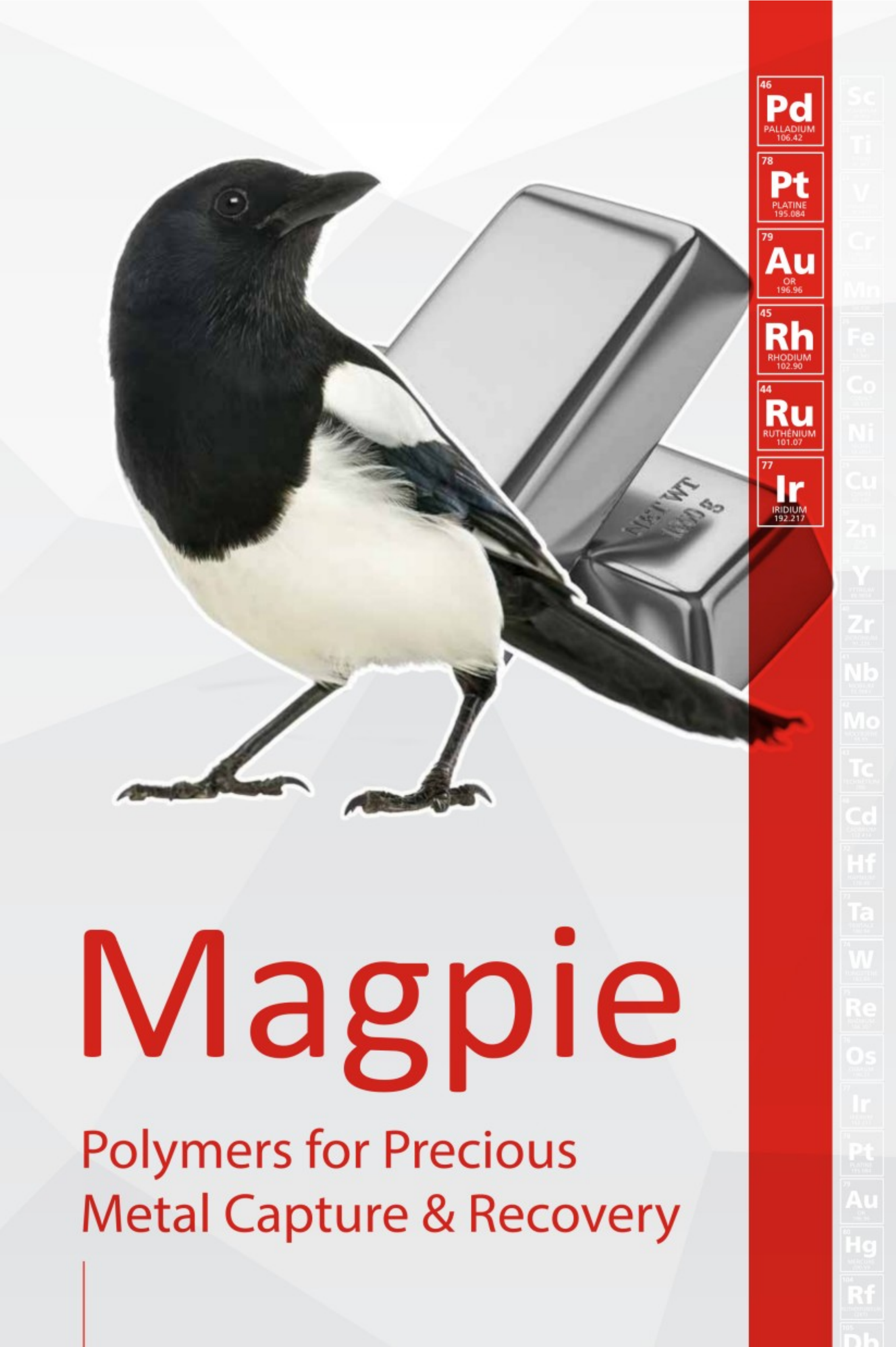

Metal Scavenging:

