



ELECTROREDUCTION OF Te(IV) FOR GLASSY-CARBON ELECTRODE IN AN ALKALINE ENVIRONMENT

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ABSTRACT

The process of electroreduction of Te(IV) on the glassy carbon electrode in an alkaline medium has been presented. The influence of main parameters such as the potential sweep rate, the concentration of Te(IV) ions, and the temperature of the electrolyte were studied. It is shown that in alkaline solutions, Te(IV) recovering with a subsequent transition phasically into solution politellurid and sodium telluride. It was found that the cathodic process is strongly dependent on the composition and temperature of the electrolyte of the solution.

Key words: Tellurium, Polarization curve, Cathode and anode polarization.

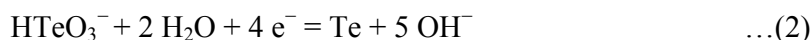
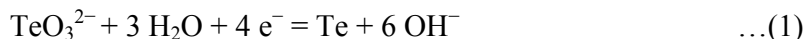
INTRODUCTION

Often electrolyte was prepared by dissolving sodium hydroxide in TeO_2 for electrodeposition of tellurium from alkaline solutions. The system $\text{TeO}_2\text{-Na}_2\text{O-H}_2\text{O}$ except simple tellurites type, Na_2TeO_3 , also revealed the presence of sodium politellurite type $\text{Na}_2\text{Te}_3\text{O}_7$, $\text{Na}_2\text{TeO}_5 \cdot 3\text{H}_2\text{O}$ and $\text{Na}_2\text{TeO}_9 \cdot 5\text{H}_2\text{O}$.¹ Recovery of tellurium on the cathode from such a solutions is a complex process, the end product, which is elemental tellurium, or tellurides and politellurides.

On an industrial scale, tellurium was obtained by Gaev with his co-workers². Electrolysis was carried out from an electrolyte, which comprised of 100 g/L of Te and 160 g/L free sodium hydroxide. Tellurium is released at the cathode like a powder, (purity 99.5%). If more pure electrolyte is used, one can get tellurium containing less impurities. At low current densities, electrodeposition of tellurium proceeds with the chemical polarization, and there is a high concentration polarization^{3,4}.

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In concentrated alkali electrolyte, i_{np} depends linearly on the concentration of tellurium in the electrolyte, and in diluted (in the absence of excess alkali), it increases. i_{np} with the concentration of tellurium is faster than it is in direct proportion. The difference in the values i_{np} tellurium in solutions of low concentration and high alkaline associated with nature of the difference discharging tellurium-containing particles in the concentrated and dilute alkali. In concentrated solutions of alkali on the polarization curves at relatively high current densities was obtained by a linear plot. When low current densities at the cathode potential curves, a decline was observed, which characteristic of the self-dissolution of the metal⁵⁻⁷. Dependence on the concentration of alkaline electrolyte in the overall reaction process of the electrode can be represented as –



Given that in the solution with a large excess of alkali in a predominant amount available ions $[\text{Te}(\text{OH})_6]^{2-}$, which dissociates according to the reaction:



It can be assumed that the electrodeposition of tellurium meets the total electrode reaction^{8,9}:



Phasically, which flows under the scheme:



Step of determining the rate of reaction is to provide the last electron.

EXPERIMENTAL

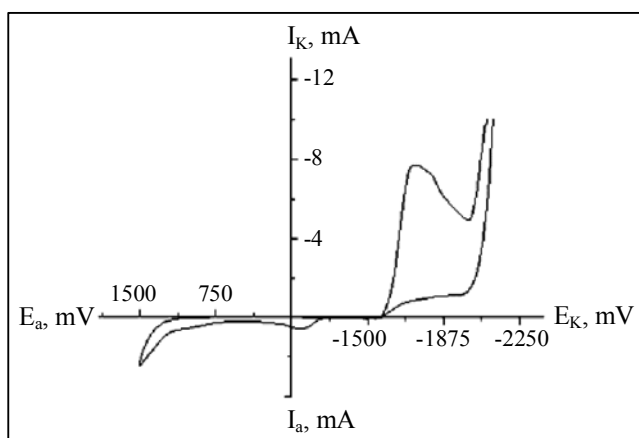
To study the electrochemical behavior of tetravalent tellurium in alkaline medium method of recording the potentiodynamic polarization curves using potentiostat IPC Pro MF

was used. Voltammetric measurements were performed in a temperature-controlled three-electrode cell with an anode and cathode separated by spaces. As a working electrode, glassy carbon electrode end portion diameter -2.1 mm was used. Measurements were carried out with respect to silver chloride reference electrode in saturated KCl ($E = + 203 \text{ mV}$). A platinum wire was used as counter electrode with a large surface.

