武漢理工大學 WUHAN UNIVERSITY OF TECHNOLOGY

SMART 硅酸盐建筑材料国家重点实验室 State Key Laboratory of Silicate Materials for Architectures

cea isec sumglass September 25-29th 2023

Thermal Plasma Treatment of Dry Waste from Nuclear Power Plants in China

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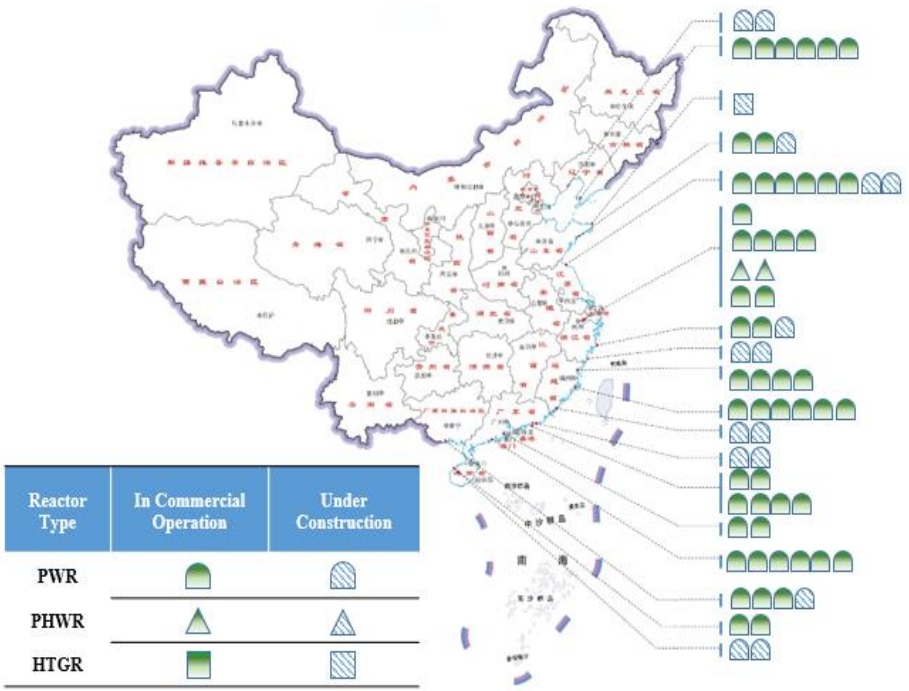
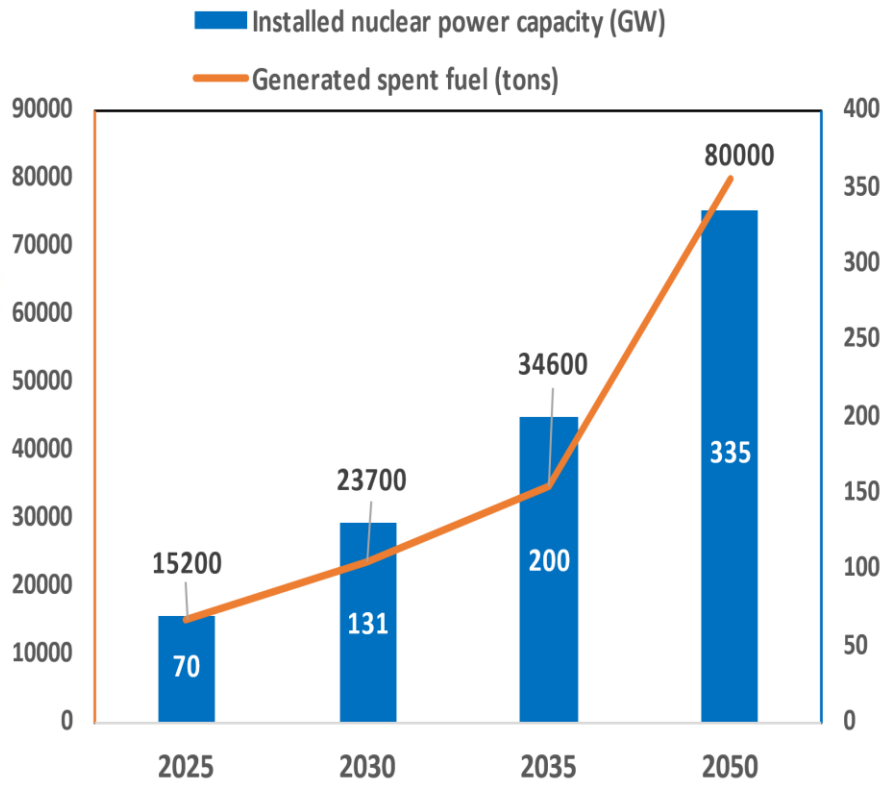
Background – rapid growth of nuclear power in China