using low-value phosphorus materials to make metal refining more sustainable

http://www.magpie-polymers.com

Steven van Zutphen
December 2016

European Sustainable Phosphorus Platform

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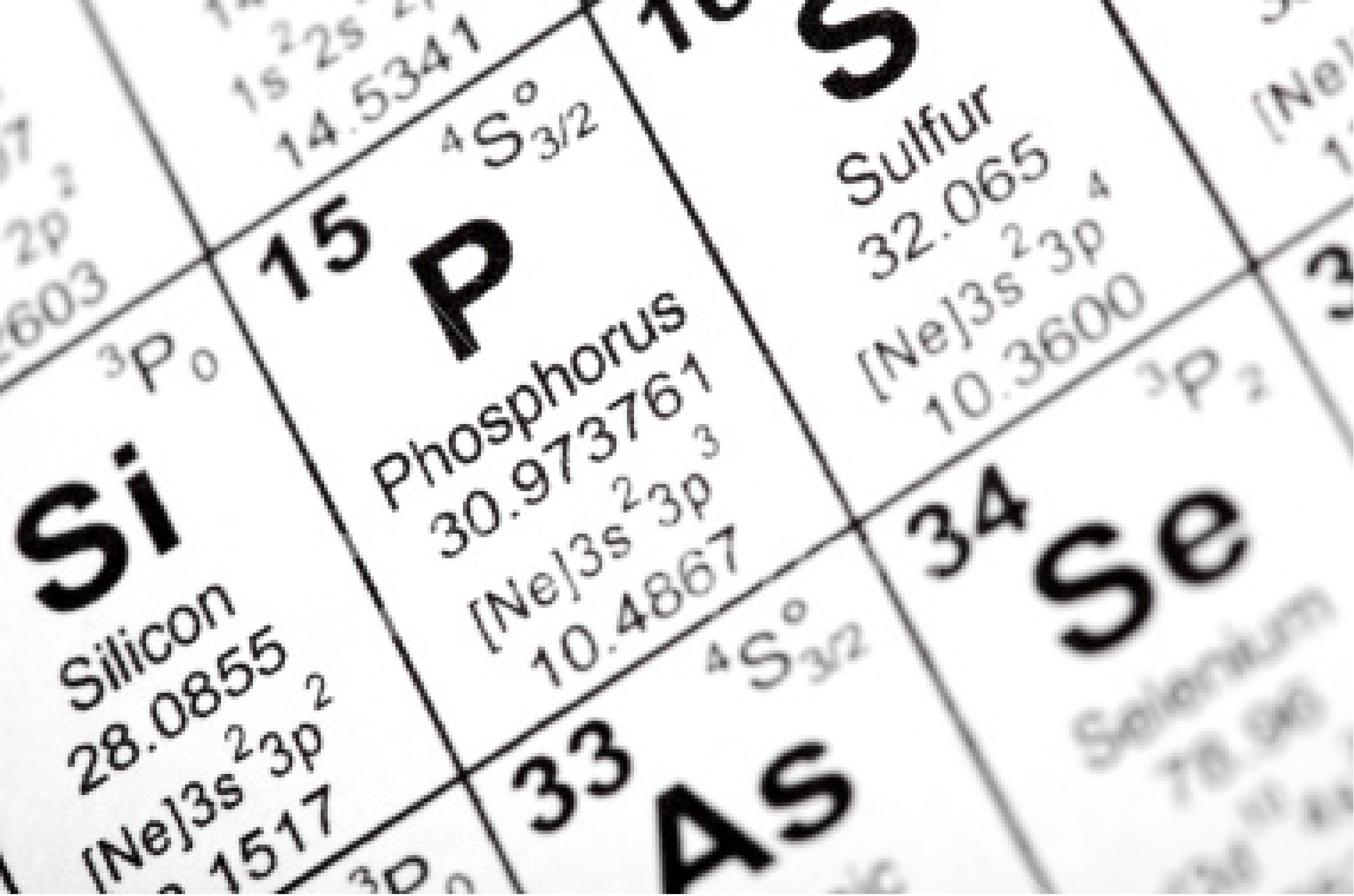
Polymers for Precious Metal Capture & Recovery


15
P
Phosphorus
30.973761
[Ne]3s2 3p3
10.4867
Sulfur
32.065
[Ne]3s2 3p4
10.3600
Si
Silicon
28.0855
[Ne]3s2 3p2
33
As
34
Se

Selective capture precious metals

Filtration of **industrial effluents**

Recover **value** from waste

SMALL EFFICIENCY INCREASES IMPACTS BOTTOM-LINE

Market Value : 28 000€/kg

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SMALL EFFICIENCY INCREASES IMPACTS BOTTOM-LINE

Market Value : 28 000€/kg

Raw materials : 26 600€

SMALL EFFICIENCY INCREASES IMPACTS BOTTOM-LINE

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Inefficiencies : 480€

SMALL EFFICIENCY INCREASES IMPACTS BOTTOM-LINE

Market Value : 28 000€/kg

Raw materials :	26 600€
Processing cost :	520€
Inefficiencies :	480€
Profit :	400€

