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Symbiosis 2014 International Conference, Athens

Production of lightweight fillers (LWFs) from recycled glass and paper sludge ash (PSA)

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EPSRC pira Aylesford Newsprint UPM

Background to the project

- EPSRC Industrial Case PhD Award
- Mixed colour glass cannot be reprocessed
- Sustainable solutions for PSA required as an alternative to landfill
- Manufacturing LWFs from waste glass and PSA would be a novel re-use application

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EPSRC pira

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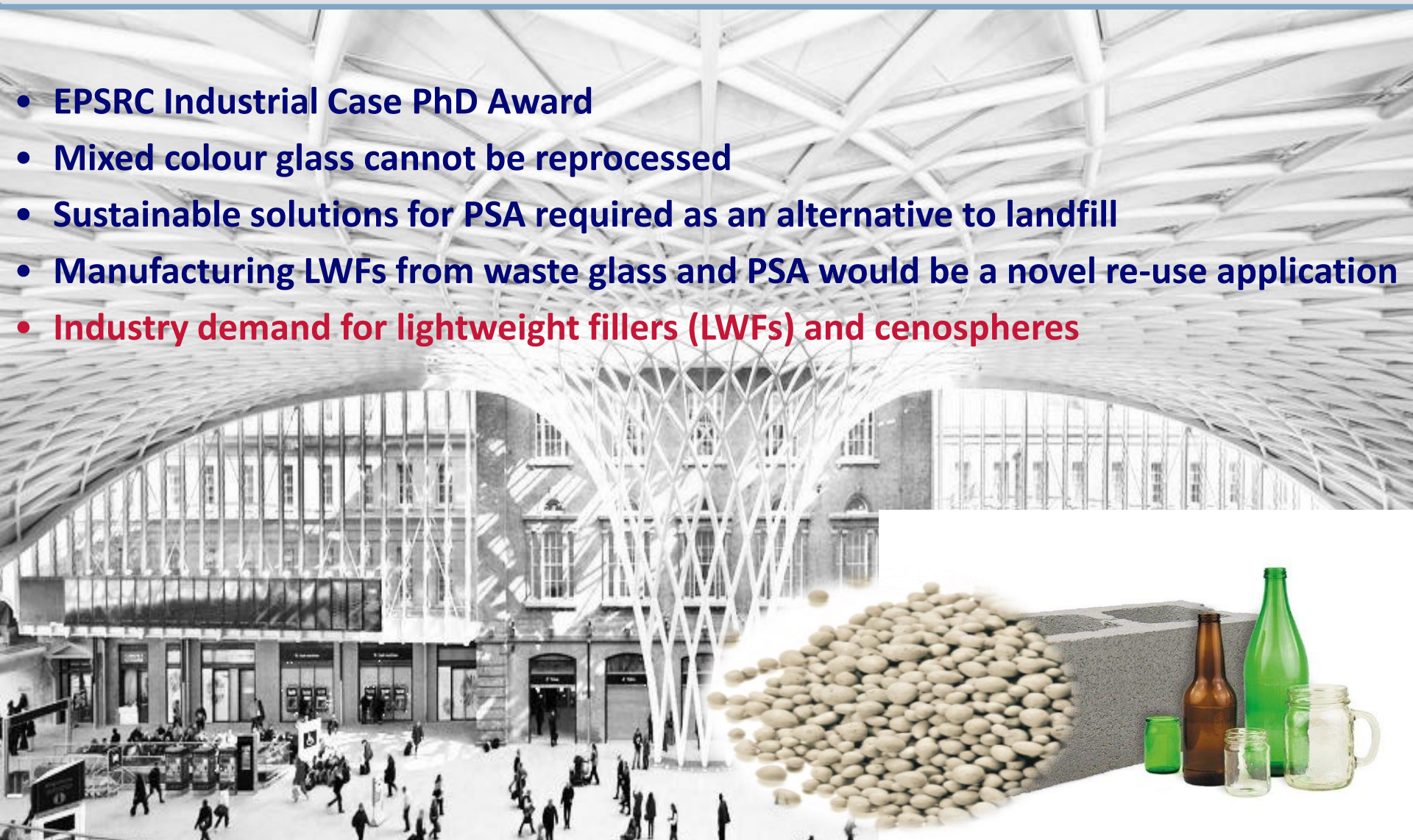
- Manufacturing LWFs from waste glass and PSA would be a novel re-use application
- Industry demand for lightweight fillers (LWFs) and cenospheres



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Industrial Project Collaborators

The Paper

Friday, June 1, 2012 | 69 Main St, Cold Spring, N.Y. | www.philipstown.info

UPM-Shotton

by Mike Turton

of two-way traffic – assuming the project continues in a timely fashion.

"We've been losing about two days of

of two-way traffic – assuming the project continues in a timely fashion.

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Aylesford Newsprint

by Mike Turton

Despite a considerable amount of inclement weather in recent weeks, major maintenance on In-

The project is being managed and supervised by Liberty Maintenance but most of the workers are members of Structural Steel and Bridge Painters of

of two-way traffic – assuming the project continues in a timely fashion.

"We've been losing about two days of

The very best of the many excellent teams Haldane has produced in its history become part of a

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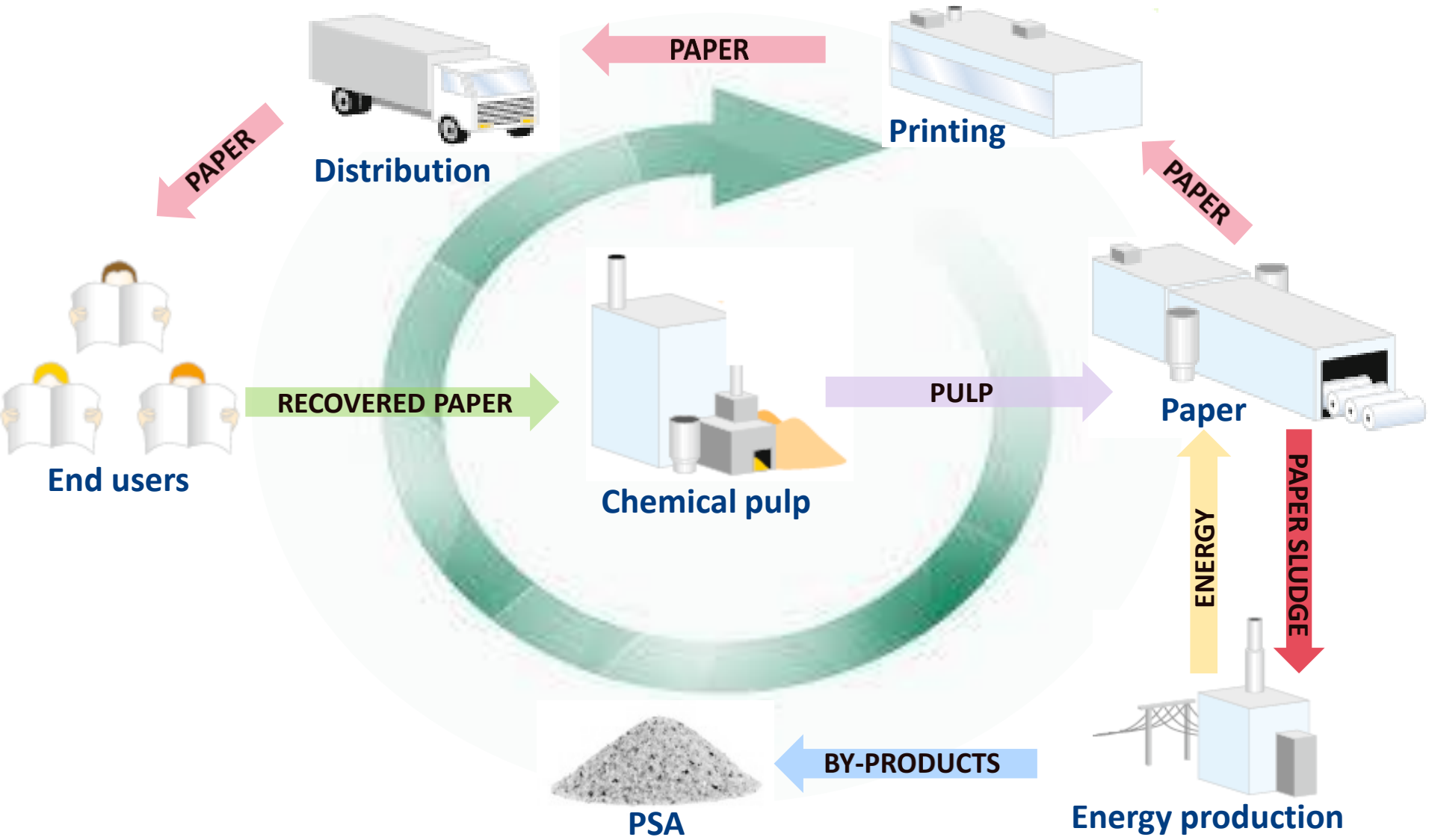
Life cycle of paper



