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The complete thermochemical recycling of sewage sludge

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The complete thermochemical recycling of sewage sludge

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InsPyro

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958267.

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MISSION: INSPIRING METALLURGY

InsPyro improves existing metallurgical processes and develops new **sustainable processes** together with its customers

Phosphorus recovery

- Why?

Elemental phosphorus (P4) is 100% imported in Europe

It is a critical raw material

- Sewage sludge is a rich source of phosphorus

- Legislation changes are changing the market

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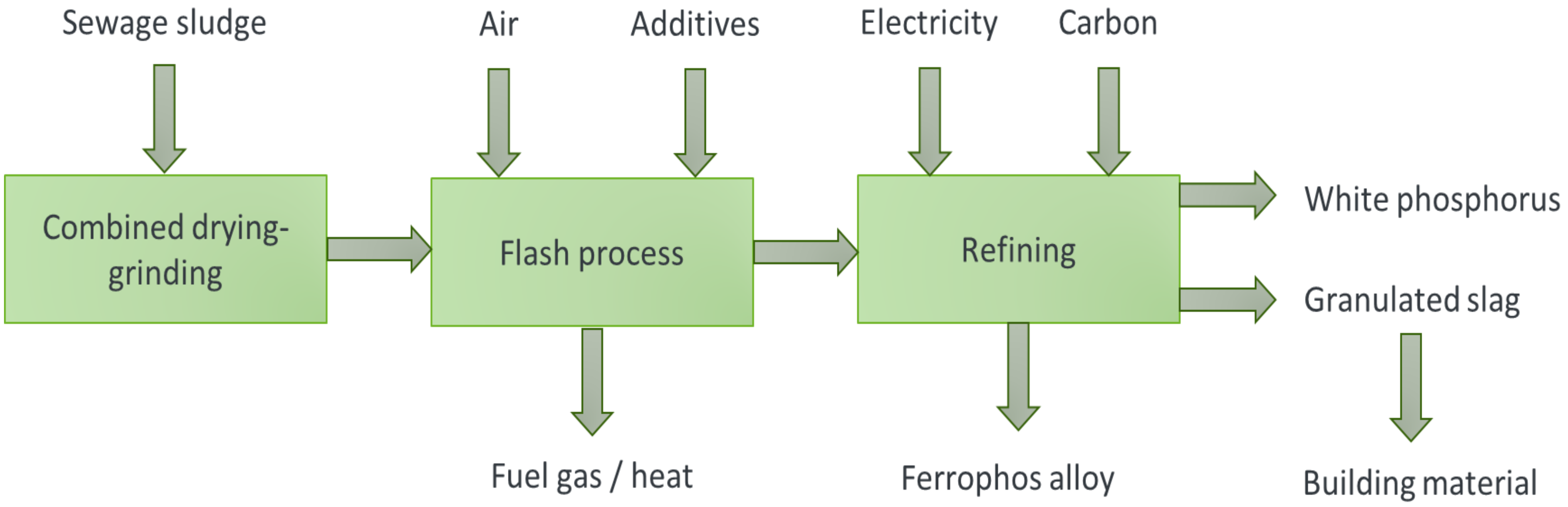
Flashphos process



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FlashPhos consortium

- Coordinator: Uni Stuttgart
- Consortium: Covering process engineering and technology, building materials, commercialization, environmental impact
- InsPyro's role:
  - Thermodynamic modelling, mass and energy balances, virtual plant (digital twin)
  - Lab scale experiments on thermal and reduction behaviour of sewage sludge

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Purpose of thermodynamic investigation

- Operational temperature
- Atmosphere conditions
- Fluxing strategies
- Energy requirements
- Distribution of elements over different phases

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Tools

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Tools

DSC-TGA

Gas outlet | Heating compartment | Control panel | Balance

FactSage™

Tube Furnace

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Process Steps

Volatilisation → Combustion → **Melting** → **Reduction**

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Melting behaviour of the ash

