Polarographic Catalytic Wave of Prednisone in the Presence of Persulfate and its Application

Wei Guo1,*, Hong Lin2, Limin Liu1, and Junfeng Song1

1 Department of Chemistry, Northwest University, Xian 710069, China
2 Department of Chemistry, Yuxi teachers College, Yuxi 653100, China

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Abstract. A polarographic catalytic wave of prednisone in the presence of K2S2O8 was observed. The polarographic catalytic wave of prednisone as catalyst was attributed to such chemical reaction parallel to electrode reaction as S2O82− oxidized the free radical from one electron reduction of the Δ1,4,3 keto group of prednisone to regenerate the original keto group. The catalytic wave can be used for the determination of prednisone with the help of conventional polarographic equipment, such as linear-potential scan polarograph. In 0.12 mol L−1 HAc-0.08 mol L−1 NaAc-0.014 mol L−1 K2S2O8 (pH 4.6) supporting electrolyte, the second-order derivative peak current of the catalytic wave was rectilinear to prednisone concentration in the range of 3.2 × 10−7 ~ 1.6 × 10−5 mol L−1. The detection limit was 8.0 × 10−8 mol L−1.

Key words: Prednisone; persulfate; polarographic catalytic wave; free radical.

Prednisone (17, 21-dihydroxy-pregna-1, 4-diene-3, 11, 20-trione) that belongs to corticosteroids has important physiological activities, such as anti-inflammatory action, and effects on carbohydrate, water and electrolyte metabolism. It has been widely used therapeutically for its physiological activities. Accordingly, the need arose for sensitive and rapid determination of prednisone. Spectrophotometric [1] and HPLC [2] methods were recommended and have been used by the pharmaceutical industry for the determination of corticosteroid. The spectrophotometric method was based on that prednisone is quantitatively oxidized by blue tetrazolium (BTZ) in strongly alkaline solution to form a highly colored formazan whose concentration was measured spectrophotometrically at 525 nm. With combining the colorimetric reaction with flow injection analysis technique, Landis [3] proposed a flow injection spectrophotometric method for the determination of prednisone. Electrochemical method is rapid, sensitive as compared with spectrophotometric and HPLC methods. Yadav et al. [4] determined prednisone of tablet in phosphate buffer of pH 5.6 by differential pulse polarography.

Although differential pulse polarography has high analytical sensitivity, it is relatively time-consuming. The polarographic catalytic wave is a simpler technique to improve the analytical sensitivity, which was generally obtained by chemical oxidation of the intermediate product of reactant reduction by suitable oxidant. Recently, the polarographic catalytic waves of such organic compounds as glycyrrhizic acid [5], medroxyprogesterone [6], cinnamic acid [7], nicotinamide [8], berberine [9], human serum albumin [10], and lysozyme [11] in the presence of H2O2 or KIO3 have been reported, which allows to rapidly determine them with current linear-potential scan polarography. However, the polarographic catalytic wave of prednisone has been not found in the previous literature.

In this work, a polarographic catalytic wave of prednisone was observed in 0.12 mol L−1 HAc-0.08 mol L−1 NaAc-0.014 mol L−1 K2S2O8 (pH 4.6)
supporting electrolyte. Both reductive and catalytic processes of prednisone were discussed. Moreover, a new method was proposed for the determination of prednisone. The proposed method was more simple, quick and sensitive than those methods mentioned above.

**Experimental**

**Reagents**

Prednisone acetate of biochemical-reagent grade was purchased from Shanghai Pharmaceutical Plant (Shanghai, China). 1.0 × 10^{-2} mol l^{-1} stock solution of prednisone acetate was prepared by dissolving 0.2002 g of prednisone acetate with anhydrous ethanol in 50 ml volumetric flask. Other standard working solutions of prednisone acetate were obtained by diluting the stock solution with water. Prednisone acetate tablets (labeled amount 5 mg per tablet) were purchased from Northwest University Hospital (Xian, China). Other chemicals are of analytical-reagent grade. Twice distilled water was used throughout the experiments.