SMALL EFFICIENCY INCREASES IMPACTS BOTTOM-LINE

Market Value : 28 000€/kg

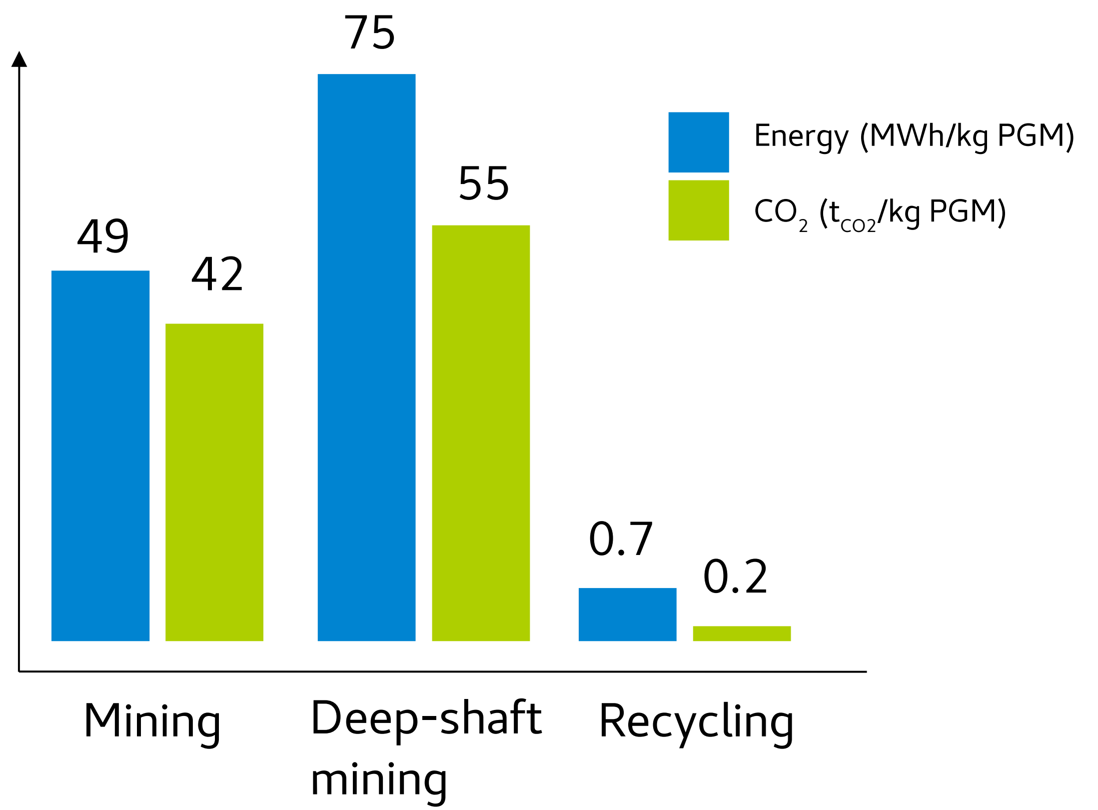
Raw materials :	26 600€	
Processing cost :	520€	
Inefficiencies :	480€	50% more efficient
Profit :	400€	

SMALL EFFICIENCY INCREASES IMPACTS BOTTOM-LINE

Market Value : 28 000€/kg

Raw materials :	26 600€	
Processing cost :	520€	
Inefficiencies :	480€	50% more efficient
Profit :	400€	60% higher

EFFICIENT RECYCLING KEY FOR SUSTAINABILITY



Sources:

Sustainable Development Report 2009, p56, Anglo Platinum
Sustainability Reporting and the Platinum Group Metals, G.M. Mud 2012,
Nature Biotech 1999, p541
PGM recycling at Hereaus, 2012

Manufacturing of **high-value chemicals**

Innovation driven by **economics**

Real and measurable impact on
health, safety and **environment**

Founded in **2011**

450 m² facilities **1h** from Paris

10 people, **10** products, **10** countries

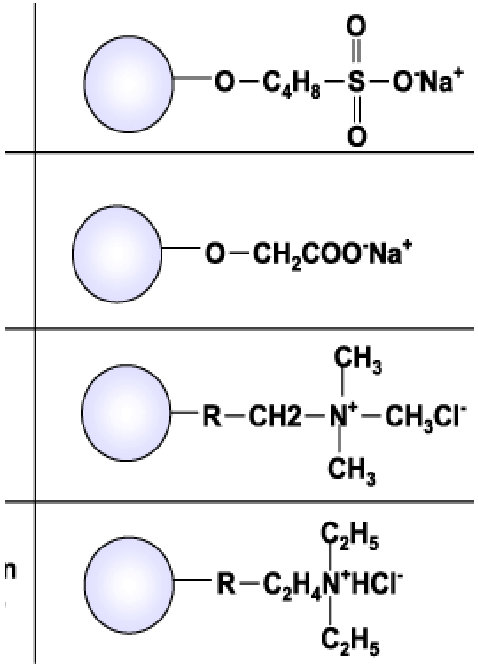
Based on **innvation** from 2007

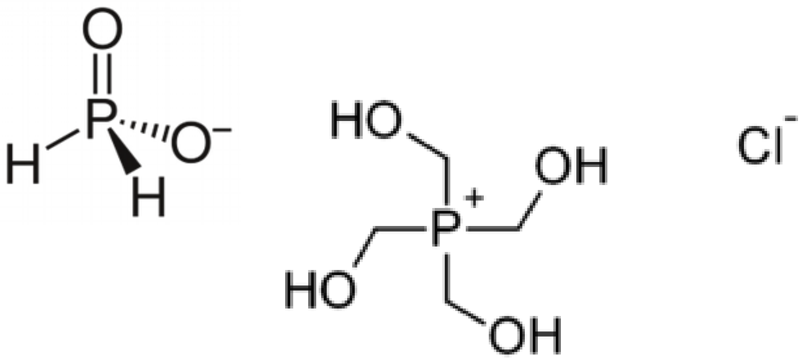
Discovery of something exisiting but unknown