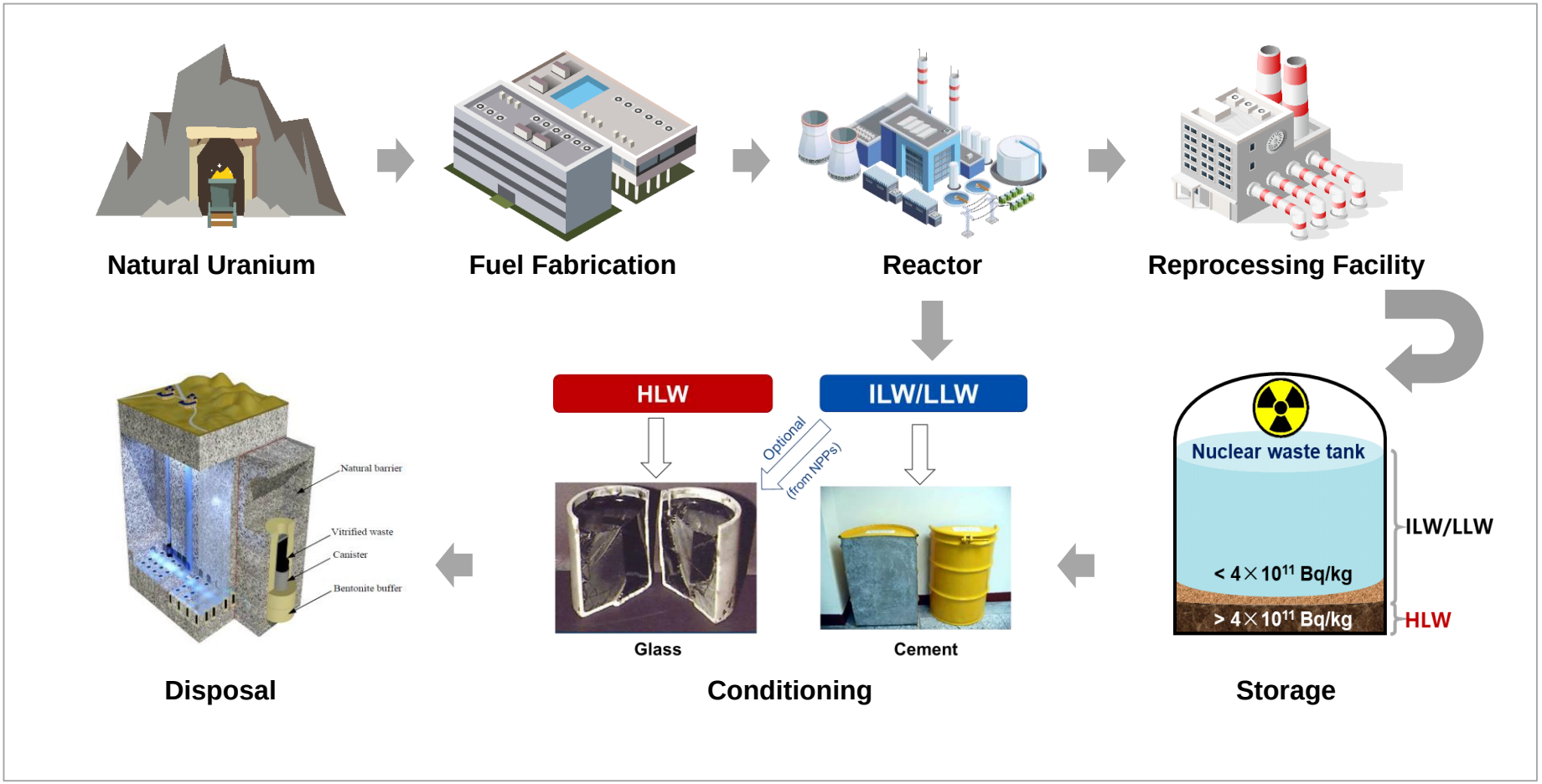
The map of nuclear power units in China





- 55 nuclear power units under operation, 23 units under construction
- 70 GW/15000 t (2025) to 200 GW/35000 t (2035)

Background – nuclear fuel cycle and nuclear waste management



- >50,000 m^3 of HLW from reprocessing by 2035
- >2000 m^3/y of ILW/LLW from NPPs

