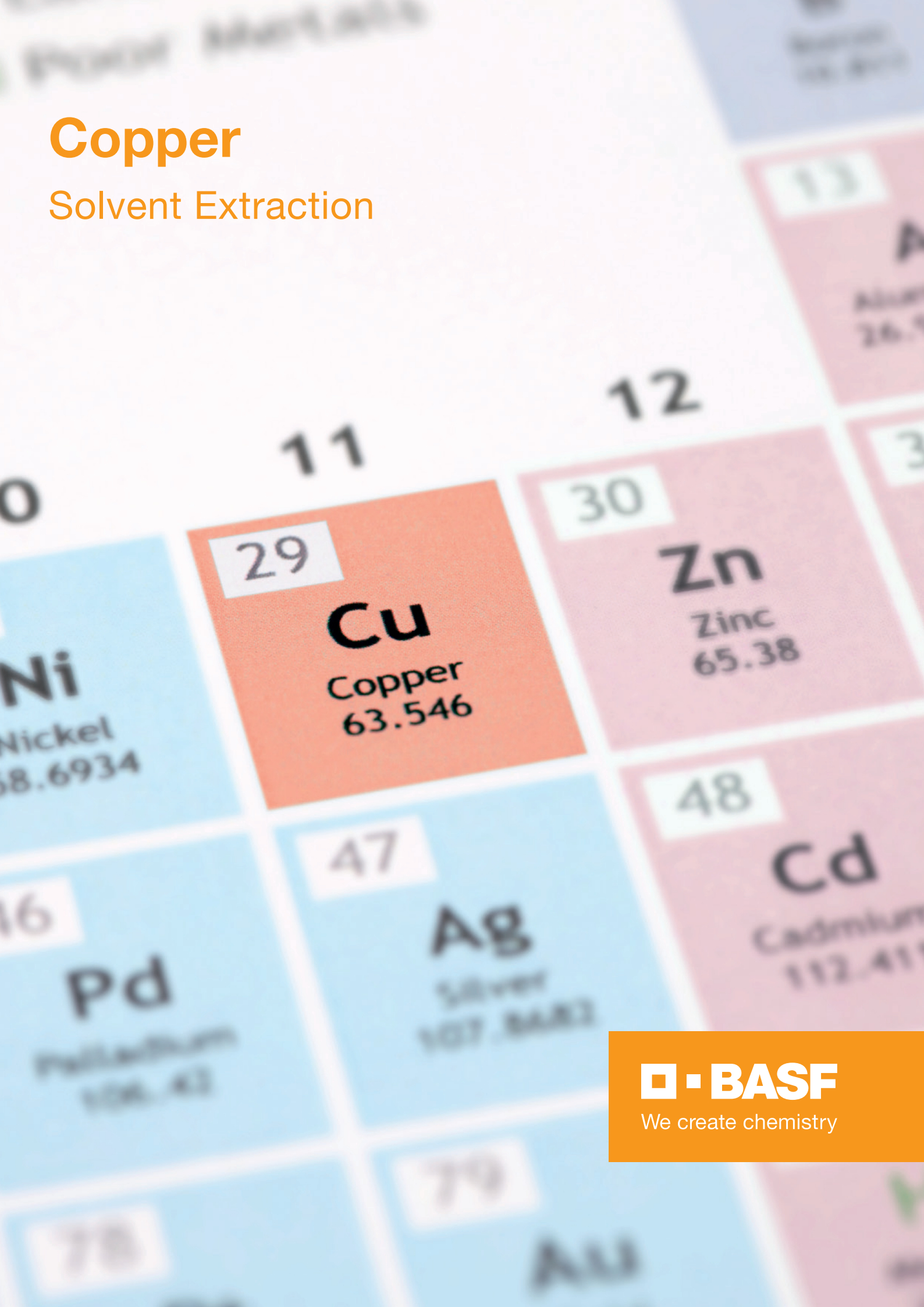


Copper

Solvent Extraction



 **BASF**

We create chemistry

BASF LIX[®] technology – recovery of copper from leach solutions

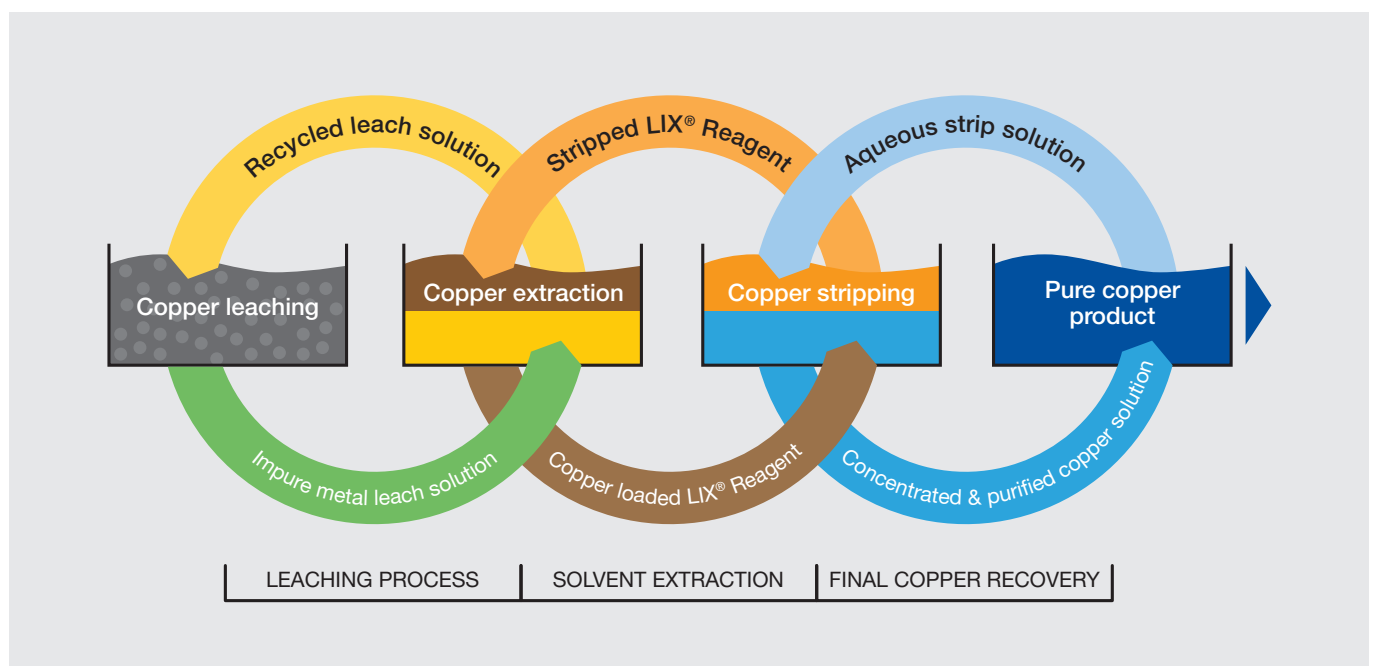
Leaching copper from oxide ores, low grade secondary sulfide ores, and primary sulfide concentrates with aqueous acid or ammonia solutions, followed by solvent extraction (SX) has been practiced commercially since the late 1960's. Over time, LIX[®] Reagents (hydroxyoximes – chelating agents) used in these solvent extraction processes have become more efficient, more selective and more economical to use.

