



Johnson Matthey plc - Advanced Ion Exchange (AIX) *Closing the Value Loop*

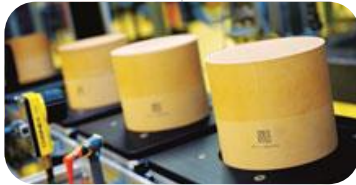
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Johnson Matthey

- A speciality chemicals company and a world leader in sustainable technologies
- Origins date back to 1817, floated 1942, FTSE 100 company since June 2002
- Operations in over 30 countries with 11,000 employees
- Leading global market positions in all its major businesses
- R&D spend of over £136m in 2012/13
- Actively growing in new business areas through organic growth and acquisitions

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Emission Control Technologies

- Light Duty Catalysts
- Heavy Duty Catalysts
- Stationary Emissions Control



Process Technologies

- Chemicals**
 - Chemical Technologies (DPT)
 - Syngas
 - Chemical Catalysts
- Oil and Gas**
 - Refineries
 - Purification
 - Tracerco



Precious Metal Products

- Services**
 - Platinum Marketing and Distribution
 - Refining
- Manufacturing**
 - Noble Metals
 - Colour Technologies
 - Chemical Products



Fine Chemicals

- Active Pharmaceutical Ingredient (API) Manufacturing
- Catalysis and Chiral Technologies
- Research Chemicals



New Businesses

- New Business Development
- [Water Technologies](#)
 - [Advanced Ion Exchange products](#)
- Battery Technologies
- Fuel Cells

- Acquisition of Purity Systems Inc in 2013
- The PSI silica polymer composite technology will complement existing Johnson Matthey products and expertise in selective metals removal
- In addition, Johnson Matthey brings considerable resources and expertise in chemistry and advanced materials which will further enhance our services and widen the range of problems we can help solve
- Further investment in support centres in the US, Europe and Asia will give access to sector leading technical and sales support for our valued customers



Advanced Ion Exchange (AIX)

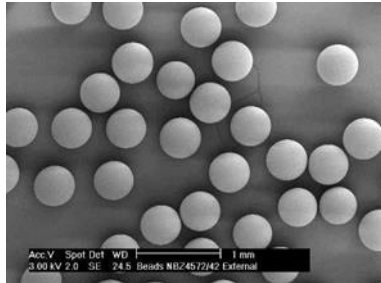
Increasing Drivers



- Tightening regulation on residual metal levels in APIs globally
- Margin pressure to minimise costs and increase resource recovery
- Broadening legislation on waste treatment
- Selective metal recovery enables the targeting of specific components in complex environments

3 III B	4 IV B	5 V B	6 VI B	7 VII B	8 VIII B	9 VIII B	10 VIII B	11 I B	12 II B	3p
21 +3 Sc scandium 44.96	22 +4,3,2 Ti titanium 47.87	23 +5,2,3,4 V vanadium 50.94	24 +3,2,6 Cr chromium 52.00	25 +2,3,4,6,7 Mn manganese 54.94	26 +3,2 Fe iron 55.85	27 +2,3 Co cobalt 58.93	28 +2,3 Ni nickel 58.69	29 +2,1 Cu copper 63.55	30 +2 Zn zinc 65.41	13 +3 Al aluminum 26.98
39 +3 Y yttrium 88.91	40 +4 Zr zirconium 91.22	41 +5,3 Nb niobium 92.91	42 +6,3,5 Mo molybdenum 95.94	43 +7,4,6 Tc technetium 98	44 +4,3,6,8 Ru ruthenium 101.1	45 +3,4,6 Rh rhodium 102.9	46 +2,4 Pd palladium 106.4	47 +1 Ag silver 107.9	48 +2 Cd cadmium 112.4	31 +3 Ga gallium 69.72
71 +3 Lu lutetium 175.0	72 +4 Hf hafnium 178.5	73 +5 Ta tantalum 180.9	74 +6,4 W tungsten 183.8	75 +7,4,6 Re rhenium 186.2	76 +4,6,8 Os osmium 190.2	77 +4,3,6 Ir iridium 192.2	78 +4,2 Pt platinum 195.1	79 +3,1 Au gold 197.0	80 +2,1 Hg mercury 200.6	32 +4,2 Ge germanium 72.64
										33 -3 As arsenic 74.92
										34 -2 Se selenium 78.96
										49 +3 In indium 114.8
										50 +4,2 Sn tin 118.7
										51 +3,5 Sb antimony 121.8
										52 -2 Te tellurium 127.6
										81 +1,3 Tl thallium 204.4
										82 +2,4 Pb lead 207.2
										83 +3,5 Bi bismuth 209.0
										84 +4,2 Po polonium 209

- Selectively removes metal impurities from API work ups enabling **cost efficient** compliance
- High purity products with strong supporting **quality** and **regulatory** packages



QuadraSil Silicas

- Uniformly spherical silicas
- Excellent recoveries at room temperature for temperature sensitive applications
- Large surface area
- Purification down to sub ppm level



