Functionalised Silicas
Tools for Sustainable Chemistry

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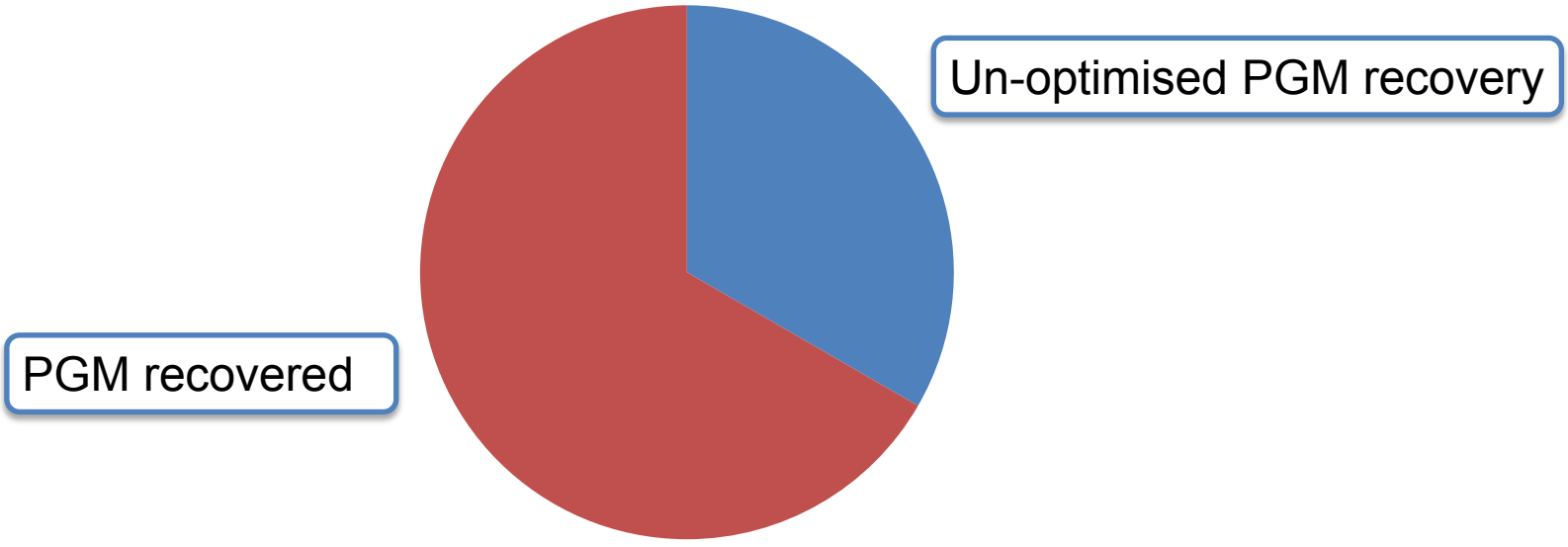
The Chemical Industry

- extensive use of precious metals in the bulk chemical, fine chemical, agrochemical and pharmaceutical industries
- estimated that >€150 million of PGM is lost each year
- significant potential for higher recovery rates

