Hypergolicity and ignition delay study of green bipropellant system without catalyst (PPT)

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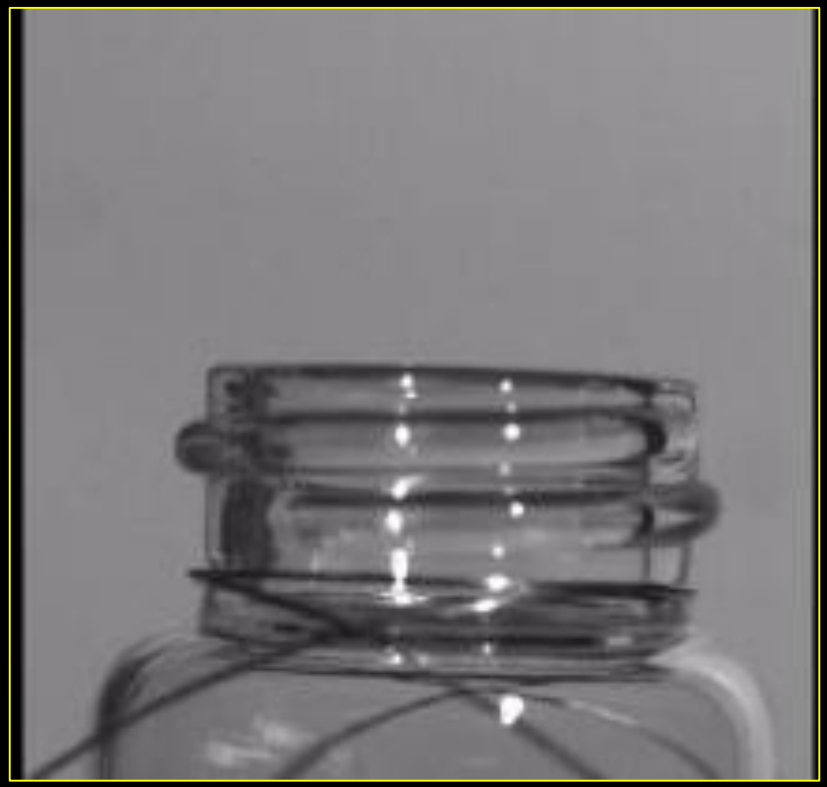

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Hypergolicity and ignition delay study of green bipropellant system without catalyst

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New Trends: Green Propellants

Hypergolic
Green
H_2O_2
EtOH
Thermally

European Space Agency

- Non-toxic 
- Easier and safer to handle
- Reduce cost

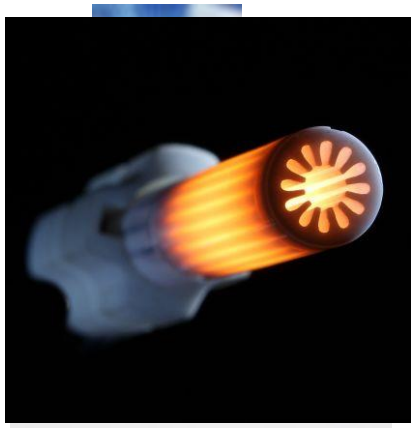
Hydrogen Peroxide H_2O_2

Ethanol (*EtOH*) C_2H_5OH

$$H_2O_2(aq.) \longrightarrow H_2O(l) + \frac{1}{2}O_2(g) + \Delta H$$

Initiation of the process:

