

# INNOVATIVE SOLUTIONS

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## metal extraction chemistry





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## Welcome to Metal Extraction from Innospec.

Innospec is a global supplier of specialty chemicals with a focus on providing our customers with solutions. Within our Metal Extraction business, our priority is to provide you with innovative solutions to get the best out of your extraction process.

This brochure introduces you to our world of metal extraction;

- Our in-depth knowledge and expertise in this area.
- Our technical capabilities and equipment.
- Our global distribution partnerships.
- Details of how our products have benefitted other metal extraction processes.

We aim to inspire and impart our knowledge to you. We look forward to working with you soon.

If you have any questions, please get in touch by emailing [mining@innospecinc.com](mailto:mining@innospecinc.com)

## Interactive navigation

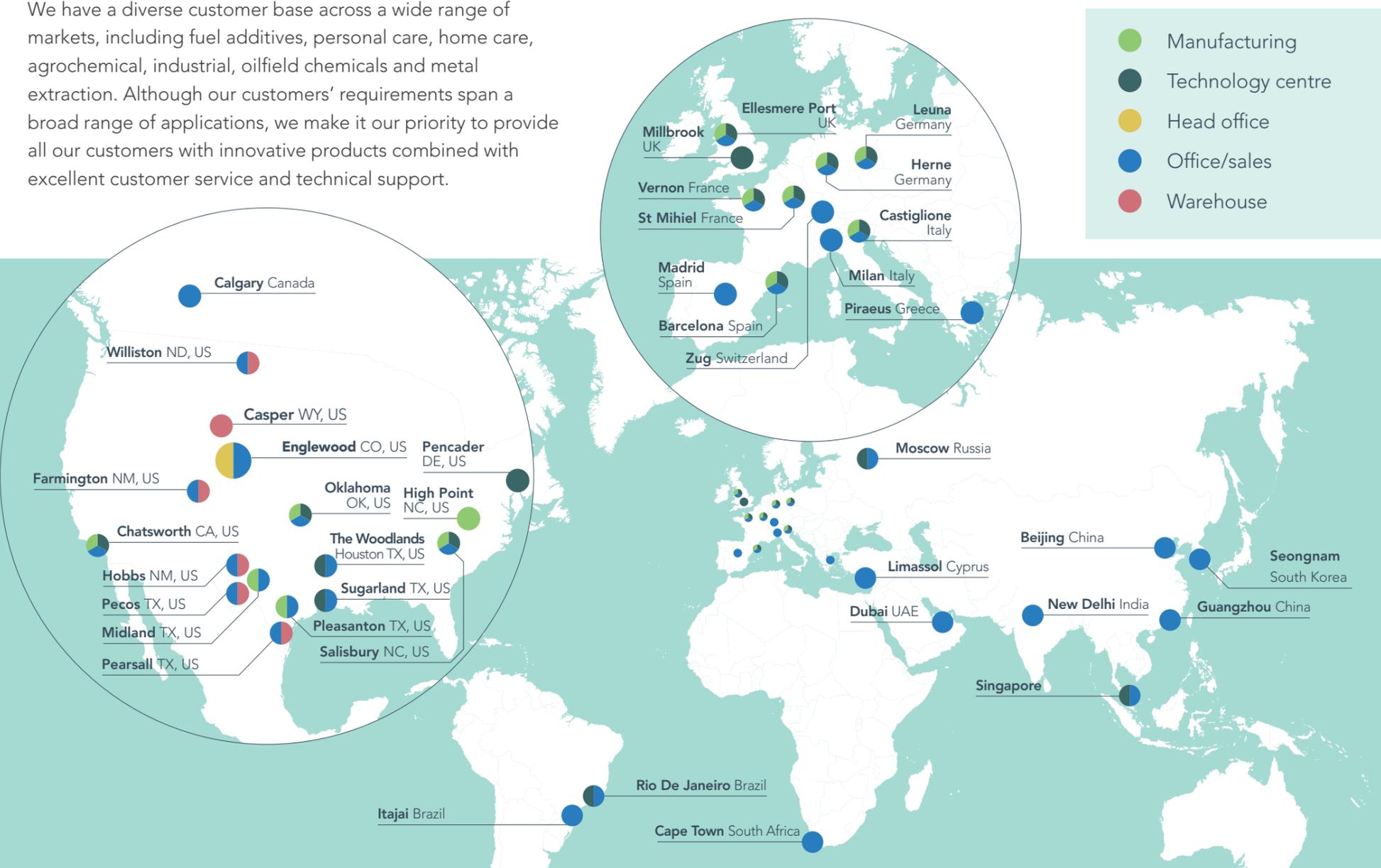
This document has been created so the reader can jump directly to the contents of interest from the main content pages, or from the start of each chapter. Use the arrow buttons > at the bottom of the page to navigate through the document. You can also use the Innospec brand at the top of the to return to the contents page.



# A global manufacturer of specialty chemicals

Innospec are a global manufacturer of specialty chemicals that focuses on bringing new, innovative technologies to our chosen markets and customers. We manufacture and supply a wide range of products through our business units: Fuel Specialties, Performance Chemicals and Oilfield Services.

