Dry, Effluent-free, Fluorination of Rare Earth Carbonates and Oxalates

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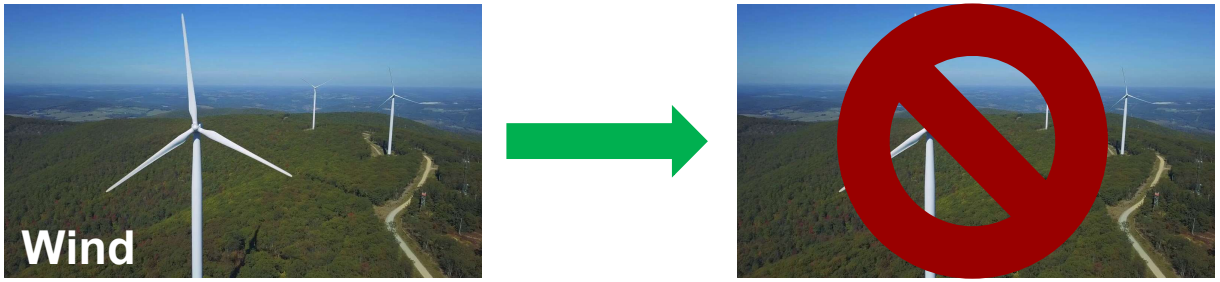
Perth, Australia

Problem: The Need for Rare Earth (RE) Magnets

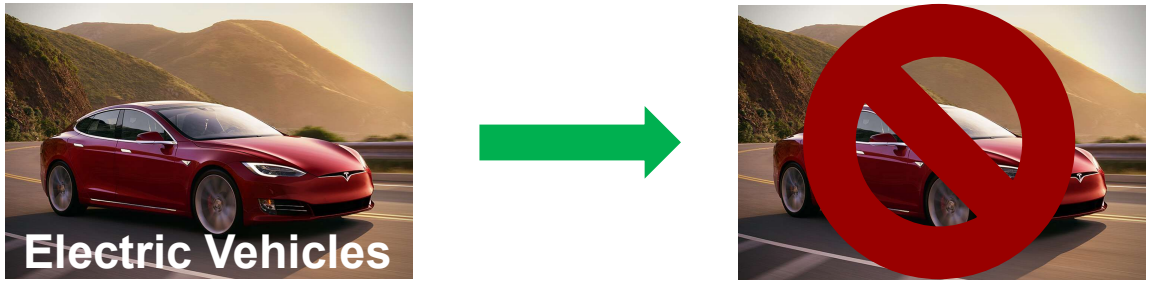
HARSH REALITY



Wind Farms without REs:

- Severe Inefficiency
- Higher Maintenance Cost
- Reduced Presence

HARSH REALITY



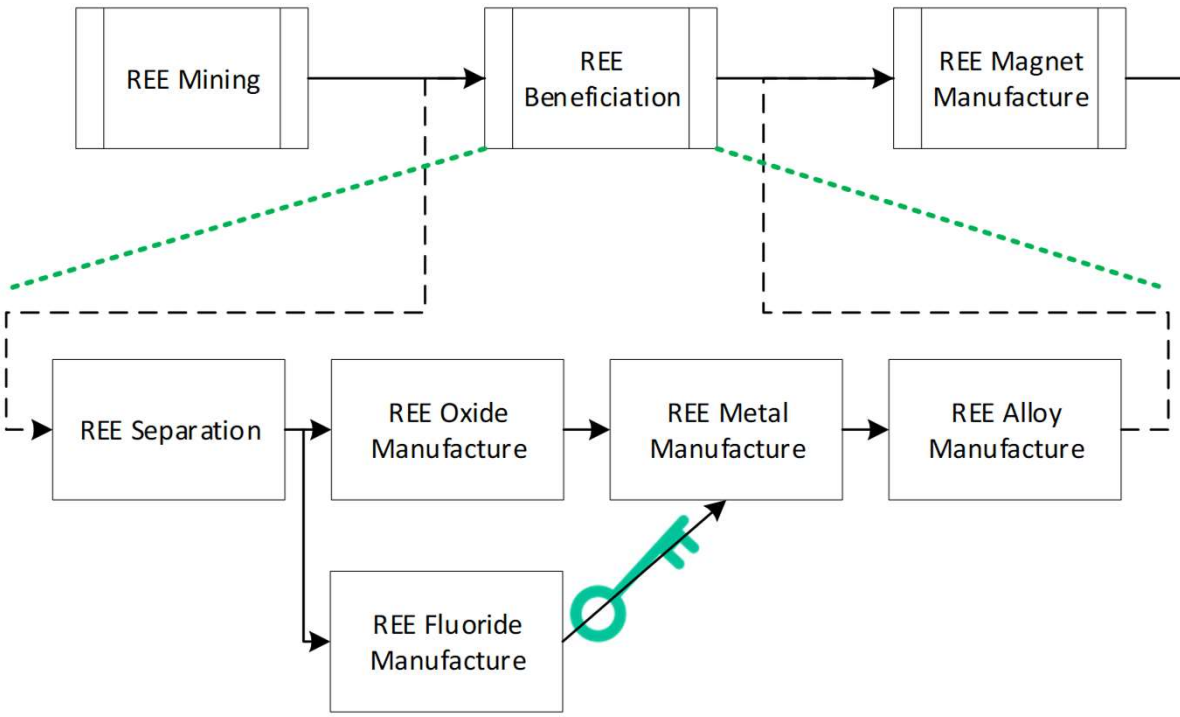
EVs without REs:

- Higher Manufacture Cost
- Higher Overall Cost
- Higher Variable Cost
- Reduced Presence