QuadraPure Resins

- Macroporous polymer beads
- Uniformly spherical
- Excellent recoveries in flow applications



Smopex Pharma grade fibres

- Grafted ion exchange fibres with strong selectivity for precious metals
- Robust and easy to use in stirred tank applications



- Enables recovery of **metals** from waste streams creating **value**
- Removal of **contaminant metals** from effluents enabling **compliance**



SPC Technology – recent acquisition from Purity Systems Inc

- Silica polymer composite resin
- Selectively recover metals from high and low flow process streams and effluents
- Metals can be eluted for multiple resin use
- Minimal swelling, unlike some other polystyrene resins
- Enables unique separations

Functional Silicas

- Irregular silica particles
- Cost effective metal recovery
- Simple flow system setup
- Pore-size, diameter, particle sizes, pore volumes tunable

Smopex fibres

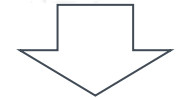
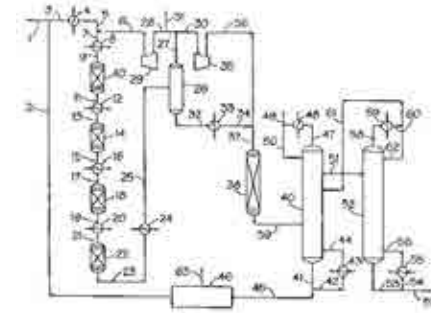
- Grafted ion exchange fibre with strong selectivity for precious metals
- Can recover low levels of metals in process streams and effluents
- Robust and easy to use in stirred tanks

Scale up and Process Development

- Leveraging JM group process engineering expertise
 - Reactor and absorber scale up - 'Reaction Engineering'
 - Design > Lab > Pilot > Full Scale
 - Scale up at typical scale factors 10^4 to 10^7
 - Physical and Computational Modelling
- Adsorption Column Scale Up
 - Hydrodynamics key to column design
 - Models used mimic hydrodynamic regime in full scale
 - Distribution, Flow patterns, Kinetics
 - Full plant scale velocity: hydrodynamics
 - Full plant residence time: kinetics/loading capacity
 - Segmented Bed, Sectional Bed
- Process design
 - Carousel Design to Mimic Load / Elute cycles
- Ability to offer both Process and Equipment Design



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Pharma purification

- Global Top 10 Pharma
- Removal of Cu from an API stream
- Driver is regulatory with FDA requirement of less than 20ppm in the API
- JM recyclable **sealed flow** process used

Pharma waste

- Global Top 10 Pharma
- 20kg solubilised Pd as waste/ annum
- Requirement for Pd recovery for value and sustainability
- JM **total value management** process chosen

Agrochemical market

- 800k€/ annum Pd lost
- Aqueous waste stream; in pilot trial, 99 % recovery (<3 mg/l), 11 wt% Pd loading
- Driver is recovery of valuable metal
- Batch process



JM provides full “cradle to grave” management

- Designed for the increasing trend in purification of potent materials
- Unique patented cartridge with innovative design features developed in conjunction with a major pharma company
- Prefilled with JM AIX materials and delivered to site with full quality package
- Spent cartridges are collected by JM, the loaded AIX material safely disposed off
- Cartridges are cleaned inspected and refilled ready for reuse

Significant Operating Benefits

- Simple implementation with “plug and play” approach
- Reduced risk of exposure on site
- Fully scalable from lab scale right through to plant making scale up quicker and simpler
- Reduced EHS burden in managing excessive PPE and health monitoring
- Improved AIX reaction kinetics due to unique cartridge design



JM provides full “cradle to grave” management

- Designed for the increasing trend in value recovery from waste streams sent for disposal
- JM can provide the AIX treatment and manage the waste management supply chain
- Typically tankers of waste destined for hazardous incineration are treated with JM AIX before destruction
- Option to carry out recovery service on site with trained personnel and mobile equipment
- Metal loaded AIX material are refined at JM through to precious metal or back into products
- Full management of compliance including chain of custody and waste destruction certification



Significant Operating Benefits

- Complete “hands off” treatment with no impact to the production site
- Value recovery can offset the waste incineration costs
- Significant improvement in sustainability and valorisation of waste
- Fast to implement, ideal for batch campaigns
- Confidence in an established full service provider



Johnson Matthey – One Trusted Supplier



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Application Assessment Services

- Initial feasibility study
- Laboratory Screening Services (China, US, Europe)
- Bench top evaluations
- On site pilot trials
- Process Design
- Preliminary Process Economics

Implementation Services

- Equipment Selection
- Process Design
- Toll Processing
- Equipment Rental
- Commissioning and Training

Support Services

- After sales service
- Technical Support
- Troubleshooting
- Reactor loading / unloading
- Sealed Flow System
- Total Value Management



Refining of Precious Metals

Precious Metal Supply and Management

Catalyst Development and Supply

Advanced effluent treatment

API Outsourcing

Support on TFS/REACH



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Any Questions?

Thank you for *your time*

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