Invention of something new

Innovation by combining things in a novel way

MAGPIE USES PHOSPHORUS UNLIKE THE OTHERS





Typical ion-exchangers

- Use acids (sulphonate or carboxylic) for **cation** exchange
- Use amines (tertiary and quaternairy) for **anion** exchange
- Use sulfur (thiol, thiouronium) for **chelating** functional groups

Magpie uses phosphorus

- **Unique coordination properties** of phosphines, phosphine oxide and phosphonates
- No need for **PCl** or **PLi** type species in production
- Use **PH** bonds for our chemistry

PRODUCT AND PROCESS INNOVATION

Process development example:

- **Surface treatment** industry
- Use our **knowledge** in solution chemistry

Product development example:

- **Silver refining** industry
- Exploit **stability** of our materials

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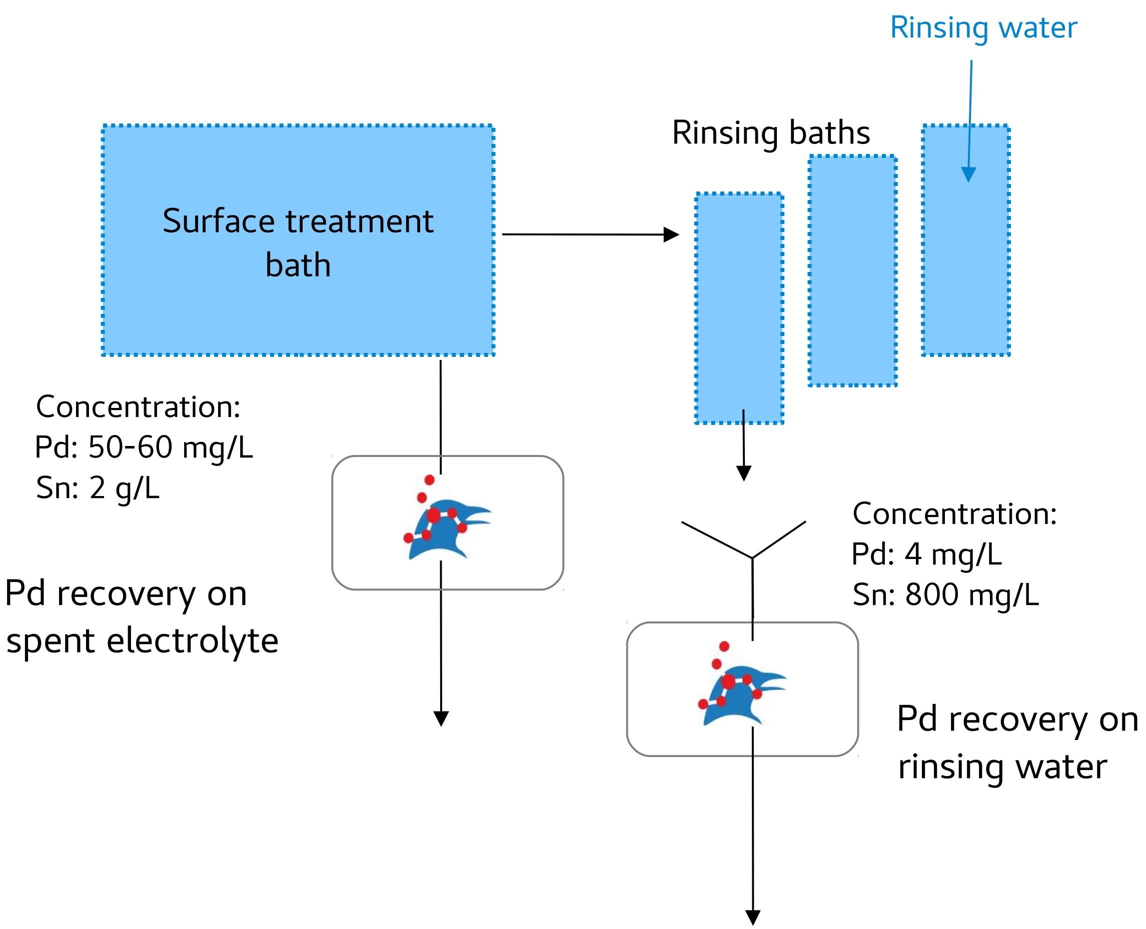
PLATING ON PLASTIC

POP, complex multistep process

- Layer **decorative** or **functional** gold/nickel/copper onto ABS plastic
- Key-step involves **Pd(0)** catalyst reducing a thin layer of metal on the surface
- Catalyst applied in **Pd/Sn colloid** form and reduced in-situ

PROBLEM FACED



MAGPIE SOLUTION

*Colloid is destablized while retaining palladium in **Pd(II)** form*

*Avoid **co-precipitation** of palladium and tin together*

*Scavange the palladium onto phosphine-oxide resin **MPS-1207***

Leave most tin in waste water to be removed at the water treatment station (hydroxide precipitation)

