the formation of a zirconium oxide coating on the surface of steel samples. Since corrosion processes can be represented through a course of cathodic and anodic processes on a metal surface, the cyclic voltammetry method was used to study the corrosion resistance of the formed anticorrosive coatings. The method of cyclic voltammetry makes it possible to obtain independent information on the processes occurring on steel samples during the deposition of oxide-zirconium coatings, and at the same time to assess the degree of their corrosion resistance [7,16]. The corrosion resistance of the formed oxide-zirconium coatings was determined by the ionization current of the iron electrode at a certain potential. The proposed electrochemical method for assessing the anticorrosion resistance of coatings on steel samples can be used to establish the qualitative and quantitative composition of phosphating solutions and control the anticorrosive activity of the formed oxide-zirconium coatings.

2. Materials and Methods

2.1. Material

The reagents sodium sulfate (Na_2SO_4), hexafluorozirconic acid (H_2ZrF_6) solution 50 wt.% in water, $(NH_4)_6Mo_7O_{24}$, and $C(NH_4)_{10}W_{12}O_{41}{\cdot}nH_2O$ of "Pure" and "Chemically Pure" grades and distilled water were used.

2.2. Sample Preparation

Plates of cold-rolled steel (grade Art. 08ps) were used as samples. The steel composition is shown in Table 1.

Table 1. Chemical composition of Art. 08ps.

Chemical Element	Content, %
Iron (Fe)	60.8
Chromium (Cr)	17–19
Nickel (Ni)	9–11
Manganese (Mn)	≤2
Silicon (Si)	≤0.8
Copper (Cu)	≤0.3
Carbon (C)	≤0.08
Phosphorus (P)	≤0.035
Sulfur (S)	≤0.02

Pretreatment of metal plates was carried out by degreasing in an aqueous alkaline detergent composition with a concentration of 15–20 g/L at a temperature of 60–65 °C for 2–10 min. Then, the surface of metal plates was cleaned with abrasive material, followed by washing with distilled water.

The deposition of the oxide-zirconium coating was carried out at room temperature with stirring on a rotating unit RDE710 with a rotation speed of 500 rpm. Using a pH meter I-130, (Tokyo, Japan) the allowable pH range of coating formation was established. After coating, the plates were dried at a temperature of 130 °C.

2.3. Methods

Electrochemical studies included cyclic voltammetry. Cyclic volt–ampere curves were recorded using the potentiostat–galvanostat Gamry Reference 3000 (Warminster, PA, USA), in a sealed three-electrode cell at 25 °C. The working electrode was a steel (grade Art. 08ps) electrode with a visible surface of 0.03 cm^2. The counter electrode was a platinum electrode with a surface of 2 cm^2. An Ag/AgCl electrode, for which the potential was 196 mV relative to the hydrogen electrode, was used as a reference electrode. Cyclic volt–ampere curves