We have a diverse customer base across a wide range of markets, including fuel additives, personal care, home care, agrochemical, industrial, oilfield chemicals and metal extraction. Although our customers' requirements span a broad range of applications, we make it our priority to provide all our customers with innovative products combined with excellent customer service and technical support.



## Global footprint

Innospec is located in 24 countries across the Americas, Europe, the Middle East, Africa and Asia Pacific. Customers benefit from the strength of our worldwide manufacturing capabilities, our global distribution facilities and our world-class technology centers equipped with state-of-the-art equipment. In total we employ approximately 1,900 people. From our scientists and sales teams to our manufacturing engineers and technicians, supply chain managers, finance, legal, SHE and administration professionals, we benefit from having an experienced, dedicated and diverse workforce.



## Employees

Innospec have 1,900 employees in 24 countries with extensive investments in Research & Technology (R&T) to support customer needs. 215 people working globally in R&T and technical support.



## Investment and growth

\$30.9m invested in R&T  
 Revenue US\$1.2 billion (December 2020)  
 Core business units  
 Performance Chemicals, Fuel Specialties and Oilfield Services.



## R&T Excellence

R&T Technology Center of Excellence with new laboratory facilities in the UK and US.  
 To focus on our mining product developments and meet customer needs we constructed a new R&T Center for metal extraction.  
 Surface science at the water/oil interface.  
 Technology exchange across core businesses.



## Maximizing operational efficiency

We supply a range of products for mineral processing with a specific focus on froth flotation and hydrometallurgy. Our flotation reagents include frothers, dispersants and depressants. Our hydrometallurgy range covers viscosity modifiers, carbon-blanking agents for gold leaching, acid mist suppressants and dewatering aids.

Whether the focus is on selectivity, kinetics, stability, water solubility or particle size, our Frother portfolio delivers a full spectrum of froth quality properties and strengths required for the ore grade being processed.

With our in-depth understanding and capabilities, we can work with you to identify the best reagent, ensuring your dosing regime is optimized, extracting the maximum quantity of metal per unit cost. We are committed to developing strong customer relationships built on trust and shared solutions to complex technical problems. Our aim is to deliver a flexible, reliable and customer-focused service to our customers.



# Discover our technical capabilities

To support the Metal Extraction business, Innospec partner with well-known local chemical distributors in Sub Saharan Africa, Australia, Scandinavia and the US. With our distributors knowledge and equipment, we are able to respond rapidly to customer needs.

Innospec also collaborate with well-known research centers as well as local mining universities and laboratories around the world.

These collaborations are our commitment to focus on the local needs, to optimize, innovate and develop new chemistries that improve processing efficiencies in the mineral processing industry.

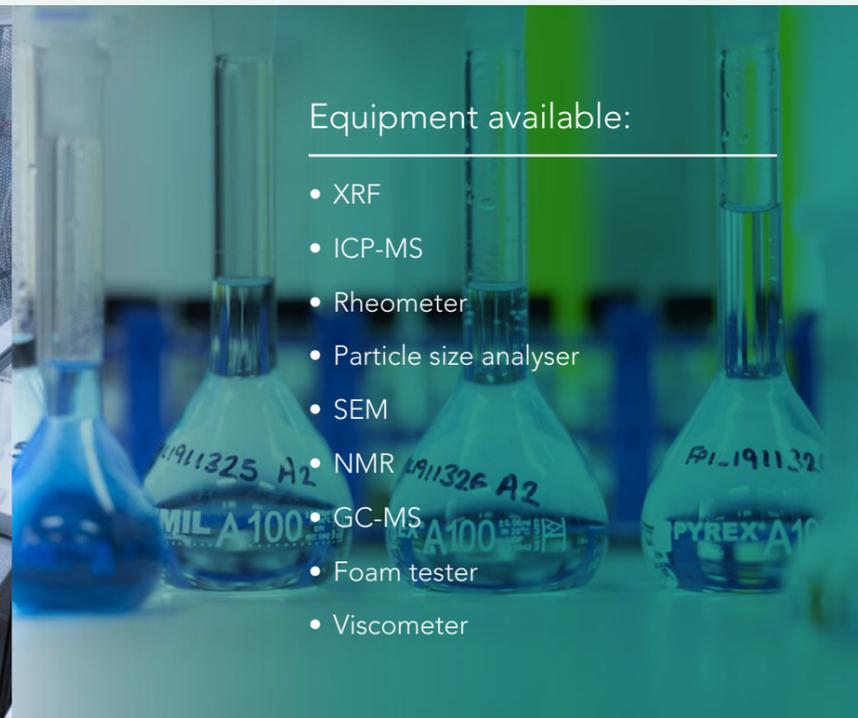
## Innospec Metallurgy R&T Laboratory in Ellesmere Port, UK

A metallurgy laboratory was developed in Ellesmere Port in 2019 with the purpose of conducting in house trials and synthesis of novel products. The lab aims to accurately simulate plant conditions for a variety of metallurgical operations. Together with the existing world-class analytical equipment on site, this forms the Innospec R&T centre for mineral processing.

