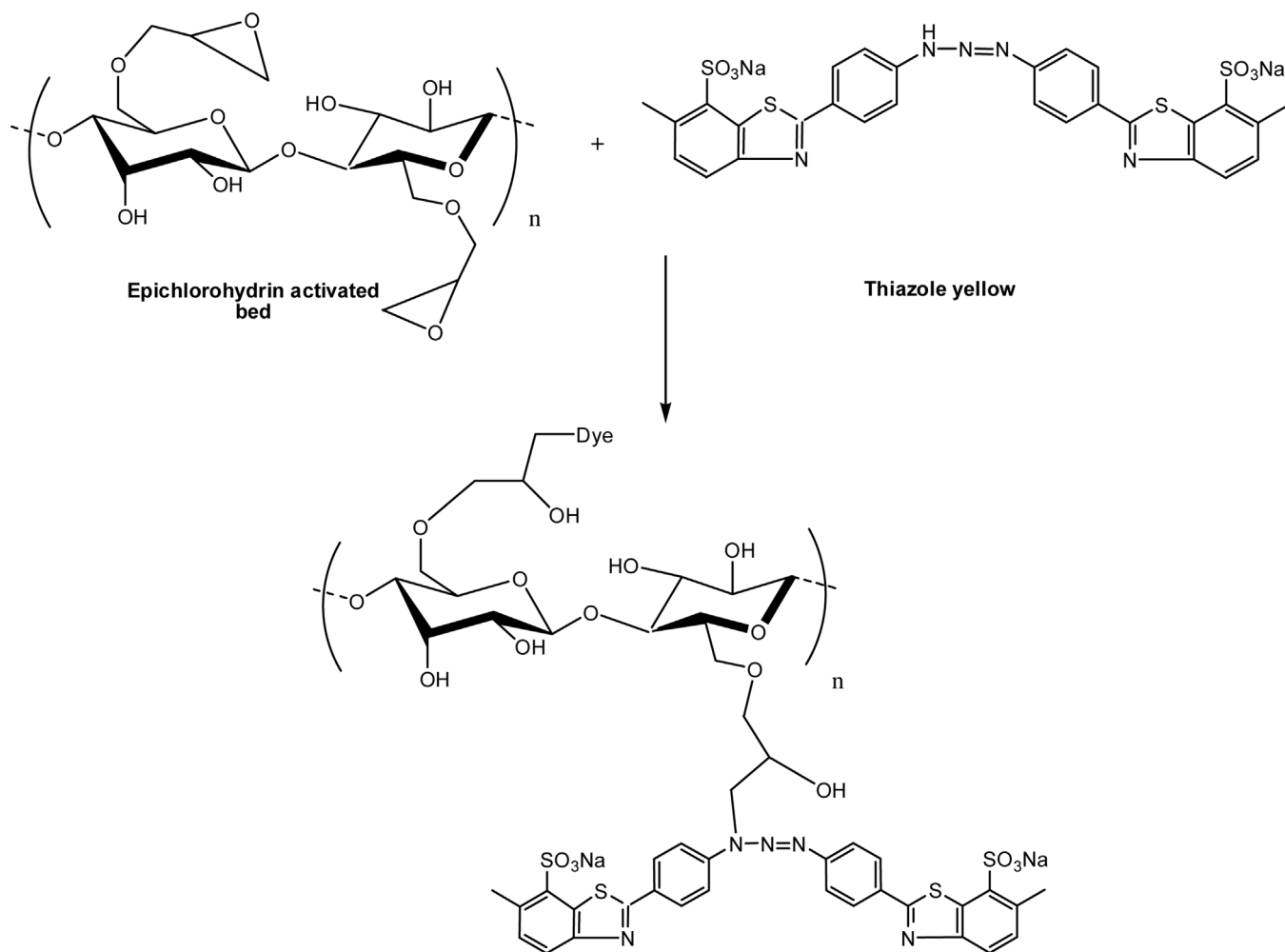


Fig. 1. Chemical reaction between thiazole yellow and the epichlorohydrin activated TAC beds.

changes from yellow to red between pH 12 and pH 13. In addition, there are numerous researches in the field of pH measurement at high levels by the optodes prepared from TY [29–32].

In this research work, we have tried to immobilize TY dye on the triacetyl cellulose (TAC) membrane for construction of a selective, sensitive and especially durable optode for determination of Hg^{2+} ion in aqueous media. To our knowledge, no report on the use of TY for measurement of mercury (II) ion and also construction of an optode for this purpose is provided yet. Furthermore, in this article, we have explained the immobilization process of amino dyes on TAC membranes via epichlorohydrin as a linker which is a new method for immobilization of some ligands on these kinds of beds. Fig. 1 shows the proposed chemical reaction between TY and the epichlorohydrin activated TAC beds.

2. Experimental

2.1. Reagents

Thiazole yellow, epichlorohydrin, mercury (II) chloride, sodium hydroxide, borax, potassium dihydrogen phosphate and disodium hydrogen phosphate were obtained from Merck chemical company. Hydrochloric acid was obtained from Chem-lab chemical company. The TAC membranes were produced from waste photographic film tapes (Kodak ProFoto XL). Universal aqueous pH buffer solutions were prepared according to CRC handbook instruction [33] and the final pH values were adjusted by addition of 1.0M

sodium hydroxide or hydrochloric acid. Deionized distilled water was used in all experiments.