Background – current management of dry waste from NPPs

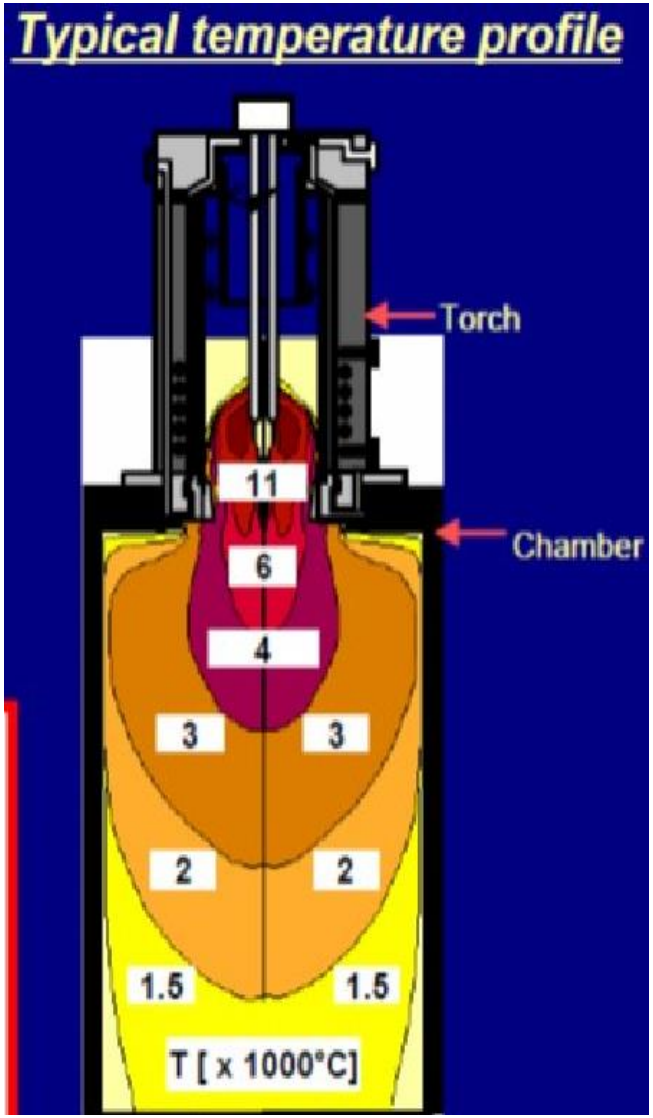
The main active dry/solid waste from NPPs

Compression

Cement

- Active dry wastes were compressed, cementitious immobilized, and then disposed in the near surface

Why TPT?



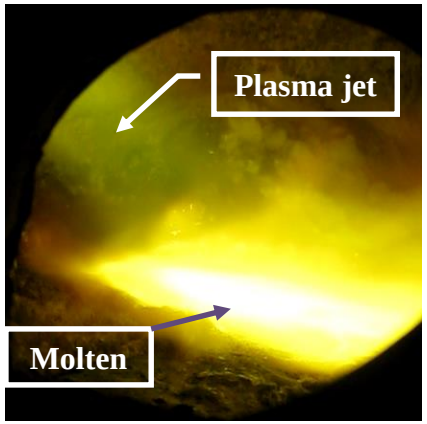
Thermal plasma is generated by a high voltage discharge as gas flowing

- **Temperature of plasma arc, high: the core: >10K °C; easily control**
- **High pyrolysis efficiency, high reactivity of the matter**
- **Controllable atmosphere, less off-gas…**

Research scaled TPT test

Waste

Glass additives



Melting

Waste glass

TPT development – mobility

- **Developed for nonactive hazardous waste**

- **Treatment of hazardous waste in a chemical plant**
- **Potential on active NPPs dry waste**

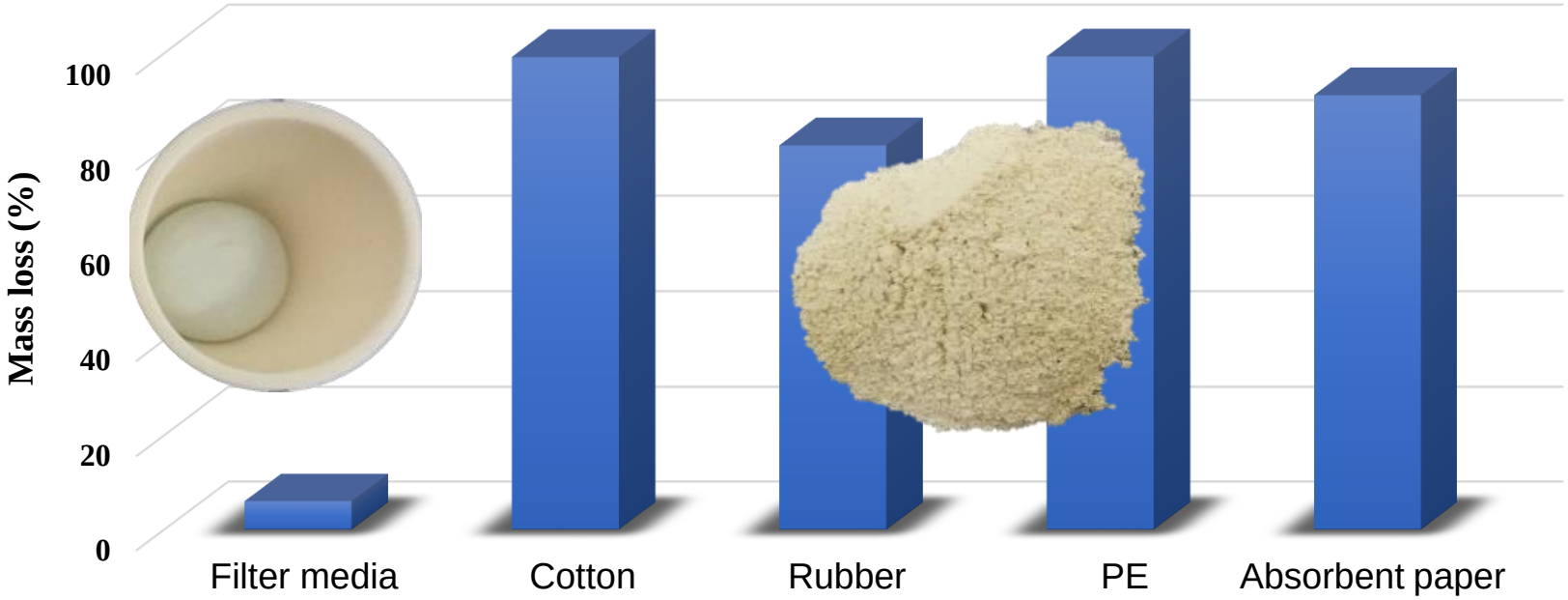
Laboratory study:

- Thermal treatment of dry waste
- Glass formulation of residual ashes

Thermal treatment of individual dry waste @1000ºC

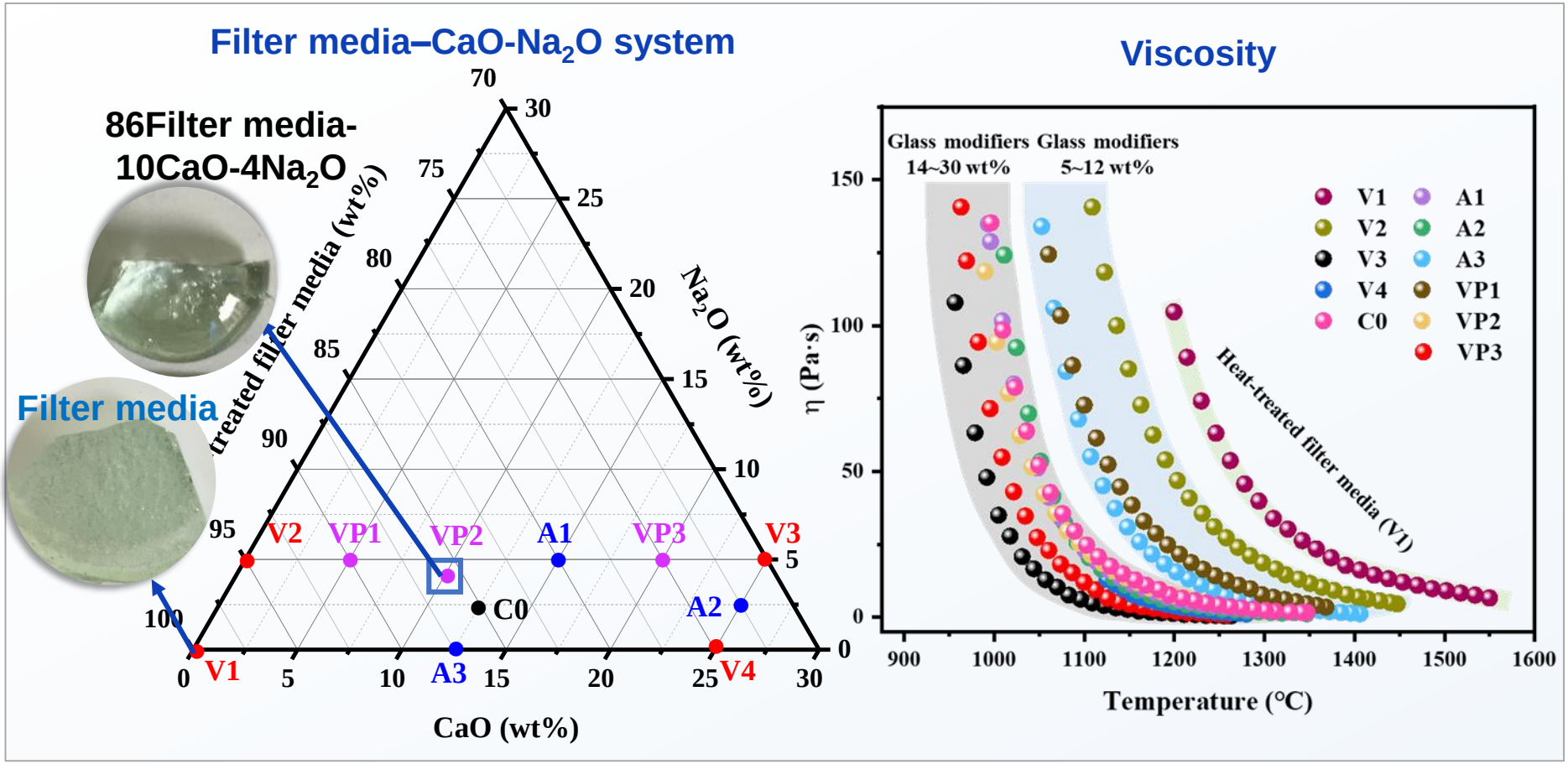






➢ **>90% mass loss, except filter media (glass fiber)**

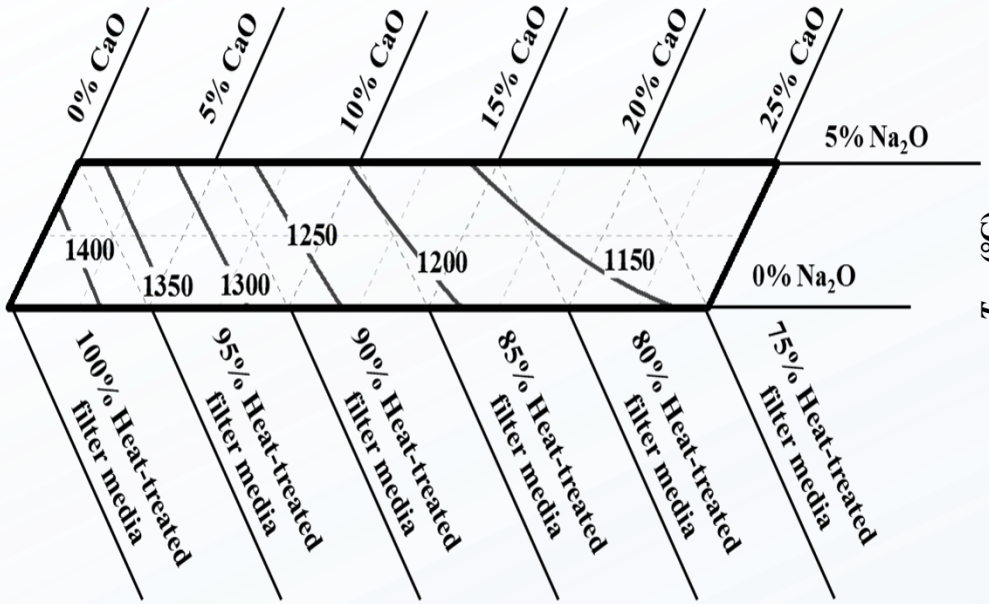
Waste glass formulation – filter media (glass fiber)