Solution: Green, Effluent-free Fluorination

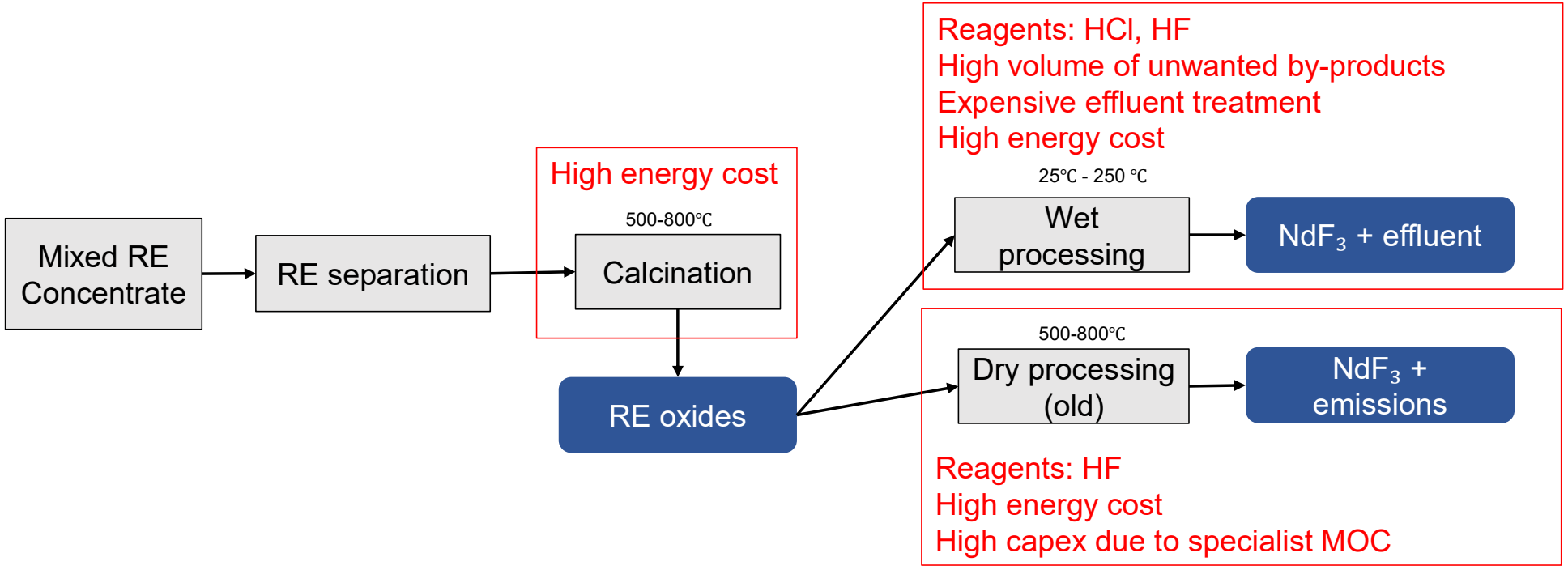




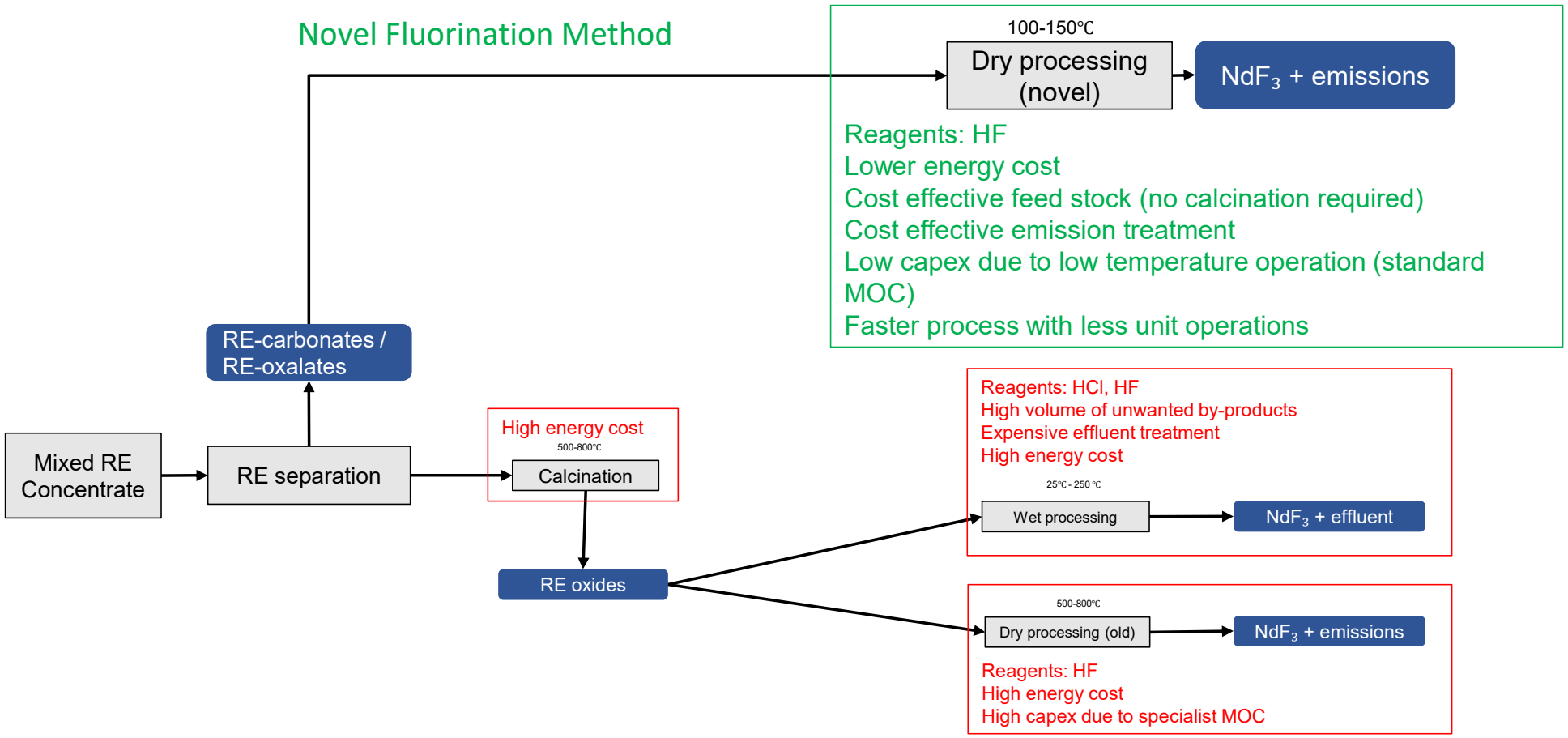



- Localized RE-fluoride production
- Provide guarantees for local industry
- Eliminate foreign dependence
- Cost efficiency (CAPEX & OPEX)