RESULTS AND DISCUSSION

Starred cyclic anode cathode and cathode-anode polarization curves in alkaline solutions of tetravalent tellurium.

Referring to Fig. 1, in the cathode-anode polarization curve at the potential of -1260 mV , maximum recovery was observed of at elemental tellurium cathode. A further increase of cathodic current associated with the transition of tellurium in politellurid and sodium telluride as the evolution of hydrogen even at these negative potentials was not observed. Shifting the potential in the anodic direction at a potential of -100 mV , a slight anodic current was observed, which associated with the ionization of residual elemental tellurium. With the further unfolding, potential significant effects were not observed with the release of oxygen.

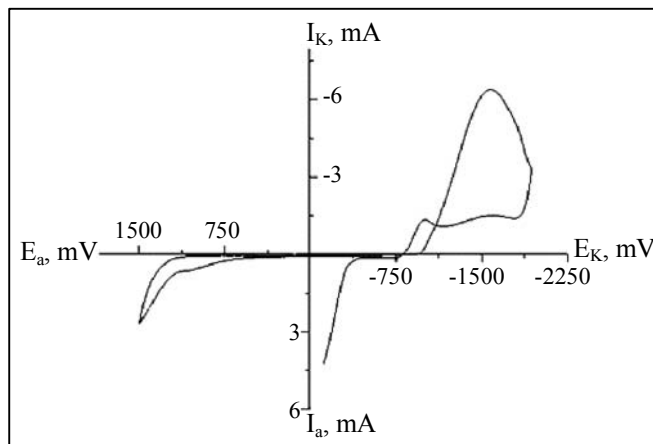


$V = 100 \text{ mV/sec}$, $t = 25^\circ\text{C}$, $\text{NaOH} = 1.5 \text{ M}$, $\text{Te(IV)} = 0.5 \text{ M}$

Fig. 1: Cyclic cathode-anode polarization curve

In accordance with Fig. 2, when the cathode cycle precedes anodic, the area, where potentials of the positive tetravalent tellurium shows electrochemical activity. After cathodic polarization within the first peak in the bias potential in the anodic direction, the next height of the anodic peak is much higher than the values of previous experience.

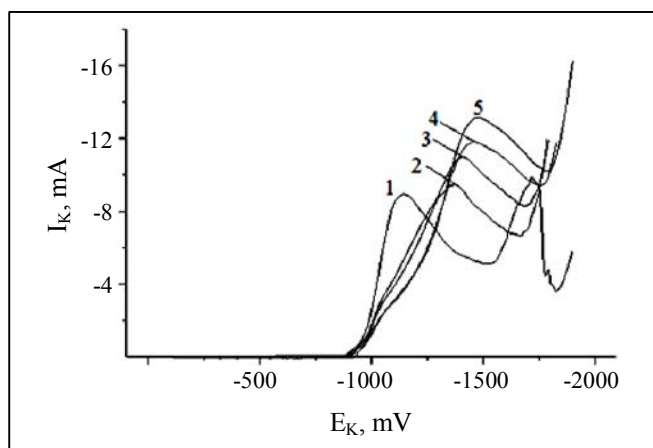
The effect on the potential sweep rate of the recovery process of Te (IV) in the first peak was studied. In accordance with Fig. 3 with increasing of potential scan rate would take place the growth of the cathode current maxima and its displacement on the negative potential side.