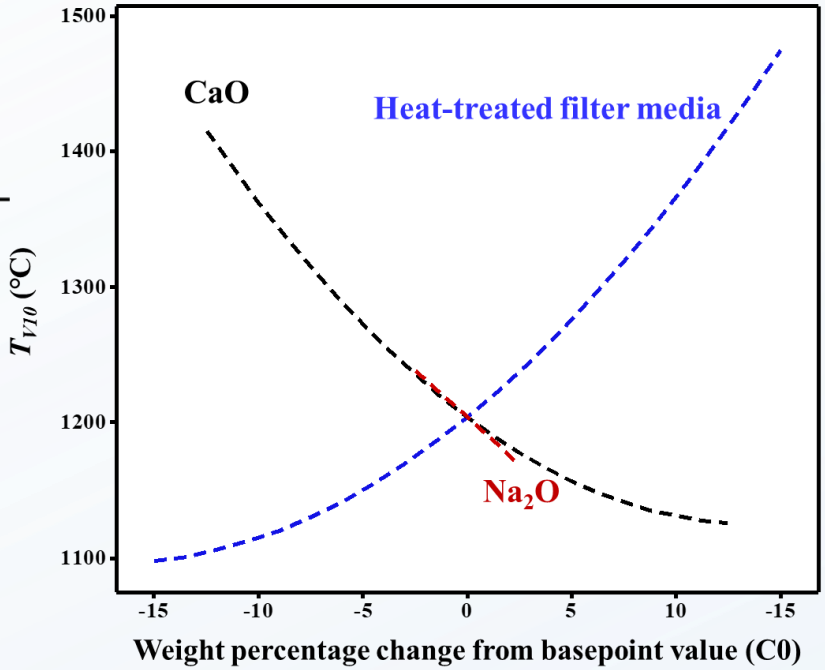
- The viscosity of filter media is high for waste glass melting
- CaO and Na_2O was added to reduce viscosity

Waste glass formulation – filter media (glass fiber)

Contour plot for T_{V10} (℃)



Component effects on T_{V10} (℃)