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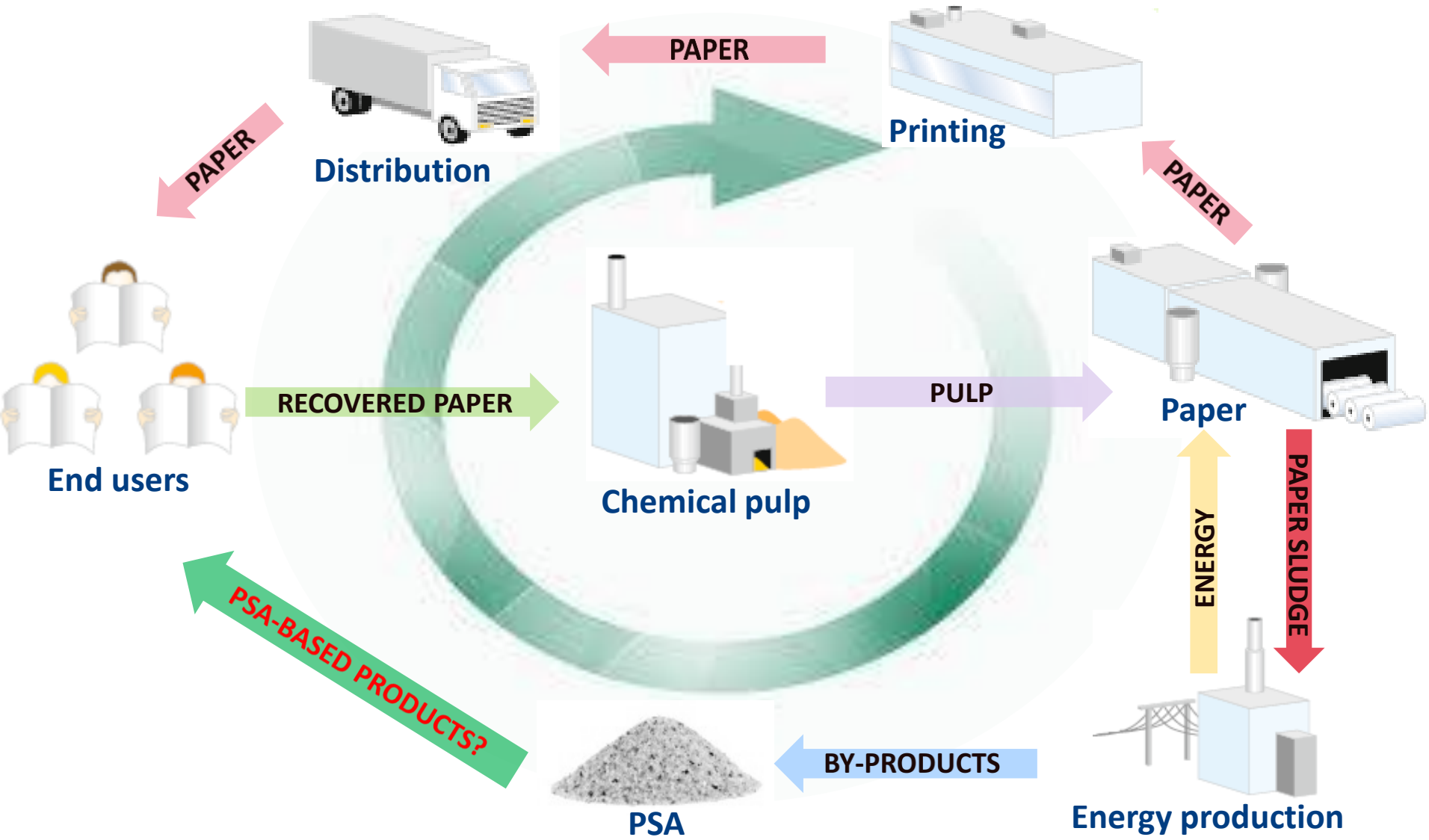
Life cycle of paper



Paper Sludge Ash (PSA)

Residue from combustion of wastepaper sludge

125,000 tonnes of PSA was produced in 2006

88,000 tonnes beneficially reused in UK markets

37,000 tonnes landfilled

Increasing volumes produced and opportunity for new applications

Material for combustion	Amount (tonnes/year)
Paper sludge	275,000
Biomass (virgin and clean non-virgin timber)	120,000
Plastics	17,000

Waste Protocols Project: A technical report on the production and use of PSA (2007)

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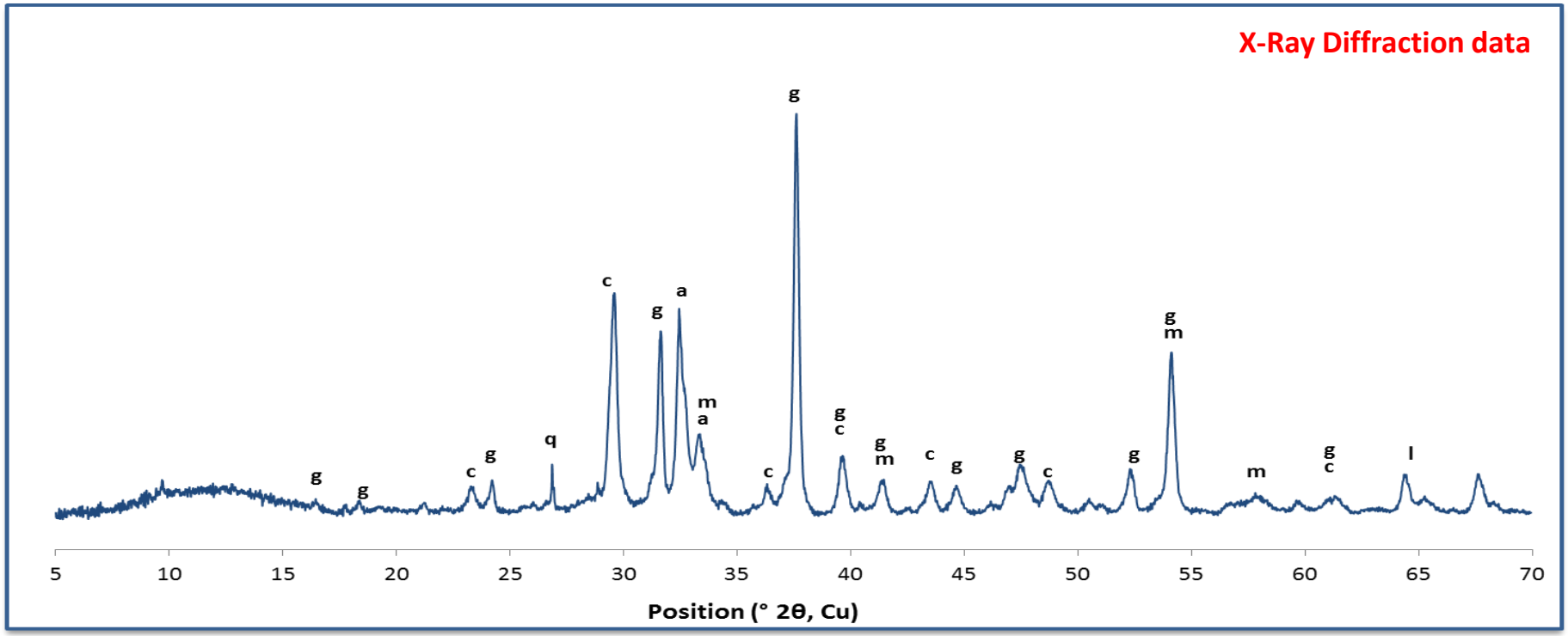
Waste glass & PSA: Chemical and mineralogical composition

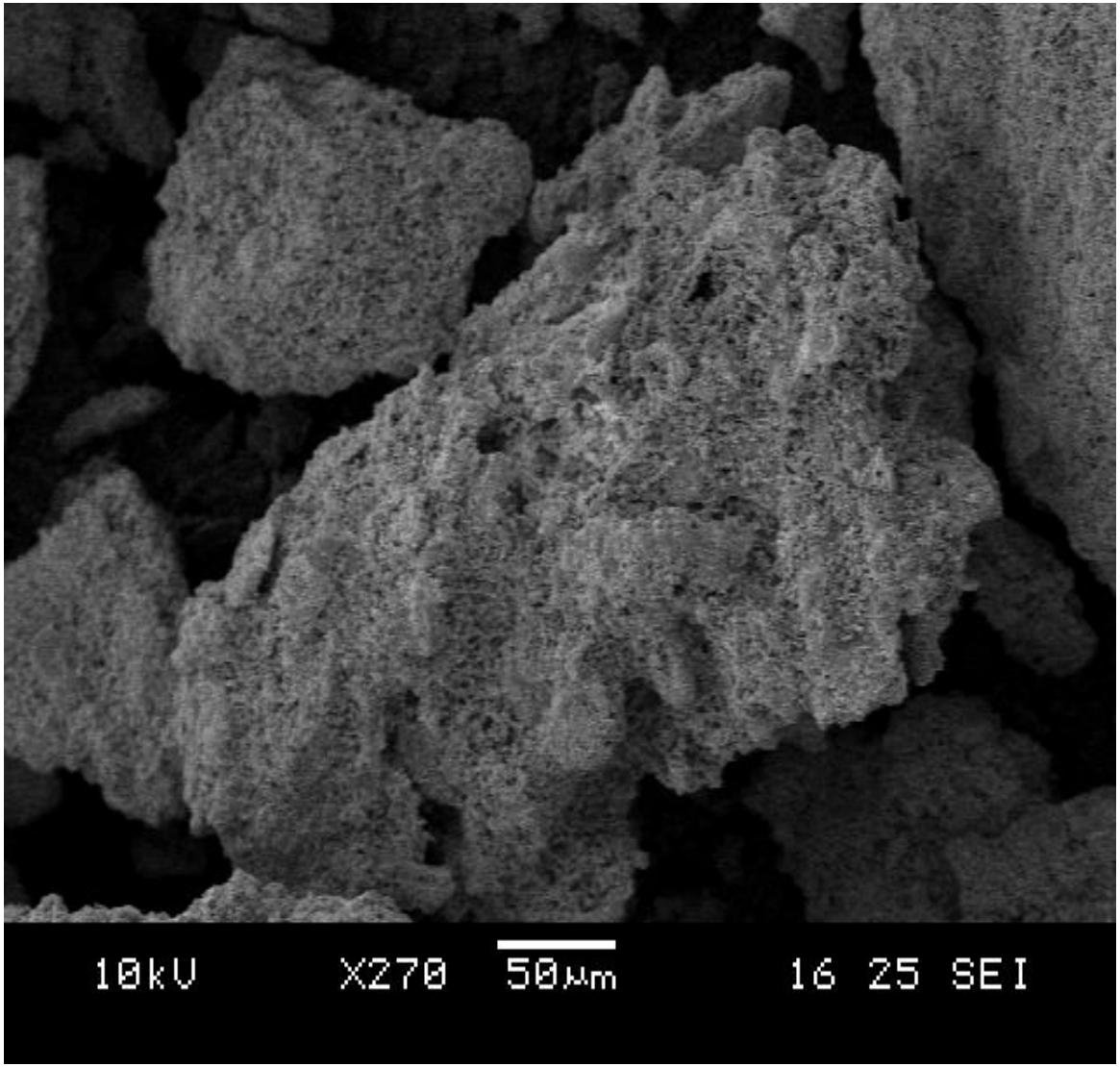
X-Ray Fluorescence data

	SiO_2	CaO	Na_2O	MgO	Al_2O_3	K_2O	Fe_2O_3	SO_3	TiO_2	P_2O_5	Others
Waste glass	75.8	12.0	7.3	2.3	1.4	0.6	0.3	0.2	nd	nd	-
PSA	21.2	61.2	nd	2.8	12.6	0.4	0.9	0.2	0.3	0.1	0.1