The Innospec R&T group developed through a diverse business background and provide a means of conducting all analytical work in house.

Over the years, Innospec have built strong relationships with industry bodies, which means any further specialized work can be outsourced.

- Equipped with a ball mill and hammer mill for accurate replication of comminution methods.
- Equipped with a flotation cell to simulate plant conditions.
- Pressure filtration and heating unit to allow processing of slurries.
- We have capabilities to evaluate slurry viscosity using a viscometer.
- Capabilities to simulate solvent extraction circuits on lab scale.
- We are equipped with an electro winning cell for product performance on a laboratory scale.



### Equipment available:

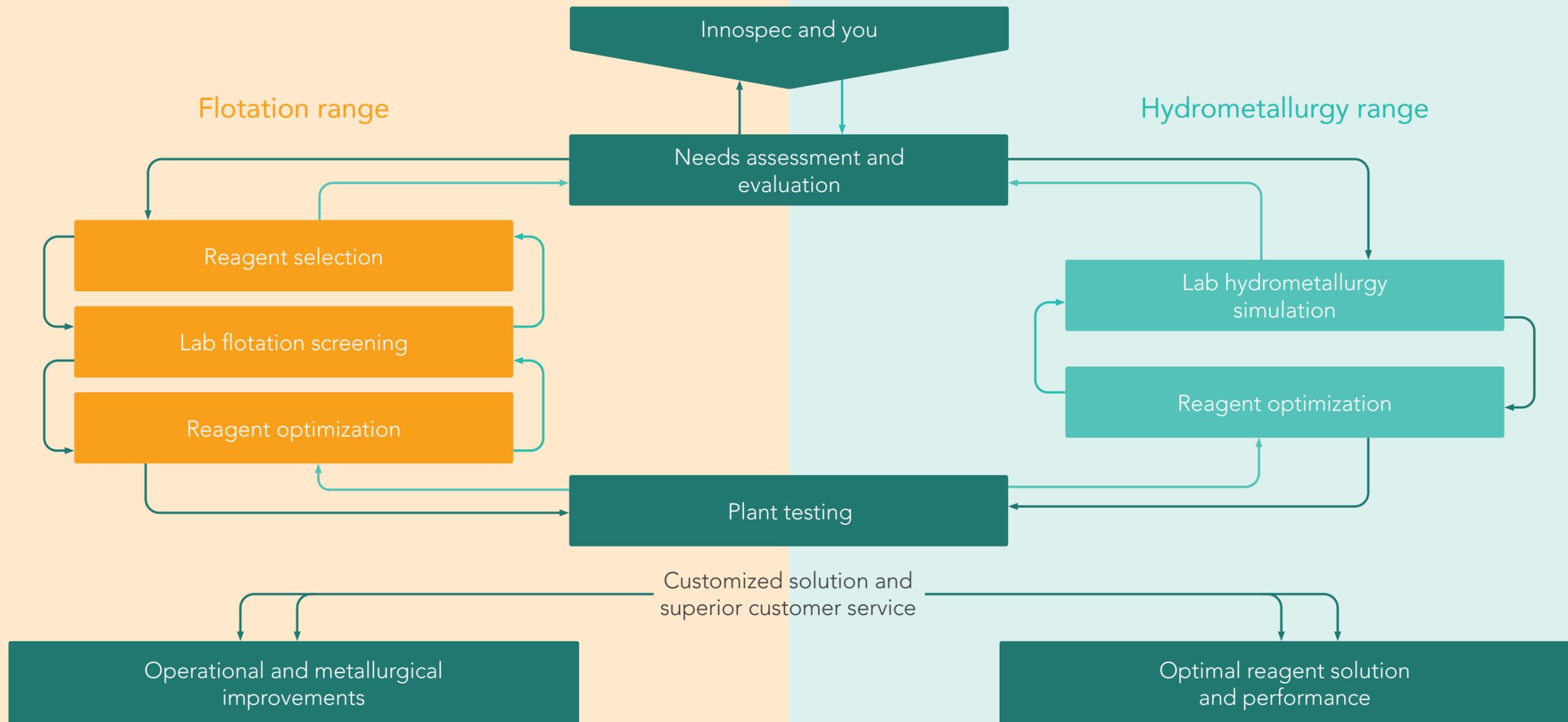
- XRF
- ICP-MS
- Rheometer
- Particle size analyser
- SEM
- NMR
- GC-MS
- Foam tester
- Viscometer



# Mineral processing and hydrometallurgy

To provide tailored ingredient solutions, we work with you to gain an in-depth, holistic overview of your operations and to understand your needs.