Step1 :	Palladium Loading
1% volume added, 15 min	25.7 g/L of MPS-1207

INDUSTRIAL SOLUTION

Automated system:

- Carries out the two step process with minimum intervention
- Recovers palladium on columns that can be changed when saturated

SILVER MARKET DEMANDS INCREASED PURITY

<3N Silver

>4N Silver

- 50/50 industrial / non-industrial uses of silver
- Electronics grade requires highest purity
- up to 30% higher in price
- 0.01% of impurity or 100 mg/kg

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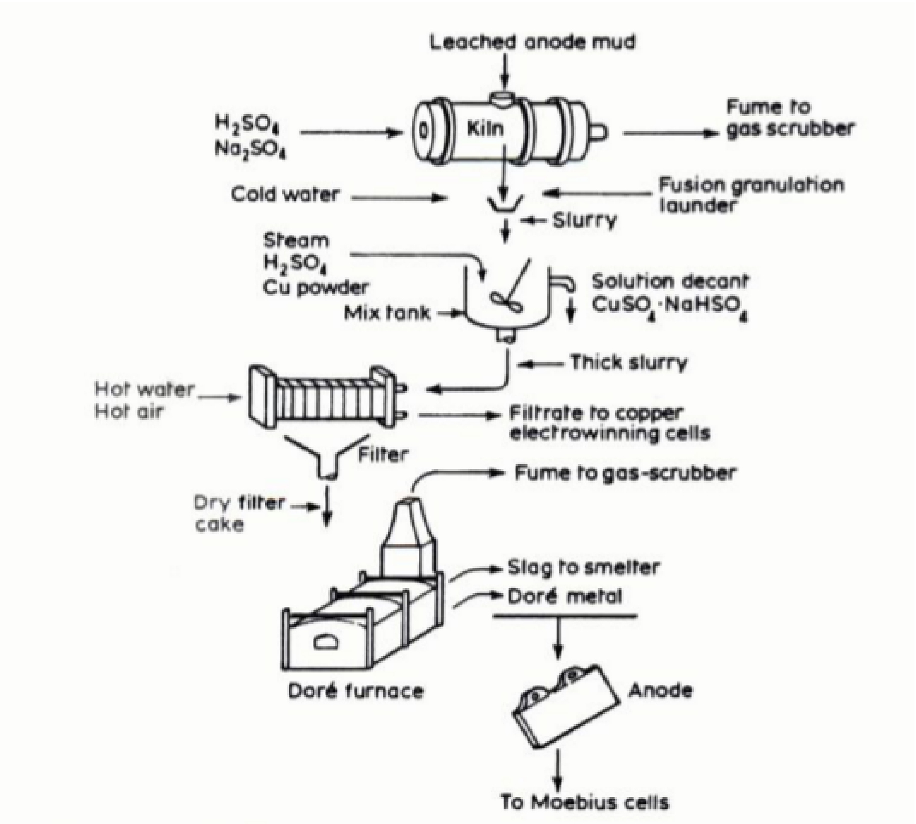
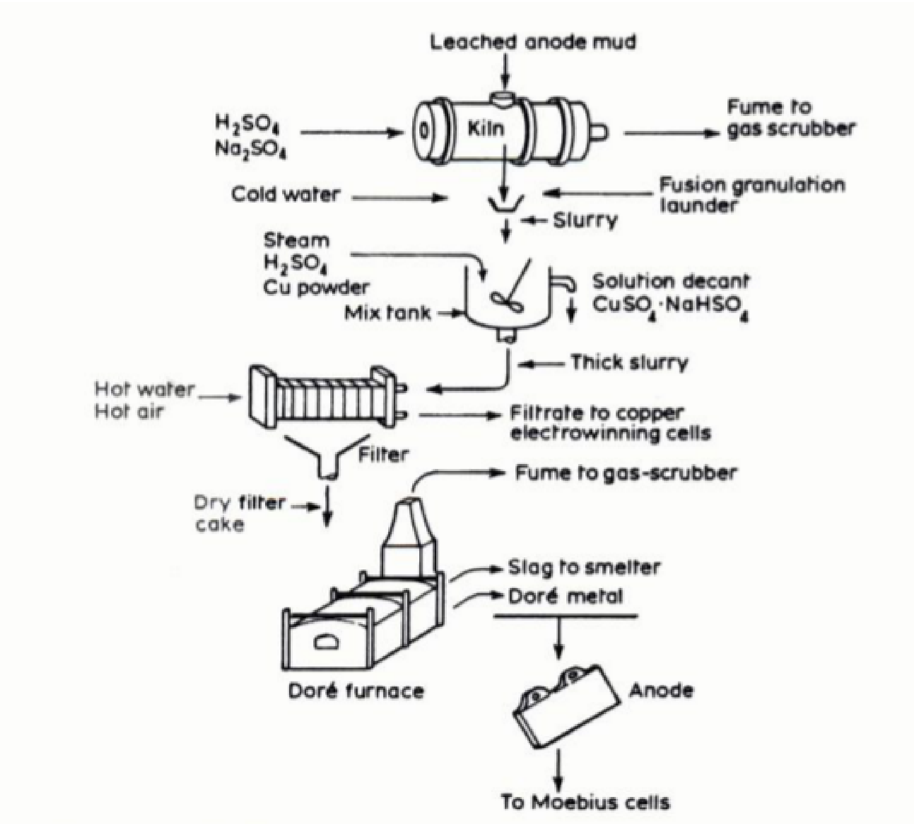
SILVER REFINING PROCESS: FROM WASTE TO VALUE

