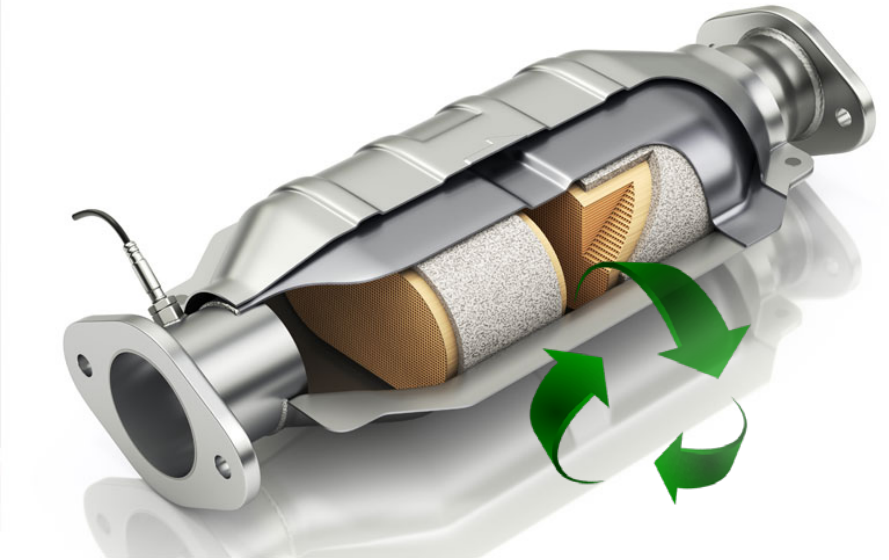
DEPARTMENT OF CHEMICAL ENGINEERING,
BIOTECHNOLOGY AND ENVIRONMENTAL TECHNOLOGY

Sustainability and recovery of precious metals from scrapped DPF



Associate professor: Shuang Ma Andersen

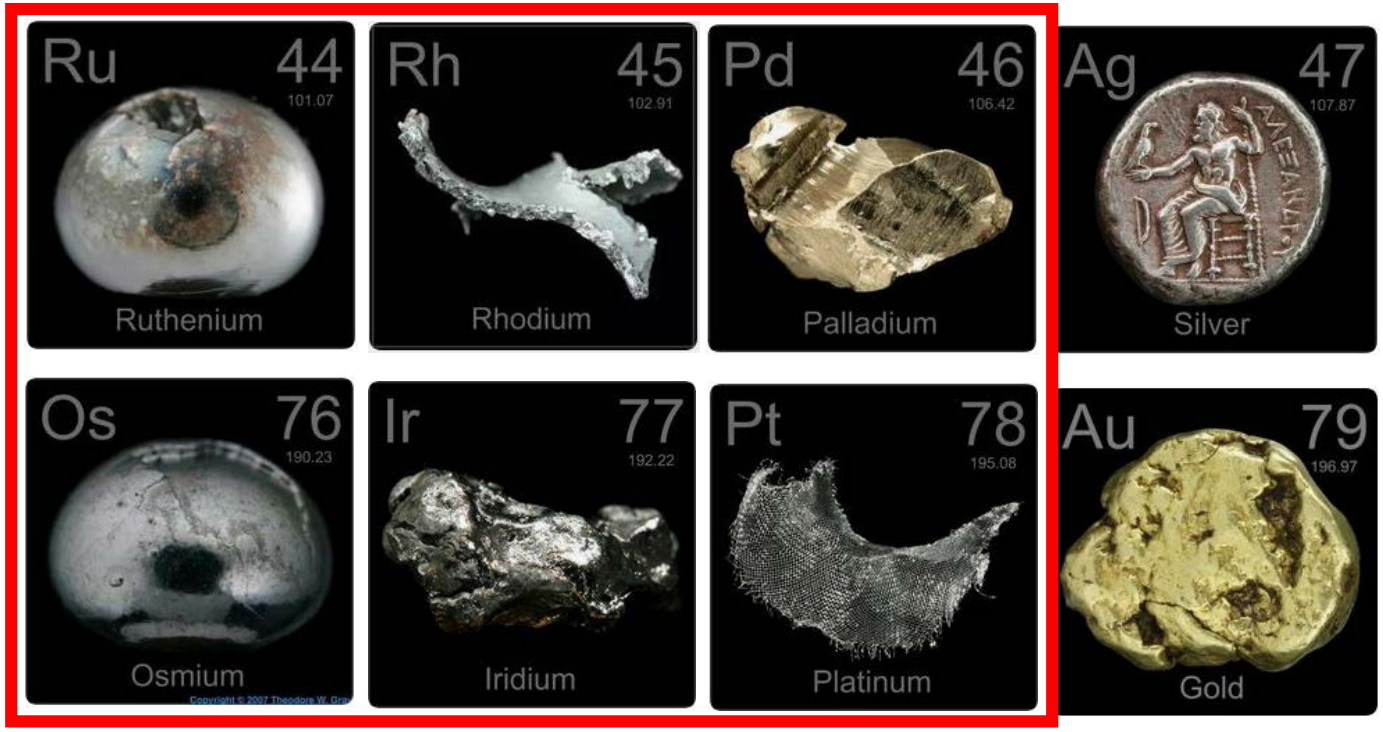
Section: Chemical Engineering
Department of Chemical engineering, Biotechnology & Environmental Technology
University of Southern Denmark
mashu@kbm.dk

SDU

Platinum Group Metals (PGMs)