2.2. Instrumentation

The spectrophotometric measurements were performed by a double-beam Lambda 25 UV/Vis spectrophotometer. A Metrohm 827 pH meter was used for measurement the pH of the solutions.

2.3. Preparation of the sensor membranes

The transparent TAC membranes were prepared from waste photographic film tapes that were previously treated with commercial sodium hypochlorite for several seconds in order to remove the gelatinous layer. Then, the membranes were washed with tap water and then distilled water, respectively. The washed membranes were hydrolyzed for 24 h in a 0.2M sodium hydroxide solution at 30 °C for de-acetylating the esteric groups and increasing the porosity of the membranes. The hydrolyzed membranes were treated with epichlorohydrin solution in a basic medium as follows: 2.5 g epichlorohydrin was added to 150 ml of 1 M sodium hydroxide solution at 25 °C and mixed adequately until a clear and homogeneous solution was formed. Then, 3 g of the hydrolyzed membranes was transferred into the reactor and the solution mixed by a magnetic stirrer at 25 °C for 3 h. The activated films were immersed in 500 ml of distilled water for 30 min and then washed completely by distilled water and finally dried at room temper-

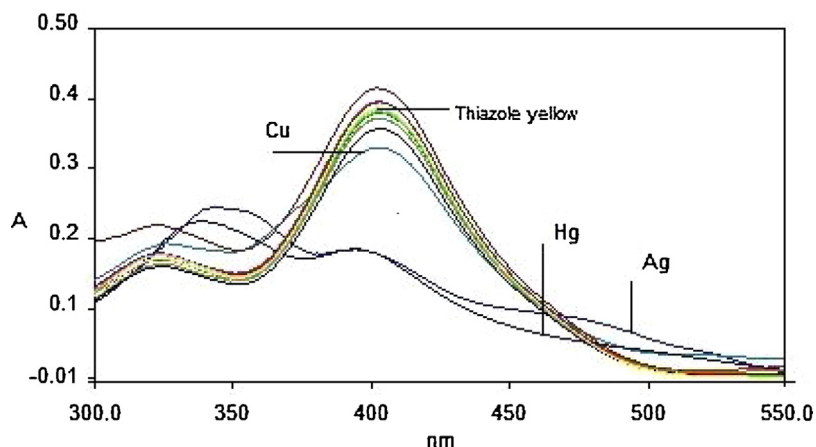


Fig. 2. Study of formation of complexes between ions: Al(III), Fe(III), Co(II), Pb(II), Hg(II), Ag(I), Cu(II), Zn(II), Ni(II), Mg(II), Mn(II) and Bi(III) and thiazole yellow molecule in aqueous solution at pH 9.

ature. The dried activated films were cut into small pieces with about 0.04 g of weight (8×35 mm pieces).

For immobilization of the TY on the surface of the activated films, 10 pieces of the films (totally about 0.4 g) were transferred into a flask and 10 ml of a 0.025 M solution of potassium dihydrogen phosphate was added subsequently. Then, 0.007 g of TY was added to the solution for preparation a solution with 1.0×10^{-3} M concentration of the dye. Finally, the pH of the solution was increased to 13 by gradual addition of solid sodium hydroxide. The resulting solution stirred for 2 h at 55 °C and then 22 h at 45 °C. The immobilized films were washed with distilled water and then they were placed 3 times in 30 ml of a buffer solution with pH 9 and mixed for 5 h at 25 °C. Finally, the constructed films were washed with distilled water and then stored in a buffer solution with pH8.

2.4. Procedure

In spectrophotometric measurements, a piece of a raw film (Hydrolyzed TAC film) that was fixed in a Teflon framework was placed vertically in a 10 mm spectrophotometric cell and it was used as a reference cell. The immobilized film was also fixed in a Teflon framework and it was placed vertically in a 10 mm spectrophotometric cell and was used as a sample cell. Then the absorption spectra were obtained by scanning the spectrophotometer.

3. Results and discussion

We studied the complexation reactions between TY molecules and Hg^{2+} ion and also some of the other metal ions such as, Al(III), Fe(III), Co(II), Pb(II), Cu(II), Zn(II), Ni(II), Mg(II), Ag(I), Mn(II) and Bi(III) at the same conditions at pH 9 using spectrophotometric technique. As is seen in Fig. 2, among these metal ions, Hg^{2+} , Ag^+ and to some extent the Cu^{2+} ion form relatively strong complexes with TY molecules in aqueous solutions, but no evidence was observed for complexation process between the TY molecules and the other studied metal cations under the experimental conditions. Based on these experimental results, it seems that the TY molecules can be used as selective ionophores for construction of an optical sensor for determination of the Hg^{2+} ion in solutions.