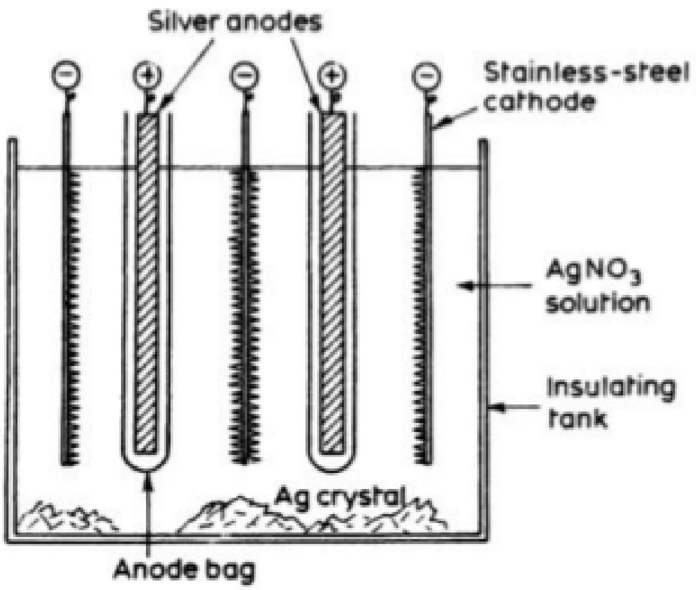


Step 1: obtain 80-90% pure silver

SILVER REFINING PROCESS: FROM WASTE TO VALUE

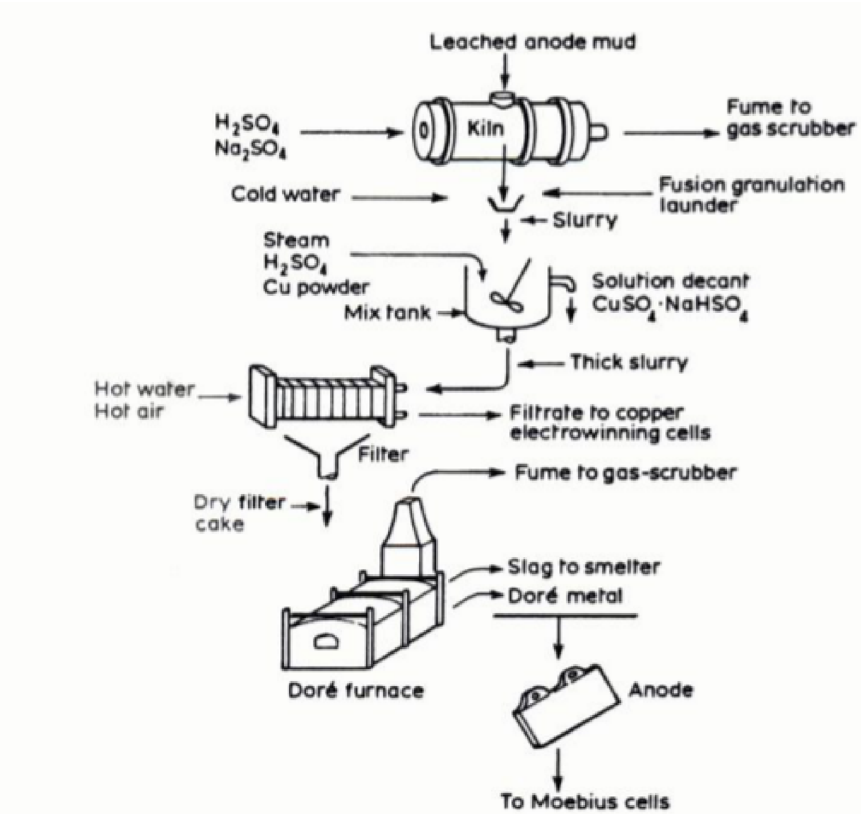


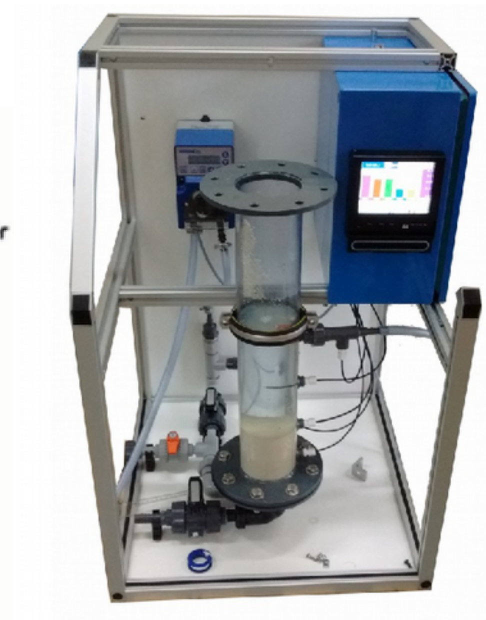
Step 1: obtain 80-90% pure silver