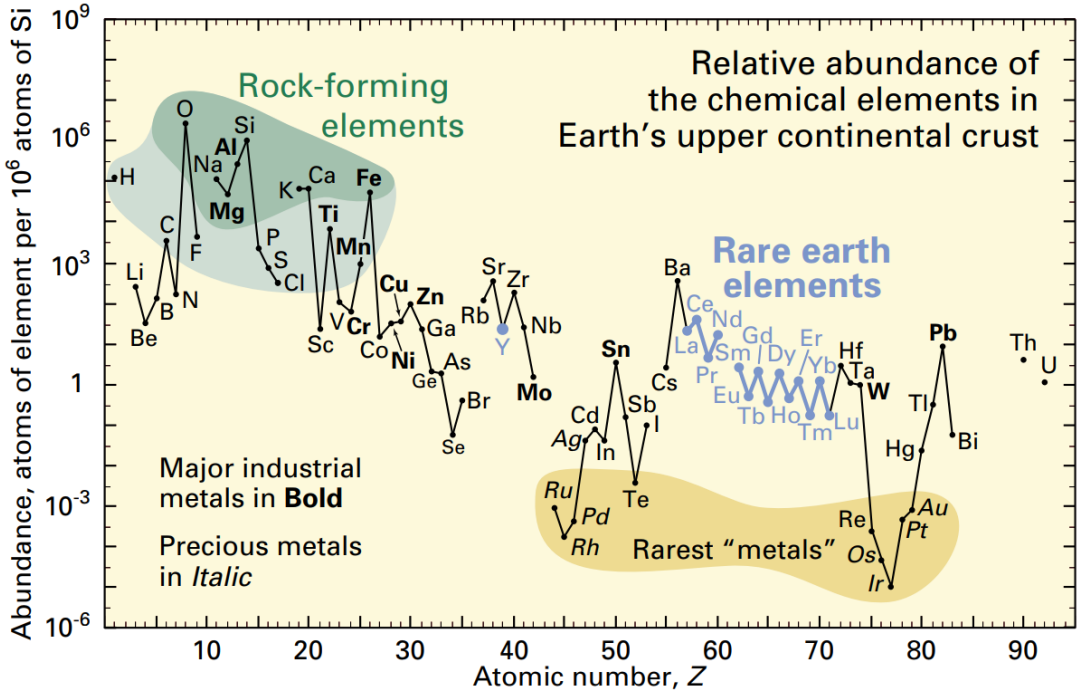
One of the 27 **critical raw materials** identified by EU

One quarter of all goods manufactured either contain a PGM or had a PGM play a key role in its production.

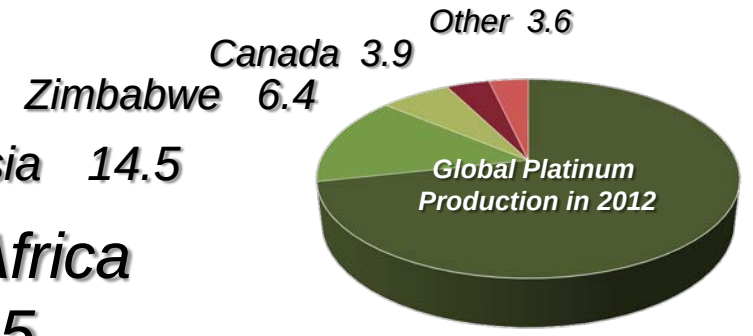


Platinum Group Metals (PGMs)

Precious Metals (PMs)

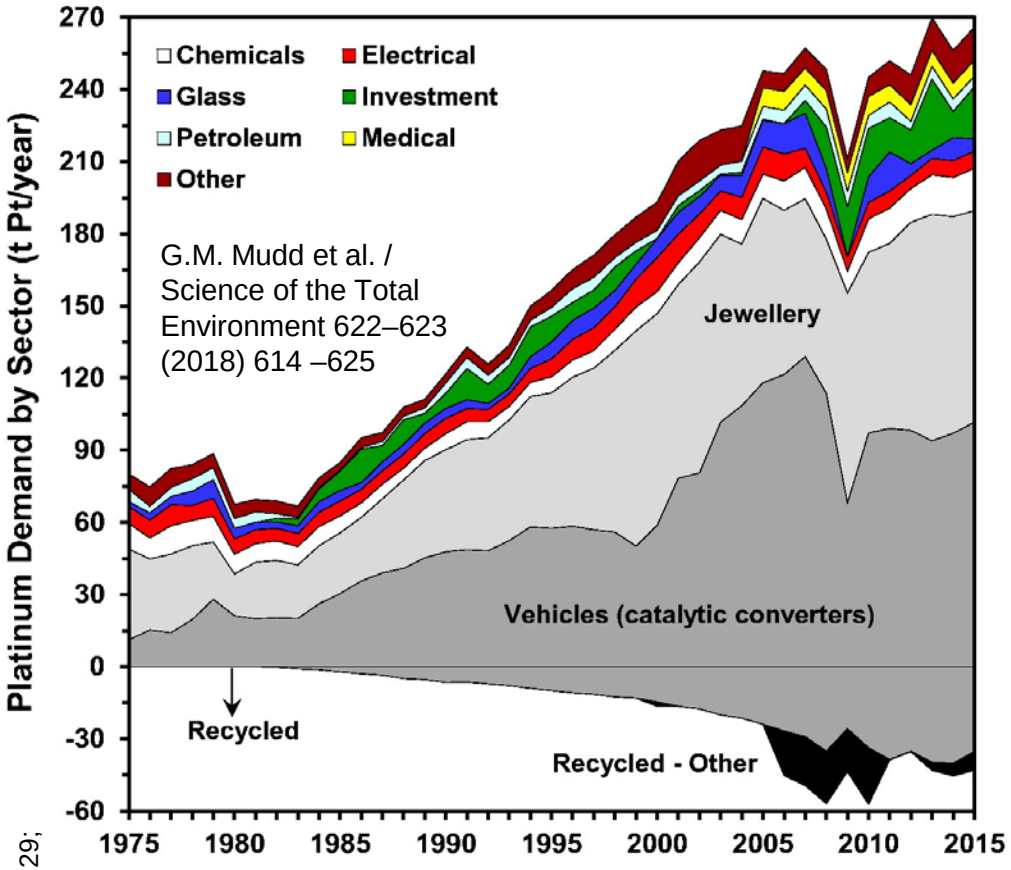


Abundance (atom fraction) of the chemical elements in Earth's upper continental crust as a function of atomic number.