The change in absorbance at the maximum wavelength (395 nm) against the metal ion/dye mole ratio is shown in Fig. 3a. As is evident in this Figure, the inflection point of the mole-ratio plot is observed at about 0.25 which is an evidence for formation of a 1:4, $[TY_4Hg]^{2+}$ complex in aqueous solution. Also, the variation of absorbance (at 395 nm) against the volume of TY is depicted in

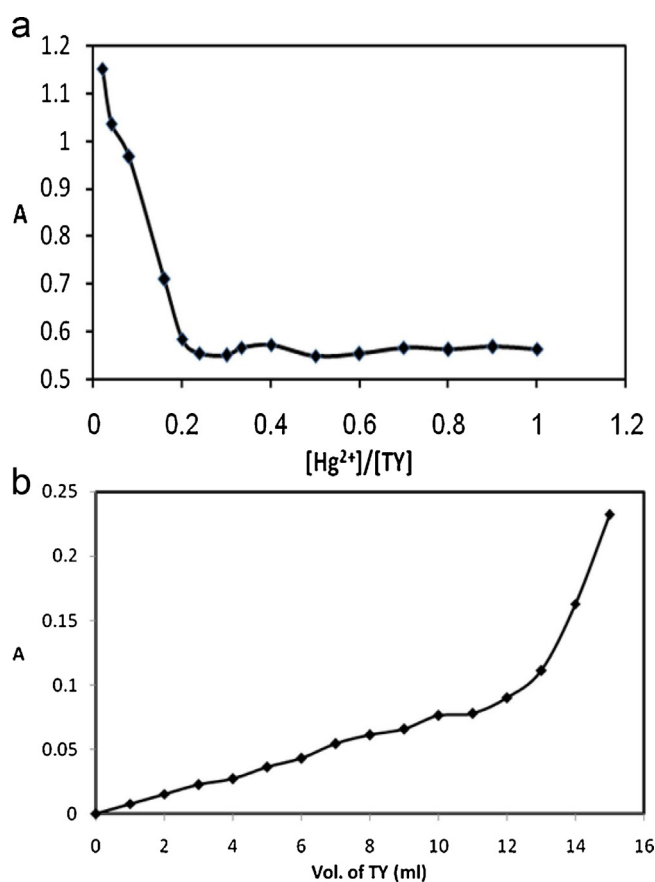


Fig. 3. a) Changes of absorbance versus metal ion/dye mole ratios at 395 nm at 25 °C and pH 9. TY concentration in all solutions was 5×10^{-5} M. b) Changes of absorbance as a function of ml solution of TY at 395 nm at 25 °C and pH 9. The concentration of TY and Hg^{2+} ion solutions was 10^{-5} M.

Fig. 3b. As is evident in this Figure, the inflection point of the plot is observed at about 13 (about 4 mole-ratio of TY to Hg^{2+} ion) which is again an evidence for formation of a 1:4, $[TY_4Hg]^{2+}$ complex in aqueous solution

3.1. Optimization the conditions for activation of TAC and immobilization of TY

The optimization conditions for activating the hydrolyzed TAC beds by epichlorohydrin was performed according to our previous

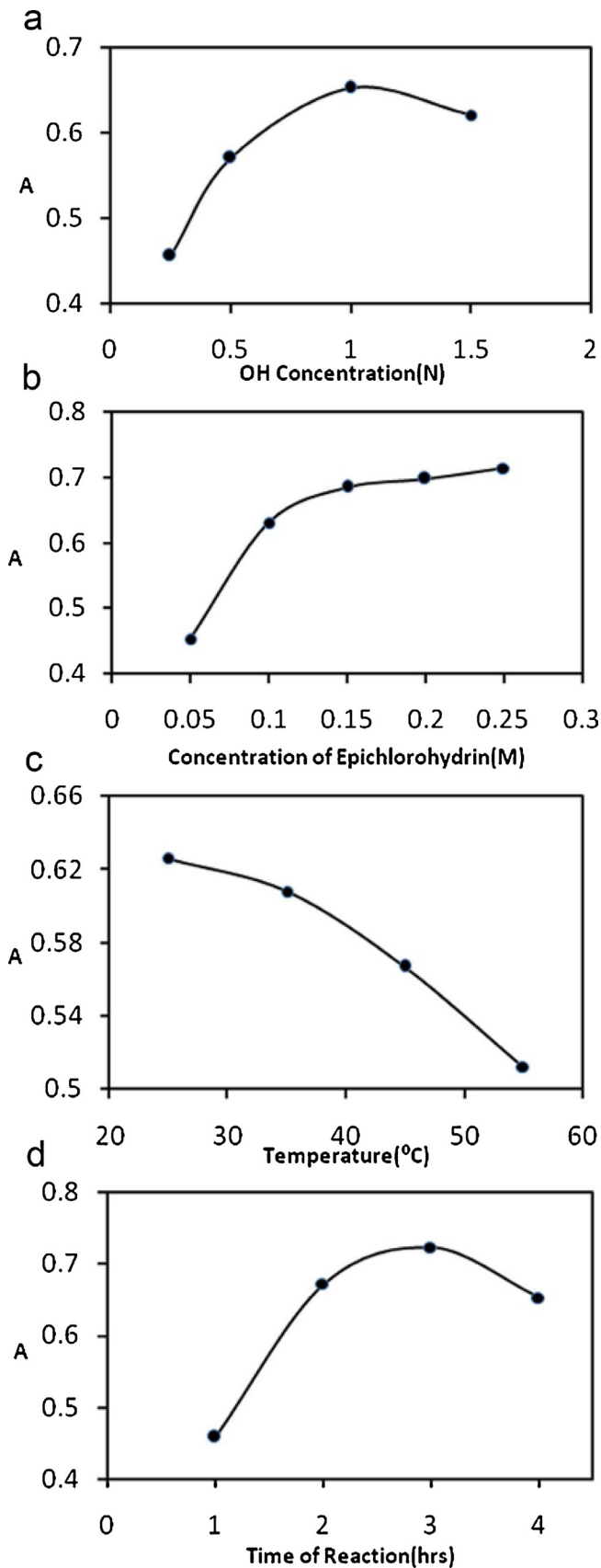


Fig. 4. The graphical results for optimization the effective parameters in activation of TAC Films. (a) Effect of NaOH concentration (the concentration of epichlorohydrin, temperature and the time of the reaction were 0.1 M, 40 °C and 2 h, respectively), (b) Effect of epichlorohydrin concentration (the concentration of NaOH, temperature and the time of the reaction were 1 M, 40 °C and 2 h, respectively), (c) Effect