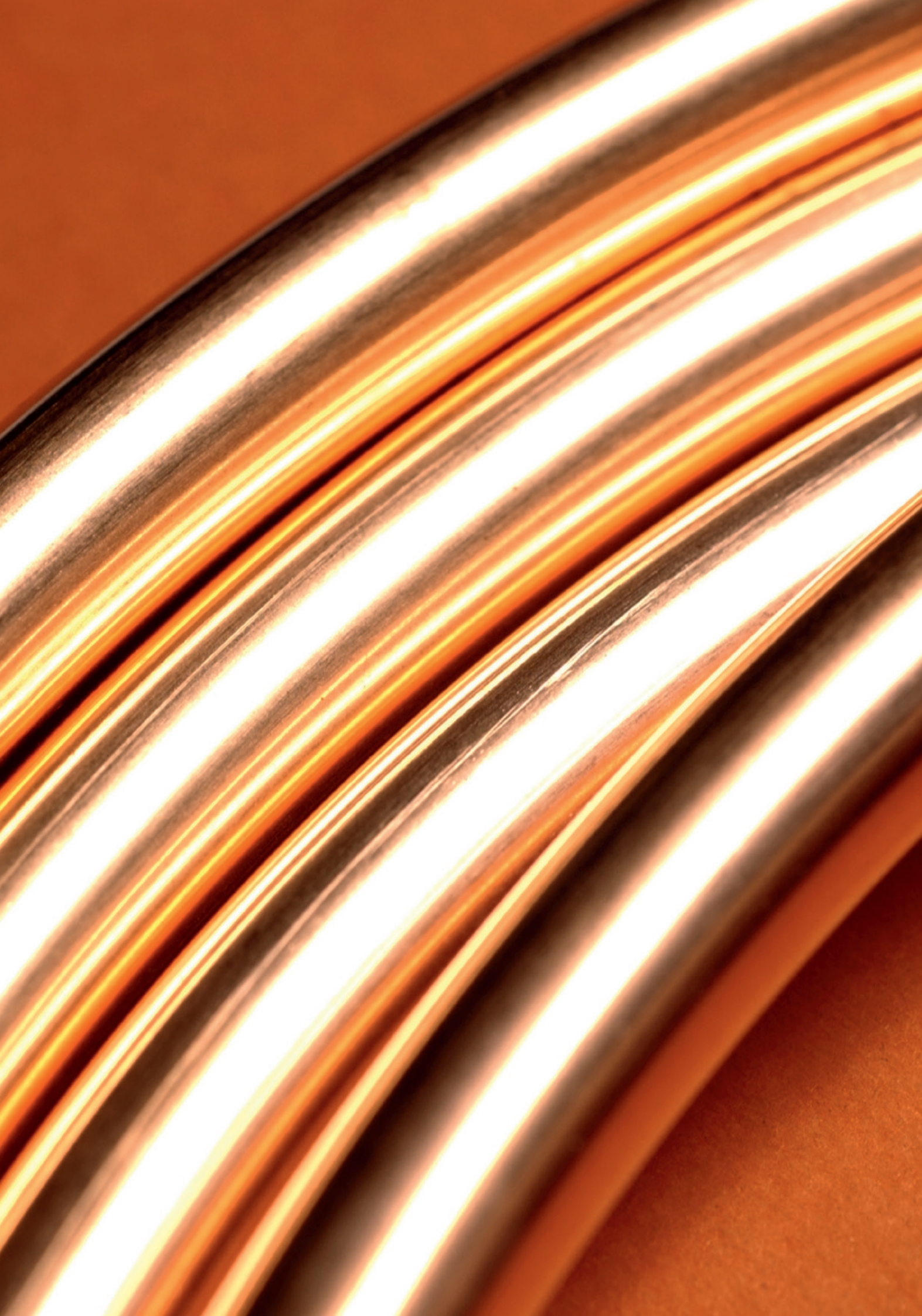
The benefits and objectives of the copper solvent extraction process are purification of copper, concentration of copper and conversion of the copper to a form that allows BASF's customers to produce desired final metal products including cathode, powder and crystals.

BASF produces a complete line of copper solvent extraction reagents, including ketoximes, aldoximes, non-modified blends and modified blends of ketoximes and aldoximes. These reagents and reagent blends allow BASF to supply its customers with an optimized reagent formulation tailored to meet the needs of their specific applications.

The overall leaching, solvent extraction and final metal production processes can be summarized in the following simplified flowsheet.

LEACHING PROCESS / SOLVENT EXTRACTION / FINAL COPPER RECOVERY





Advantages of BASF LIX® Reagents

- **Fast kinetics:** Rapid copper uptake and copper stripping
- **Selective:** Very high iron rejection
- **Net copper transfer:** Can be adjusted to maximize process performance
- **Ease of operations:** Cleaner phase separation and lower crud formation
- **High purity final copper product:** Lower entrainment levels and lower transfer of contaminants
- **Low viscosity:** Operate better at high reagent concentrations and low temperatures
- **Lower costs:** Lower losses, higher net transfer, improved chemical stability

Service

All LIX® Reagents are backed by BASF's comprehensive MSP® Minesite Services Program and BASF's qualified experts and engineers.