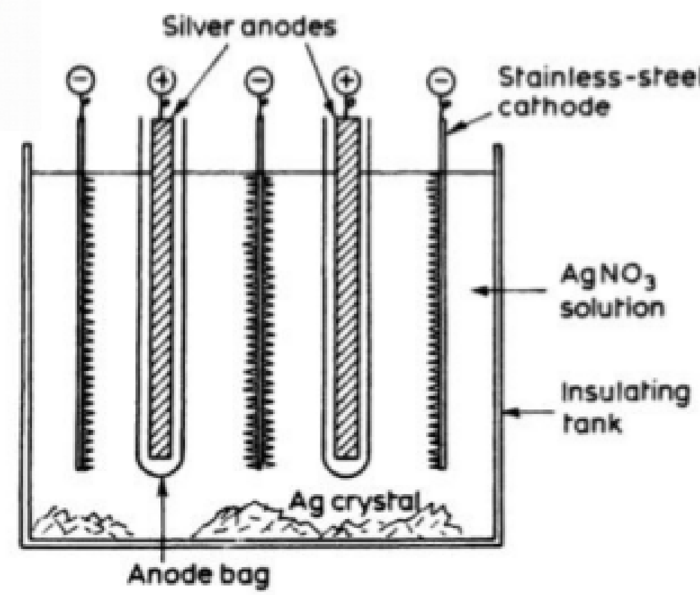


Step 2: obtain 99.9-99.99% pure silver

SILVER REFINING PROCESS: FROM WASTE TO VALUE



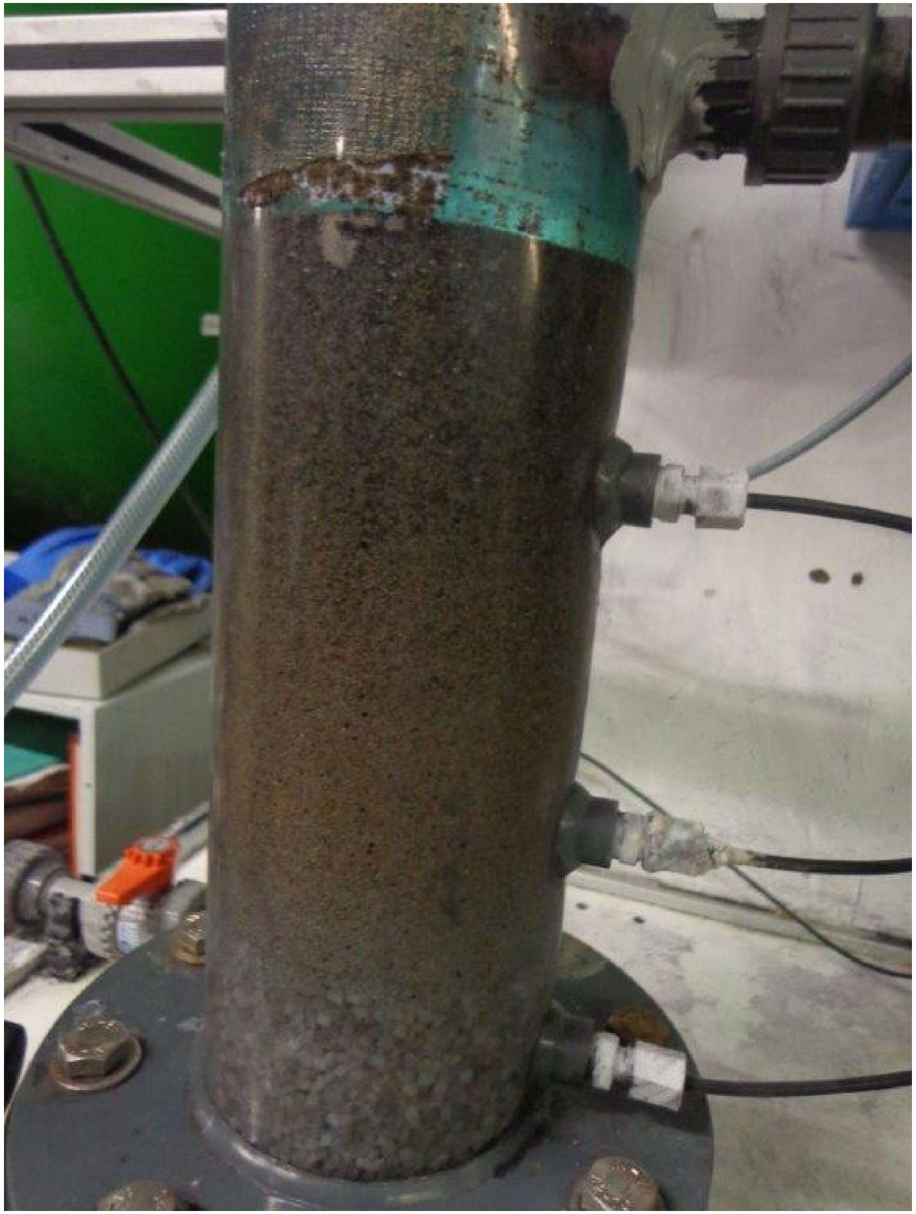




Step 1: obtain 80-90% pure silver