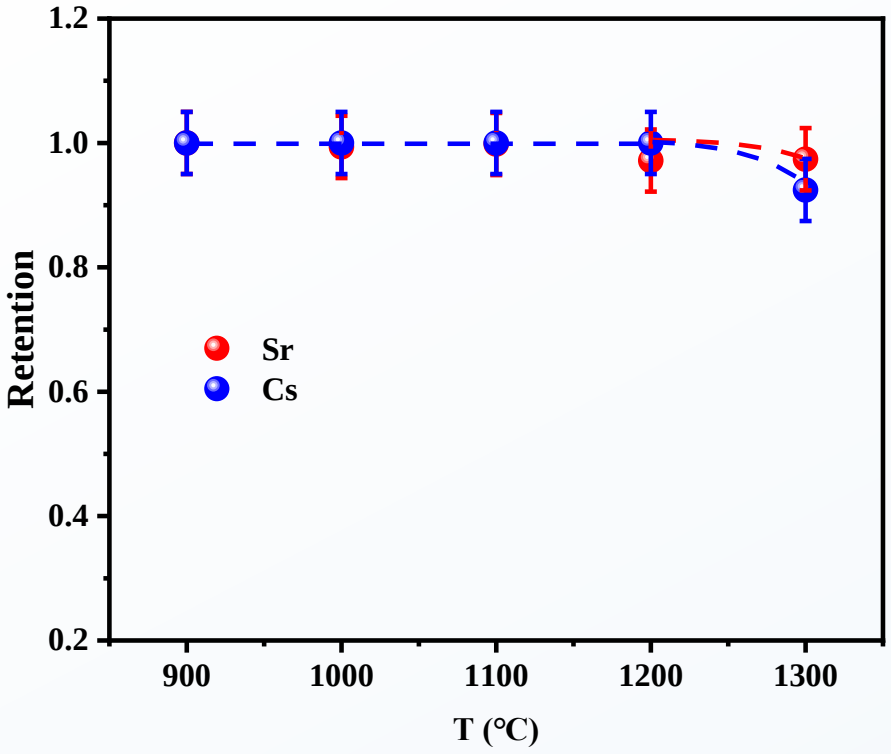


- Plot *T* profile (η=10 Pa·s) to filter media-CaO-Na_2O
- Determine effects of CaO and on T_{v10}

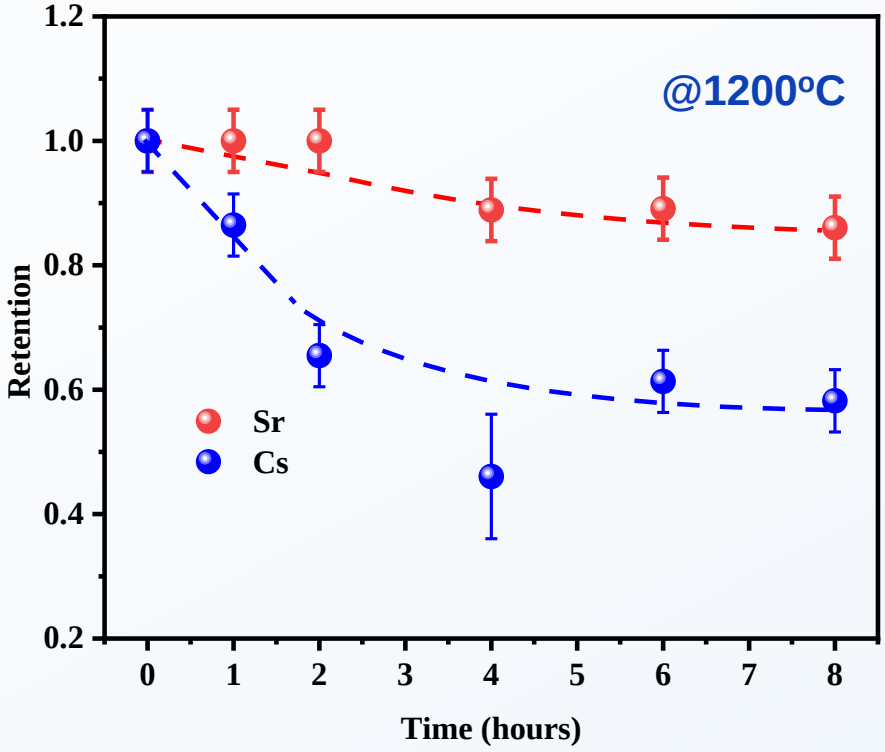
Volatilization test for 86filter media-10CaO-4Na_2O