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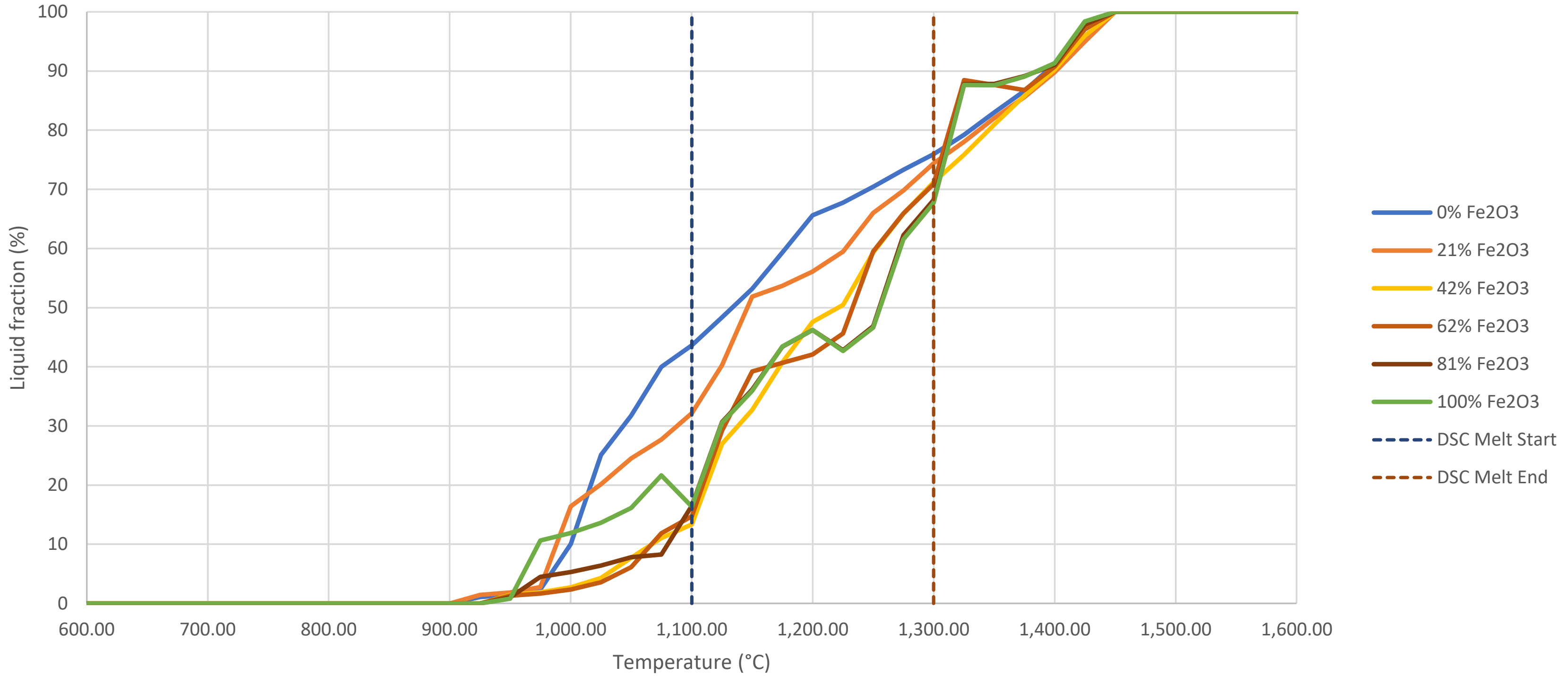
Ash composition

Component	Weight (%)
CaO	11
SiO_2	21
Al_2O_3	23
Fe_2O_3	24
SO_3	3
MgO	2
K_2O	2
P_2O_5	10
Minor compounds	2
Total	100

