# THERMAL STABILITY AND DURABILITY OF BIMETALLIC PHOSPHIDES

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**ANNOTATSIYA:**

*This work presents the results of determining the electrocatalytic activity and thermal stability of bimetallic phosphides. The band gap width was determined, indicating the potential of using Ni-Co-P bimetallic phosphide as an efficient electrocatalyst for solar-driven water splitting.*

The development of sustainable energy sources is one of the key challenges of modern science and technology. One promising direction is hydrogen production via water electrolysis, especially when combined with renewable energy sources [1–3]. Water electrolysis enables the production of hydrogen fuel without carbon emissions; however, the widespread adoption of this technology is hindered by its high cost. The primary reason is the need for efficient catalysts for two key half-reactions: the Hydrogen Evolution Reaction (HER): $2H^+ + 2e^- \rightarrow H_2$ and the Oxygen Evolution Reaction (OER): $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ [1–5]. To date, the most effective materials are considered to be platinum (Pt) for HER and iridium dioxide ($IrO_2$) for OER. However, their high cost limits widespread application. Consequently, an urgent task is the search for alternative, inexpensive, and highly active catalysts capable of effectively replacing noble metals while maintaining high activity and stability.

Analysis of a significant volume of literature data on bimetallic phosphides of transition metals indicates that the catalytic properties of materials based on metals such as nickel, cobalt, copper, and iron are relatively understudied. In this regard, the synthesis of bimetallic phosphide compounds and the determination of their physicochemical and catalytic properties in hydrogen energy are of particular scientific and practical interest. The high cost of catalysts is the main obstacle to the mass adoption of water electrolysis. In recent years, inexpensive transition metals have been applied for water electrolysis. Nickel and its alloys are widely used as alternative materials for efficient water splitting due to their excellent activity and stability [6-8].

The electrocatalytic activity towards HER, as shown in Fig. 1, Linear Sweep Voltammetry (LSV) curves demonstrate that the Ni-Co-P electrocatalyst possesses superior catalytic activity compared to other samples.

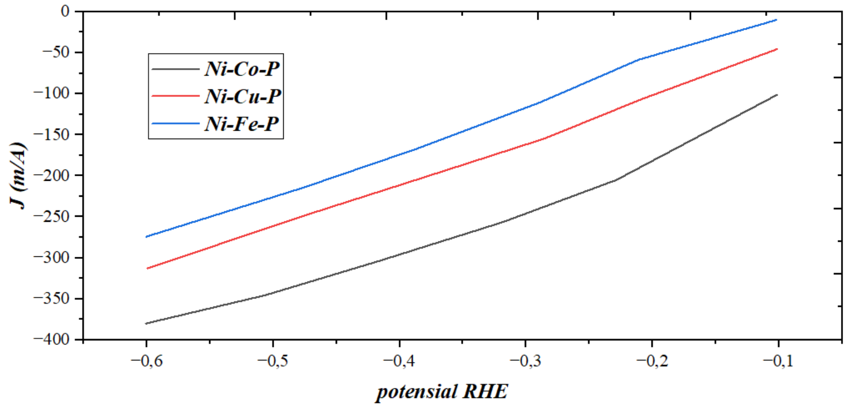


**Fig. 1. Electrocatalytic activity of NiMP bimetallic phosphides.**

To further determine the catalytic activity, corresponding Tafel plots constructed from the LSV data can be used (Fig. 1). Analysis of the kinetic control region on the LSV curve (typically at low current densities) allows for the determination of the Tafel slope, which is related to the reaction mechanism and the rate of charge transfer on the catalyst surface.

Thermogravimetric analysis (TGA) showed that upon heating Ni-Co-P to 72.44 °C, moisture and water are removed from the composition. At 238.35 °C, recrystallization of the structure begins in the sample. At 472.16 °C, oxidation of phosphorus is observed. At 619.33 °C, the sample transitions to a liquid state. According to the TGA curve, in the temperature range from 238 °C to 619.33 °C, a mass loss of 23.75% is observed (from 8 g to 6.1 g).

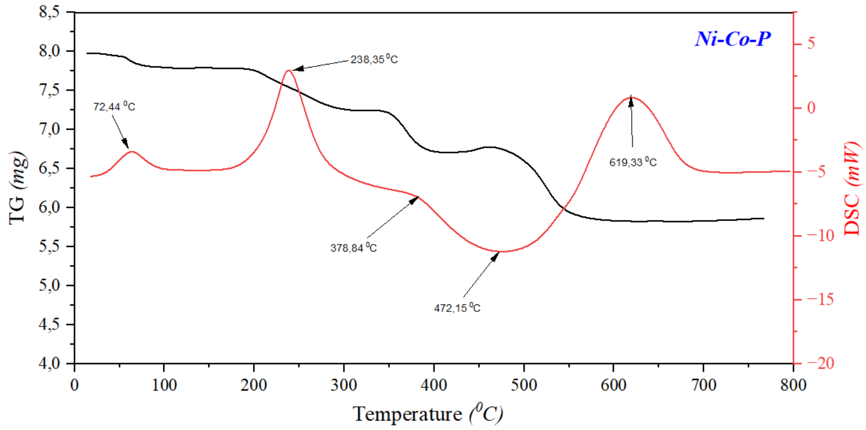


**Fig. 2. Thermogravimetric analysis of Ni-Co-P.**

To assess the durability of the Ni-Co-P electrocatalyst in 1 M KOH, sequential chronopotentiometric measurements were conducted at 100 mA/cm². Over 48 hours, the overpotential increased by approximately 18 mV, indicating the superior stability of Ni-Co-P.

The ability of Ni-Co-P to maintain a stable potential value (E, V vs. RHE) at high current density and temperature indicates its reliability for long-term operation as an electrocatalyst. Thus, it represents a promising catalyst for industrial application in both HER and OER reactions.

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