Industrial Process Options

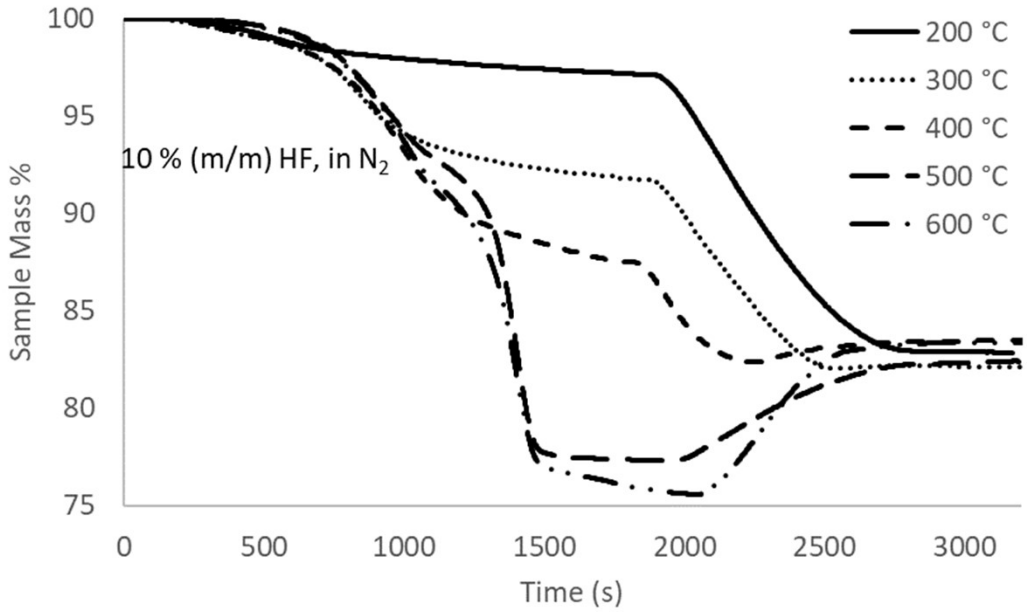


Industrial Process Options

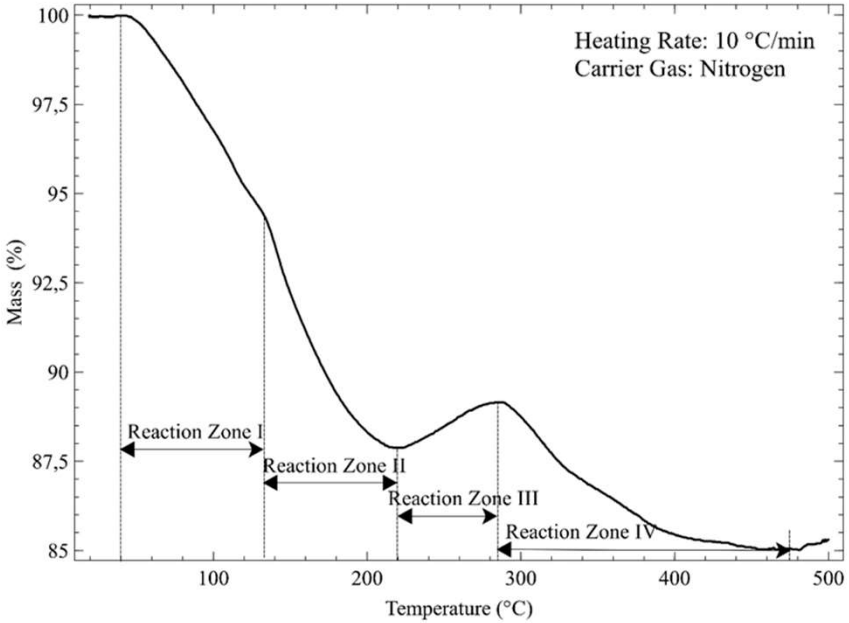


Fundamental Reaction Investigation

$$Nd_2(CO_3)_3 \cdot 8H_2O(s) + 6HF(g) \rightarrow 2NdF_3(s) + 11H_2O(g) + 3CO_2(g)$$

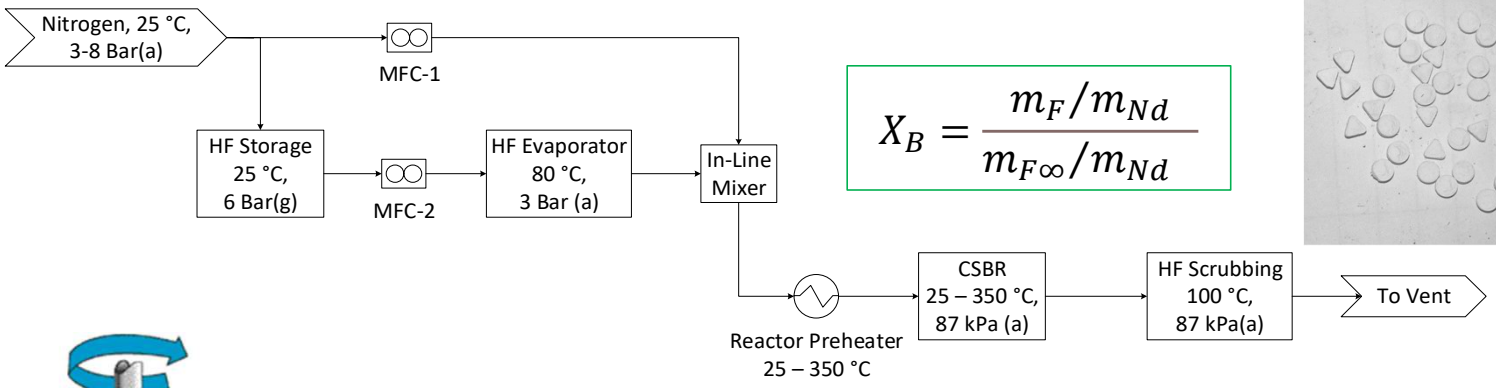


Isothermal thermogram of $Nd_2(CO_3)_3 \cdot H_2O$ during isothermal reaction with AHF at various temperatures.

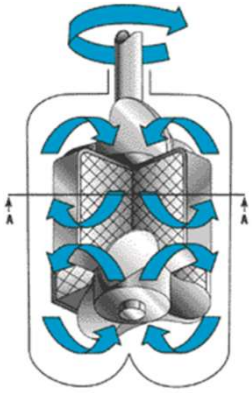


Dynamic thermogram of $Nd_2(CO_3)_3 \cdot H_2O$ in a 10 % (m/m) HF atmosphere.