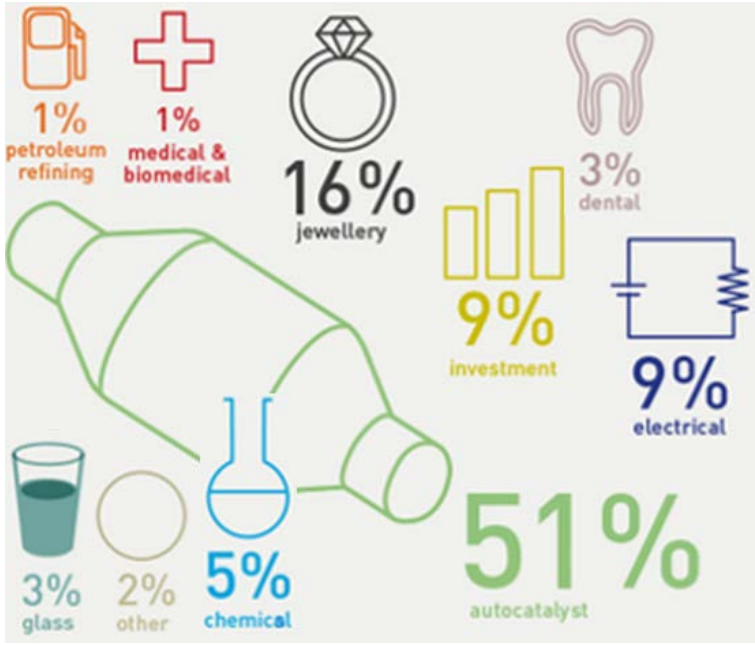
Gordon B. Haxel, Sara Boore, and Susan Mayfield from USGS

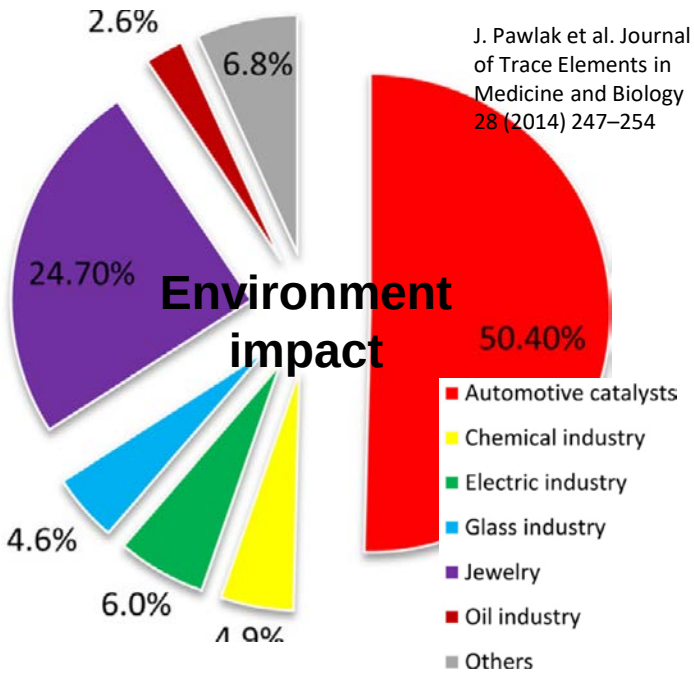
SDU



Platinum Metals Rev., 2012, 56, (1), 29;

PGM usages per industry as in 2010





Environment impact

J. Pawlak et al. Journal of Trace Elements in Medicine and Biology 28 (2014) 247–254

Primary ore: ~E-3 wt%

Auto catalyst: ~E-1wt%

Type of plant material	Concentration [ng/g]		
	Pt	Pd	Rh
Grass	8.98	3.20	0.68
Pine, birch	12.0	2.0	2.0
Tomato (without skin)	0.10	–	–
Carrot	0.31	–	–
Cabbage	1.1	–	–
Lettuce	2.1	–	–
Celery	1.3	–	–
Onion (without skin)	0.03	–	–
Dandelion	5.4–30	0.83–1.5	2.0–7.0
Greater plantain	3.6–10.1	0.45–2.1	1.1–3.4
Lichen	30.0	2.4	5.4
Rye grass	4.6–5.8	0.1	2.1–2.2

	Concentration [ng/g]		
	Pt	Pd	Rh
Shellfish tissue (*Asellus aquaticus*)	0.04–12.4	–	–
Mussel tissue (*Dreissena polymorpha*)	0.1–0.5	1.0	–
Eel liver (*Anguilla anguilla*)	–	0.18	–
Fish tissue (*Barbus barbus*)	0.1–0.4	0.3–7.0	0.1–2.0
Peregrine falcon (*Falco peregrinus*)			
Feathers	0.5	1.4	0.3
Blood	2.7	0.8	0.6
Eggs	0.4	0.5	0.3
Feces	0.2	–	–
Liver	0.2	0.7	0.3
Kidneys	0.2	0.3	0.3