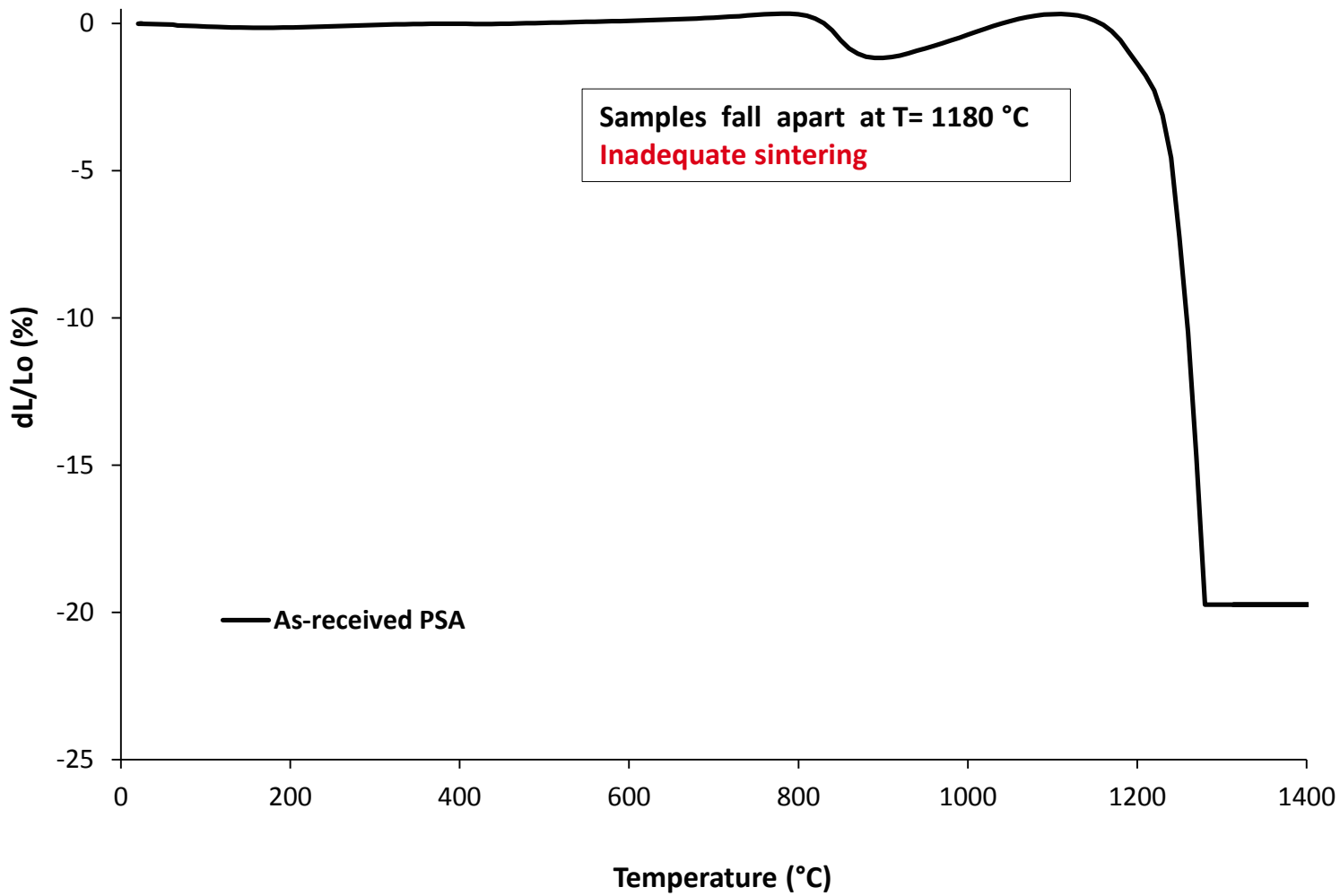
a: calcium silicate (Ca_2SiO_4), c: calcite ($CaCO_3$), g: gehlenite ($Ca_2Al_2SiO_7$), l: lime (CaO), m: mayenite ($Ca_{12}Al_{14}O_{33}$), q: quartz (SiO_2)

PSA: Microstructure



- Agglomerated particles
- Loosely bonded
- Porous

PSA: Dilatometer results



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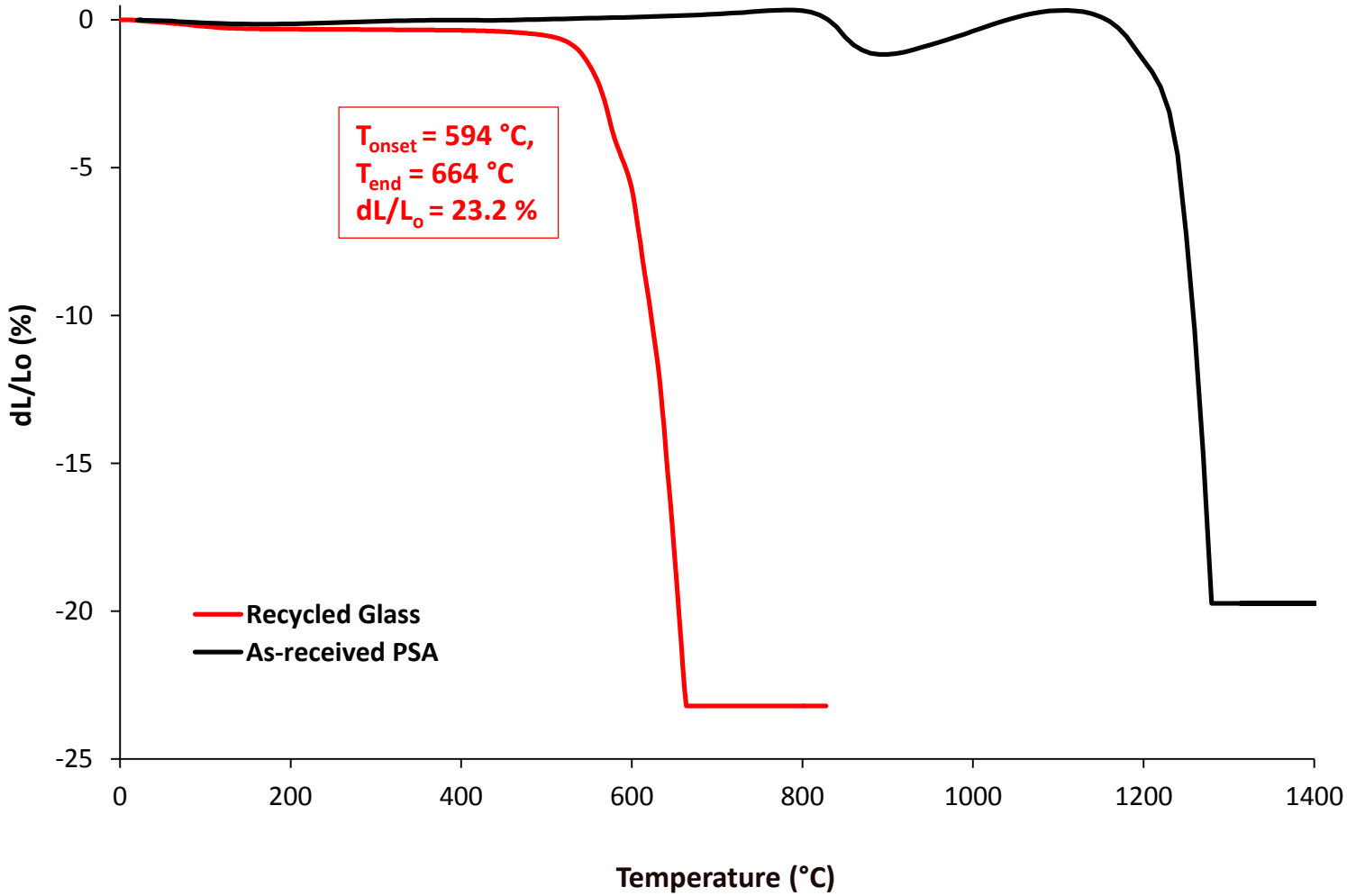
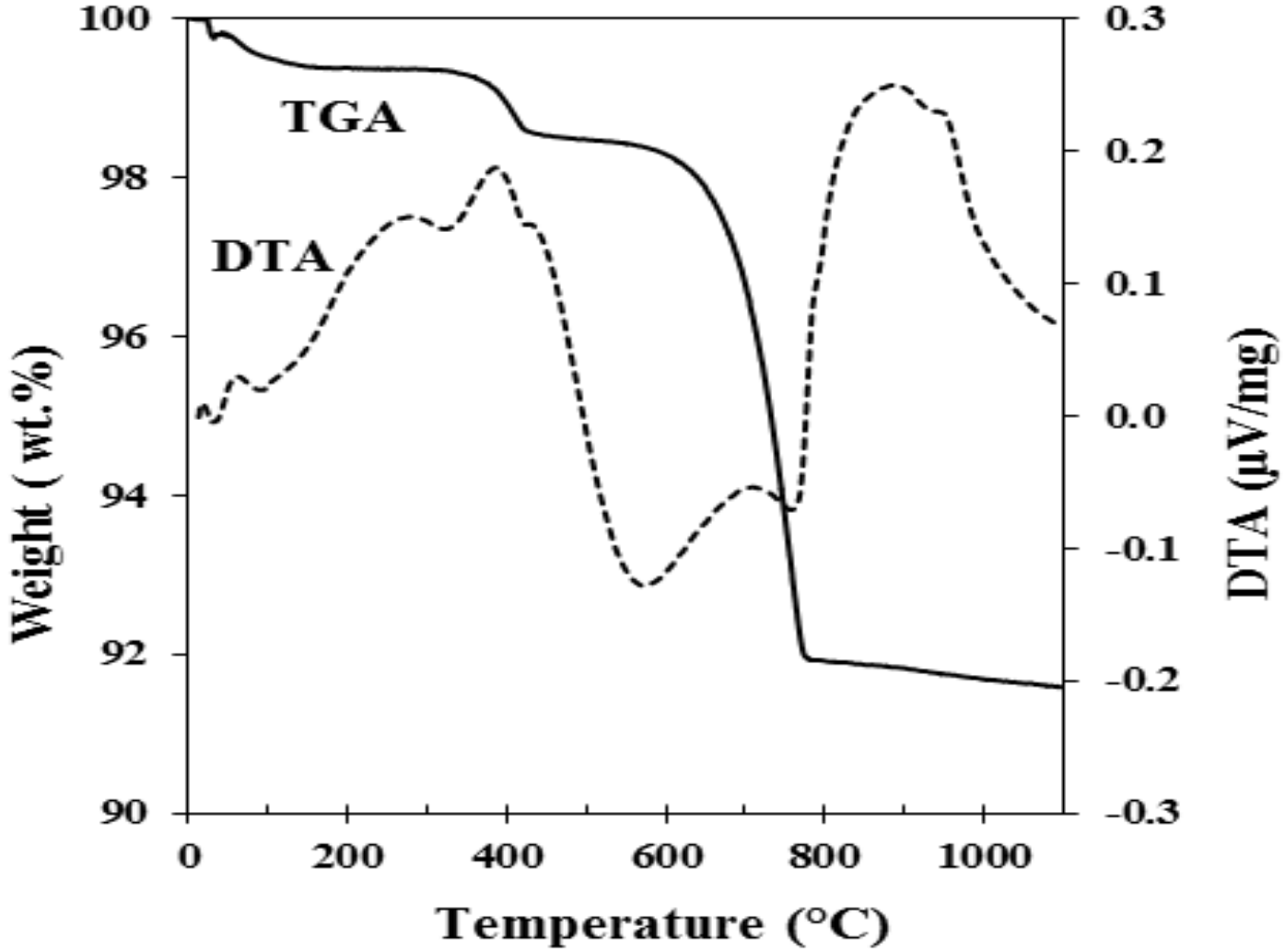
PSA and recycled glass: Dilatometer results