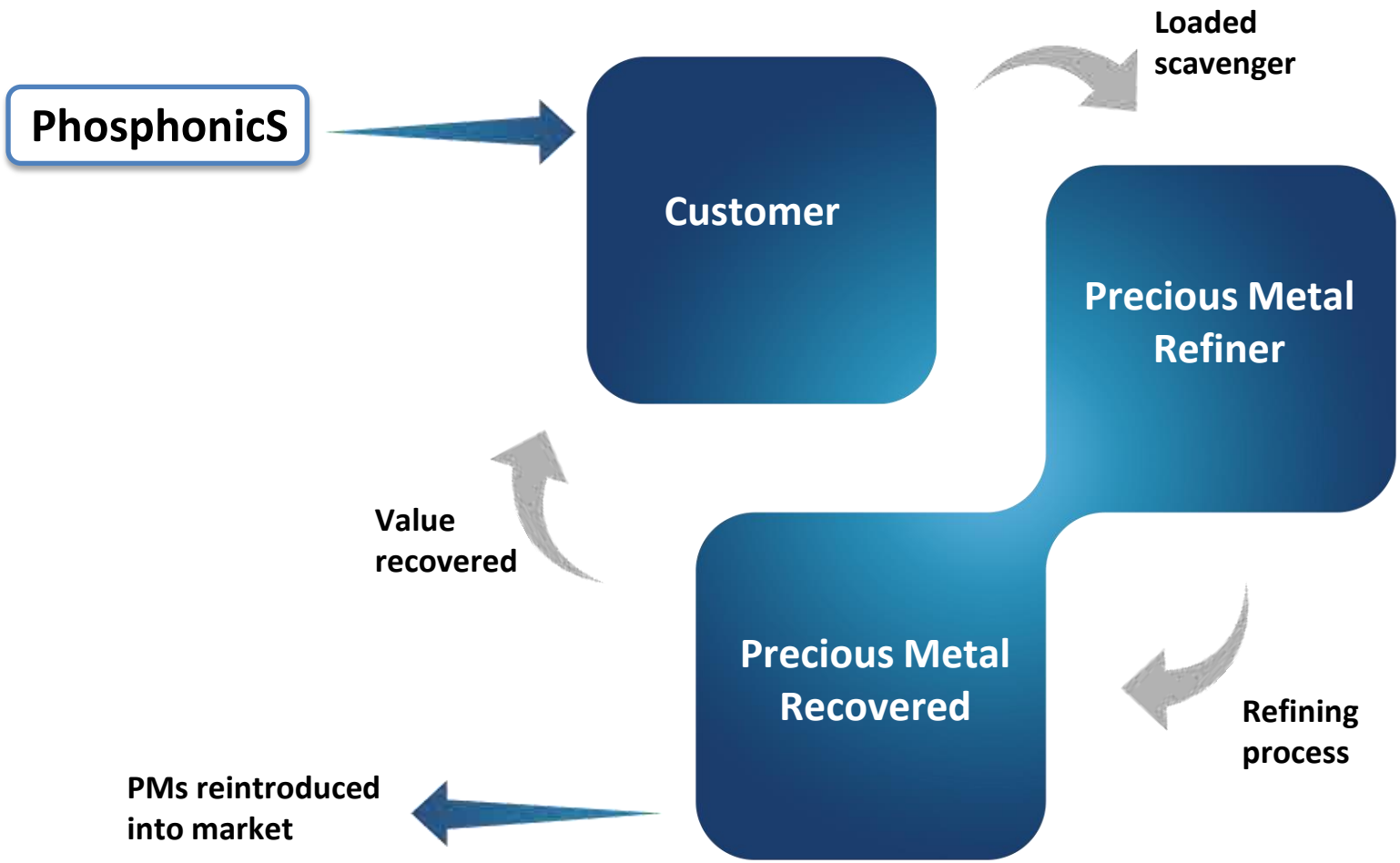


PhosphonicS
Maximising Potential Returns

PhosphonicS Overview

- headquarters and R+D facility near Oxford, UK
- worldwide sales network with customers in over 25 countries
- global development partners including, Heraeus
- manufacturing sites in Europe and Asia

Value Recovery Loop



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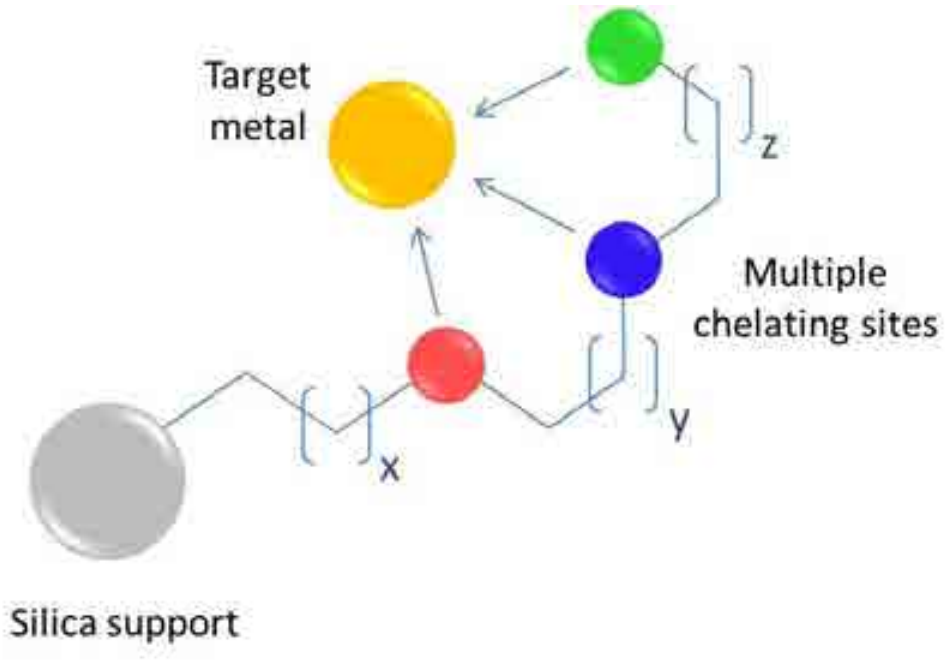
Smartest silica technology