$V = 100 \text{ mV/sec}$, $t = 25^\circ\text{C}$, $\text{NaOH} = 1.5 \text{ M}$, $\text{Te(IV)} = 0.5 \text{ M}$

Fig. 2: Cyclic anodic-cathodic polarization curve

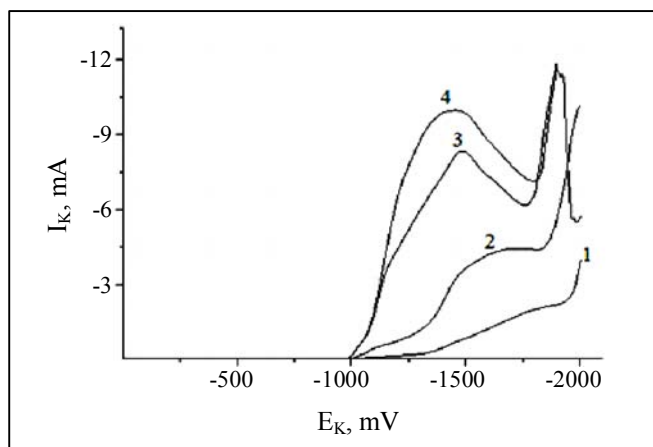
Depending on the slope of the $\lg I_p / \lg V$ was composed 0.2. This value may be underestimated due to the suppression of the dissociation of the $[\text{Te}(\text{OH})_6]^{2-}$ by increasing of OH^- ions concentration in the electrode layer by reduction of tellurium.



$t = 25^\circ\text{C}$, $\text{NaOH} = 1.5 \text{ M}$, $\text{Te(IV)} = 0.5 \text{ M}$, V , mV/s: 1 - 50 2 - 100 3 - 150 4 - 200, 5 250

Fig. 3: Cathodic polarization curves at different rates of potential sweep

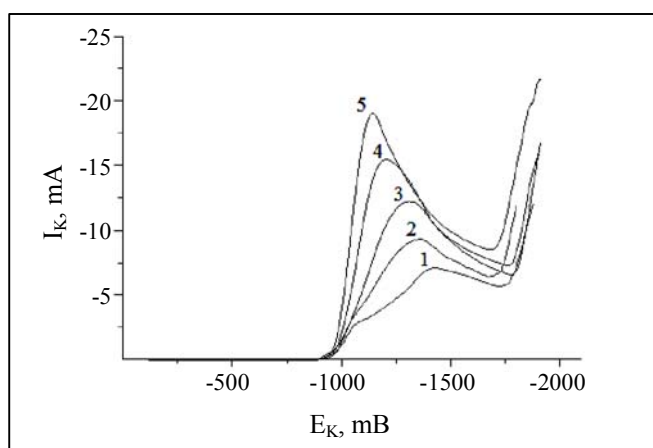
In accordance with Fig. 4, with increasing Te (IV) concentrations in the solution, the cathode maxima is increased and thus, they become more pronounced.



$t = 25^{\circ}\text{C}$, $\text{NaOH} = 1.5 \text{ M}$, $V = 100 \text{ mV/s}$: Te(IV) M : 1 – 0.16; 2 – 0.32; 3 – 0.5; 4 – 0.66

Fig. 4: Potentiodynamic cathodic polarization curves for different concentrations of tellurium

The effect of temperature on the course of cathodic curves was studied. In accordance with Fig. 5, by the increasing of temperature, there is a significant increase in the maxima with a simultaneous shift of the potential maximum towards positive potentials, which indicated the facilitation of the cathodic process.



$\text{NaOH} = 2.0 \text{ M}$, $V = 100 \text{ mV/s}$, $\text{Te (IV)} = 0.5 \text{ M}$, t , $^{\circ}\text{C}$: 1 - 20; 2 - 30; 3 - 40; 4 - 50; 5 - 60;

Fig. 5: Effect of temperature on the electroreduction of Te (IV)

CONCLUSION

Thus, in alkaline solutions, tetravalent tellurium is recovered by stages to the elemental state at a potential of -1260 mV, with a subsequent transition into the solution in the form of sodium telluride and politelluridov. The process is strongly dependent on the concentration of tellurium solution. At low concentrations, the process is characterized only by the rise of current in this potential region, at high concentrations clearly distinguishable current maximum was observed. Increasing temperature leads to an increase in the steepness of the curves polarizing the deposition potential expectation in the positive direction.

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