**Apparatus**

Cyclic voltammograms and direct current polarogram were recorded by using a model CH660 electrochemical workstation (CH Instrument, USA), which was controlled by CH660 software and worked under Windows 98 environment. The three-electrode system involves a model 303A stationary mercury drop working electrode (EG & G PARC, USA), a platinum wire counter electrode and a saturated calomel reference electrode (SCE).

Condition optimization and sample analysis were done by using a model JP-3 linear-potential scan polarograph (Shandong Electric & Telecommunication Factory No. 7, China) and by using a HP 1100 series liquid chromatograph (Agilent Co., USA), respectively. The three-electrode system equipped with JP-3 linear-potential scan polarograph involves a dropping mercury working electrode (DME), a platinum wire counter electrode and a SCE reference electrode. The potential scan rate was 0.25 V s^{-1}. The drop time of DME was 7 s. The HP 1100 series liquid chromatograph (Agilent Co., USA) equipped with a diode array detector. Chromatographic column is octadecyl derivatized, 150 mm × 4.6 mm. A HP Chemstation achieves instrument control and data acquisition.

**Sample Analysis**

Fine powder of ten tablets was weighed accurately and dissolved with 50 ml of anhydrous ethanol in 50 ml volumetric flask. To suitable amounts of sample solution or standard solution of prednisone, 2.0 ml of 1.0 mol l^{-1} NaAc solution, 3.0 ml of 1.0 mol l^{-1} HAc and 7.0 ml of 0.05 mol l^{-1} K_{2}S_{2}O_{8} solution were successively added into a 25 ml volumetric flask before dilution to the mark with water. The prepared solution was transferred into polarographic cell. The linear-potential scan was performed cathodically from −0.80 V to −1.30 V, and the second-order derivative peak current of the catalytic wave was measured at −1.13 V. The calibration graph was constructed by plotting the second-order derivative peak current of the catalytic wave against prednisone concentration. Prednisone contents were calculated from calibration graph. The sample was analyzed with the official HPLC method [2] that is recommended by the Pharmacopoeia of People’s Public of China too. Chromatographic conditions are: water/furanidime/methanol (688:250:62) mobile phase, detection wavelength $\lambda$ 254 nm, cetanilide internal standard, 0.8 ml/min flow rate.

**Results and Discussion**

**Reduction Mechanism of Prednisone**

The reduction patterns of the corticosteroids have been established [12]. Dimerization and alcohol formation take place with the reduction of the C-keto group resulting in one or two polarographic reduction peaks, depending on both the number of double bonds in the A-ring and medium pH value. Kabasakalian et al. [13] investigated the polarographic reduction process of prednisone in 50% ethanol at pH 5.5. They proposed the Δ1,4-3 keto group of prednisone was reduced to a free radical that dimerized and irreversibly formed a pinacol. In order to illustrate the polarographic catalytic wave of prednisone under the condition used in this work, the reduction process of prednisone was verified again based on the following experiments.

Cyclic voltammetry was performed in the potential range from −0.80 V to −1.50 V in 0.12 mol l^{-1} HAc-0.08 mol l^{-1} NaAc (pH 4.6) buffer after deaeration by passage of oxygen-free nitrogen for 10 min. The cyclic voltammograms of prednisone showed in Fig. 1a. There was a single reduction wave of prednisone with peak potential $E_{p}$ = −1.13 V on cathodic scan and no oxidation wave on anodic scan. With potential scan rate $v$ increasing, the peak potential $E_{p}$ linearly shifted to negative direction. The relationship of $E_{p}$ with log $v$ was $E_{p}/V = 1.20 + 0.120 \log v$.

![Fig. 1. Cyclic voltammograms of 4.0 × 10^{-5} mol l^{-1} prednisone in a 0.12 mol l^{-1} HAc-0.08 mol l^{-1} NaAc (pH 4.6) buffer; b $a + 0.014$ mol l^{-1} K_{2}S_{2}O_{8} Scan rate 0.25 V s^{-1}](image-url)