PSA: Thermogravimetric Analysis (TGA)



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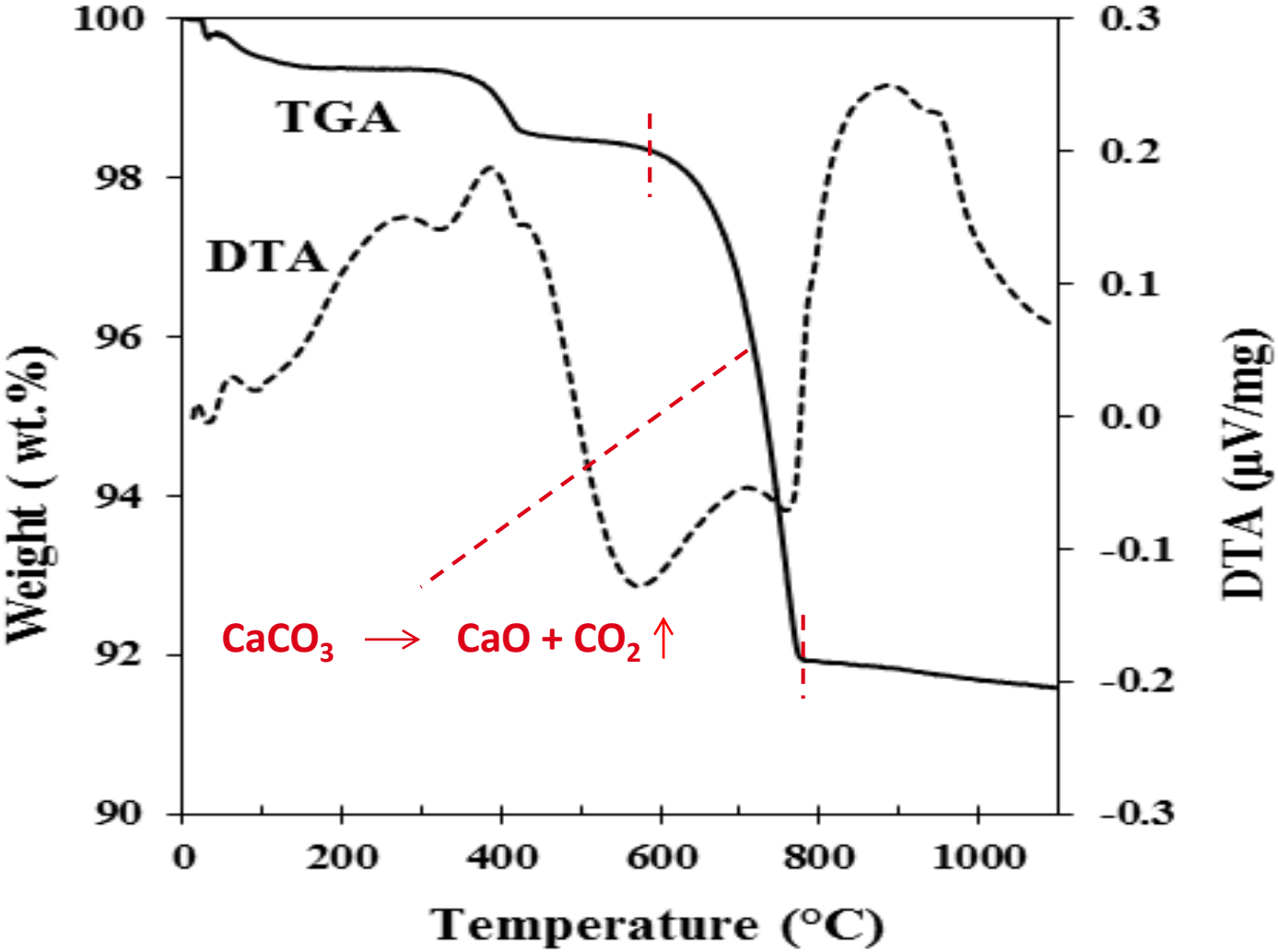
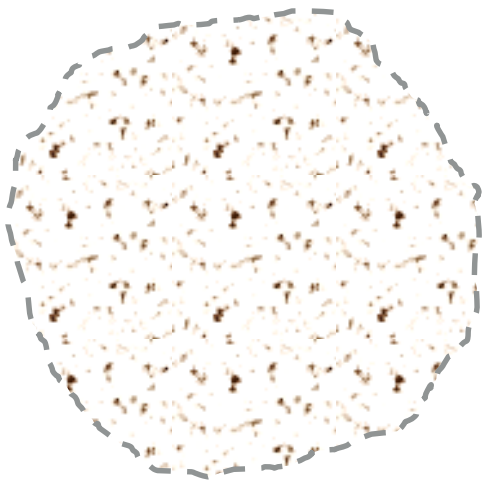


T_{onset} = 600 °C,
T_{end} = 780 °C
m_{loss} = 5.5 wt%

Mechanisms for expansion during rapid sintering

Green particle



particle packing

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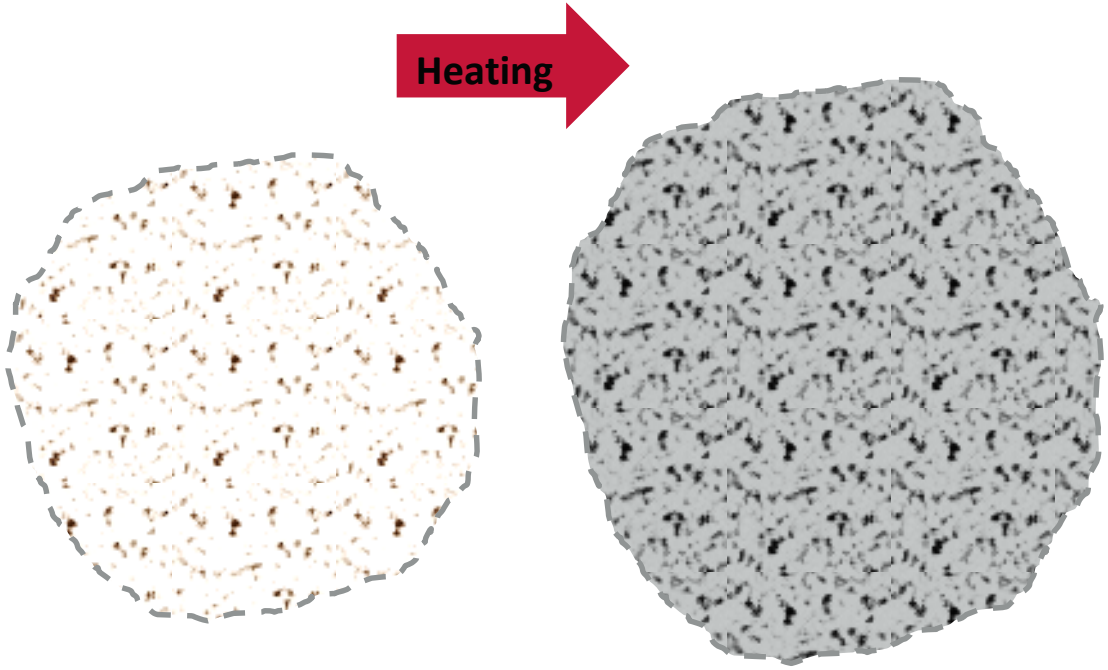
Mechanisms for expansion during rapid sintering

Green particle

Liquid phase sintering



particle packing

vitreous phases formed

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Mechanisms for expansion during rapid sintering