Crucible test without lid

RT to target temperature



Dwelling time



➢ **Volatility of nuclides：Cs>Sr**

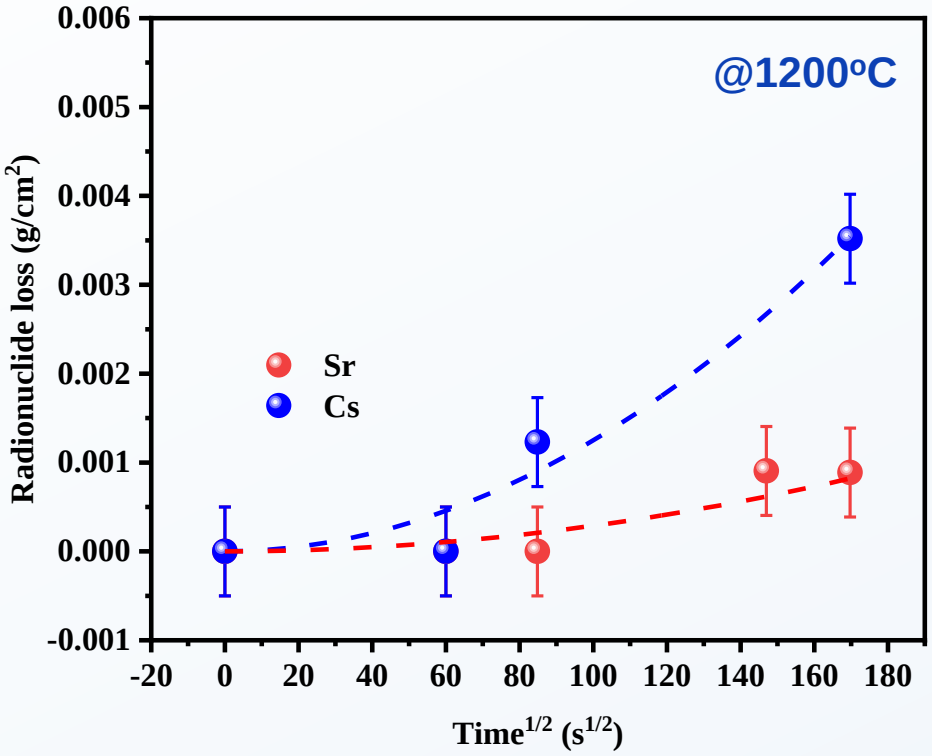
Volatilization test for 86filter media-10CaO-4Na_2O

The loss was defined as:

$$Q = \frac{C_0}{h}\left[exp(h^2Dt)erfc(h\sqrt{Dt}) - 1 + \frac{2}{\sqrt{\pi}}h\sqrt{Dt}\right]$$

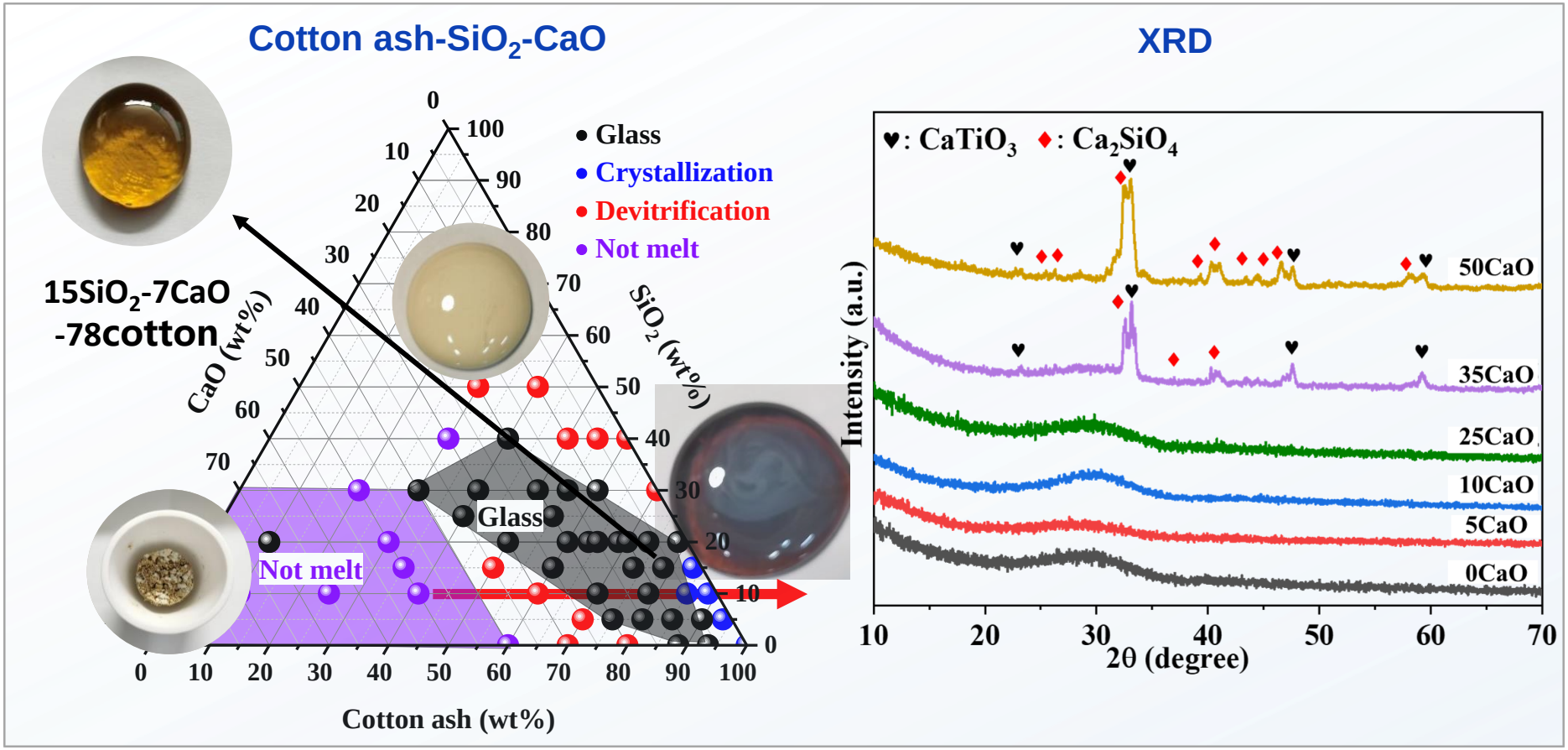
- D is the diffusion coefficient
- C_0 is the initial concentration of volatile species
- $h = K/D$, K is the chemical reaction rate