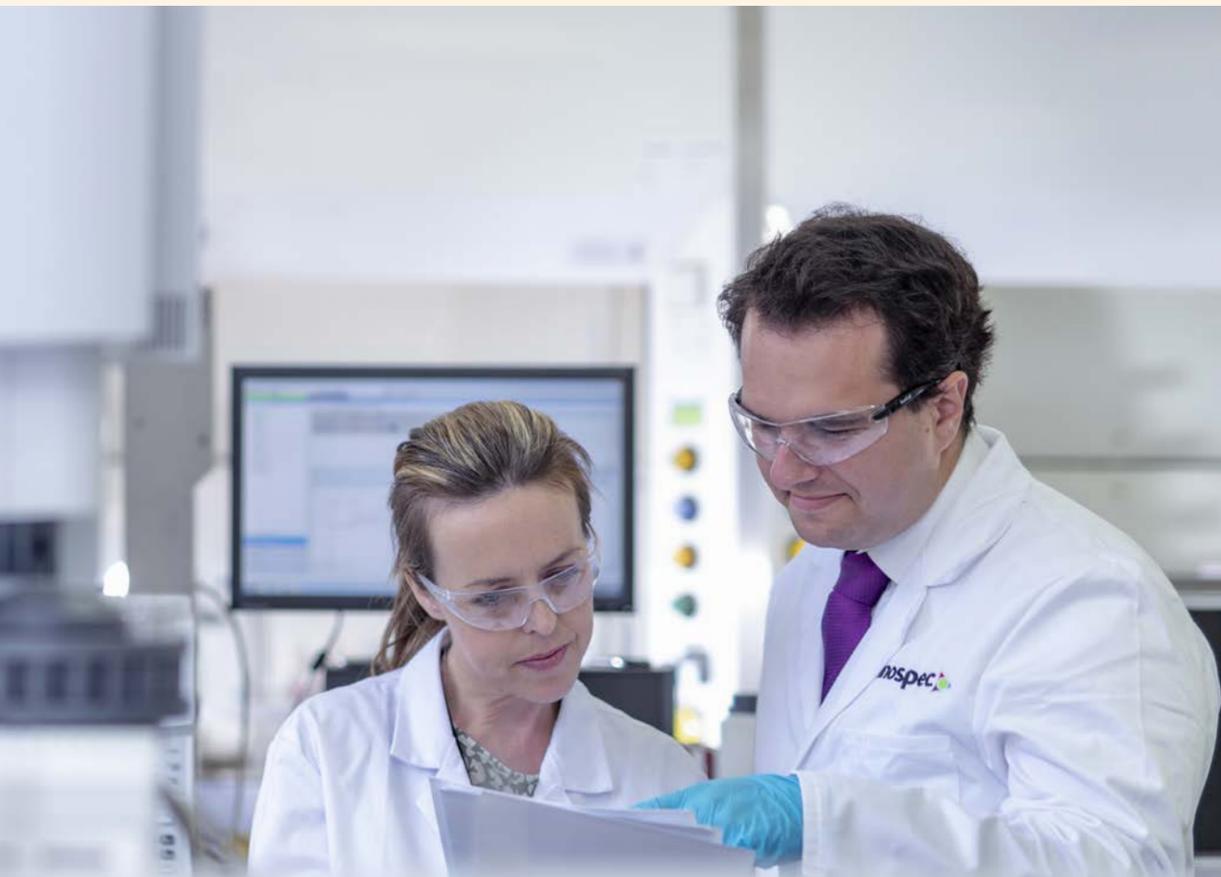
Whether you work with our flotation range or hydrometallurgy range, this flowsheet has been designed to overcome any challenges you may be facing. Laboratory work can be conducted either directly on the mine site or with our metal extraction experts in Ellesmere Port, UK.