Calculated melting behavior of ash



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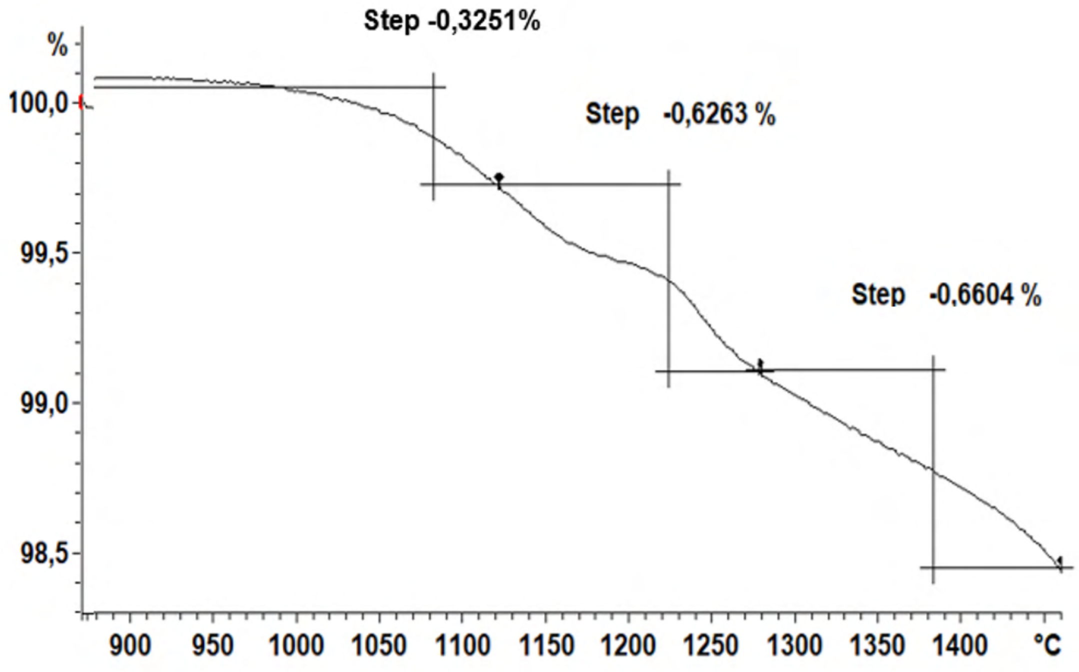
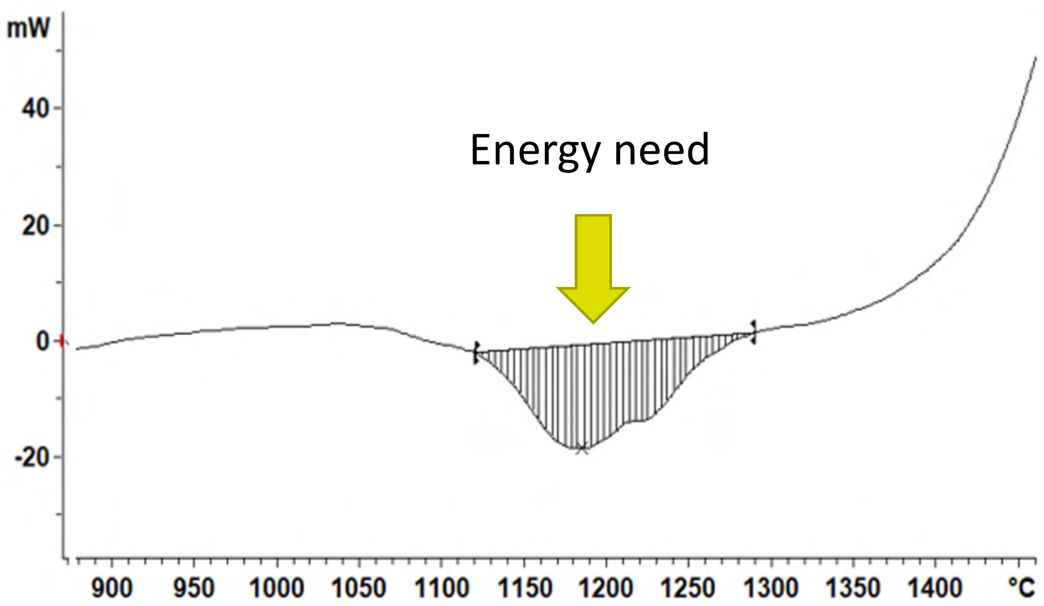
Melting behaviour of the ash