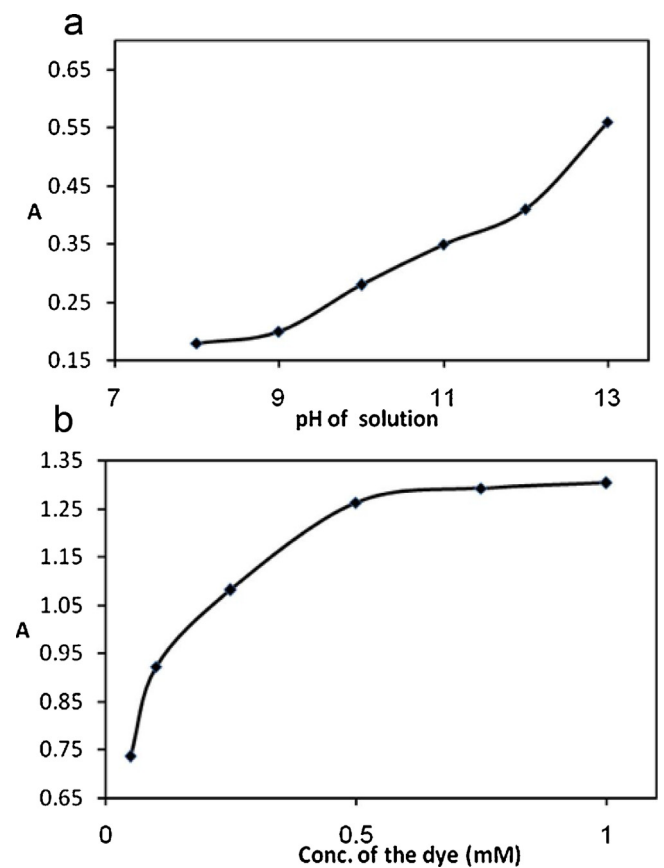


Fig. 5. (a) Effect of solution pH on immobilization of the dye on the film's surface (time of the reaction, temperature and concentration of the dye were adjusted on 24 h, 45 °C and 1.15×10^{-4} M respectively), (b) Effect of the dye concentration on immobilization of the dye (pH of the reaction was 13, temperature adjusted at 55 °C for 2 h and then at 45 °C for next 22 h).

experiences for the temperature of the reaction, time of the reaction, concentration of epichlorohydrin and also the concentration of NaOH and they were set at 25 °C, 3 h, 0.2 M and 1 M, respectively (Fig. 4).

Fig. 5a, shows the effect of pH of the solution on immobilization of the dye on the film's surface. As is seen in this Figure, the intensity of the absorption signal increases when pH increases from 6 to 13. Therefore, for the next experiments, the pH of the immobilization reaction was adjusted to 13. In order to study the effect of temperature, the immobilization process of the dye was performed at different temperatures. The experimental results showed that the amount of the immobilized dye on the film surface becomes more at higher temperatures but, since exposure to high temperatures for a long time deforms the film, we decided to perform the reaction at 60 °C for first 2 h and then at 45 °C for 22 h. The effect of concentration of the dye upon immobilization of the TY molecules was also investigated. For this purpose, the pH of 10 ml of a 0.025 M potassium dihydrogen phosphate solution which contained a certain amount of the dye was adjusted at 13 by addition of solid sodium hydroxide and then an epoxy activated film slide with about 0.04 g of weight was immersed in the resulting solution. The graphical results are shown in Fig. 5b. As is evident in this Figure, the absorption signal increases with concentration of the dye up to 0.5 mM, but at higher concentrations it reminds nearly constant.

of temperature of the reaction (time of reaction, concentration of epichlorohydrin and NaOH were 2 h, 0.2 M and 1 M, respectively) and (d) Effect of time of the reaction (temperature of the reaction, concentration of epichlorohydrin and NaOH were 45 °C, 0.2 M, 1 M, respectively).