PGM content in selected samples of plants and animal tissues

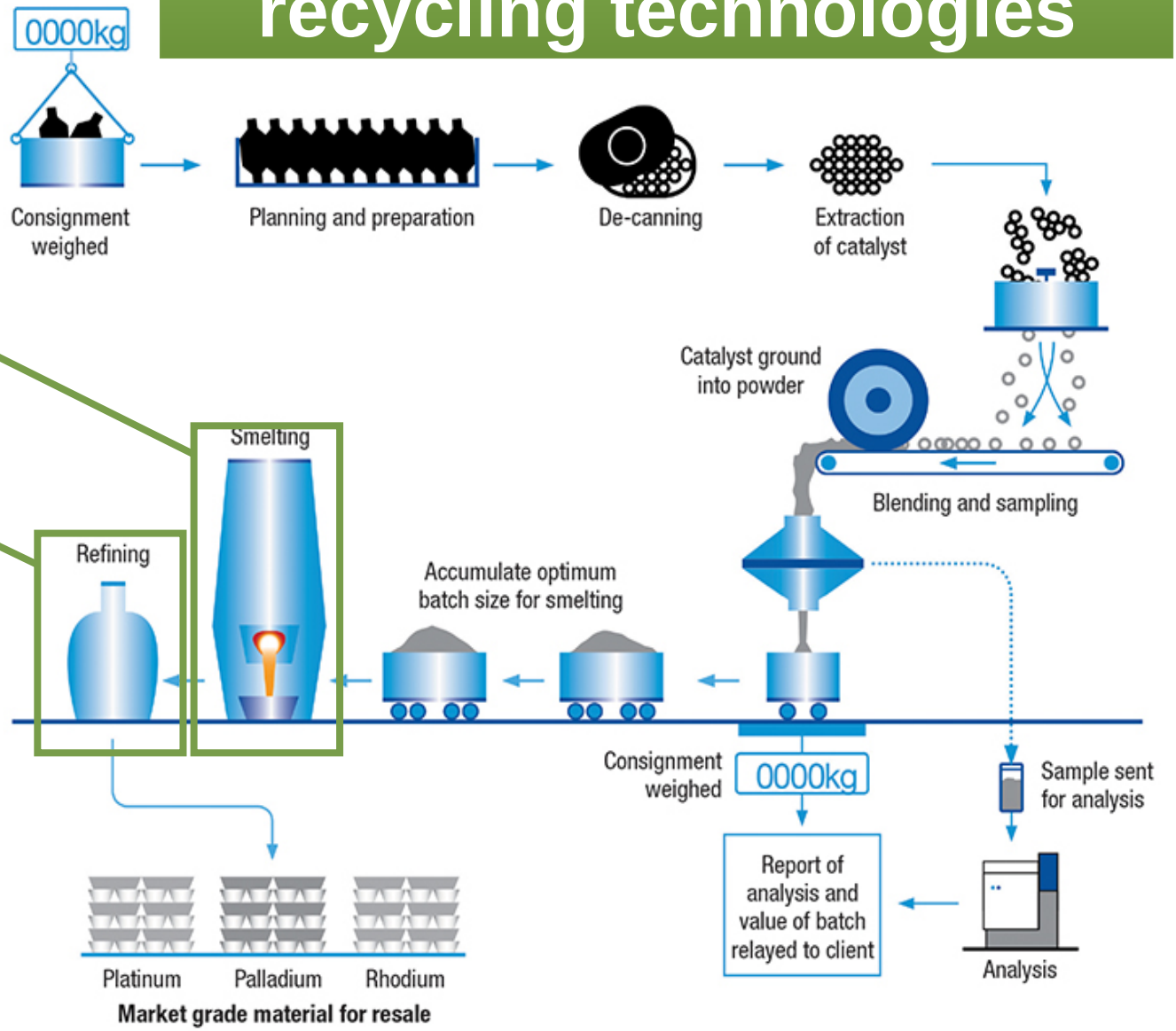
Current industrial PGM recycling technologies