Pilot Operation and Reaction Kinetic Determination



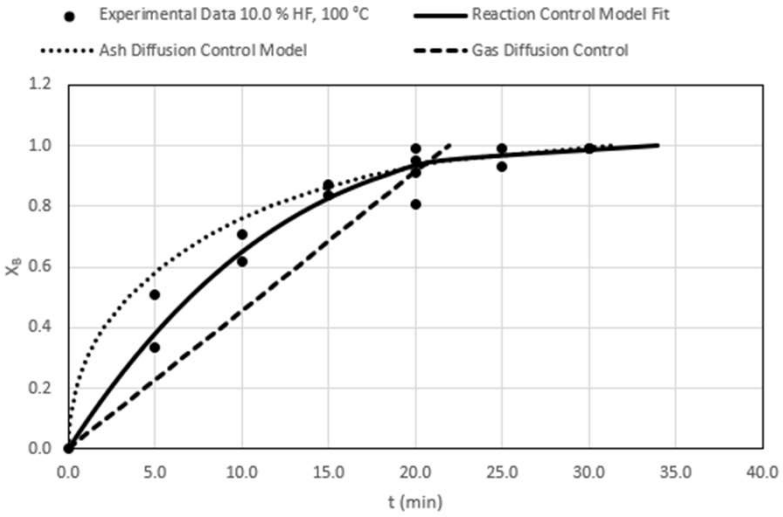
$$X_B = \frac{m_F/m_{Nd}}{m_{F\infty}/m_{Nd}}$$

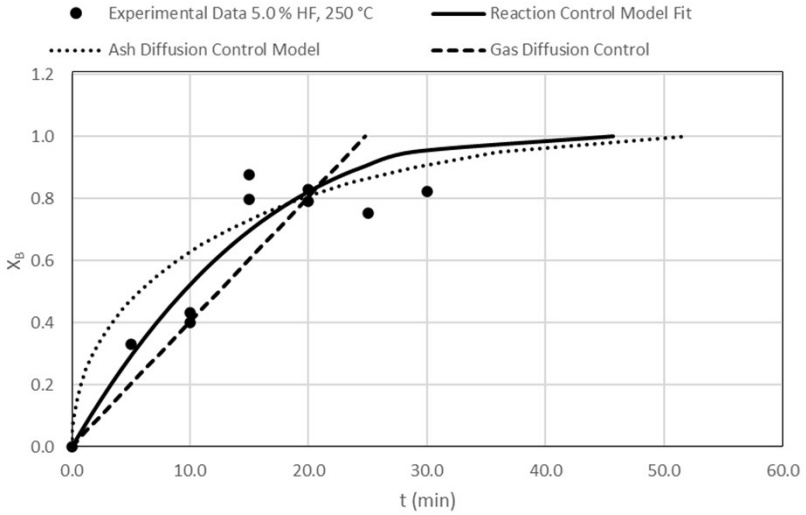


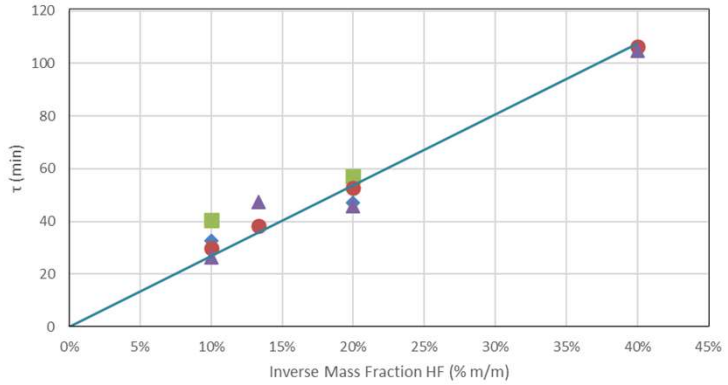
Cross-
Section A-A

HF Concentration (m/m %)	Experimental Temperature (°C)			
	100	150	200	250
2.5		X		X
5.0	X	X	X	X
7.5		X		X
10.0	X	X	X	X