PhosphonicS scavengers are unique silica-based products, surface-coated with multifunctional ligands.



pre-scavenging

post-scavenging

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Key Features of the Technology

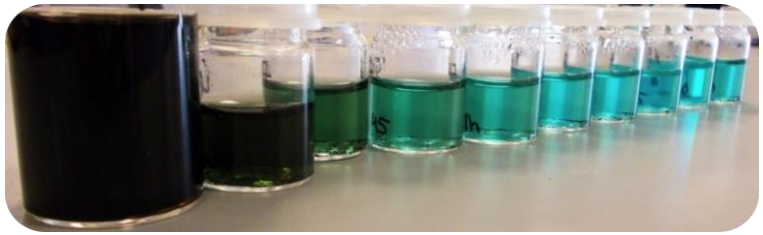
- no pre-treatment of scavenger or stream
- applied as batch (slurry) or as continuous (fixed-bed) process

Recovery applications

- high affinity for PGMs in different oxidation states
- high selectivity for PGMs over base metals
- high capacity, achieving 2-8 % loading
- high refining recovery of PGMs from scavenger

Removal applications

- high affinity for targeted impurities
- high efficacy with very low residuals
- minimal leaching



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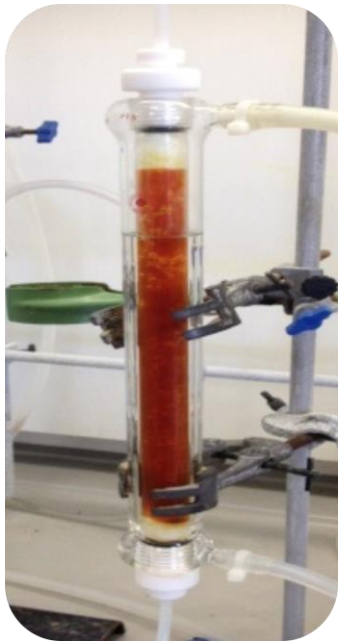
PhosphonicS Process Development

Screening → Isotherms → Batch Kinetics → Lab Scale Cartridge → Implementation

screen + optimisation

laboratories in the UK and China



lab-scale cartridge

plant implementation

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The Falcon™

scavenger cartridge

plinth & controls

- easy to use “plug + play” unit
- available for purchase or rental
- accelerates evaluation of technology

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A Range of Engineering Solutions

- working theoretical model for column sizing based on laboratory tests
- standardized approach to scavenger handling depending on scale and stream tenor
- heat transfer and preheat calculations
- mechanical design, P&IDs and drafting
- manufacture by PhosphonicS or customer

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Pd Removal from an API

- API prepared via Pd-catalysed Suzuki coupling
- Pd concentration in crude product 1,000 ppm
- slurry treatment with PhosphonicS scavenger
- DMF/Me-THF, 60^{o}C, 12 hours
- 4 ppm Pd
- no loss of product

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Removal of Metals from Liquid Crystals

- stream comprises of 15-20 different base and precious metals
- each metal concentration varies between 1-100 ppm
- scavenger used in stirred slurry at 20 or 50 ^{o}C for 2-4 hours
- after scavenging all metals reach <0.1 ppm
- electro-resistance of purer product increases 60-300%

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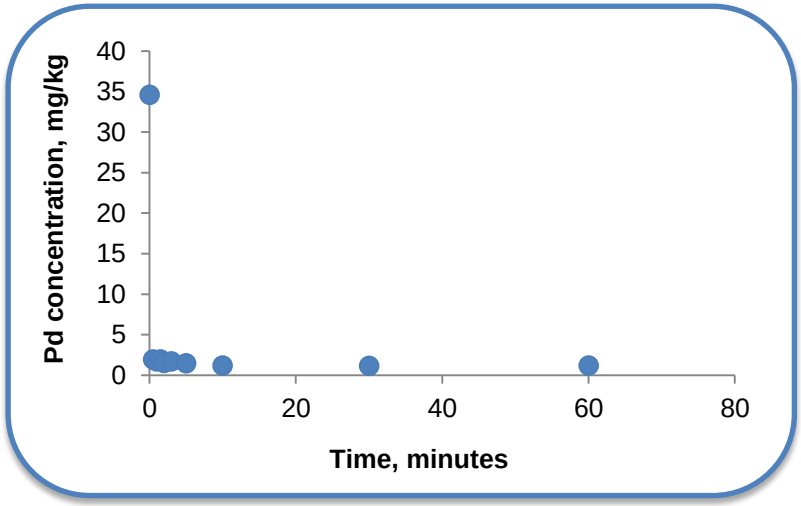
Pd Recovery from Agrochemicals