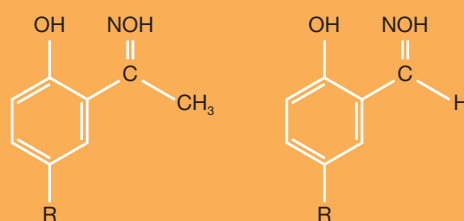
Computer modeling

The BASF Isocalc® computer simulation program provides plant operators with fast and accurate simulations of virtually any copper solvent extraction process involving sulfuric acid leaching followed by copper solvent extraction with LIX® Reagents. The Isocalc® program will generate extraction and stripping isotherms and construct McCabe-Thiele diagrams for a large number of circuit configurations. The program can also be calibrated to match the performance of commercial SX plants, which allows the production engineer to accurately determine the impact that changes in PLS chemistry, reagent concentration, reagent blend and/or circuit configuration will have on copper recovery.



THE CHEMICAL STRUCTURES FOR THE KETOXIME AND ALDOXIME REAGENTS

LIX® OXIME EXTRACTANTS



Ketoxime R = C₉H₁₉

Aldoxime R = C₉H₂₅ or C₁₂H₂₅

COPPER EQUILIBRIUM REACTION



Ketoximes: Moderately strong extractants and can be used without equilibrium modifiers.

Aldoximes: Very strong extractants and have to be used in mixture with an equilibrium modifier or ketoxime to aid the stripping process and obtain adequate net copper transfer.

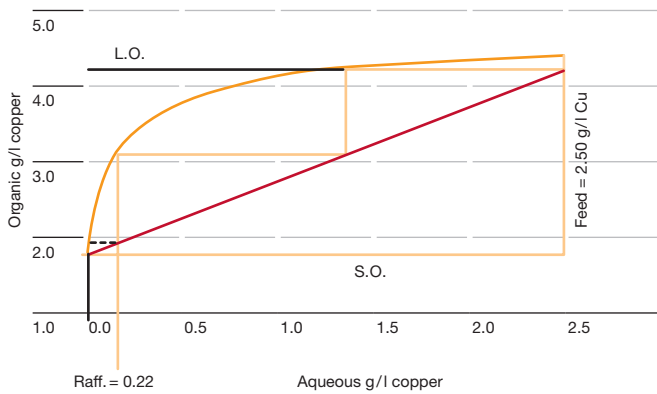
LIX® Reagents work on a hydrogen ion cycle. Acid is generated in electrowinning, transferred to the organic in stripping in exchange for copper and then exchanged for copper in extraction.

Final Copper Cathode product bundled, weighed and ready for shipment.

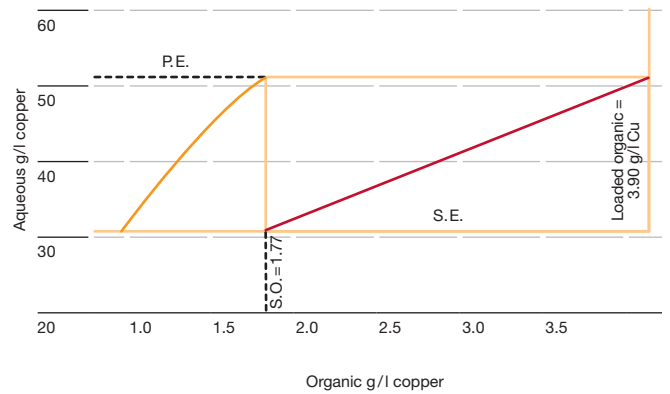




**Equilibrium extraction isotherm/two stage
McCabe-Thiele diagram with a typical LIX® Reagent**



**Equilibrium strip isotherm/one strip stage
McCabe-Thiele diagram with a typical LIX® Reagent**



SX plant configurations and final copper product

Commercial copper SX plants are designed around one of the several proven circuit configurations: series, series parallel, modified series parallel and optimum series parallel (or inter-laced). The circuit configuration chosen will depend on several variables unique to the site including economics, leach solution chemistry and the operating philosophy of the company associated with each plant. The solvent extraction process can produce several different final copper products, however, most SX plants produce copper cathode.

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