Hydrometallurgy

Enhanced Extraction: Base, Precious and Rare Earth Metals

Base, precious and rare earth metals are essential raw materials for electronic devices, electrical generation and many of today's consumer and industrial products. Mining these metals has evolved to a specialized skill. Dow enables highly sophisticated hydrometallurgy operations and processes – from in-situ leaching (ISL) to selective recovery and purification. Through the development of metal selective media and ion exchange (IX) process expertise, Dow products and technologies have helped the mining industry recover valuable metals in an efficient and environmentally sustainable manner for decades.

The Power of ORE
From increasing cost pressures, to more stringent environmental and safety regulations, to declining ore grades, the mining industry faces numerous challenges impacting profitability. Dow is helping to address these challenges with the Power of ORE – a wide range of products and expertise to address a broad spectrum of mining, mineral processing and remediation challenges.

The Power of ORE gives companies striving to extract more value from mining operations a real choice in the marketplace. Dow can help enable **O**perational efficiency, boost **R**ecovery enhancement and facilitate **E**nvironmental protection.

Hydrometallurgy Offerings and Solutions

Function	Dow Product	Description
Ion Exchange Resins	AMBERSEP™	For the extraction, separation and purification of base, precious and rare earth metals, as well as uranium. Applicable in a wide range of operations and processes.
Extraction Solvents	PRIMENE™	Primary amines on t-alkyl aliphatic chains for primary and secondary metals extraction

The AMBERSEP™ Family of Resins

AMBERSEP products are a family of ion exchange resins for hydrometallurgical extraction. These macroporous, styrene-divinyl benzene, copolymer beads are available with a wide range of functional groups and particle sizes for extracting precious and industrial metallic ions from process solutions. The table below lists common extraction applications where AMBERSEP is used.

Application	Dow Product
Uranium Acid Leach Fixed Beds	AMBERSEP 4400 Cl
	AMBERSEP 400 SO4
	AMBERSEP 21K XLT
	AMBERSEP 21K 16-20
	AMBERSEP 940
	AMBERSEP 950
Uranium Acid Leach CCIX / NIMCIX	AMBERSEP 4400 Cl
	AMBERSEP 400 SO4
Uranium Acid Leach Porter Systems	AMBERSEP RPU
	AMBERSEP 400 SO4
Uranium Acid Leach U shape / Higgins	AMBERSEP 920 U SO4
	AMBERSEP 925 U Cl
Uranium Acid Leach Resin-In-Pulp	AMBERSEP 920 UHC SO4
	AMBERSEP 920 UXL Cl
	AMBERSEP 920 U SO4
	AMBERSEP 925 U Cl
Uranium Alkaline Leach Fixed Beds	AMBERSEP 4400 HCO3
	AMBERSEP 400 HCO3
	AMBERSEP 21K XLT
Uranium Alkaline Leach Resin-In-Pulp	AMBERSEP 21K 16-20
	AMBERSEP RPU

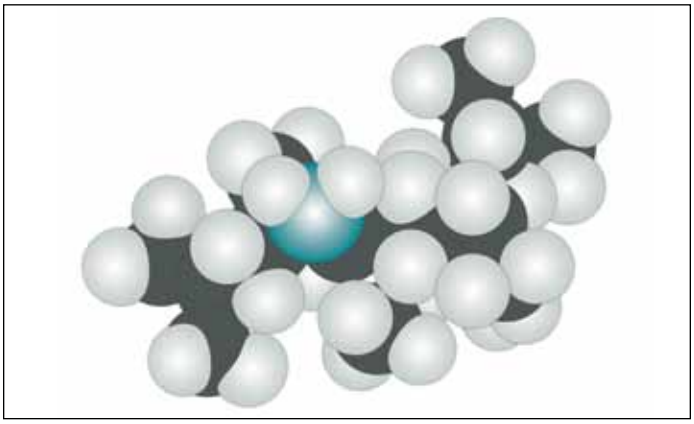
Application	Dow Product
Uranium Alkaline Leach CCIX / Higgins	AMBERSEP 4400 HCO3
	AMBERSEP 400 HCO3
	AMBERSEP 21K XLT
Uranium from Phosphoric Acid	AMBERSEP 940
Gold Cyanide Leach	AMBERSEP XZ-91419
	AMBERSEP 920 UXL Cl
Gold Thiosulphate Leach	AMBERSEP 21K 16-20
	AMBERSEP 920UXL Cl
Cobalt Refining	AMBERSEP M-4195
	AMBERSEP M-4195 UPS
	AMBERSEP M-4196 UPS
Copper Mining /Refining	AMBERSEP M-4195
	AMBERSEP M-4195 UPS
	AMBERSEP M-4196 UPS
	AMBERSEP 950
Laterite Nickel	AMBERSEP M-4195
	AMBERSEP M-4195 UPS
Vanadium Acid Leach	AMBERSEP 920 U SO4
	AMBERSEP 925 U Cl