Step 2: obtain 99.9-99.99% pure silver

SILVER REFINING PROCESS: FROM WASTE TO VALUE



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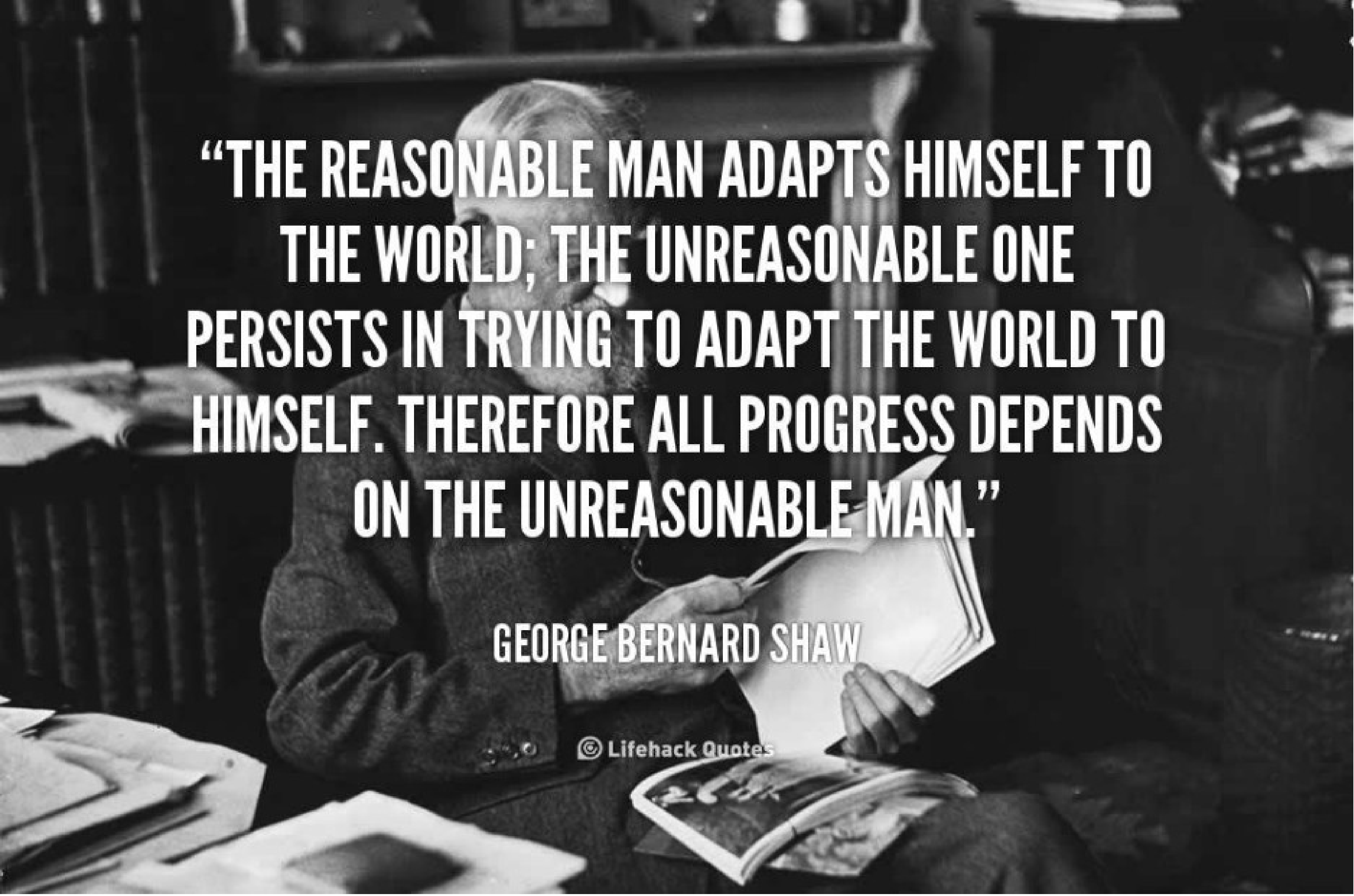

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