Measured ash melting behaviour



Solid

Liquid



Solid

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Reduction of ash

Ash composition

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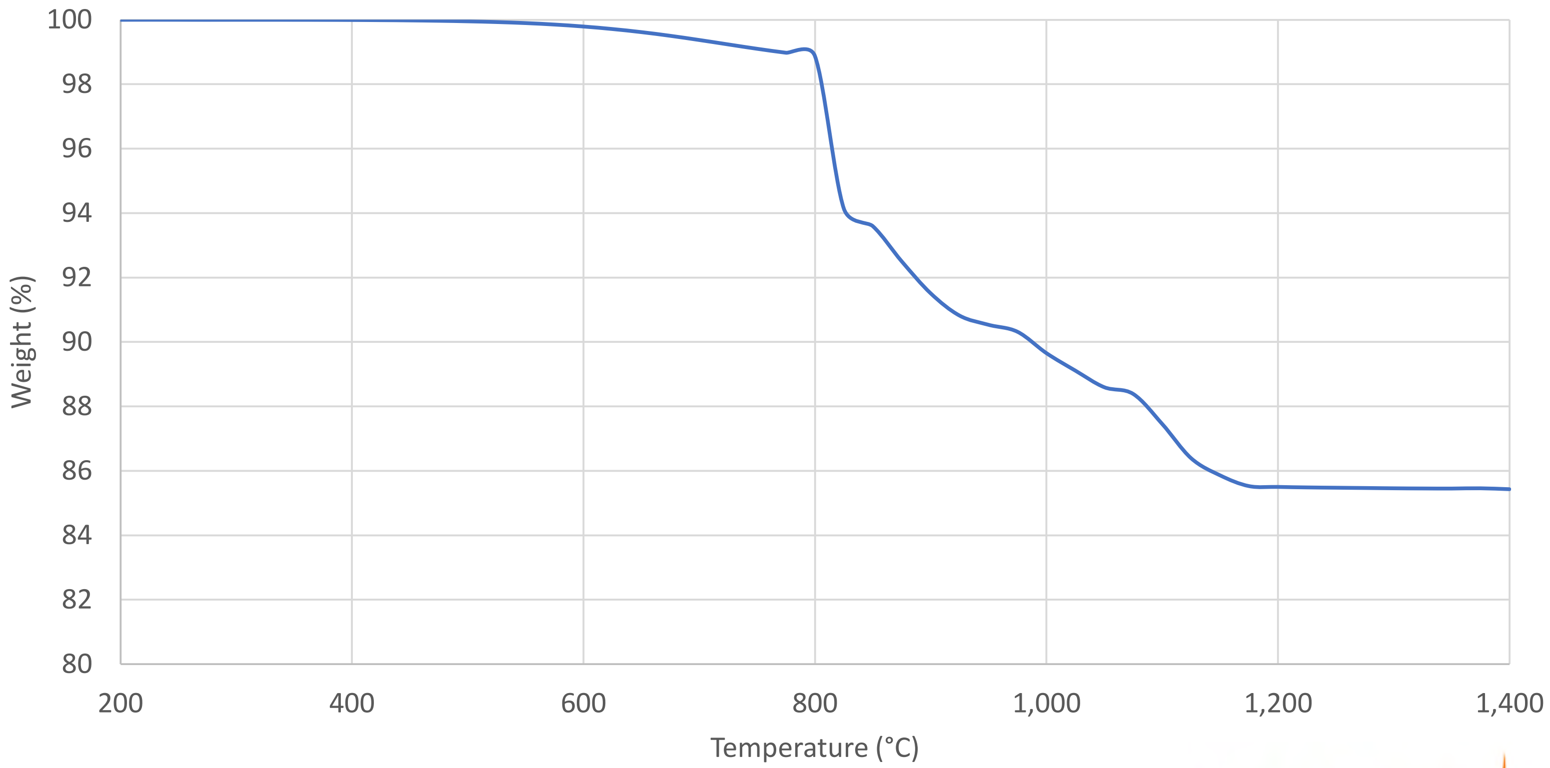
Minor compounds	2
Total	100

