Direct Production Process for Reduced Metal Oxides from Solution at Ambient Temperatures

The competitive position of U.S. specialty metal-based producers has greatly declined with the rapidly increasing industrial production capacities in China, India and South America. The recent jumps in competing foreign demand for raw materials have also resulted in historic price increases and shortages of refined and scrap metal feedstocks. These issues have led to decreases in the profitability of manufacturing cuprous oxide (Cu$_2$O) and other specialty copper-based products. The rapidly rising cost of energy has also greatly affected manufacturing costs for high temperature processes such as producing ceramic magnets and pigments. Securing reliable supplies of inexpensive feedstocks and reducing energy consumption in manufacturing are projected to become significant issues hampering the growth of specialty chemical manufacturing in the future.

**Benefits**

- Low operating costs
- Refractory ceramic ferrites are produced at ambient temperatures in powder form
- Reduced-metal oxide products are recovered by setline, filtration, magnetic separation
- No additional chemical reagents required
- Recovery of metals or reduced-metal oxides from low concentration streams
- Selective production from mixed and low-grade feed streams
- Modular scalability for a variety of applications

**Current Approaches**

Reduced metal oxides such as Cu$_2$O are typically produced by electrolytic oxidation of copper metal or caustic chemical reduction of copper sulfate. Raw materials for Cu$_2$O and other copper-based products include refined cathode copper and #1–#2 scrap. These copper resources are in heavy demand, especially in China’s booming industrial manufacturing sector, resulting in scarce domestic supplies and unprecedented price increases. The current industry must now settle for increased prices for raw materials in forms less convenient to process in order to keep up with production demand.

Refractory ceramics such as metal ferrites and other spinel-structured oxides are produced in bulk by high temperature (600–1200°C), solid state synthesis methods or rigorous hydrothermal conditions from metal oxide and carbonate precursors. The products must then be ground to small particles and powders for use. Both of these manufacturing steps are very energy intensive.

**Issues**

It is necessary to decreasing manufacturing costs in raw materials and specialty products production in order to maintain or improve the competitiveness and profitability of domestic manufacturing for global markets. Reducing power consumption and eliminating processing steps are desirable methods for doing this, which in turn reduce energy cost and process time. For some industries, the competition for metal resources is ever increasing, driving the profitability of specialty chemical manufacturing down dramatically. Finding new, reliable, low-cost sources of metal-based raw materials is essential for maintaining the growth and competitiveness of domestic manufacturers of specialty products.
Eltron’s Strategy
A new process technology has been developed at Eltron for producing valuable reduced metal oxides of significant commercial value such as Cu$_2$O and ferrites directly from acidic feed-streams of simple metal salts at room temperature. The technology that does this is an innovative turn-key electrolytic system designed to recover saleable metals and metal-based products from aqueous streams and acid mine drainage (AMD). This electrowinning technology can either capture metals or transform metal ions directly to various reduced-metal oxides directly from aqueous streams. These aqueous feed-streams can be acidic sulfate solutions and potentially heap-leach extraction fluids or AMD. The use of dilute feed streams (<500 mg/L) is economically efficient allowing low concentration leaching, refining and mine drainage streams to be utilized or treated with net economic profit. The system is also capable of selectively removing metals from mixed streams allowing higher purity products to be recovered.

Eltron’s electrowinning technology addresses needs for reducing capital, operating, processing, and waste treatment costs in a variety of industries including mining, refining, specialty products manufacture, magnetics, electronics, automotive, and environmental remediation. This technology was originally designed to provide an economically profitable means to recover saleable metals from aqueous streams that are otherwise considered waste or an environmental liability. This technology has recently been demonstrated be a valuable manufacturing method for various metal-based products that can greatly reduce manufacturing costs.

Examples
Eltron’s electrowinning technology produces Cu$_2$O in powder form directly from acidic copper sulfate solutions. Ideally, the production of Cu$_2$O will be made directly from sulfate-based heap-leach extraction fluids at a production cost of less than $0.15/lb, thereby completely bypassing copper metal refining or processing steps. The primary uses of cuprous oxide are anti-fungal agents in agriculture and horticulture and as the typical active ingredient in anti-fouling marine paints and coatings.

Alternatively, the same technology can be configured to recover copper in metallic form from a variety of feed streams at a similar cost. The increased process efficiencies allow copper to be economically recovered from liquid streams too dilute for conventional electrowinning processes (<1000 mg/L) providing a method for greater product recovery, increased profitability from liquid extraction processes, and reduced waste generation and treatment costs. Efforts are under way to develop efficient recovery of several other valuable metals.

Selective production of iron ferrite (magnetite), Fe$_3$O$_4$, is achieved directly from solutions of iron sulfate at ambient temperatures. The powders obtained are pure, crystalline powders with particle sizes on the order of 0.5 microns and are recovered by settling, particle filtration, or magnetic separation. The production selectivity has been demonstrated repeatedly using a mixed feed stream containing nickel and iron sulfates that mimic waste stream compositions.
Eltron’s electrowinning system eliminates the high temperature production energy cost and greatly reduces the amount of energy and time necessary for grinding the product prior to use. Metal ferrites are very important materials used for a variety of applications including magnetic recording media, magnetic cores in electric power transformers and chokes, magnetic shielding, ferrofluids, biomedical imaging, feedstocks for color pigments and catalysts. Production of other spinel-structured materials is of future interest.

Low-grade metal feedstocks can be economically utilized by Eltron’s technology as a result of very high removal efficiencies and selectivity for metal recovery from mixtures. The toxic waters filling the Berkeley Mine pit in Butte, MT contains about 52 million pounds of copper and 165 million pounds of zinc at its current liquid volume, but at low concentration (172 mg/L Cu and 550 mg/L Zn, pH 2.8 H₂SO₄). Eltron’s technology is anticipated to selectively recover copper or Cu₂O near $0.30/lb based on current performance. Zinc can be recovered at slightly higher power cost. Iron, which is present near 1060 mg/L can be selectively recovered as iron ferrite at even lower cost.

Contact Us
To discuss the possibility of entering into a business relationship with Eltron, contact the Business Development Group at business@eltronresearch.com.

To learn more about the technologies Eltron Research & Development is researching and commercializing, visit www.eltronresearch.com.