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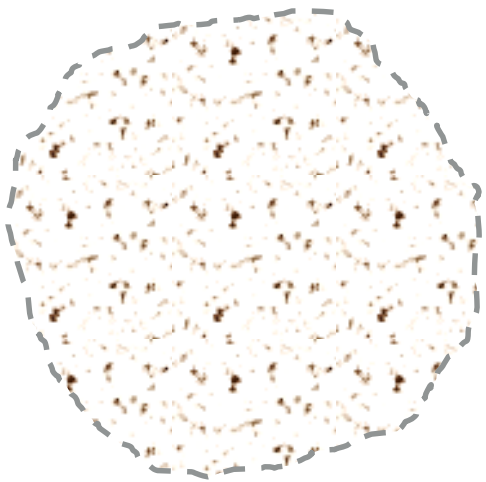
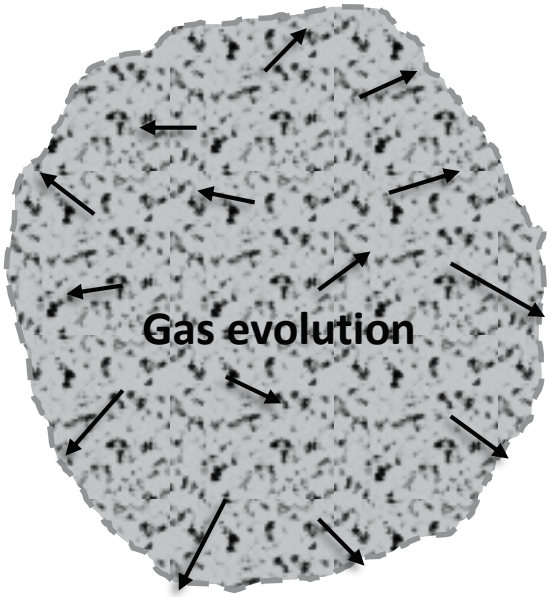


particle packing

Liquid phase sintering



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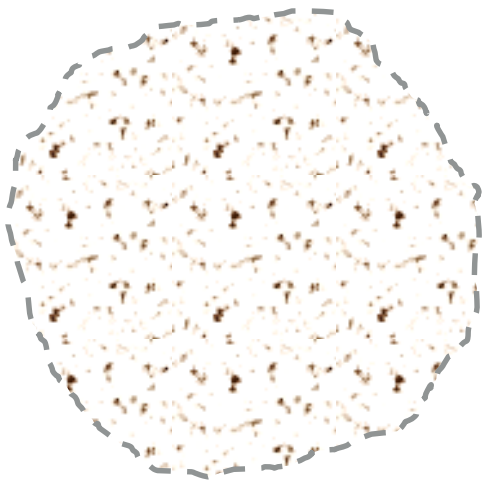

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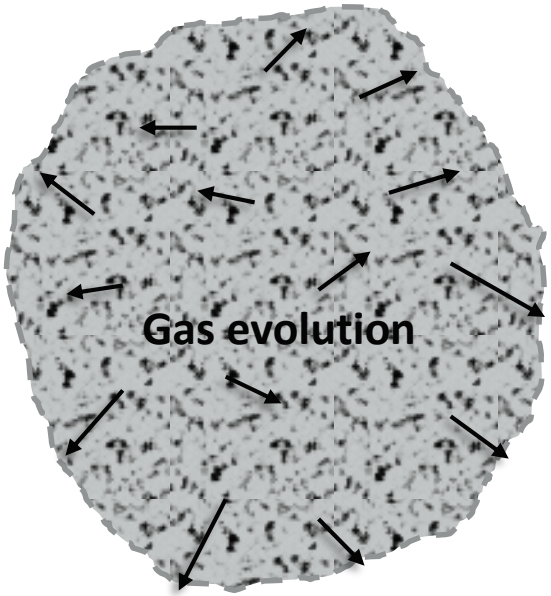
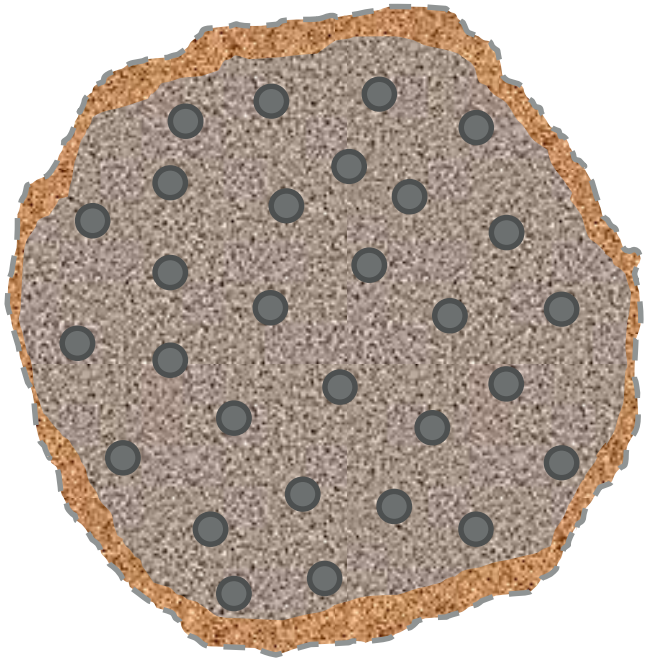


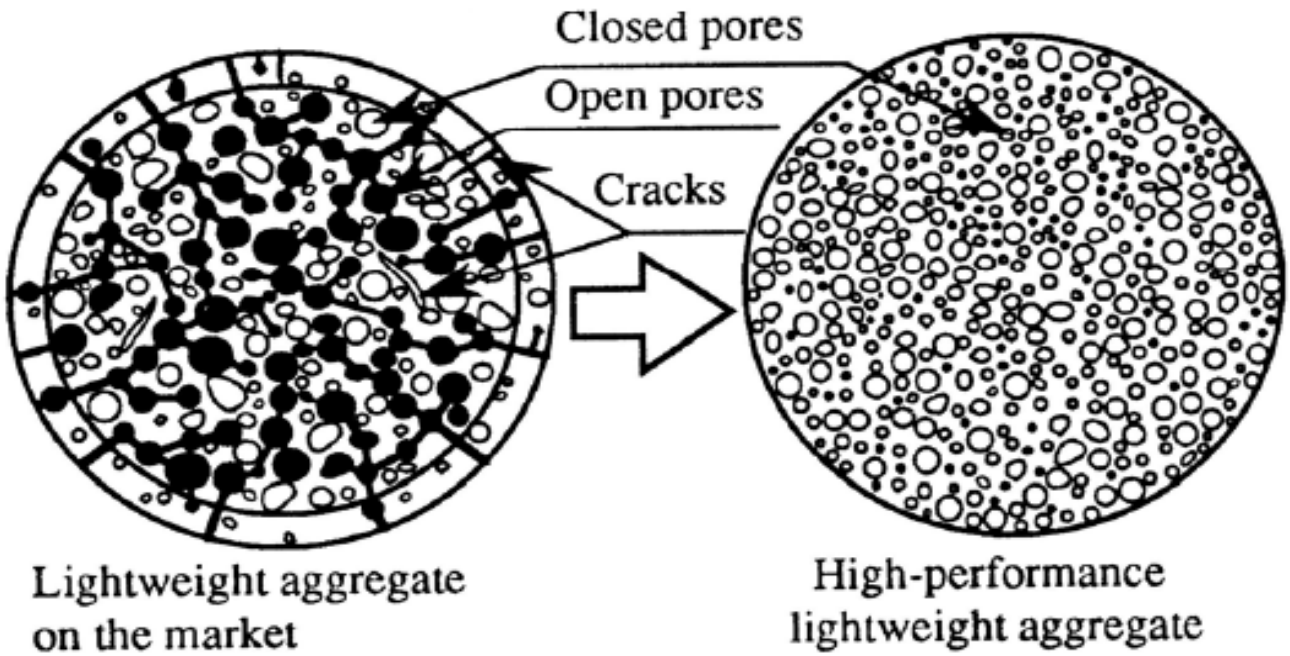
vitreous phases formed

Rapidly sintered particle



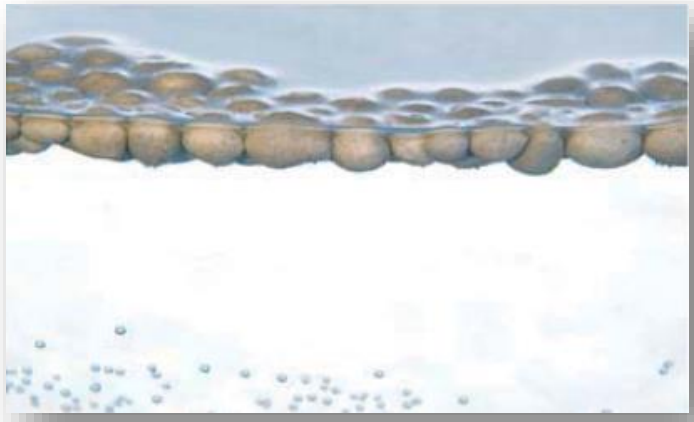
closed cell structure

Specifications of potential LWF products



Desired properties

- Low density ~ < 1 g cm^{-3}
- Relatively low water absorption
- High strength
- Particle size ranging from ~ 60µm to 2mm

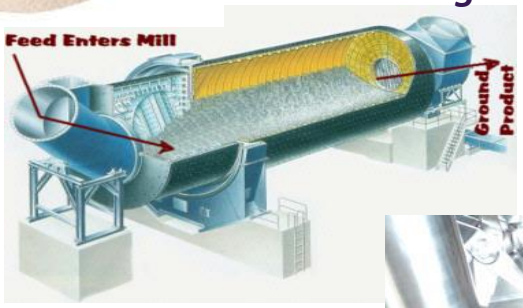


Industrial manufacturing process

Raw materials (recycled glass)

As used by Poraver, Liaver and Ecoglass manufacturers

Ball milling



Mixing

Pan pelletising

Sintering (rotary kiln)

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Laboratory manufacturing process