PRIMENE™ Products

PRIMENE™ products are primary aliphatic amines with highly branched alkyl chains in which the nitrogen atom is sterically hindered. PRIMENE products have been used to extract the following metals: gold, indium, thorium, rare earth metals, uranium, molybdenum, scandium, palladium, platinum, vanadium, rhenium and mercury.

Unique properties of PRIMENE include:

- High solubility in non-polar solvents
- Excellent metal ligands
- High resistance to oxidation
- Low viscosity
- Outstanding color stability



Model showing the sterically hindered nitrogen atom (in blue) in PRIMENE JM-T

Refined thorium

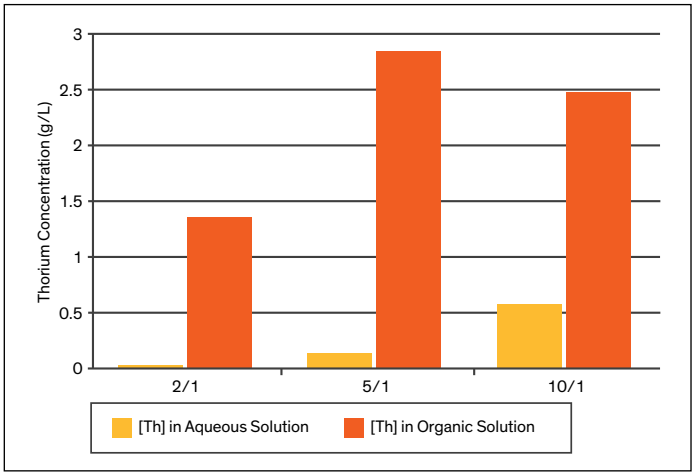
Dow's History in the Mining Industry

Since our earliest roots isolating compounds from prehistoric brine in the 1890s, to pioneering chemistries for froth flotation processes, to developing innovative technologies for water treatment and reuse today, Dow has continued to innovate to help customers extract more value in the mining industry.

Dow is a world leader in membrane (RO/NF/UF) and ion exchange technologies, and provides a powerful portfolio of chemistries and solutions to address:

- Mine water management, including tailings and waste treatment
- Slurry management
- Dust control
- Grinding and milling
- Flotation and hydrometallurgy, focused on maximizing metal recovery utilizing select chemistries, polymer additives and ion exchange technologies

PRIMENE™ Solvent Dosage for Thorium Extraction.[1]



[1]An aqueous solution containing 0.91g/L of thorium and pH adjusted to 1.8 using H_2SO_4 is mixed at various ratios with 0.1M PRIMENE™ in kerosene. Thorium oxide concentration is determined gravimetrically in the organic solution and colorimetrically in the aqueous solution.

Commitment to Sustainability

Dow's commitment to sustainability is infused into the very DNA of our Company. In 2006, we launched our current set of 2015 Sustainability Goals, which focus not only on the Company's footprint in our own operations but also our handprint through the positive impact of Dow products and their role in global sustainable development. Focused on addressing global challenges like water, food, climate change and energy, Dow has made significant progress against these goals. For more information on how sustainability is integrated into all aspects of our business and operations, please visit www.dow.com/sustainability.

Product Stewardship and Safety

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products – from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

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