Experimental, Results and Kinetics







$$\tau = \frac{1}{\alpha^n k_0 e^{-E_a/RT}}$$

$$\tau = \frac{2.6}{\alpha} \pm 10\%$$

"Fluorination of neodymium carbonate monohydrate with anhydrous hydrogen fluoride in a Carberry spinning basket reactor" – Royal Society of Chemistry: Reaction Chemistry & Engineering

"Preparation Process for Rare Earth Metal Fluorides" - WO 2018/142337-PCT/IB2018050665

Demonstration Plant

- Enclosed system containing three heated Monel tube reactors, anhydrous hydrogen fluoride (AHF) storage and evaporation as well as a wet and dry scrubbers.
- Raw materials processed: $Nd_2(CO_3)\cdot xH_2O$, $(Nd_2,Pr_2)(C_2O_4)_3\cdot xH_2O$.
- Samples produced to client specifications (complete conversion): NdF_3, $(Nd,Pr)F_3$.
- Plant Capacity: 200 kg of RE-fluoride per batch.
- Confirmation of kinetic parameters.
- Plant OPEX and CAPEX.

Conclusions

- We developed a chemical reaction from a line on a piece of paper, through a bench scale concept, to a commercially capable technology product.
- Our process produces rare earth fluorides with a simple one-step chemical reaction in an effluent-free, cost effective manner.
- Samples were produced to client requirements.
- Our process is a more sustainable alternative to traditional processes.
- We offer significant advantages to other methods of fluorination both in terms of capital, operating and maintenance costs.
- Designs are finalised for modularly expandable plant solutions and can now be offered to clients for in-house licensed manufacture.

Thank you

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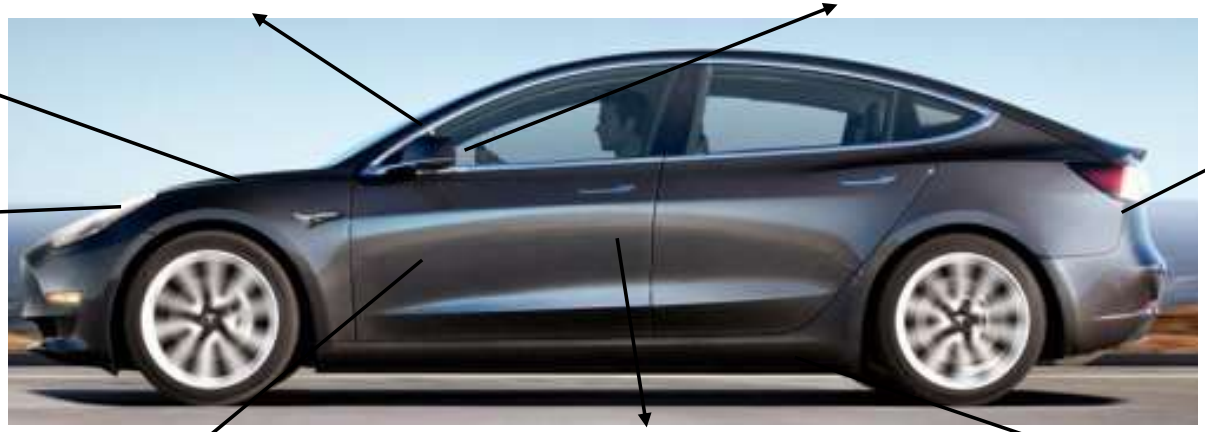
Rare Earths Every Day

Component Sensors
Yttrium

UV Cut Glass
Cerium

LCD Screen
Europium, Yttrium, Cerium

Electric Motor Permanent Magnet
~772g Rare Earths[1]: Neodymium, Praseodymium, Dysprosium, Terbium



Headlight Glass
Neodymium

Speaker Magnets
Neodymium

Electric Motor Magnets – HVAC, windows, seats
Neodymium

High Performance Batteries
Cerium
Lanthanum

[*] Advanced Research Projects Agency, "REACT Program Overview," Arpa, Washington, 2015.