Calculated weight evolution



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Reduction of ash

Measured ash reduction behaviour

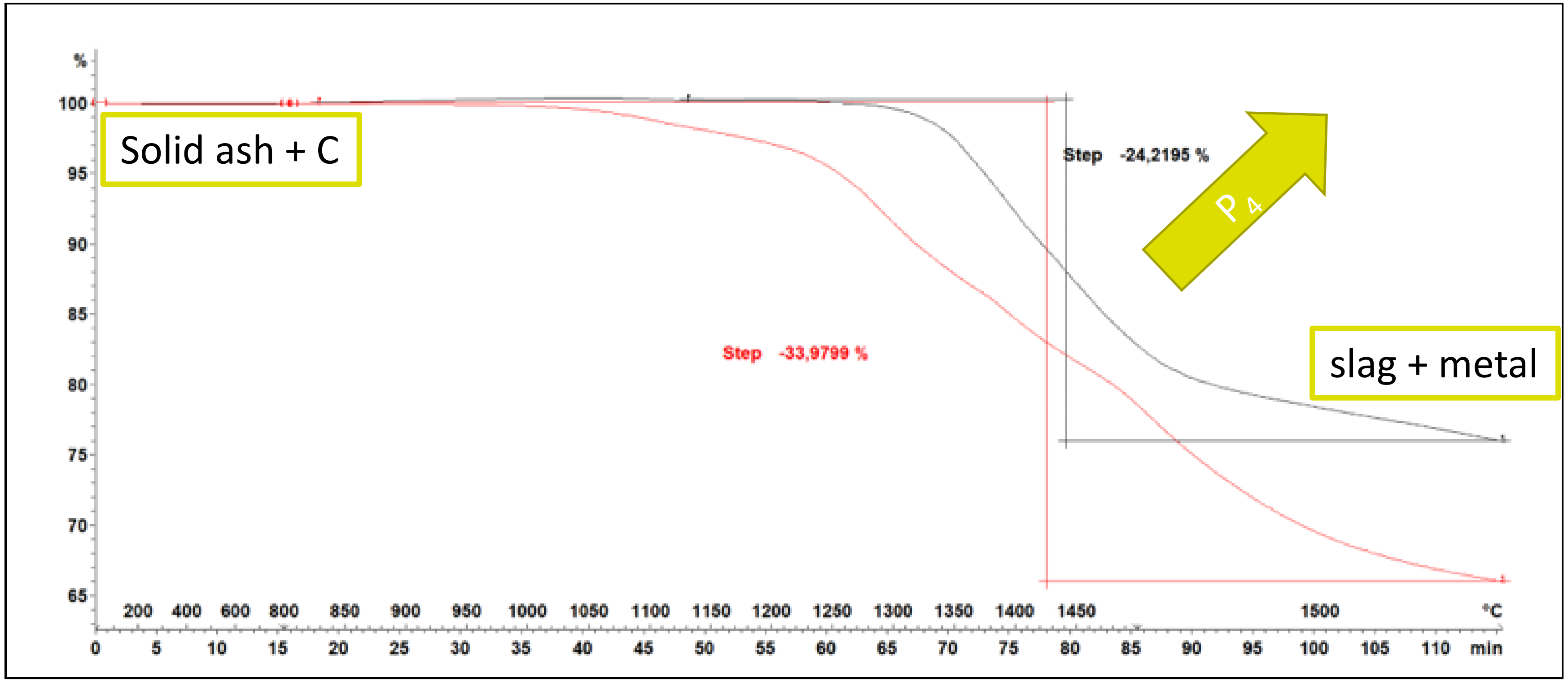

Figure 11: Carbon size comparison between fine (red) and coarser (black) carbon particles.