1. Raw materials

Fine glass powder
PSA

2. Grinding

1-4 hours

3. Mixing

Water

4. Pelletising

Angle and rotation speed adjusted

5. Rapid sintering

Temp.: 800 °C
Time: < 40 min

6. Sieving

Size: 1 – 7 mm

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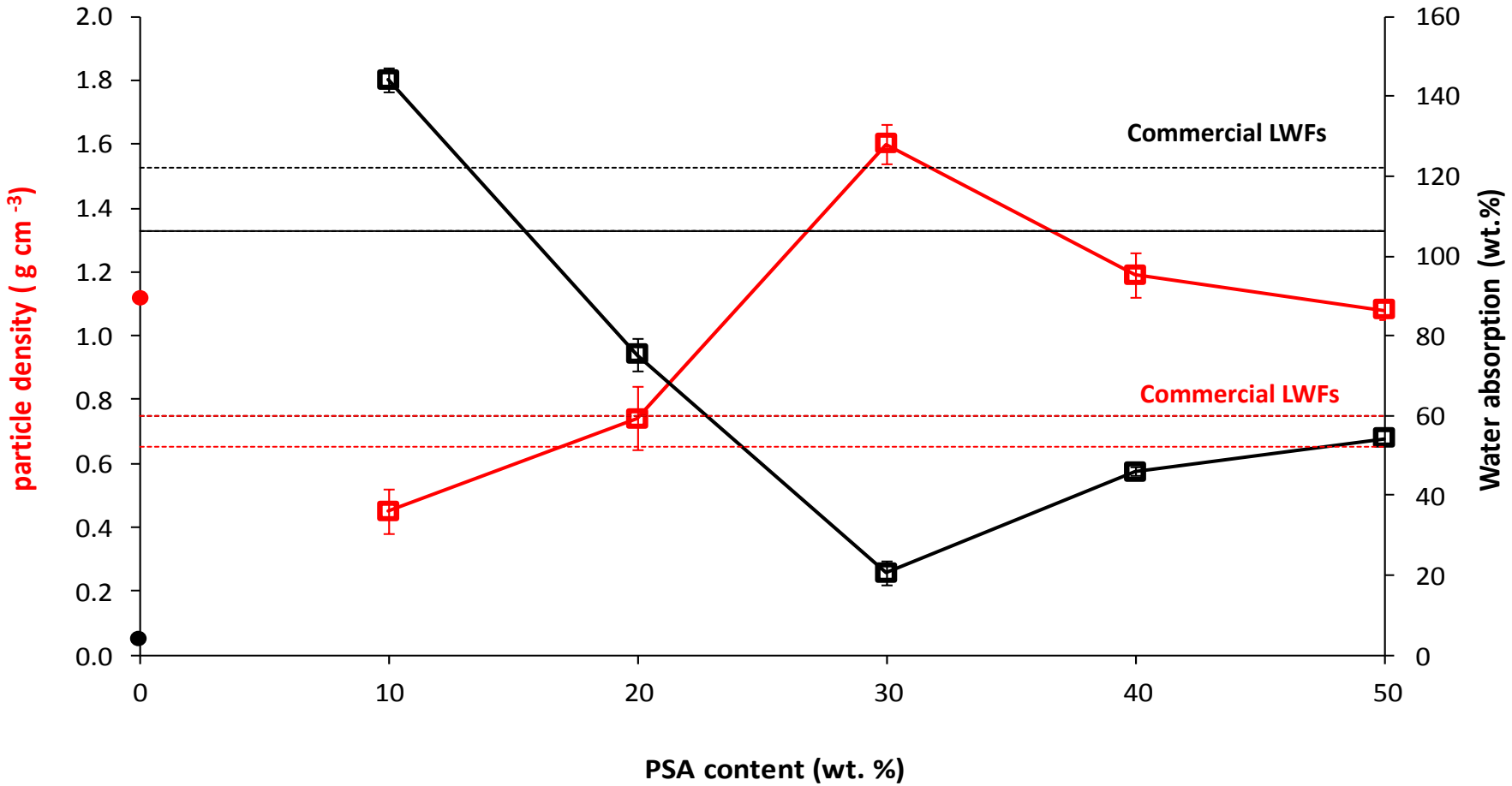
Effect of PSA content on density and water absorption

Wet milled for 1 hour, T_{sint}= 800 °C, t_{sint}= 20 minutes



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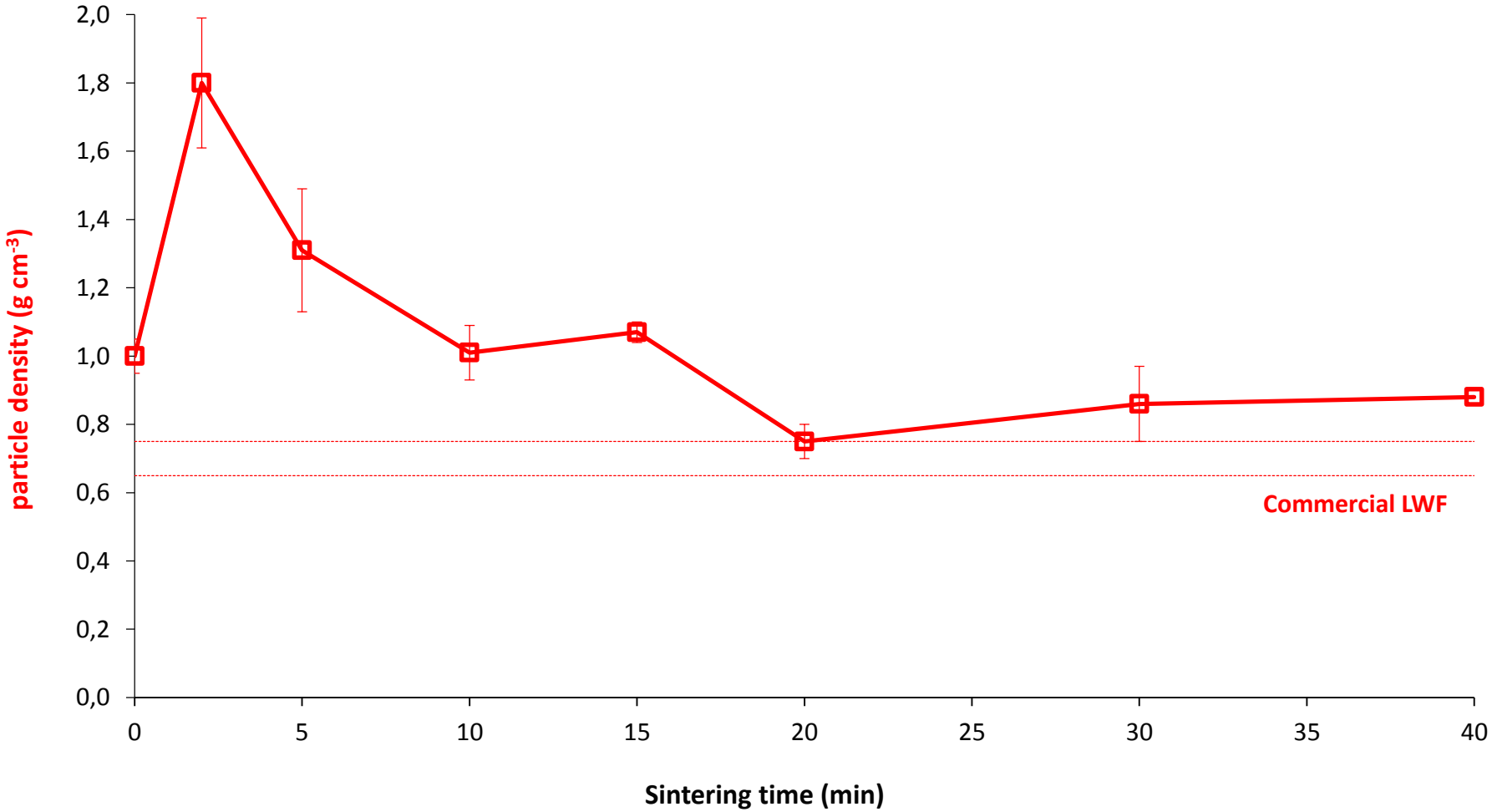
Effect of sintering time: 20% PSA-80% glass mix