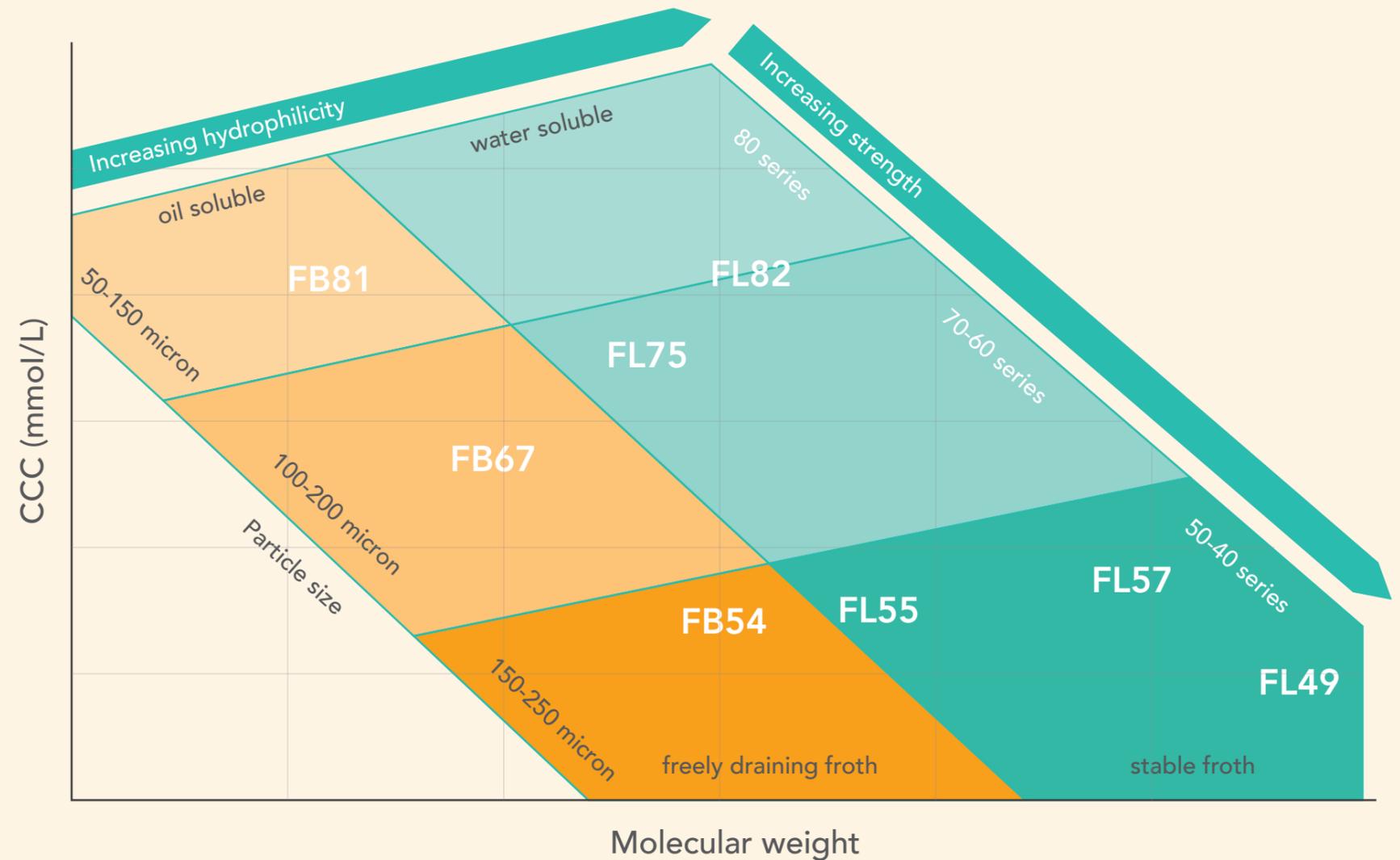
# Frother selection

The DEHSCOFIX® flotation frothers aim to deliver a full spectrum of froth flotation properties.

They provide the strength and selectivity required in mineral and coal flotation applications. DEHSCOFIX® flotation frothers range includes alcohols, glycol ethers, polyglycol ethers and blends of increasing strength. Innospec frothers are proprietary chemicals that have been tested for fine as well as coarse particle size recovery in laboratories, pilot plants and operational plant across the globe. Our frothers are split between oil soluble (FB series) and water soluble (FL series). DEHSCOFIX® 40 and 50 series are categorized as strong, stable and persistent frothers, DEHSCOFIX® 60-70 series are categorized as medium strength frothers and DEHSCOFIX® 80 series are categorized as weak and selective frothers.



Our selection chart shows the respective strength and hydrophobicity of our Frother products. It is an invaluable tool for choosing the correct Frother for a particular application.



# Flotation product selection

Product Description	Trademark	Product Code	Type	Flash Point (°C COC)	Specific Gravity (g/m3)	Chemical Description	Characteristics	Performance Benefit	Common Applications							
									Sulfide Metals				Other			
									Nickel	Gold	Lead-Zinc	Copper	Iron	Industrial	Coal	Uranium
<p>DEHSCOFIX® STRONG FROTHER Series are often used alone, where their strength (due in part to their higher molecular weight) imparts superior qualities for coarse particles recovery in flotation circuits. They can be combined with other products to augment froth characteristics for desired properties and performance.</p>	DEHSCOFIX®	FB54	Alcohol - Ether	114	0.936	Hydrophobic and produces strong, drier froth characterized with fine froth structure and mobility. Demonstrates fast kinetics.	Robust frother suitable for operations where strong froths are required to assist flotation of coarse and middlings fractions and where rapid kinetics initially are desirable. Efficient frother useful for overcoming froth resistance and stability problems.	Alternative to polyglycol and polyglycol ether type frothers of higher molecular weight. Typically requires reduced dosage compared to alkoxy frother blends.	█	█	█	█	█	█	█	█
	DEHSCOFIX®	FL49	Glycol Ether	238	1.02	Stronger frother with moderate hydrophobicity and improved water retention. Strong froth generation and froth persistence, producing well defined bubbles and uniform froth generation down-the-bank.	Suitable for operations where strong froths are required, and where froth persistence and stability is more important than rapid kinetics. Recommended for recovery of coarse size fractions. Usually results in reduced dosage and better froth depth control.	An alternative to TEB based frothers, matching their metallurgical performance and offering potential dose savings. Stability is similar to stronger alcohol/polyglycol ether blends.	█	█	█	█	█	█	█	█
	DEHSCOFIX®	FL55	Glycol Ether	208	0.98	Low to moderate hydrophobicity. High froth strength and fast flotation kinetics. Produces tight, strong bubbles of good mobility.	The combination of high froth strength and rapid flotation kinetics offers improved recovery of coarse size fraction particles in rougher-scavenger cells.	Offers comparable stability and strength to higher strength TEB based and alcohol/glycol ether/polyglycol blends, with potential for reduced dosage.	█	█	█	█	█	█	█	█
	DEHSCOFIX®	FL57	Glycol Ether	198	1.12	Produces mobile, fluid froths with well defined froth structure and bubble size distribution.	Suitable for applications requiring strong froth stability and good froth depth control. Demonstrates a fine balance between stability and selectivity. Suited to both intermediate and coarse particles size distributions.	An alternative to the TEB based frothers, and to mid-strength alcohol based frothers containing small quantities of glycol ethers or polypropylene glycols.	█	█	█	█	█	█	█	█