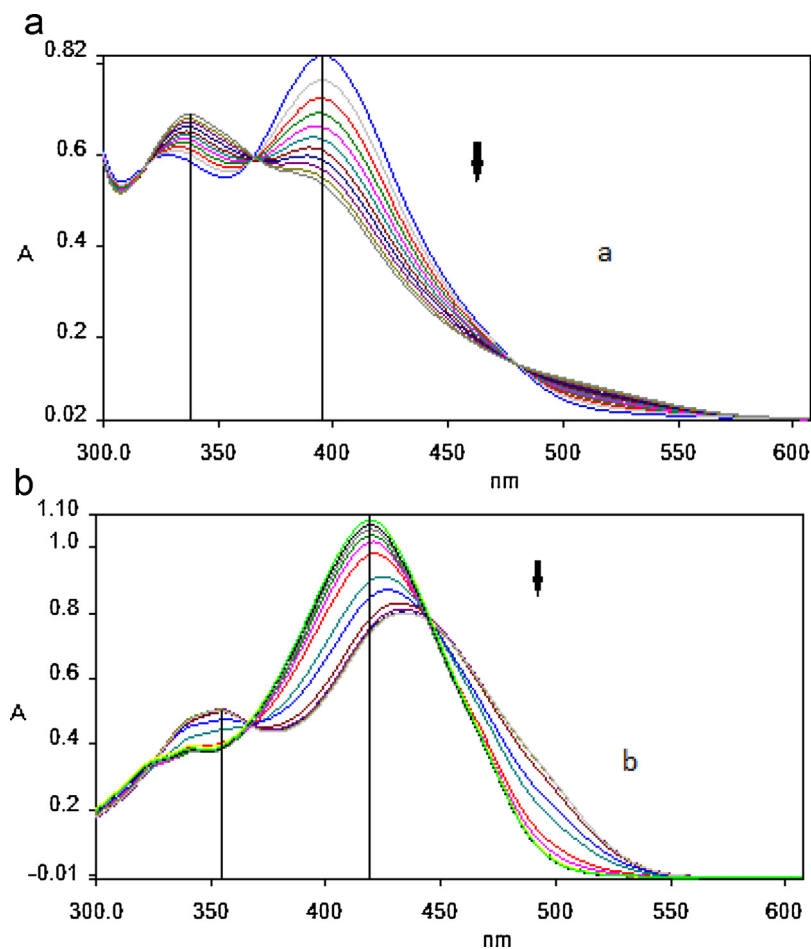


Fig. 6. Absorbance spectra of Hg-TY complex in (a) dissolved form (concentration of TY; 8×10^{-5} M and concentration of Hg^{2+} ; 0, 0.24, 0.48, 0.72, 0.96, 1.2, 1.44, 1.68, 1.92, 2.16 and $2.4 \mu\text{M}$) and (b) immobilized form (the concentrations of Hg^{2+} ion are same as the concentrations are presented in Fig. 9a). The arrows in the Figures, show the direction of increasing the concentration of Hg^{2+} ion.

We used 1 mM of the dye concentration in the next experiments. According to the obtained results, we performed the immobilization reaction at the optimum conditions; pH 13, 2 h at 60°C and then 22 h at 45°C and 1 mM of TY for 10 pieces of the film slides.

3.2. Analytical characteristics of the constructed optodes

The absorption spectra for TY in solution and in its immobilized form at different mercury (II) ion concentrations at pH 9 are shown in Fig. 6. As is evident in this Figure, The TY molecule shows two maximum peaks at 325 nm and 395 nm in solution phase, but in the case of its immobilized form, it has two maximum peaks at 330 nm and 420 nm. The red shift of the maximum wavelengths in immobilized form can be attributed to the more flat structure of the ligand in this case as compared to its dissolved form.

As is evident in Fig. 6a and b, some spectral changes are observed upon complexation of Hg^{2+} ion with the TY molecules in their immobilized and dissolved forms. These spectral changes clearly indicate the formation of a complex between the mercury (II) ion and the dye molecules. In the case of immobilized form of the dye molecules (Fig. 6b), the maximum absorption wavelength ($\lambda_{\text{max}} = 420 \text{ nm}$) shows a red shift upon progress in complex formation which is the opposite of what happens in the dissolved form. These experimental results probably indicate a difference in the interactions between the dye molecule and the Hg^{2+} ion in immobilized form compared to its soluble form of the dye. As is evident in these absorption spectra, there is a distinct isobestic point for

the dissolved and immobilized forms of the dye at about 365 nm and 370 nm, respectively which is an evidence for the presence of a simple equilibrium between the ligands, mercury (II) ions and the resulting complex in immobilized and also in dissolved form of the TY molecules.

3.3. The effect of pH on the optode response

Fig. 7 shows the influence of the pH of the solution on the absorbance of the membrane. By increasing the pH of the solution, the absorbance decreases up to about pH 8 and then it becomes nearly constant. Therefore, in the next experiments, we adjusted the pH of the solutions at 9.

3.4. Regeneration of the optode

The effect of some chemical species that can be used for regeneration of Hg^{2+} optodes was studied. Thiourea and S^{2-} ion can be used for regeneration of the used optodes, but they apparently precipitate with Hg^{2+} ions on the surface of the optode which results in the inactivation of the optode. We used EDTA solution at different concentrations for regenerating of the optode and the results showed that EDTA molecules can regenerate the optode but, the time of regeneration was very long. Then, we tried to recover the optodes in buffer solutions at different pH values and the experimental results showed that the constructed optode can be regenerated at pH 5 or lower pH values. In pH 5, the optode is recovered in about 2 min.