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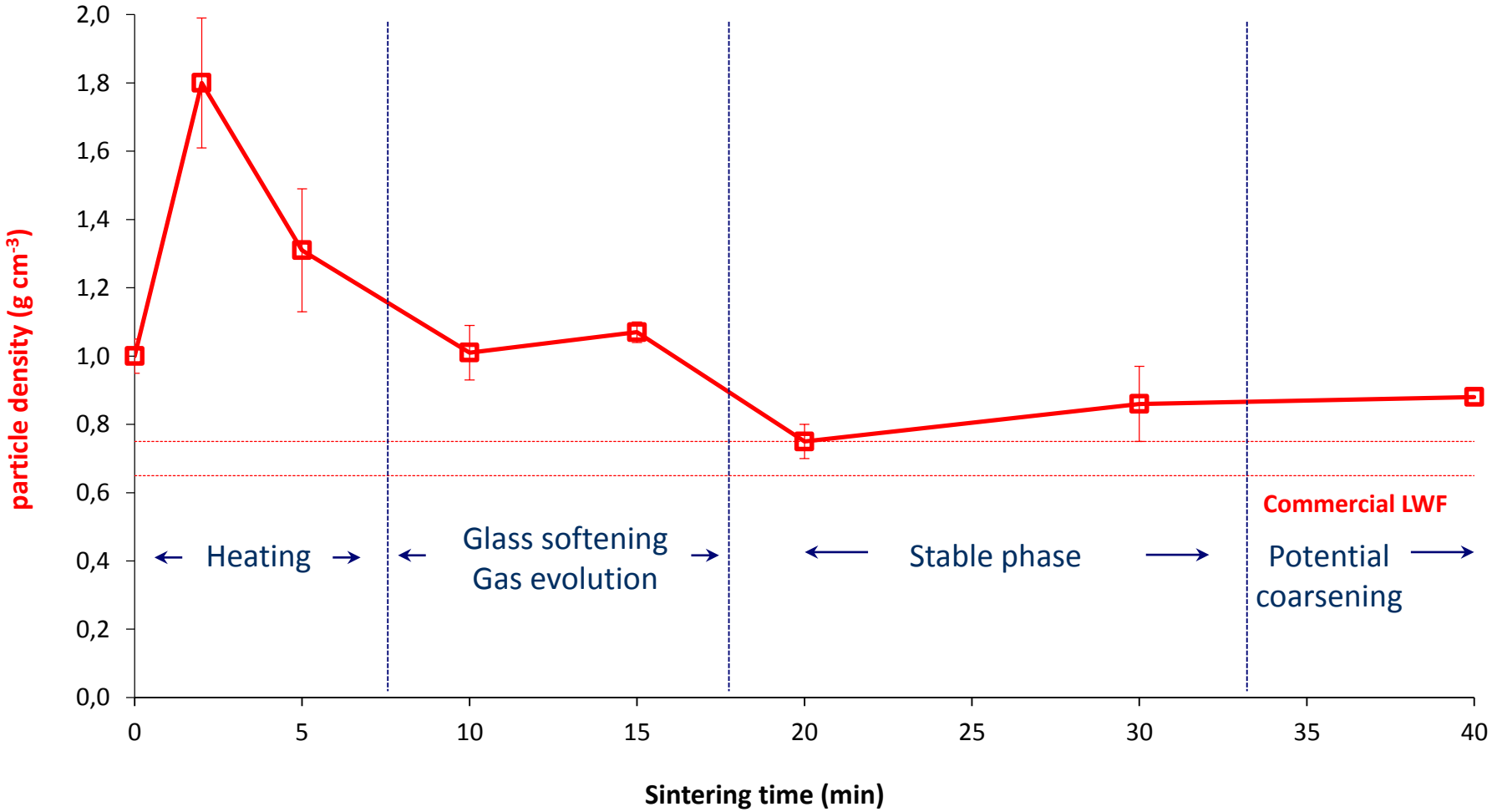

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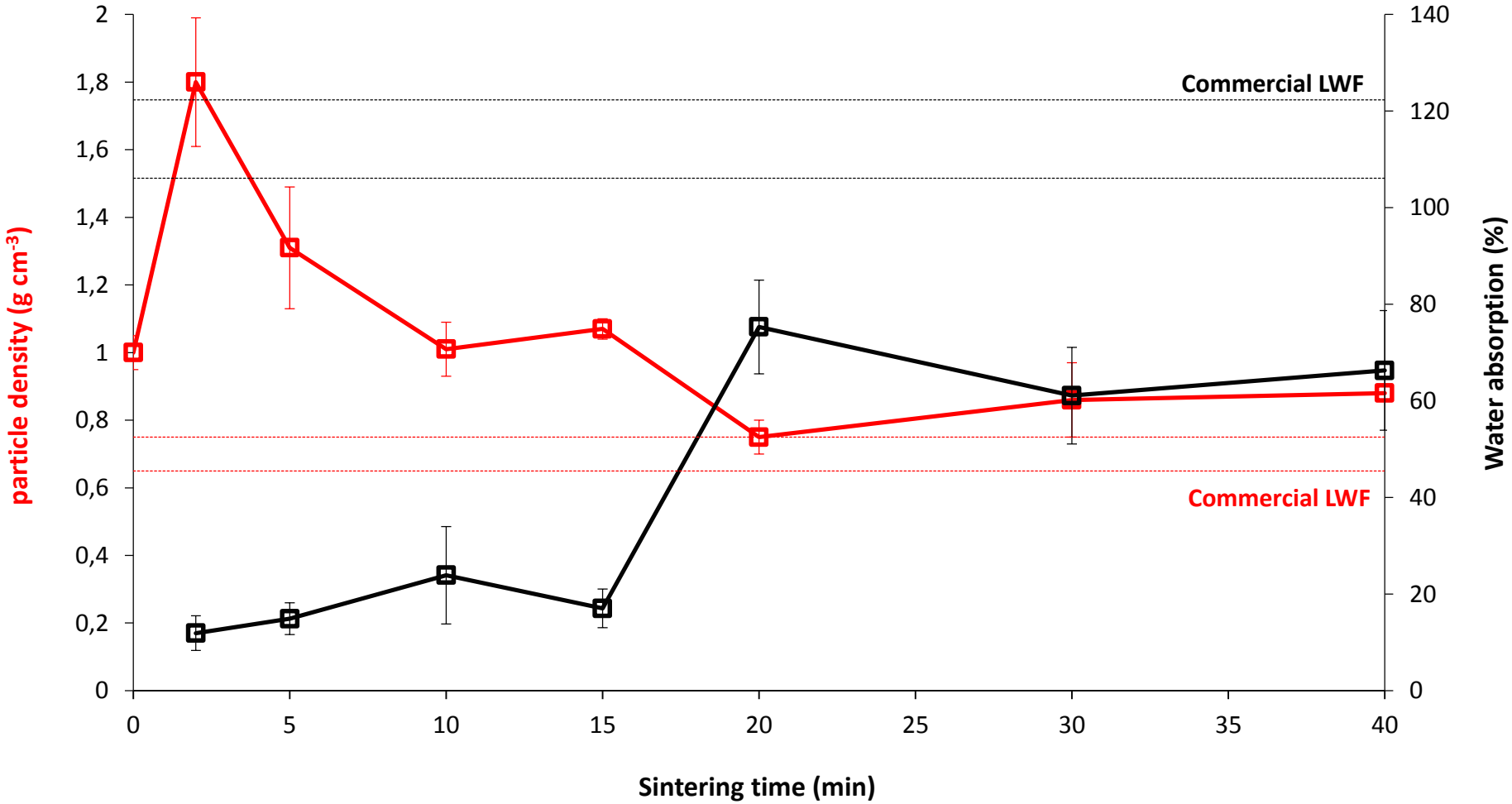

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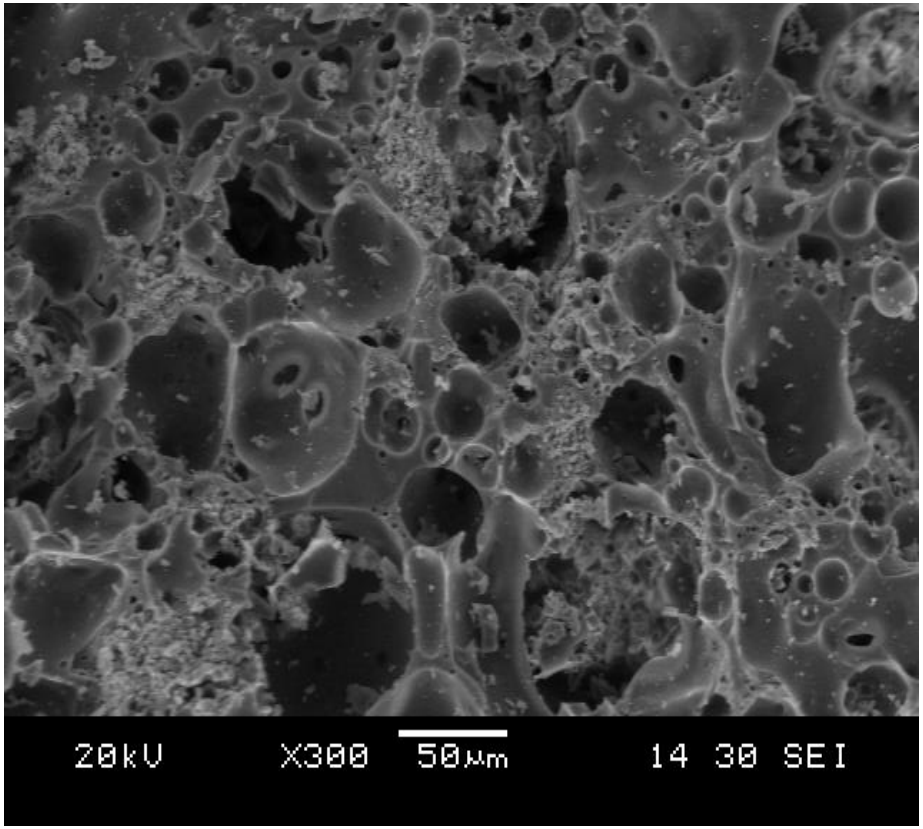
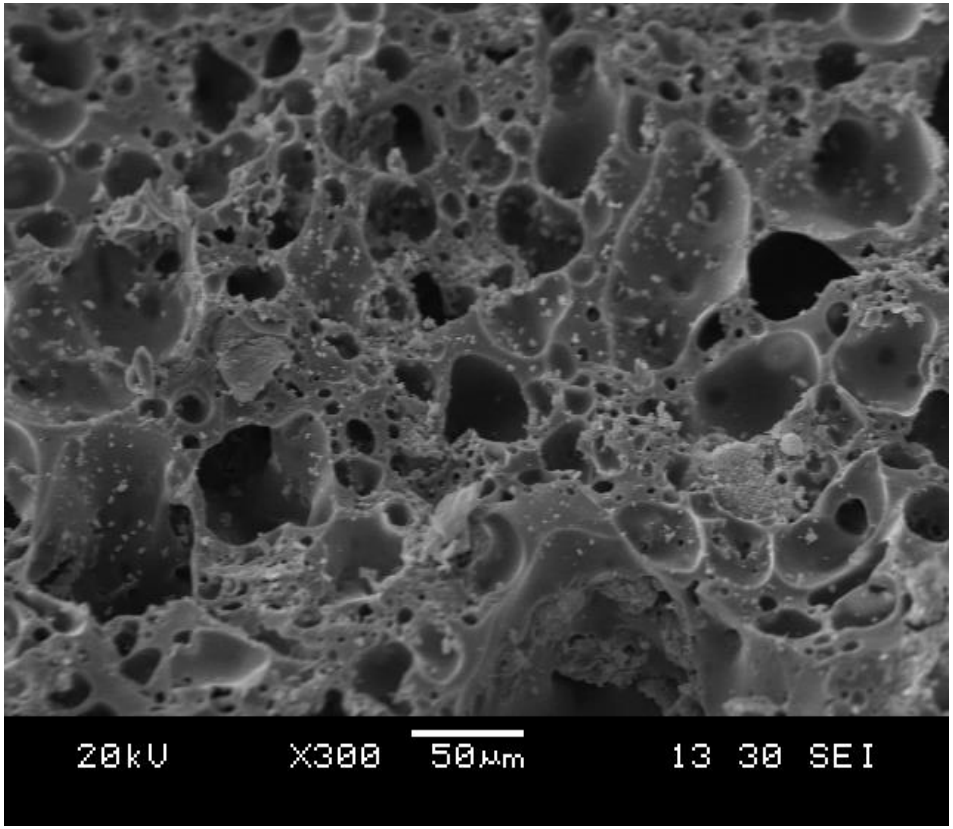
Effect of sintering time on microstructure