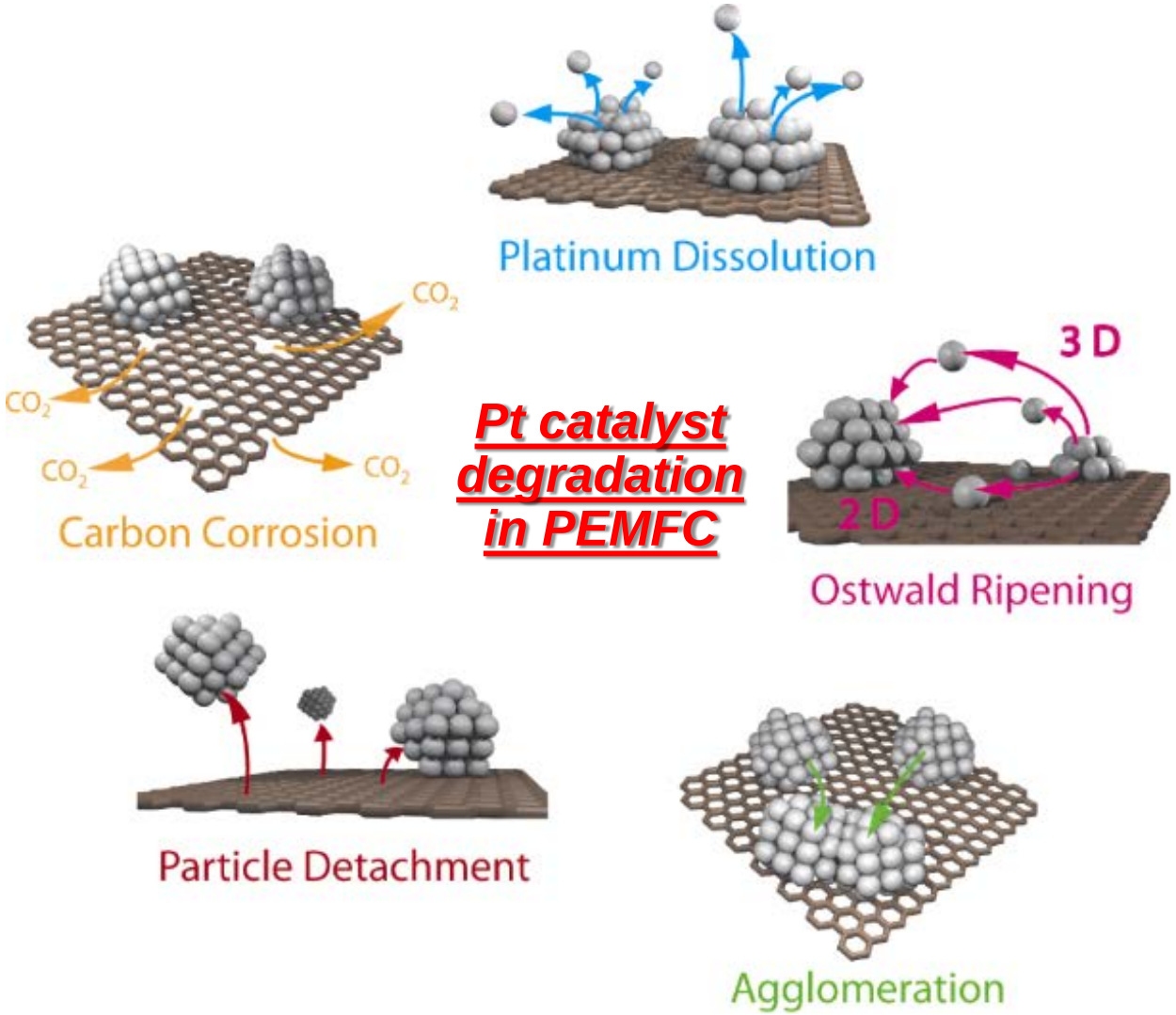
Pyrometallurgy

High temperate - energy demanding and may generate harmful substances

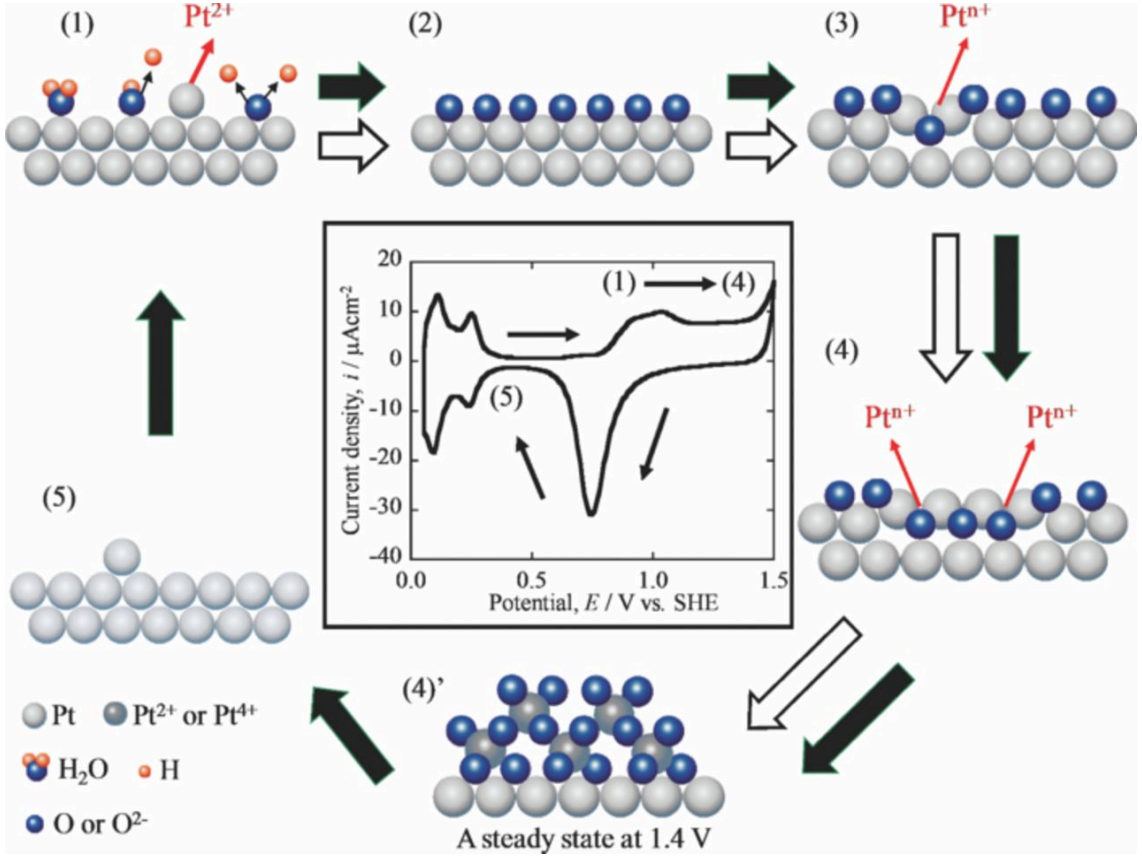
Hydrometallurgy

Hazardous chemicals such as the toxic complexing agent NaCN or the corrosive *aqua regia*





Fundamental principle of platinum dissolution is described by surface reaction dominated by transit potential treatment.



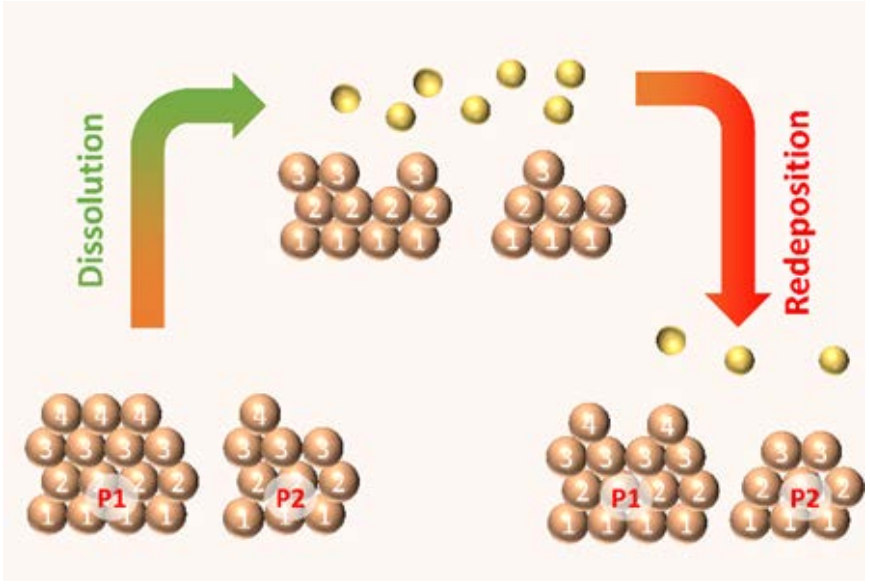
Electrochemical potential cycling enhances the dissolution rates (2-3 order) as compared to static potential

