TECHNOLOGY OF HEAVY METAL ION EXTRACTION
FROM INDUSTRIAL WASTE WATERS

A. I. Maslii, A. G. Belobaba, G. I. Pushkareva*, and S. A. Bobyleva**

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The results are presented for the investigation into a two-stage technological scheme of copper, nickel, tin, zinc, and chromium ion extraction from industrial effluent. It is shown that when electrolysis on porous flowing cathodes is combined with sorption on brucite, the problem of metal loss is solved with simultaneously minimized ecological impact.

Electrolysis, sorption, brucite, extraction, porous cathode, heavy metals

Many industries, such as mechanical engineering, instrument-making, mining and others, form and use on a large scale technological solutions with high content of heavy metal ions (HMI). These metals are considerably lost due to imperfect technologies and equipment applied in production for HMI extraction. For example, losses of heavy metal salts in electrodeposition are up to 60–70% [1]. The losses of HMI and ecological impact caused may be decreased by reducing residual metal concentration in waste water effluent up to the maximum concentration limit. This goal is as a rule reached by combining several physico-chemical processes, and one of the most promising ways is combination of electrolysis with sorption and membrane methods [1–4].

This paper presents the results of investigation into a two-stage scheme of industrial waste water purification from ions of copper, nickel, tin, and chromium. In the first stage, waste waters were subjected to electrolysis with metal extraction on porous flowing cathodes made of carbon fiber materials, and then the waters were fine cleaned by sorption on natural mineral sorbent — brucite.

The electrolysis was investigated using a laboratory device shown schematically in Fig. 1.

The treated solution was fed from reservoir 4 to cathode space of electrolyzer 7 by pump 5; then it passed through porous cathode 3, where metal recovery took place, and returned into the reservoir. The solution circulation velocity was 10 l/h. In the electrolyzer separation of electrode spaces by anion-exchange membrane or by cation-exchange membrane was used when required; at that, solution H₂SO₄ (10 g/l) was poured in the anode chamber. Platinized titanium served as anode, and porous cathode was one layer of carbon felt with overall area, including pores, of 0.3 dm². The investigations were carried out in galvanostatic regime, and current intensities were preliminarily selected.

Real effluent of one of Novosibirsk enterprises and artificial mixtures were used in the experiments. During testing, change in concentration of extracted metals in the solution was regulated by voltamperometry on a renewal graphite electrode [5], atomic absorption, and photocolorimetry.

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Fig. 1. Schematic diagram of experimental electrolysis device: 1 — electrolyzer, 2 — anode chamber; 3 — cathode block; 4 — buffer reservoir for solution; 5 — peristaltic pump; 6 — power supply

It was established that electrolysis, when conducted in the selected regimes, allows effective extraction of Cu and Sn with initial concentration of 1.5–4 g/l up to 20–30 mg/l, nickel is harder removed by electrolysis — to 100 mg/l (Fig. 2). Further decrease in HMI concentration by electrolysis is economically inexpedient, since the solution processing velocity sharply becomes lower and degree of metal extraction is practically unaffected. Consequently, the maximal concentration limit can be reached using the second stage of solution purification — HMI sorption.

It was earlier reported on high sorption properties of brucite (chemical formula Mg(OH)$_2$) relative to HMI [6, 7]. In the present article, a possibility of applying brucite for extraction of HMI residual concentrations (5–30 mg/l) after electrochemical separation of the main metal mass was studied. Solutions of HMI after electrolysis have pH = 1.8–2.5, i.e. it is necessary to neutralize them up to pH = 4–5. This can be done with any alkaline reagents (soda, alkaline metal hydrates), but fine-ground brucite is the most effectively used. The sorbent consumption on neutralizing the mentioned solutions is 1.5–2 g/l.

Copper was sorbed from the after-electrolysis solutions with metal content of 20–30 mg/l in static and dynamic regimes.

The static sorption regime was realized by adding HMI solution with brucite of 10–50 μm in size. Then the obtained solution was mixed in magnetic mixer within 20 min, filtered, and the content of metal was determined in filtrate. At brucite consumption of 1.5–2.5 g/l, including its amount required for neutralization, Cu residual concentrations were less than 0.01–0.05 mg/l. The sorption kinetics increases by a factor of 50–100 if the suspension is mixed by ultrasound disperser during 0.5–1.0 min [8].

Fig. 2. Electrolysis time-dependence of change in Cu concentration in washing solutions of (1) sulfuric and (2) pyrophosphate copper plating, as well as in (3) Sn and (4) Ni concentrations in washing solutions of sulfuric electrolytes (V = 1 l; current intensity: 1 — 1.4; 2 — 1.7; 3 — 0.8; and 4 — 0.7 A/dm$^2$)