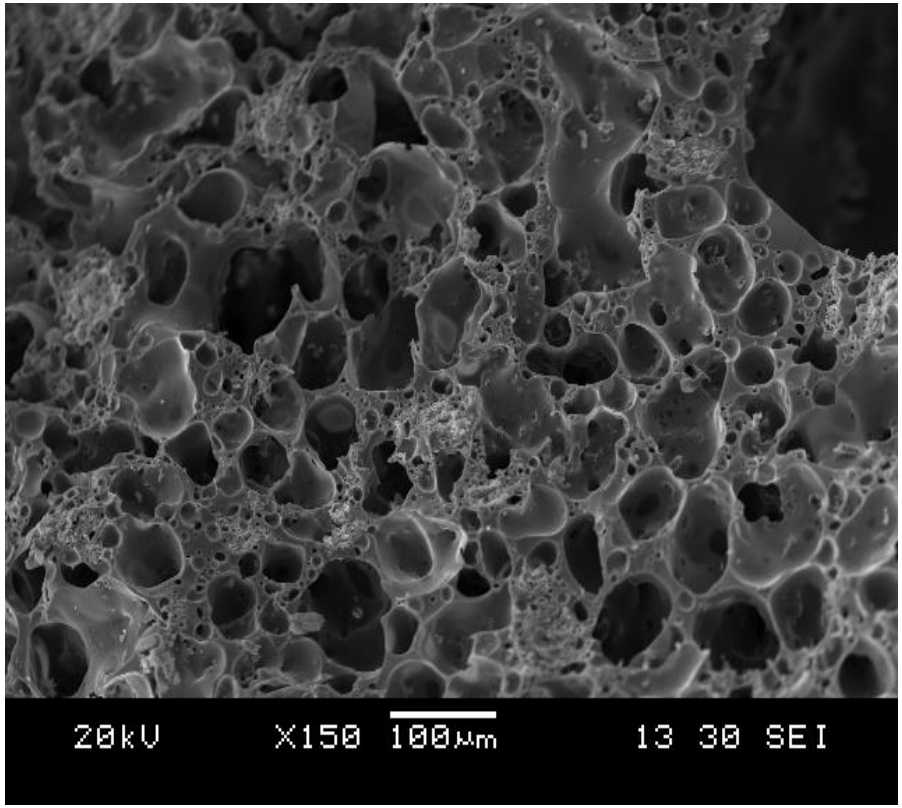


Sintering time: 5 minutes

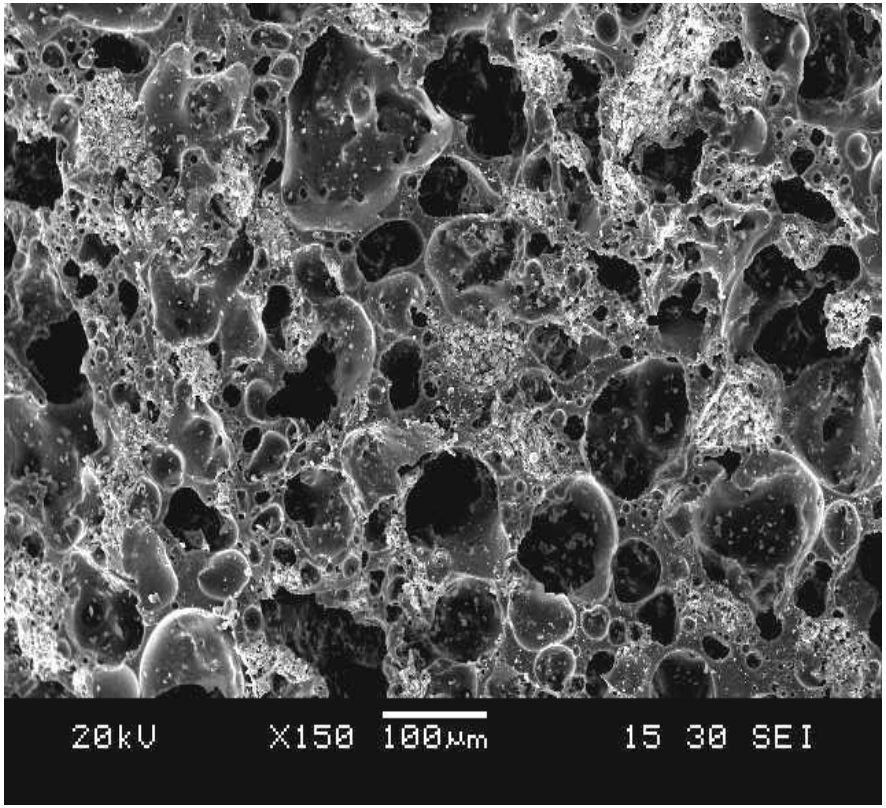


Sintering time: 10 minutes

Effect of sintering time on microstructure



Sintering time: 15 minutes



Sintering time: 20 minutes

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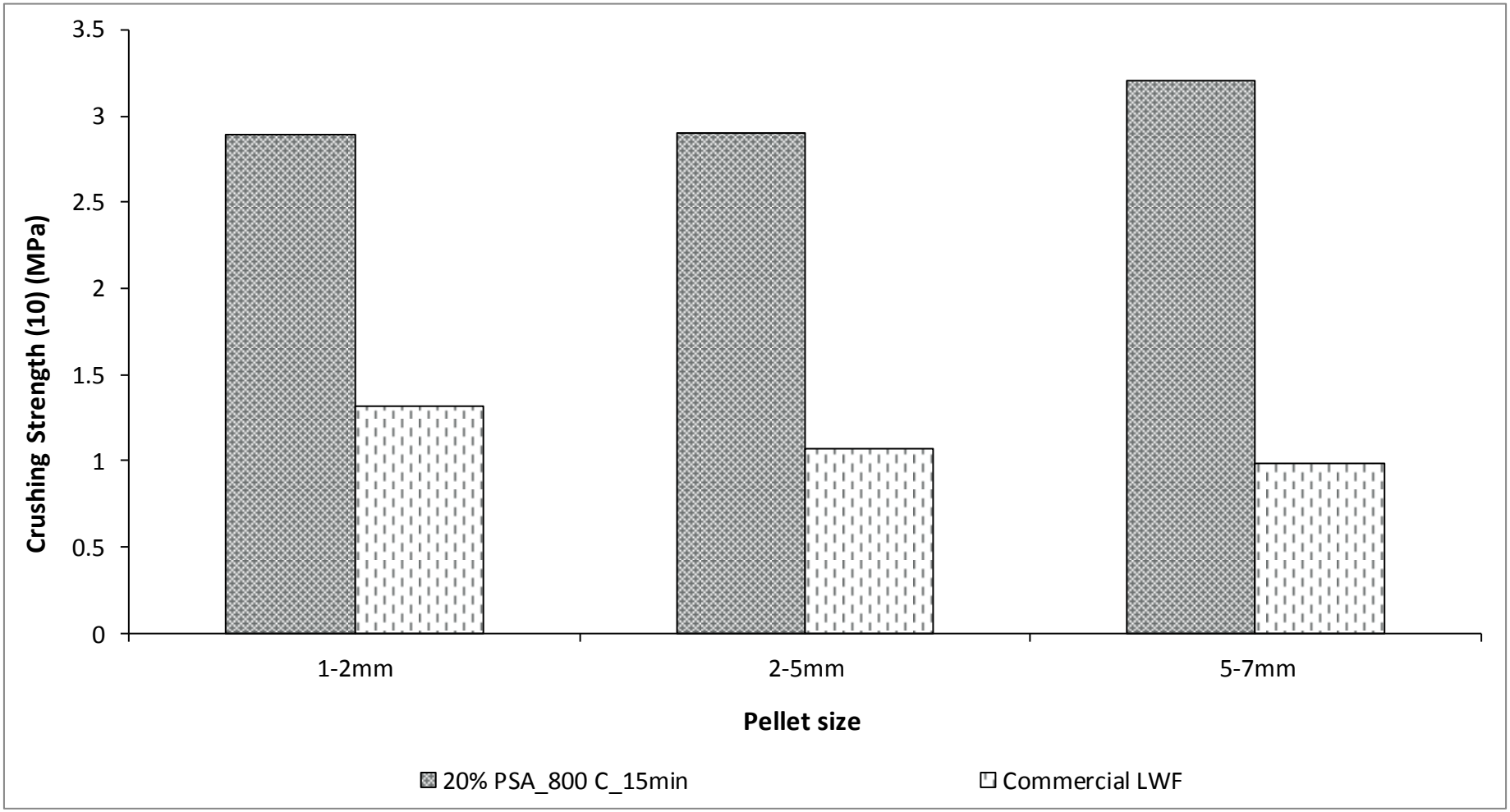
20% PSA-80% glass mix: Effect of pellet size on CS (10)



Conclusions

- Identified LWFs as the target product – cenosphere-type products
- PSA can be mixed with glass (1:4) to form LWFs
- Laboratory production process mimics industrial manufacturing
- Promising results to date:
  - Light weight fillers are produced at particle sizes ranging from 1-7 mm
  - Relatively low sintering temperature (800 °C) and time (15 min)
  - Optimum PSA-glass LWFs have higher crushing strength than commercial LWFs

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Questions and Answers