Dissolution efficiency > 95%

J.C. Meier, et al. Beilstein J. Nanotechnol. 2014, 5, 44–67

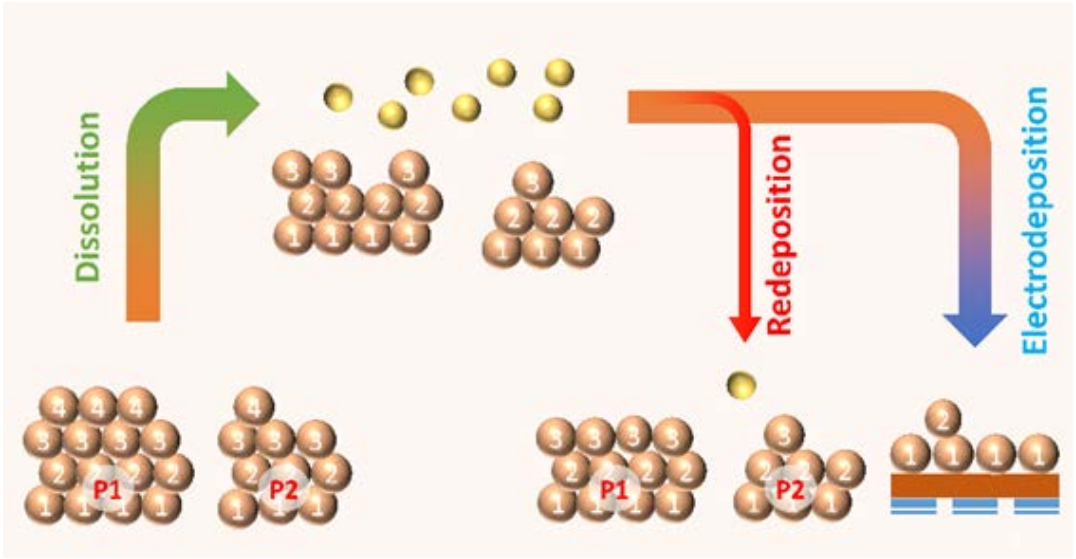
Y. Sugawara, et al, J. Electrochem. Soc. 2012, 159, 11, F779-F786

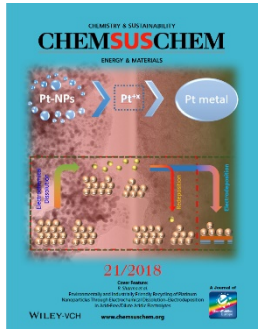
SDU

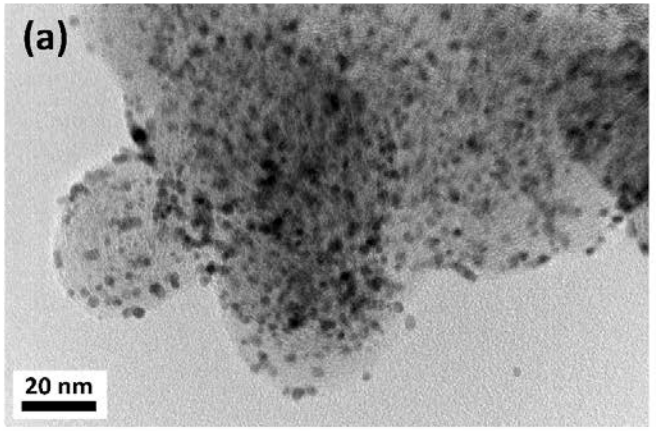


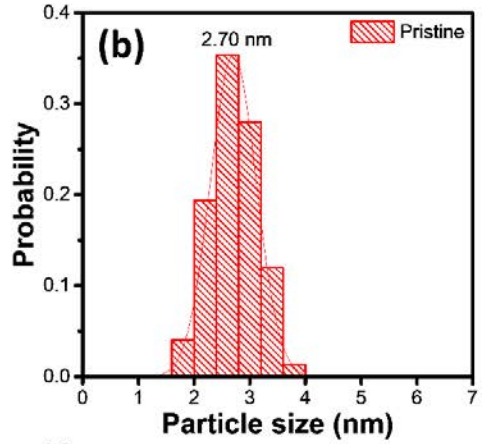
Ordinary potentiodynamic operation leads to significant redeposition.

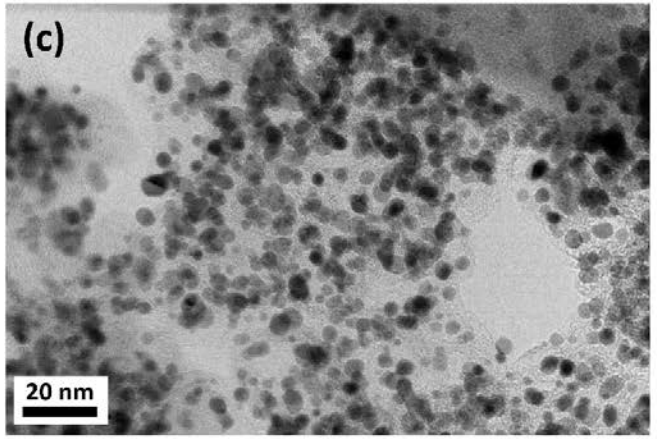
Continuous collection of dissolved Pt species with a separate electrode increases dissolution efficiency and improve reaction kinetic.