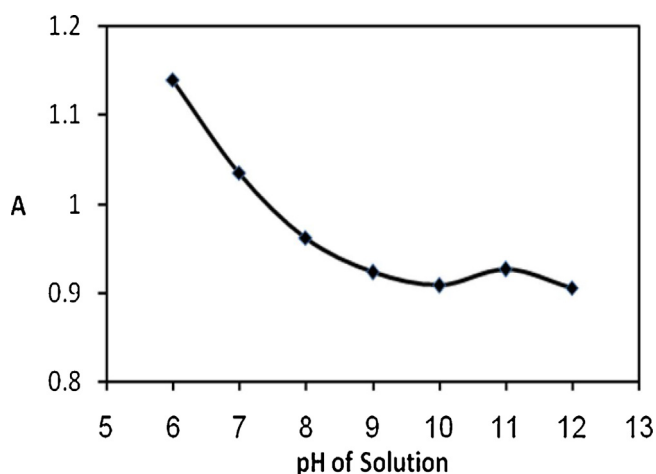


Fig. 7. Effect of pH on the absorbance of a typical membrane. The concentration of Hg^{2+} ion in all experiments was 3×10^{-5} M.

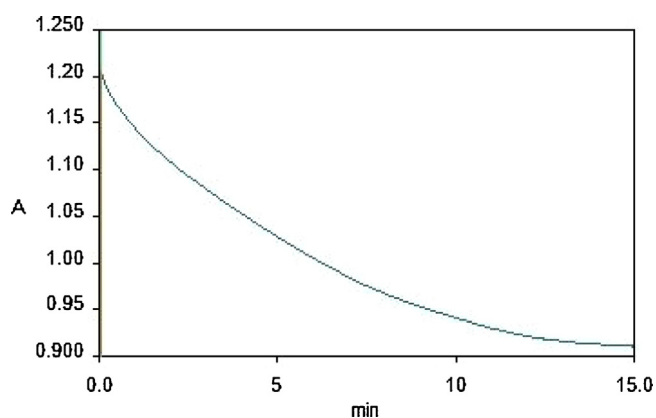


Fig. 8. Time-dependence response profile for the constructed optode at 420 nm. The concentration of Hg^{2+} ion and pH of the solution were 3×10^{-3} M and 9, respectively.

For preparation the buffer solution with pH 5, we dissolved 25.0 g of ammonium acetate in 25 ml of distilled water and the pH of the solution was adjusted by addition of 6 M hydrochloric acid solution and then, we diluted the resulting solution with distilled water to 100 ml.

3.5. Analytical specifications of the optode

Fig. 8 shows the time-dependence response for the constructed optode at 420 nm for a period of 15 min. It can be seen from this Figure that the absorption signal reaches to about 95% of its steady state in about 12 min. **Fig. 9** shows the response profile of the constructed optode upon repetitive change in concentration of Hg^{2+} ion. As is obvious in this Figure, upon increasing and decreasing the concentration of Hg^{2+} ion, the optode represents a reproducible and reversible optical response.

In order to evaluate the reproducibility of the construction of the optode, eight immobilized films were prepared simultaneously under optimum experimental conditions. The relative standard deviation of the absorption signal at 420 nm and at pH 9 for these prepared optodes was 2.95%. The relative standard deviation for successive measurements of the concentration of Hg^{2+} ion using one single optode was calculated for ten replicated measurements at 420 nm at pH 9 and it was found to be: 1.21%. For determination the long term stability (durability) of the fabricated optode, some of the prepared films were kept in buffer solutions with different pH values between 0 and 13 and also in distilled water. The

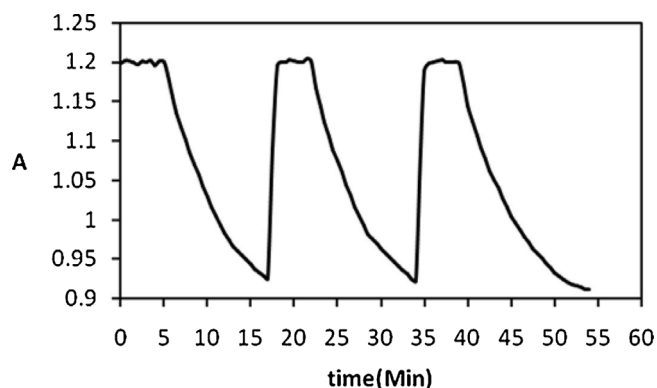


Fig. 9. The response profile for the constructed optode upon repetitive changing of the concentration of Hg^{2+} ion from 0 to 3×10^{-5} and vice versa. The pH of the solution was adjusted at 9.