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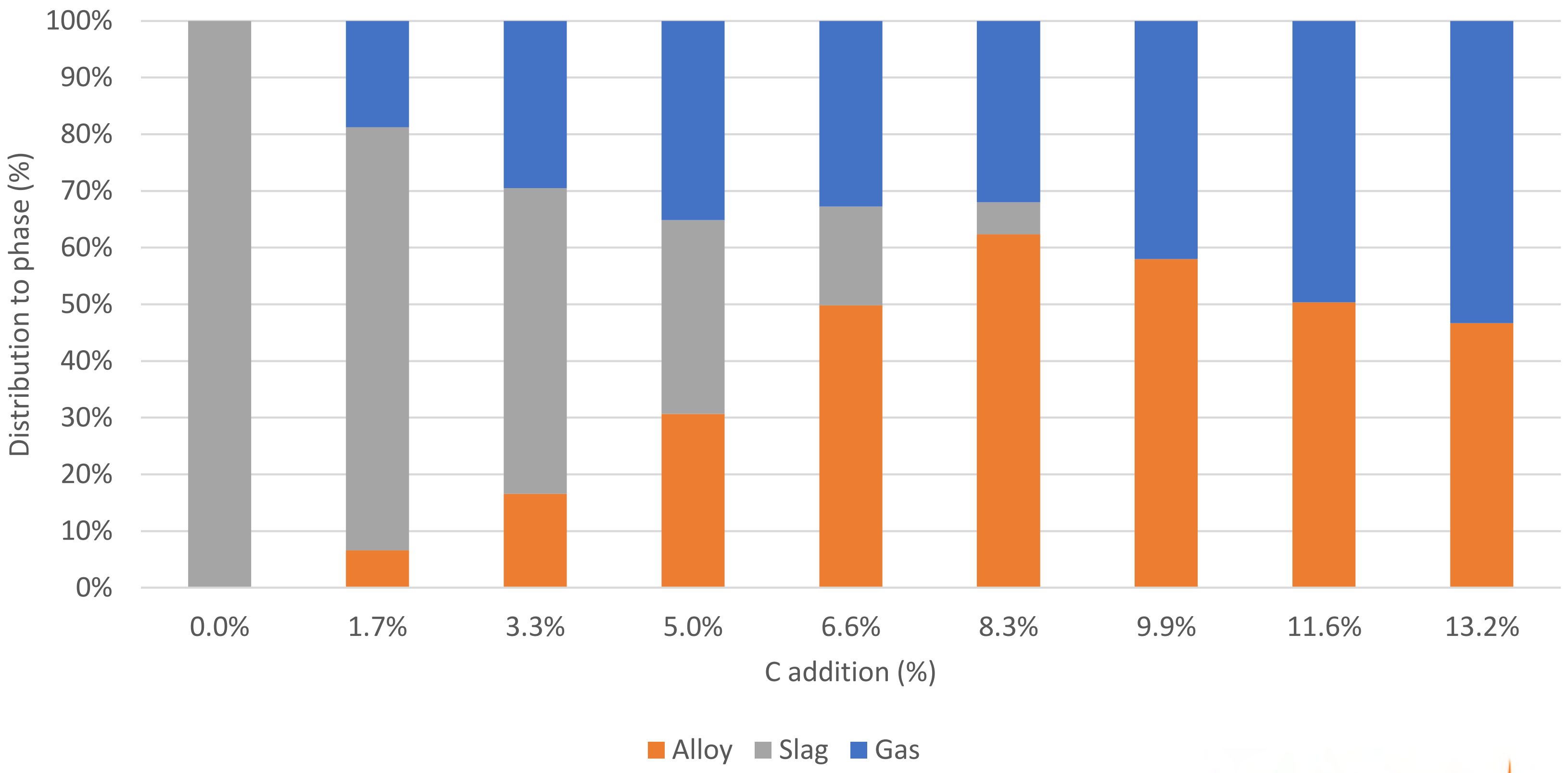
Phase distribution upon reduction

Ash composition

Component	Weight (%)
CaO	11
SiO_2	21
Al_2O_3	23
Fe_2O_3	24
SO_3	3
MgO	2
K_2O	2
P_2O_5	10
Minor compounds	2
Total	100

Calculated P distribution over different phases



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Phase composition

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Ash composition

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SiO_2	21
Al_2O_3	23
Fe_2O_3	24
SO_3	3
MgO	2
K_2O	2
P_2O_5	10
Minor compounds	2
Total	100

+ Operational conditions

Table 3: Calculated slag and alloy compositions at 1500 °C and 11.6% carbon.