# Flotation product selection

Product Description	Trademark	Product Code	Type	Flash Point (°C COC)	Specific Gravity (g/m3)	Chemical Description	Characteristics	Performance Benefit	Common Applications								
									Sulfide Metals			Other					
									Nickel	Gold	Lead-Zinc	Copper	Iron	Industrial	Coal	Uranium	
DEHSCOFIX® INTERMEDIATE FROTHER Series are the medium strength (due to molecular weight) with a combination of selectivity, stability and moderate kinetics. Performance is comparable to medium strength, intermediate molecular weight, glycol ether based frothers.	DEHSCOFIX®	FL75	Alcohol - Ether	142	0.98	DEHSCOFIX® FL79 is an industry alternative to Dowfroth™ 250. It can also be used as an alternative to other medium strength, intermediate molecular weight, glycol ether/propylene glycol based frothers. It produces a mobile, freely draining froth of intermediate strength. Offers a combination of selectivity, froth stability and moderate kinetics. It can be used in a wide range of flotation applications where a balance of selectivity and strength is required.	Suitable for a wide range of flotation applications where a balance of selectivity and strength is required, with moderate persistence and good froth control enabled.	An alternative to mid-strength, intermediate molecular weight glycol ether/propylene glycol based frothers.	█	█	█	█	█	█	█	█	█
	DEHSCOFIX®	FB67	Ester	154	1.08	Fine, freely draining froth intermediate strength. Offers good selectivity, efficiency and kinetics.	Suitable for flotation applications where both selectivity and froth strength is required. Offers good depth control and applicable to coarse sizes.	Alternative to mid-strength glycol ether/propylene glycol based frothers and stronger alcohol based frothers.	█	█	█	█	█	█	█	█	█
DEHSCOFIX® WEAK FROTHERS Series is the lower strength, highly selective frother range. It produces a mobile, dry froth with low to moderate stability. Performance is comparable to MIBC and other low molecular weight, alcohol based.	DEHSCOFIX®	FL82	Alcohol - Ether	179	1.02	Low to moderate hydrophobicity producing mobile, well draining froths of intermediate stability.	Selective in base metal flotation, providing improved flotation kinetics and intermediate froth strengths. Often results in lower water recovery and improved gangue rejection.	Alternative to lower molecular weight alcohol/ester/propylene glycol based frother blends.	█	█	█	█	█	█	█	█	█
	DEHSCOFIX®	FB81	Ester	156	1.191	Dry, loose and brittle froths of low to moderate stability.	Selective in base and precious metal flotation, providing good flotation circuit control.	Alternative to MIBC and low molecular weight alcohol based frothers.	█	█	█	█	█	█	█	█	█
Innospec manufactures non-ionic, anionic and cationic polymers for the depression of gangue in flotation. These low and intermediate molecular weight polymers are specifically designed to depress iron sulfides, maintain low viscosity, disperse slimes, disperse clays and silicates.	DEHSCOFIX®	DK	Vary	-	Vary	DEHSCOFIX® DK Series are versatile dispersants used to facilitate the rejection of clays, fibrous minerals and hydrophobic gangue typically found in sulfide ores.	Selective where preferential flotation is required.	Alternative to low and intermediate molecular weight dispersants.	█	█	█	█	█	█	█	█	█



