Joe E. House (1923-1998)

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Joe Estes House (1923-1998)

Tucson Arizona
I met Joe E. House in Tucson, Arizona when I was invited in December 1981 by his company Henkel Corporation [formerly General Mills] to give a short course on hydrometallurgy. Extraction by organic solvents is a chemical process in which metal species in the aqueous phase react with an organic reagent to form an organometallic complex; thus, the metal species leave the aqueous phase and enter the organic phase from which it can be stripped back in the aqueous phase to obtain a pure and a concentrated solution. The metal in the organic phase is not bound to carbon atoms as in organometallic compounds but to oxygen, nitrogen, sulfur, or hydrogen by a co-ordination (dative) bond.

Solvent extraction of copper
Solvent extraction was used for the first time in hydrometallurgy in connection with the special and urgent materials requirements of nuclear energy during World War II in the Manhattan Project. A plant was constructed in the United States for the preparation of high-purity uranyl nitrate solution. In this plant, the yellow cake (a high-grade sodium or ammonium uranate) was dissolved in nitric acid, and uranium was selectively extracted by ether then stripped by water to give a concentrated solution of pure uranyl nitrate. This was gradually followed by developing methods for other high-priced metals such as plutonium, thorium, niobium, tantalum, zirconium, hafnium, boron, beryllium, and molybdenum. The second step took place in the 1960s when solvent extraction was applied for the first time to extract a relatively cheap metal — copper, and this was the role of Joe House.

At the First International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955, much of the work of the US Atomic Energy Commission, AEC, was declassified. In late 1962, the oxime group, - N-OH, was identified by General Mills as a ligand that would form a water-insoluble copper complex. A compound containing this ligand was prepared and was called LIX 63, i.e., Liquid Ion Exchange 1963. General Mills then proposed solvent extraction to replace the cementation process for copper removal from leach solutions, using scrap iron. The response of the copper industry was, however, negative. Plant operators thought that the process could be well used for an expensive metal such as uranium but not for a cheap metal like copper. Fears were also expressed that traces of solvent could destroy the bacteria in the dumps. It was also believed that cementation followed by smelting the cement copper was the cheapest route.

A research director of a large copper company predicted that there would never be a pound of copper recovered using solvent extraction. In spite of such arguments, two companies gave some encouragement — Bagdad Copper and Asarco's Silver Bell. Some research laboratories, for example, the Colorado Research Foundation, some personnel in the US Bureau of Mines at Salt Lake, and some operators of uranium solvent extraction
plants, of Kerr-McGee gave encouragement. During the period 1962-1964, General Mills built a portable, continuous operating solvent extraction unit, complete with electrowinning cells, and in September 1964, introduced the LIX 64 by operating a unit first at the SME fall meeting in Phoenix, Arizona, and at the American Mining Congress Show which opened a week later in Las Vegas, Nevada.

Bagdad Copper worked out an arrangement to jointly design, construct, and operate a pilot plant. General Mills acquired access to and the right to use all the data generated from the operation of the pilot plant, as well as the rights to show the pilot plant to other interested parties. A similar arrangement with Duval Corporation in Arizona followed, in 1965. In addition, the effect of residual organics on the bacteria of the dump leach was to be evaluated. In the same year, Ranchers Exploration and Development Corporation bought the old Bluebird deposit, in Miami, Arizona, that used cementation to recover copper from their heap leach liquor. Kenneth Power, using data generated by Hazen Research, Bagdad, and Duval pilot plants made the decision to build the first commercial solvent extraction plant for copper. It was dedicated on January 24, 1969. Bagdad Copper followed, and dedicated their plant on November 17, 1970. These plants produced 13.6 tons of copper/day. N'Changa Consolidated Copper Mines in Zambia brought a plant on stream in 1973 that produced 40.8 tons/day. In 1978, Henkel Corporation in Dusseldorf, Germany acquired General Mills.

**Heap leaching**

The recovery of copper from heap leaching solutions containing around 1 g/L Cu is usually achieved by displacing the copper ion by scrap iron — the cementation process. The cost of precipitation by this method is still high despite increased mechanization and better control techniques. Also, the process suffers from the introduction of ferrous ion in the solutions which are to be recycled in the dumps. Precipitated copper still has to be processed further to yield a marketable product. It is not a particularly attractive material for handling because of its fineness and the difficulty of washing it free from acid. Solvent extraction with subsequent electrodeposition of a marketable product offers a convenient method of recovery. There is the added advantage that acid is liberated in the recovery step and can therefore be used as a stripping solution in the extraction process. The extractant commonly used is LIX-64. A scheme of copper recovery by dump leaching, solvent extraction, and electrowinning is shown below which now accounts for about 20% of copper produced.

![LIX 64 formula](formula.png)

**Biographical note**

Joe Estes House was born in Newtonia, Missouri, studied chemistry at Southwest Missouri State University, earned an M.S. degree from the University of Oklahoma and an MBA degree from Washington University in St. Louis. From 1947 until 1956 he taught chemistry at secondary and college levels, and in 1956 he joined the Research and Development Department of General Mills Chemical Company which became later a part of Henkel Corporation. He was assigned to work on development of mining chemicals and almost immediately introduced new amine reagents for nonmetallic flotation. In 1958
he synthesized the first tertiary amine for uranium extraction which was used for 85 % of Free World uranium production. In 1960 he played an important role in introducing solvent extraction technology to the copper industry.

Heap leaching, solvent extraction, and electrowinning of copper

References