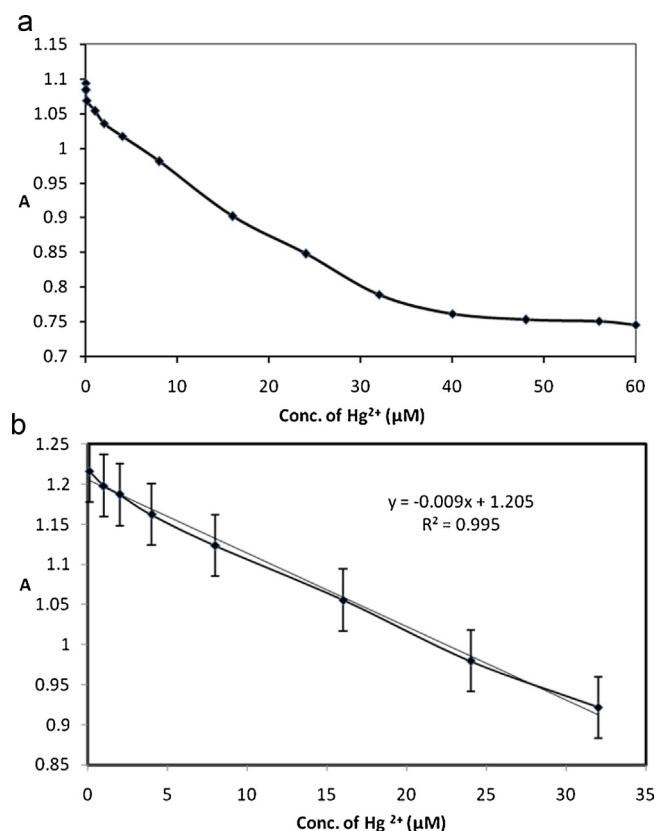


Fig. 10. a) The response graph for Hg^{2+} ion in the concentration range 0–60 μM at pH 9. b) the calibration graph for Hg^{2+} ion in the concentration range 10^{-7} – 3.2×10^{-5} M at pH 9.

experimental results showed that the change in absorption signal after 5 months was less than 5% in the pH range between 7 and 11, especially in the pH range 7–9. Therefore, pH 8 was chosen for storage the constructed sensors. **Fig. 10a** shows the dependence of absorbance versus Hg^{2+} ion concentration for a typical constructed optode under optimum experimental conditions. As can be seen from this Figure, the dynamic range of the constructed optode is between 10^{-7} and 3.2×10^{-5} M with respect to concentration of Hg^{2+} ion in aqueous solution. **Fig. 10b** shows the calibration graph obtained by one of the constructed optodes for 10^{-7} – 3.2×10^{-5} M solutions of Hg^{2+} ion with three replicate measurements the concentration of the Hg^{2+} ion in solutions.

Table 1
Study the Interferences in Hg (II) ion determination. The concentration of the Hg²⁺ ion is 3.0×10^{-5} M.

Species	Tolerance limit ($M_{\text{ion}}/M_{\text{Hg(II)}}$)
Al(III), Fe(III), Co(II), Pb(II), Cu(II), Zn(II), Ni(II), Mg(II), Mn(II), Bi(III), Ba (II)	100
Ag ⁺ ^a	100
K ⁺ , Na ⁺ , NH ₄ ⁺ , Cl ⁻ , SO ₄ ²⁻ , NO ₃ ⁻	500

^a After precipitation with Cl⁻.

Table 2
Determination of Hg (II) in real samples at the optimum conditions.

Sample	Hg(II) added (M)	Hg(II) found (M) ^a	Recovery (%)	Cold Vapor ^a method
Persian Gulf water	0	<DL ^b	...	$5.50 (\pm 0.07) \times 10^{-9}$ M
	3×10^{-5}	$2.96 (\pm 0.01) \times 10^{-5}$	98.67%	$2.98 (\pm 0.05) \times 10^{-5}$ M
Dousti Dam water	0	<DL	...	$5.0 (\pm 0.1) \times 10^{-9}$ M
	3×10^{-5}	$3.02 (\pm 0.011) \times 10^{-5}$	100.67%	$2.91 (\pm 0.04) \times 10^{-5}$ M
Tap water	0	<DL	...	$5.50 (\pm 0.11) \times 10^{-9}$ M
	3×10^{-5}	$3.03 (\pm 0.06) \times 10^{-5}$	101%	$3.18 (\pm 0.07) \times 10^{-5}$ M

^a For three replicate measurements.

^b Limit of detection.

Table 3
Comparison of the presented optode with some of the other reported optodes for determination of Hg (II).

Reagent	Response time (min)	Life time	Detection limit (M)	Linear range (M)	Detection mode	Immobilization type	Ref.
Tris[2-(4-phenyldiazenyl)phenylaminoethoxy]cyclotriveratrylene	1	6 month	5×10^{-7}	10^{-6} – 2.5×10^{-4}	Absorbance	Non covalent	[9]
(1Z,2Z)-N'1,N'2-Dihydroxy-N1,N2-dipyridin-2-ylethanediiimidamide	3	3 month	2.2×10^{-8}	3×10^{-7} – 2×10^{-5}	Absorbance	Non covalent	[10]
4-Ethyl-5-hydroxy-5,6-dipyridin-2-yl-4,5-dihydro-2H-[1,2,4]triazine-3-thione	3	N.S. ^a	1.8×10^{-10}	5×10^{-10} – 5×10^{-5}	Fluorescence	Non covalent	[11]
2-Mercapto-2-thiazoline	<1	1 month	5×10^{-11}	2×10^{-10} – 1.5×10^{-5}	Absorbance	Non covalent	[12]
Trityl-picolinamide	10	3 week	5×10^{-7}	5×10^{-7} – 5×10^{-4}	Absorbance	Non covalent	[14]
1-(2-Pyridylazo)-2-naphthol	8	1 month	5.5×10^{-7}	10^{-5} – 10^{-3}	Reflectance	Non covalent	[13]
2-(5-Amino-3,4-dicyano-2H-pyrrol-2-ylidene)-1,1,2-tricyanoethanide	10	N.S.	5×10^{-5}	5×10^{-4} – 5×10^{-3}	Absorbance	Non covalent	[15]
4-Phenyl-2,6-bis(2,3,5,6-tetrahydrobenzo[b][1,4,7]trioxononin-9-yl)pyrylium perchlorate	<2	3 month	1.01×10^{-10}	2.95×10^{-10} – 3.2×10^{-3}	Absorbance	Non covalent	[16]
4-(2-Pyridylazo)-resorcinol	20	N.S.	1.5×10^{-6}	5×10^{-6} – 3.36×10^{-3}	Absorbance	Covalent	[19]
4-Hydroxy salophen	6	6 month	1.3×10^{-7}	10^{-6} – 10^{-2}	Absorbance	Covalent	[20]
Dithizone	9	N.S.	10^{-7}	7.5×10^{-7} – 9.7×10^{-6}	Absorbance	Covalent	[21]
2-[(2-Sulfanylphenyl)ethanimidoyl]phenol	4	4 month	10^{-7}	10^{-5} – 10^{-2}	Absorbance	Covalent	[8]
Triazene ((E)-1-(2-ethoxyphenyl)-3-(4-nitrophenyl)triazene-1-ene)	15	N.S.	3.2×10^{-7}	3.5×10^{-5} – 4.5×10^{-4}	Absorbance	Covalent	[22]
1-[2-Pyridylazo]-2-naphthol	15	N.S.	8×10^{-7}	10^{-6} – 10^{-3}	Absorbance	Covalent	[23]
Thiazole yellow G	12	>5 month	1×10^{-8}	10^{-7} – 3.2×10^{-5}	Absorbance	Covalent	Current work