# Hydrometallurgy product selection

Product Description	Trademark	Product Code	Type	Flash Point (°C COC)	Specific Gravity (g/m3)	Chemical Description	Characteristics	Performance Benefit	Common Applications								
									Sulfide Metals					Other			
									Nickel	Gold	Lead-Zinc	Copper	Iron	Industrial	Coal	Uranium	
Naturally occurring carbonaceous ore and fine residue carbon can have a negative impact on gold recovery in CIL/CIP processes. This is as a result of their "preg-robbing" nature of the gold-cyanide complex. Fine carbon bearing material has, by definition, high surface area, thereby increasing the tendency for leach liquor adsorption. The aim is to find the correct dosing strategy of the blinding agent to completely adsorb onto the preg-robbing carbon without any residual left in solution to impact down stream.	DEHSCOFIX®	DG	Vary	-	Vary	DEHSCOFIX® DG series are blinding agents used in gold leaching processes (CIL/CIP) to prevent preg-robbing by carbonaceous or graphitic material. This allows gold-cyanide complex to attach preferentially to activated carbon.	The addition of the blinding agent improves gold recovery during leach.	Alternative to kerosene and other carbon blinding reagents.									
The digestion of minerals in strong acids/alkalis or at elevated temperatures can result in the release of large amounts of silicic acid, which can polymerize in a solution to form colloidal silica and gels. Colloidal silica can cause a number of problems in mineral processing, including interfering with flocculation, initiating CRUD formation in solvent extraction (SX), decreasing extraction kinetics and increasing SX phase disengagement times (PDTs). DEHSCOFIX® coagulants help lower the concentration of colloidal silica in solution, improve process efficiency and reduce organic reagent losses by minimizing crud formation.	DEHSCOFIX®	SC	Vary	-	Vary	DEHSCOFIX® SC Series are liquid polymeric coagulants for the treatment of fine particles in aqueous suspension. These products are designed to be effective against colloidal silica across a broad pH range.	Selective and very effective for colloidal silica coagulation, providing good PLS clarity after filtration.	Applicable for any acid leach applications where as a result of colloidal silica, filtration, CRUD, high PDTs are an issue. Alternative to cationic coagulants.									
Acid mist is generated during electrowinning in the final stage of hydrometallurgical production processes of metals including copper, zinc and nickel. In electrowinning, oxygen bubbles are formed on the anode. Burst of these bubbles at the solution/air interface produces fine acid-containing liquid droplets which become airborne and disperse throughout the tankhouse. These droplets are known as acid mist and possess a serious health hazard to the operators. It also results in severe structural and equipment corrosion.	DEHSCOFIX®	EW	Vary	-	Vary	Combination of low foam surfactants to tackle issues with acid mist and cathode morphology.	Effective in reducing the mist as well as improving the morphology of the cathode.	Acid mist suppressant and smoothing agent. Reduces the need for starch addition. Improves the tankhouse environment.									
Dewatering aids are used to reduce cake moisture in the filtration of mineral slurries, such as sulfide flotation concentrates, iron ore concentrates and coal concentrates and tailings. The main goal is to increase filtration throughput in mineral processing by reducing moisture content and improving release of the filter cake.	DEHSCOFIX®	DA	Anionic surfactant	-	Vary	DEHSCOFIX® DA Series are versatile dewatering aids used to reduce the surface tension of the water to facilitate filtration in solid liquid separation systems.	Suitable for systems that require reduced cake moisture content.	Moisture reduction and control.									



# DEHSCOFIX® SC 12

## Colloidal Silica Coagulant

The digestion of minerals in strong acids or at elevated temperatures can result in the release of large amounts of silicic acid, which can polymerize in solution to form colloidal silica and gels. Colloidal silica can cause a number of problems including interfering with flocculation, initiating crud formation in solvent extraction (SX), decreasing SX extraction kinetics and increasing SX phase disengagement times.

## How can DEHSCOFIX® SC12 work for you?

DEHSCOFIX® SC12 should be added to the Liquid Solid (L/S) separation circuit before the addition of flocculant. In a Counter Current Decantation (CCD) circuit, it is best added to the CCD1, or lead CCD launder.

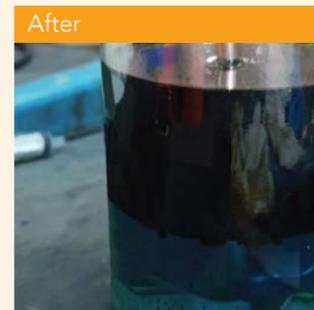
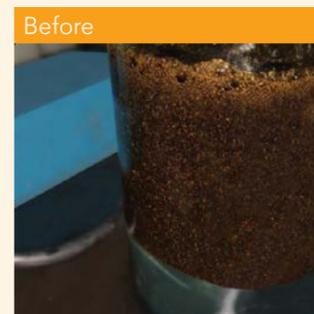
In a filtration circuit, it should be added before the filter. While DEHSCOFIX® SC12 binds selectively to colloidal silica, it will also bind to precipitated silica in the leach solids. When added directly to leach discharge it may be very effective in improving settling in the high-grade thickener, CCD circuit as well as in the clarifier.

In all cases, good mixing must be used. Shear will help coagulation, and shearing of the coagulated particles formed is not a concern. After this contact period, add solids and flocculate as normal. If colloidal silica was responsible for poor solution clarity, the benefit of adding DEHSCOFIX® SC12 will be dramatic.

## Product Benefits

DEHSCOFIX® SC12 works by assisting the removal of this colloidal silica by promoting the agglomeration of the particles. The coagulants have a “lock and key” relationship with the surface of colloidal silica as the coagulants have a similar hydrogen bonding spacing to colloidal silica. This allows them to bind to the surface, displacing the water, and destabilizing the colloid. Once two silica particles touch, they bind to each other by forming ether linkages.

Coagulation of the silica is twice beneficial as coagulated silica is easier to remove from solution and its removal will reduce crud formation and solvent losses in the solvent extraction stage of the process.