Material	Component	Weight (%)
Alloy	Fe	64.6
	P	16.7
	Si	12.0
	C	3.4
	Mn	1.2
	Ti	1.2
	Minor	0.9
	Total	**100.0**
Slag	CaO	25.6
	SiO2	39.9
	Al2O3	26.2
	MgO	5.0
	K2O	2.2
	Minor	1.0
	Total	**100.0**

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Tube furnace: mg → gram scale

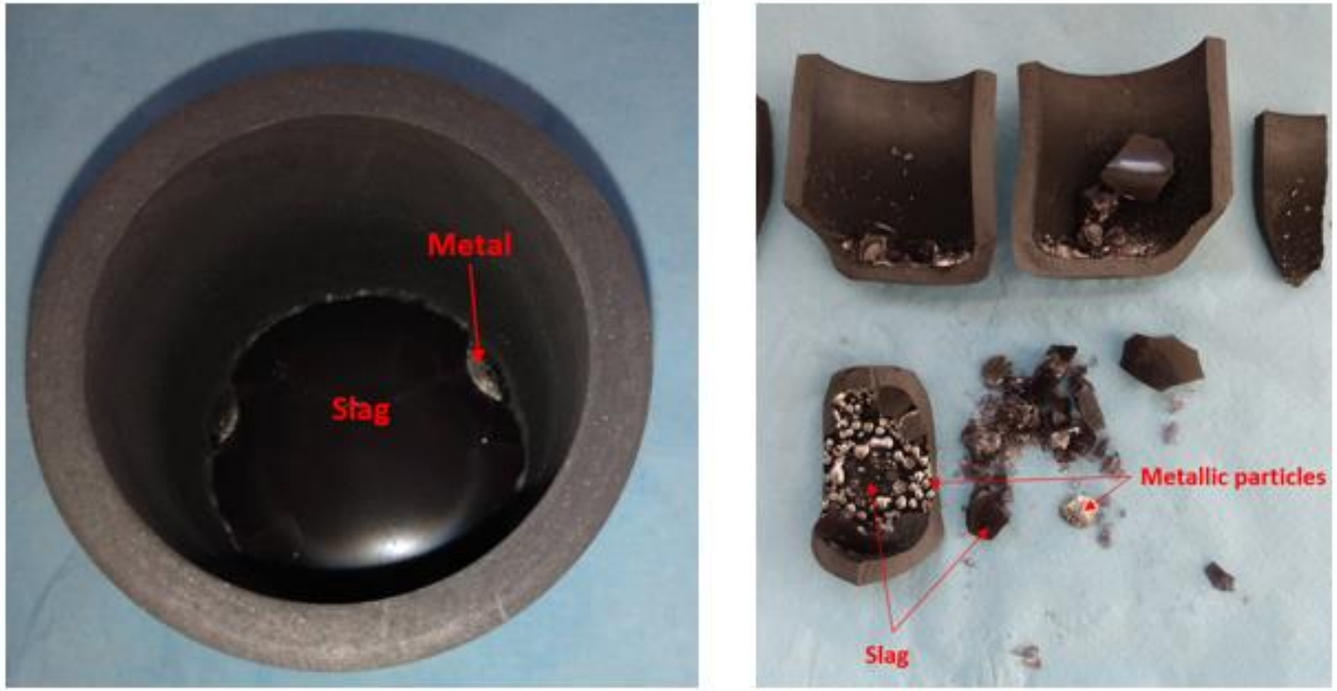

Figure 13: Crucible before and after being crushed showing the slag and metal portions after the experiment in the tube furnace.

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Product composition comparison

Slag comparison between SEM-EDX (1400 °C, B-0.8) and FactSage (1400 °C, B-0.6).

Component	SEM-EDX (w%)	FactSage (w%)
CaO	25.5	19.9
SiO_2	37.0	38.3
Al_2O_3	17.9	33.1
P_2O_5	9.8	0.1
Fe_2O_3	4.7	0.2
MgO	9.8	3.1
K_2O	4.7	4.3
TiO_2	3.3	0.7
MnO	-	0.4

Metal comparison in between SEM-EDX and FactSage at 1600 °C, B-0.6.

Element	SEM-EDX (w%)	FactSage (w%)
P	16.6	14.5
Fe	79.7	67.3
Si	3.6	14.5
wC	Not analyzed	1.5
Mn	Not analyzed	1.1
Ti	Not analyzed	0.9
Other	Not analyzed	0.9

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Thank you for your attention!

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EU Project FlashPhos

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