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Electrochemical Studies of the Recognition Interaction of Rhodamine B with DNA

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Abstract: The recognition interaction of rhodamine B (RB) with DNA was studied in pH 7.5 Britton-Robinson (B-R) buffer solution by electrochemical techniques. An irreversible oxidation peak at glassy carbon electrode was obtained at +0.92V (*vs*. SCE). After the addition of DNA into the RB solution, the peak current of RB decreased apparently without the shift of peak potential. The electrochemical parameters such as the charge transfer coefficient α and the electrode reaction standard rate constant k_s of RB in the absence and presence of DNA were determined, which did not change, indicating that a non-electroactive complex was formed, so the concentration of RB in the solution decreased and the peak current decreased correspondingly.

Keywords: Rhodamine B, DNA, recognition interaction, electrochemistry.

The recognition interaction of DNA molecule is of great importance in drug composition, carcinogenic mechanism and gene mutation. The interaction of small organic molecules with DNA and the investigation of their effect on DNA molecule structure and function are hot topics in recent years[1, 2]. Rhodamine B (RB) belongs to xanthene dyes, with azoxyanthrone as the parent structure, which has been widely used in detecting metal ions in luminescent analysis[3]. In this paper the electrochemical behaviors of RB and its recognition interactions with DNA were investigated using electrochemical techniques. The result showed that an electrochemical non-active complex was formed, and the recognition interaction was carefully studied.

Figure 1 shows the UV-Vis spectra of RB and RB-DNA interaction system. Over the scan range of 300 nm-700 nm, RB has a maximum absorbance at 553.9 nm (Curve 1). After the addition of DNA, the maximum wavelength did not change while the peak absorbance decreased apparently (Curve 2). The more the addition of DNA was, the larger the decrease of the peak absorbance and the result was in good agreement with what Wang[4] had studied. These results indicated that RB had entered into the groove of DNA and had strongly interacted with DNA in groove-binding model.

In 0.2 mol/L of pH 7.5 B-R buffer solution, RB had an irreversible oxidation peak at +0.92V (*vs*. SCE) at a glassy carbon (GC) electrode (Curve 1 in **Figure 2**). The half peak width $W_{1/2}$ of this oxidation peak was 71 mV. According to the formula:

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$$W_{1/2}=62.5/(1-\alpha)n \text{ mV } (25℃)$$

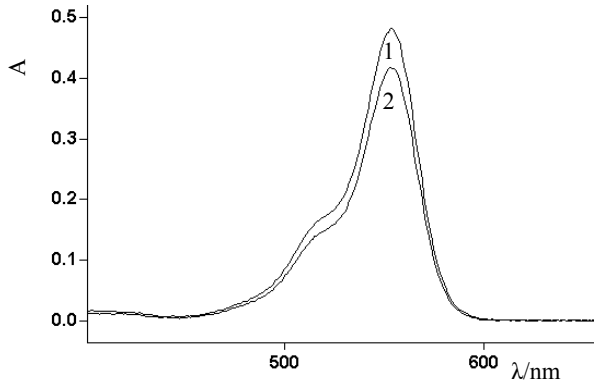
The following equation was deduced:

$$(1-\alpha)\ n=0.88 \qquad (1)$$

From formula (1) together with formula (2), n was calculated as 3, illustrating that the oxidation process of RB at GC electrode was three electrons irreversible adsorption wave under this experimental conditions.

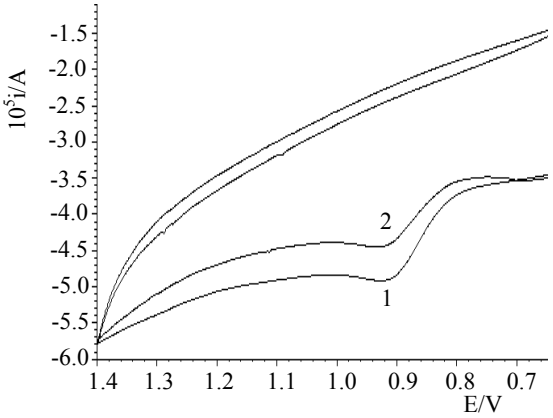
In pH 7.5 B-R buffer solution, RB had an oxidation peak and no reduction peak. After the addition of DNA, the peak current of RB decreased apparently without the shift of the peak potential (Curve 2 in **Figure 2**), further illustrating that an interaction had been happened between RB and DNA, and an electrochemical non-active complex was formed, which resulted in the decrease of the peak current of RB.

Figure 1 UV-Vis absorption spectra of RB interaction with DNA



The conditions are: 1. 5.0×10^{-6}mol/L RB + pH 7.5 B-R; 2. 1 + 100.0 mg/L DNA

Figure 2 Cyclic voltammograms of RB interaction with DNA



The conditions are: 1. 3.0×10^{-4} mol/L RB + pH 7.5 B-R; 2. 1 + 100.0 mg/L DNA

According to Laviron[5] theory:

$$E_p=E^0-RT\ln(k_sRT/\alpha nF)/\alpha nF+RT\ln\nu/\alpha nF \qquad (2)$$

where E_p (V) is the peak potential, E^0 (V) the electrode reaction formal potential, k_s (s^{-1}) the electrode reaction stand rate constant, α the charge transfer constant, n the reaction electron number, F ($C\cdot mol^{-1}$) Faraday's constant, R ($J\cdot mol^{-1}\cdot K^{-1}$) gas constant, T(K) the absolute temperature, ν (V/s) the scan rate.

From the slope of the plot of E_p *vs*. lnν the αn value can be determined and from the intercept the k_s can be calculated if the E^0 value is known. The value of E^0 in formula (2) can be determined from the intercept of E_p *vs*. ν plot on the ordinate by extrapolating the line to ν=0. According to this method, the α and k_s were calculated in the absence and presence of DNA. The results were 0.71, 1.27 s^{-1} and 0.73, 1.33 s^{-1}, respectively. Obviously, whether RB interaction with DNA or not the α and k_s value almost had not changed, so RB and DNA formed an electrochemical non-active complex.

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References

1. R. T. Liu, J. H. Yang, X. Wu, T. Wu. *Anal. Chim. Acta*, **2001**, *448*(1), 85.
2. H. L.Wu, W. Y. Li, X. W. He, H. Liang, P. Y. Yang. *Chin. J. Chem.*, **2003**, *21*(3), 305.
3. J. X. Gao. *Chemistry (in Chinese)*, **1997**, (8), 38.
4. X. M. Wang, S. J. Gong, Y. Li. *Modern Science Instrument (in Chinese)*, **2001**, *2*, 46.
5. E. Laviron. *J. Electroanal. Chem.*, **1997**, *101*, 19.

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