- Reduces CRUD formation
- Reduces entrainment losses
- Improves cathode quality
- Increases throughput
- Reduces continuity flipping
- Reduces organic losses

# DEHSCOFIX® DG30

## Carbon Blanking Agent

Preg-robbing of gold is a phenomenon whereby the cyanide complex, Au(CN)<sub>2</sub><sup>-</sup>, is removed from solution by carbonaceous matter present in the ore. This occurs by a physical adsorption process when the ore contains “active” carbon, which adsorb the gold from the pregnant solution. This carbon then acts as an adsorbent similar to the activated carbon that is physically added to the leach minimizing the recovery of gold and increasing gold loss to tailings.

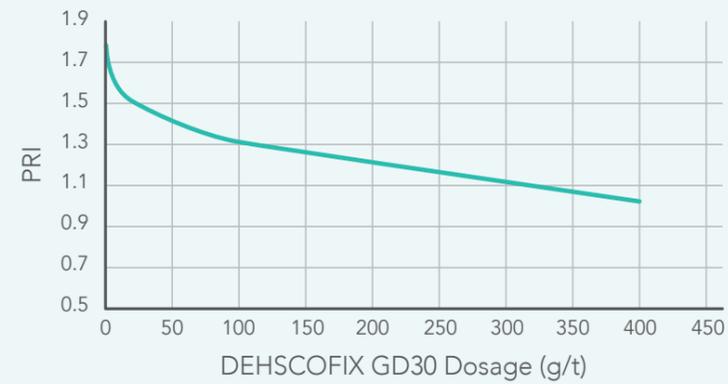
## How can DEHSCOFIX® DG30 work for you?

DEHSCOFIX® DG30 Carbon Blanking Agent is a preg-robbing agent that should be added at a point prior to the slurry conditioning for pH adjustment. The product has demonstrated effectiveness in blinding the preg-robbing carbon that tends to adsorb the dissolved gold during cyanidation.

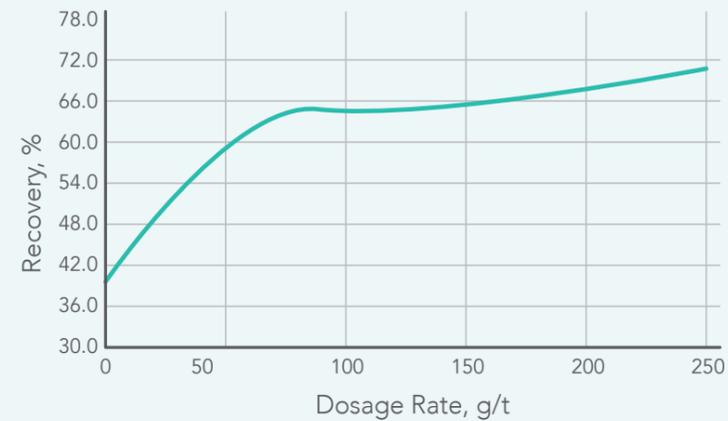
## Product Benefits

- Increased gold recovery
- Easy to apply
- Non flammable

Reduction in Preg-robbing capacity



Dose response and gold recovery increase



# Sustainability at Innospec

As a NASDAQ listed (IOSP) global specialty chemical company, we recognize that being a responsible business is key to our continued success. We understand that the Environment, Social and Governance aspects of our business are of increasing focus for our investors.

As a company, we look carefully at our supply chain and seek to provide as much information as possible on the impacts of our products. At Innospec, we take this extremely seriously and work to ensure our investors and customers have the information they need to fully understand the impacts and benefits of our products. We aim to understand the impact of our products from the 'cradle to the grave' and develop products that deliver a positive benefit to society by helping to increase efficiency and reduce environmental impacts.

As well as generating returns for our shareholders and providing vital products to the modern world, we also have a responsibility to ensure that we operate safely, deliver to regulatory standards, and to reduce our footprint on the environment.

Innospec has a strong history of corporate responsibility activities, reporting our performance in this area since 1999 through our Sustainability Reports.

## Renewable electricity and being carbon neutral

All Innospec Performance Chemicals manufacturing sites globally now use only renewable sources of electricity. Manufacturing sites in Herne, Germany, and Vernon, France, maintain their carbon neutral energy status.



## Verified sustainability performance

CDP Climate and Water Assessment Scores:  
 Climate Disclosure B (global average = C)  
 Supplier Engagement B- (sector average = C)  
 Water Disclosure B- (global average = B-)



## Ecovadis gold award

Awarded Gold medal in 2019 and 2020



## We are a member of RSPO

Innospec has been an Ordinary Member of RSPO since 2013

- All applicable manufacturing sites are RSPO MB supply chain certified
  - All of our palm based products can be offered as a RSPO MB certified version upon request
- Palm policy updated in 2020 – NDPE Compliant



## Palm oil transparency

- Annual Palm Oil Transparency
- Increasing the transparency & understanding of palm based materials & players in our supply chain



For inspiration, ideas or further information,  
please contact us:

**Innospec Performance Chemicals**

**Americas**

Tel: +1 704 633 8028

**Europe, Middle East and Africa**

Tel: +44 (0)1513553611

**Asia Pacific**

Tel: +65 63366286

Email: [mining@innospecinc.com](mailto:mining@innospecinc.com)

[www.innospec.com](http://www.innospec.com)