- agrochemical intermediate produced by Pd-cross coupling reaction
- organic toluene/THF solvent mixture containing 33 ppm Pd
- Pd concentration >0.4 ppm after treatment
- >6% loading of Pd
- extremely fast kinetics



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Rh Recovery from OXO Process

- variable concentration 2 to 30 mg/kg Rh
- 1 hour residence time
- 2.5 – 3.5 w/w % loading
- operating continuously for more than 3 years
- 360 m³ stream per annum
- > 95% metal capture

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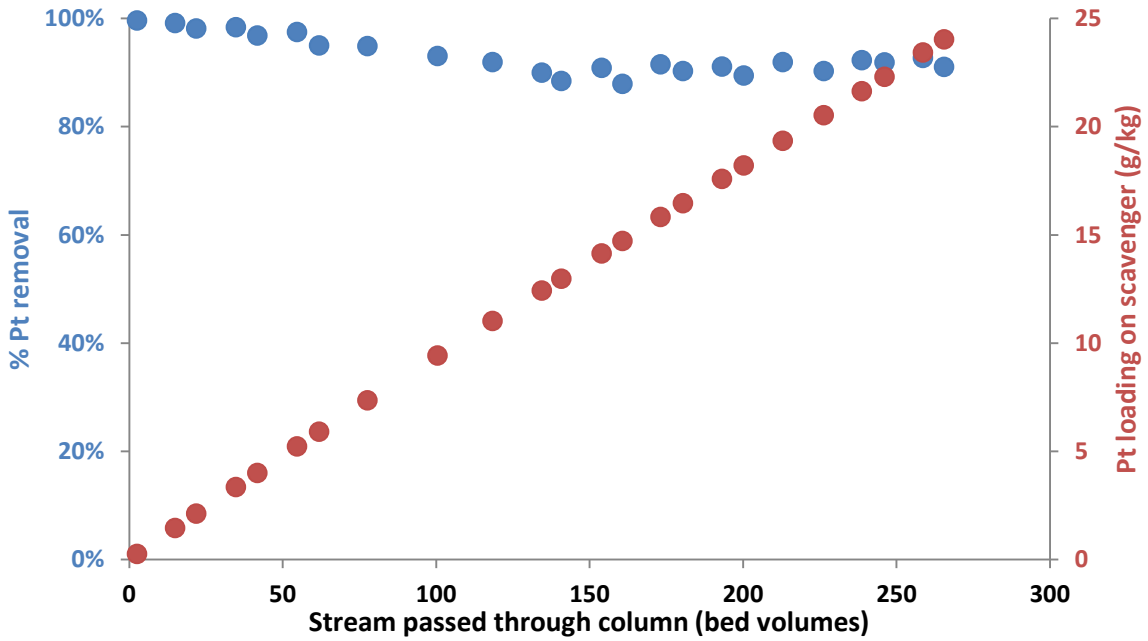
Pt Recovery from Silane Production

- organic waste stream from silane production containing ~ 50 ppm Pt
- >90% Pt recovery
- >2.5% loading of Pt on the scavenger



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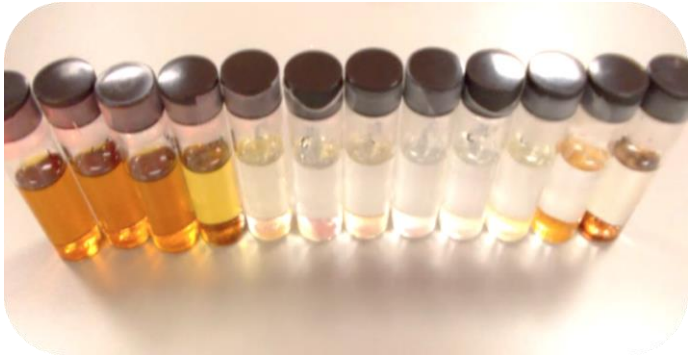
Au recovery from etching process



- Au waste from a gold etching process in the manufacture of PCBs
- acidic aqueous solution pH ~ 3.5
- 100 ppm Au

Fixed-bed performance

- before 104 mg/kg Au
- after < 0.4 mg/kg Au
- 4% Au loading on scavenger

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Thank you for your attention!

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