	K	D
Sr	2.85×10^{-8}	2.03×10^{-8}
Cs	1.34×10^{-7}	3.37×10^{-8}



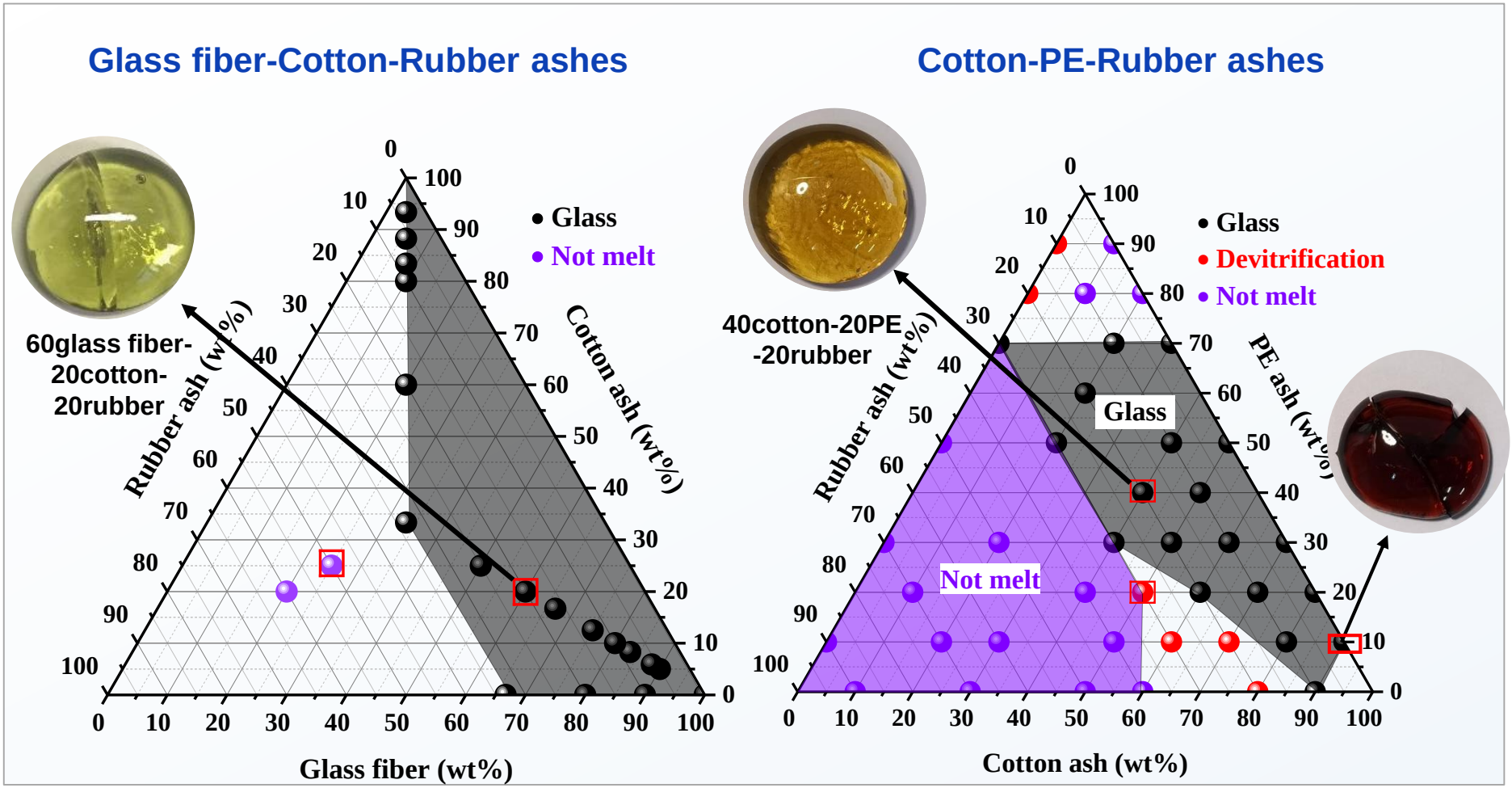
➢ **The losses of Cs and Sr could be estimated**

Waste glass formulation – single waste (cotton) ash



- The min. glass additive: ~5 wt%
- Easy to form the Ca-related crystalline phases

Waste glass formulation – mixing single waste ash



- **Rationally mixing single waste ashes could form the durable glass without any additives**

For more information, please contact

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