^a Not stated.

3.6. Selectivity

The selectivity of the fabricated optode was determined by adding some of the cations and anions which are listed in Table 1 to a sample solution containing 3.5×10^{-5} M of Hg²⁺ ions. The tolerance limit of the interfering ions is defined as the concentration of the added ions causing less than ± 5 relative error in the absorption signal. As is evident in this Table, the tested ions have not significant interference in measurement of Hg²⁺ ion except the silver (I) ion. Therefore, the constructed optode has a good selectivity toward the Hg²⁺ ion in aqueous solutions.

3.7. Analytical applications of the optode

To study the analytical performance of the proposed optode, the sensor was applied for determination the concentration of Hg²⁺ ion in some water samples. Three samples including Persian Gulf water (from Kish island shores), Dousti Dam water (in Iran- Turkmenistan border) and also tap water (from Ferdowsi University of Mashhad in Iran) were tested. At first, the pH of water samples was buffered at 9 by addition of borax (and 1 M nitric acid if necessary) for preparing a 0.025 M solution with respect to borax and then filtered through a filter paper for removing of any produced particles. The real samples were analyzed by single standard addition method. Each water sample was analyzed for three replicates. The Hg²⁺ content of these

samples was also determined by a Cold Vapor–AAS method and the results are shown in Table 2. As is seen in this Table, there is a good agreement between the results obtained by the two techniques. Therefore, the fabricated optode is suitable for determination the concentration of Hg^{2+} ion in real samples with a good accuracy (Table 2).

3.8. Comparison the analytical performance of the constructed optode with the other optodes

The principle analytical characteristics of the fabricated optode with those of some of the other reported optodes for determination the concentration of Hg^{2+} ion in aqueous solutions are compared in Table 3. As is seen from this Table, our presented optode has a proper limit of detection, a moderate response time and linear range and a good life time in comparison with the other presented optodes.

4. Conclusion

In the present work, an optical chemical sensor was constructed by immobilization of Thiazole yellow on a triacetyl cellulose film via epichlorohydrin as a linker for determination the concentration of Hg^{2+} ion in aqueous solutions. The immobilization of amino dyes on triacetyl cellulose membrane, via epichlorohydrin as a linker, is a new presented method for immobilization of the ligands on these kinds of membranes for fabrication of the optical sensors. To our knowledge, this is the first time that TY is used for construction of an optical sensor for measurement of the mercury (II) ion in aqueous solutions. The effect of influencing parameters on the reaction of the activated film with the indicator was studied and they were optimized. The constructed optode has a proper repeatability and reproducibility and also good short term and long term stability. The advantage features of this optode include a good long-term stability (at least 5 months), ease of construction and regeneration, high selectivity and a relatively good sensitivity and relatively a wide linear range with respect to Hg^{2+} ion in aqueous solutions.

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Biographies

Mohammad Salmani Golkhatmi is a Ph.D. student of Analytical Chemistry at Ferdowsi University of Mashhad, Mashhad, Iran. He received his M.Sc. degree in Analytical Chemistry from Chemistry and Chemical Engineering Research Center of Iran in 2004. His research interests include the optical chemical sensors and Chromatography.

Gholam Hossien Rounaghi is a full distinguished professor of Chemistry at Ferdowsi University of Mashhad, Mashhad, Iran. He received his B.Sc. degree in Chemistry from Ferdowsi University of Mashhad, in 1970, his M.Sc. degree in Analytical Chemistry at the same university in 1973, and his PhD degree from Michigan State University (MSU) in Analytical Chemistry in 1980. His research interests focus on the study of complexation of macrocyclic ligands with metal cations in non-aqueous solvents and development of electrochemical sensors for cations and pharmaceutical compounds.

Mahmoud Chamsaz is a full distinguished professor of Chemistry at Ferdowsi University of Mashhad, Mashhad, Iran. He received his B.Sc. degree in Chemistry from Ferdowsi University of Mashhad, in 1972, his M.Sc. degree in Imperial college university of London in 1974, and his PhD degree at the same university in Analytical Chemistry in 1978. His research interests focus on Spectroscopy.