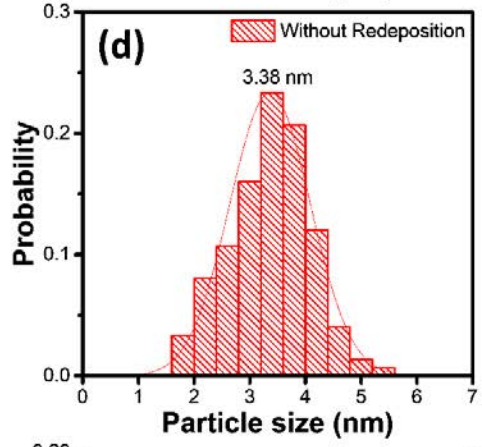


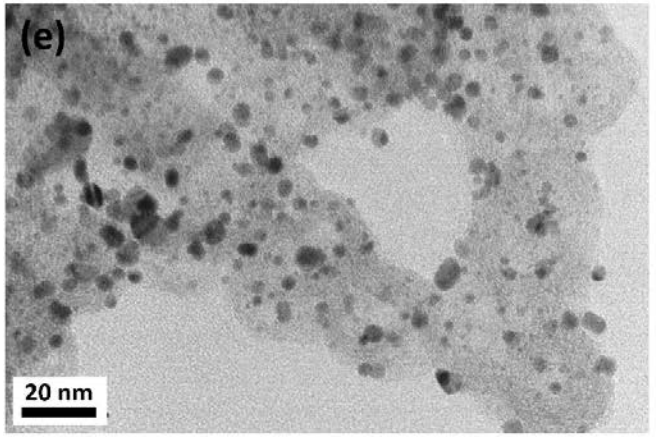


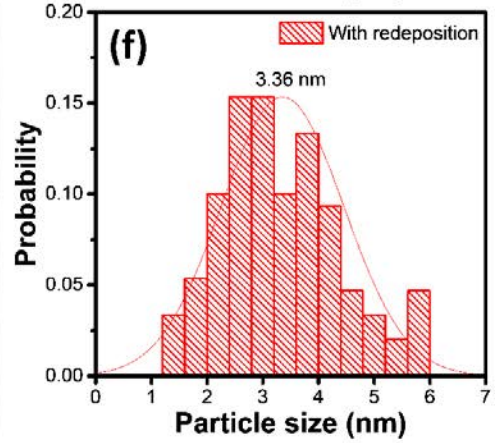




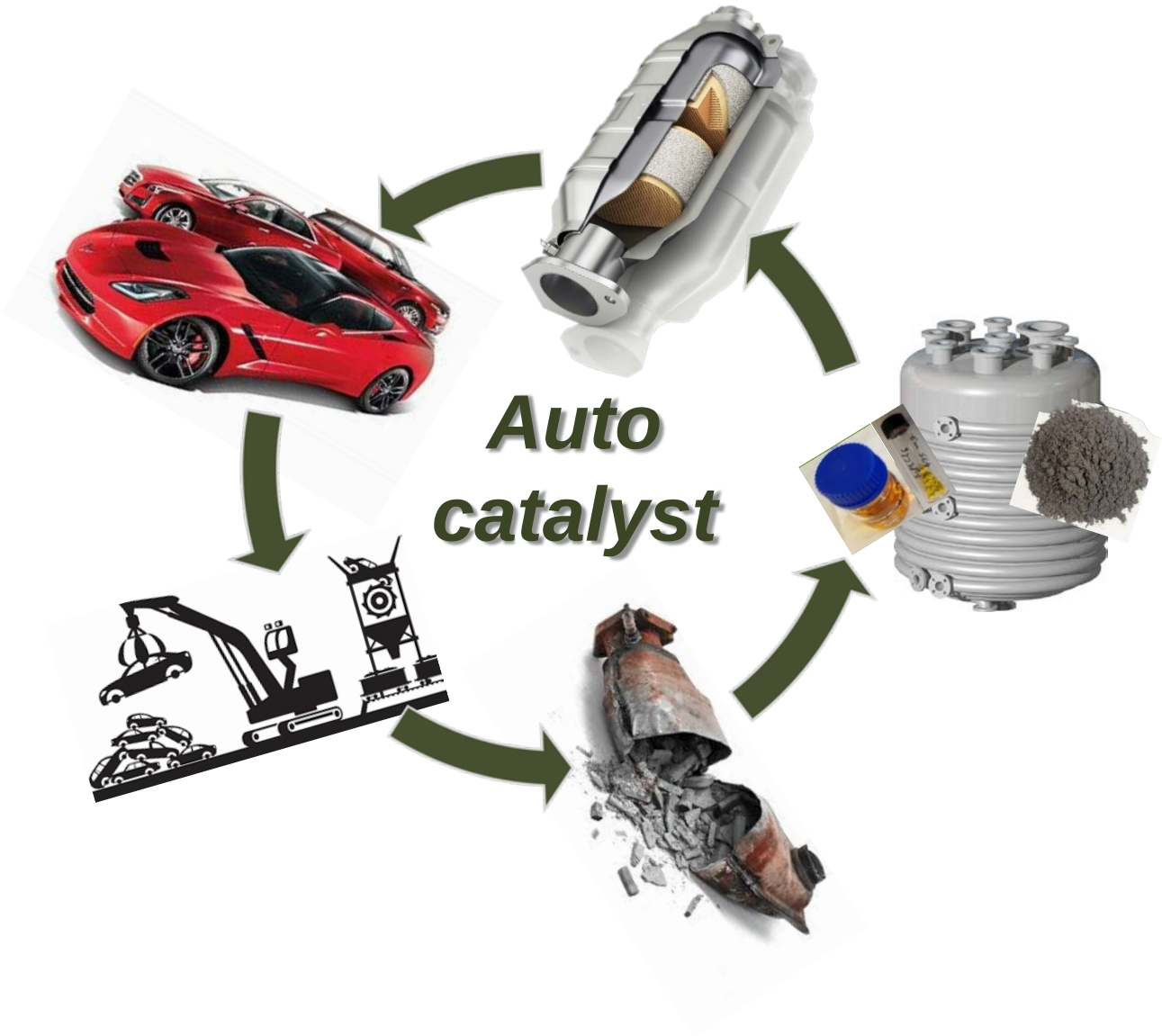








R. Sharma, S. Gyergyek& S.M. Andersen. ChemSusChem, 2018, 11, 3742 – 3750.



Economy and benefit

Secondary raw materials

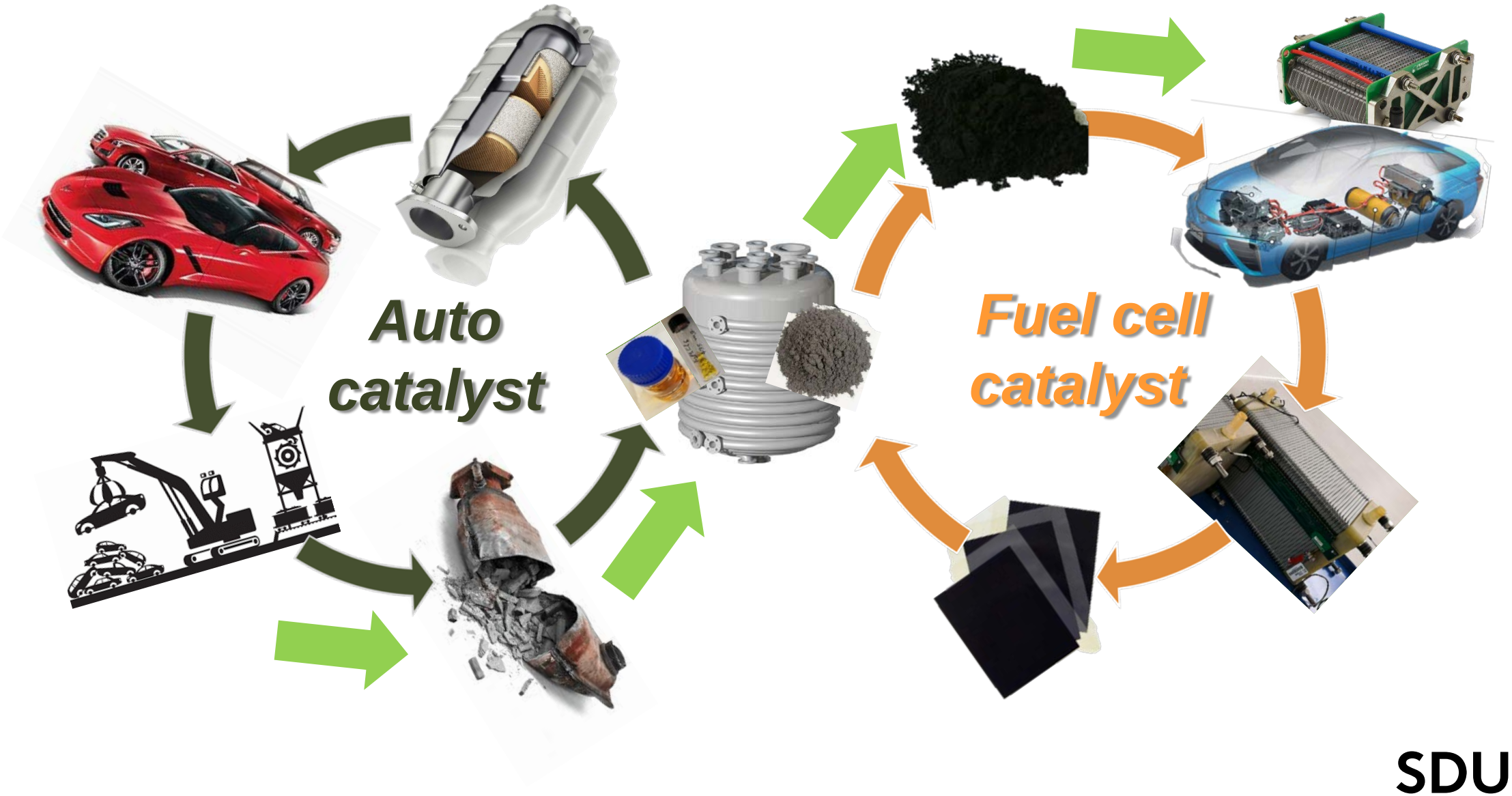
- 90% cheaper than primary production
- Reduce environmental and health issues
- Smart waste management – urban mining

Alternative process

- Flexible and low capital cost
- Environmentally friendly
- Potential for decentralized facility
- Value added products

SDU


Fuel cell
catalyst


Auto
catalyst
Fuel cell
catalyst

- **Improve waste management and regulation**
- **Sustainable recycling development**
- **Green transformation**

SDU

Acknowledge

THE VELUX FOUNDATIONS
VILLUM FONDEN VELUX FONDEN

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad

EUDP
Energiteknologisk udvikling og demonstration

Jožef Stefan Institute

CriMaRec Aps
Critical Material Recovery

UCLM
UNIVERSIDAD DE CASTILLA-LA MANCHA

ENERGINET.DK

DTU

HyPlat

Innovationsfonden

Ser energy®
The Power of Simplicity

DANIDA
Ministry of Foreign Affairs of Denmark

Danish Power Systems®

SDU

Thanks for your attention

mashu@kbm.sdu.dk