- Catalysts
- Spark
- *Thermally?*



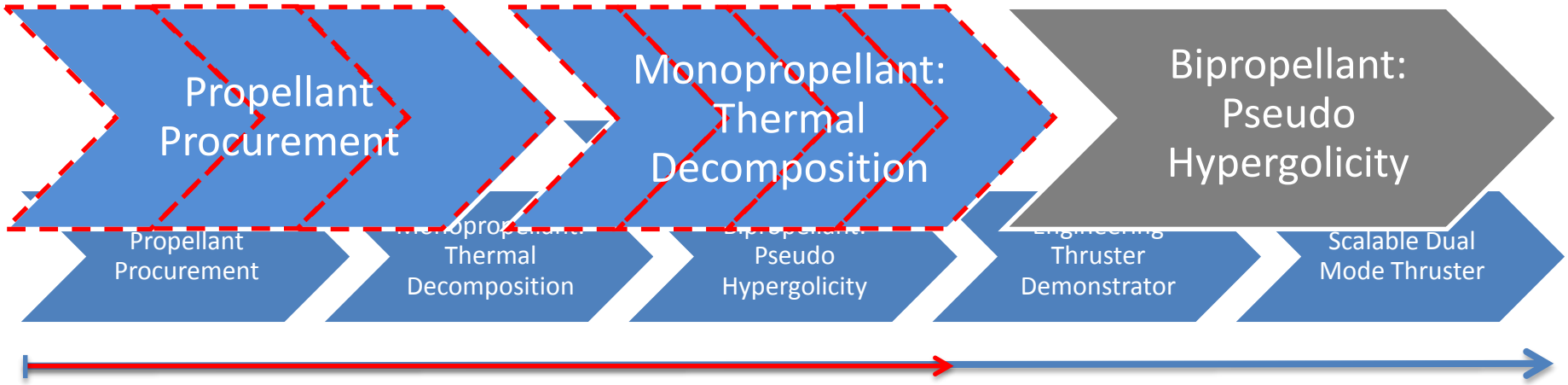
Research Goal

Hypergolic
Green
H_2O_2
EtOH
Thermally

Is the use of thermal energy sufficient to achieve in-house refined High Test Peroxide decomposition to allow for dual-mode system, as monopropellant and as pseudo hypergolic bipropellant with ethanol, and if so, under what conditions?

- **Procurement of H_2O_2** through in-house approach
- **Thermal decomposition of HTP** to provide detailed study of required conditions
- **Pseudo hypergolicity** to prove and characterize its possibility avoiding catalysts
- **Characterization** to provide with an understanding of the the process for its future application

Outline



Scope of my MSc. thesis

1. **Direct obtaining**
2. **Freezing method**

1. **Innovative solution**

1. **Temperature: needed and expected**
2. **Experimental setup**

1. **Methodology**

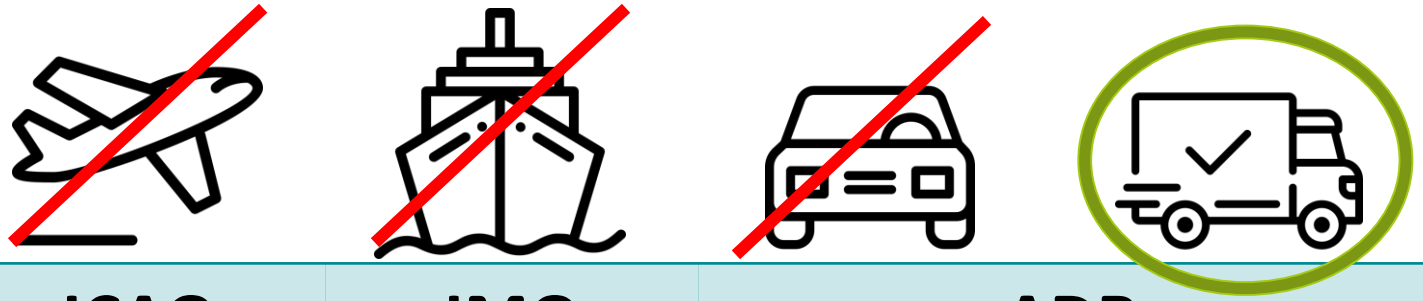
2. **Test results**

Procuring High Test Peroxide

Propellant Procurement

Monopropellant: Thermal decomposition

Bipropellant: Pseudo-hypergolicity



ICAO	IMO	ADR	
<40%	<60%	>60%	***70-98%***

- ✓ Suppliers
- ✓ Research institutions

Supplier 1 – Germany

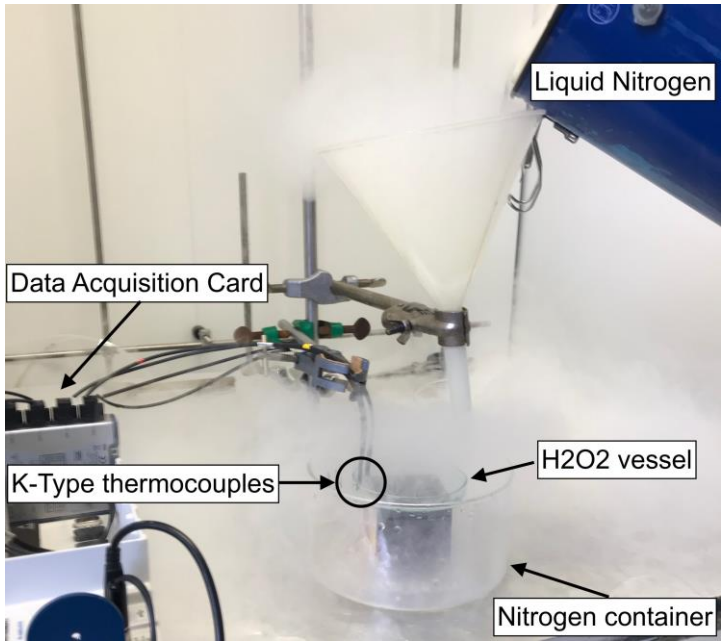
- 98%/87.5 %
- 1kg

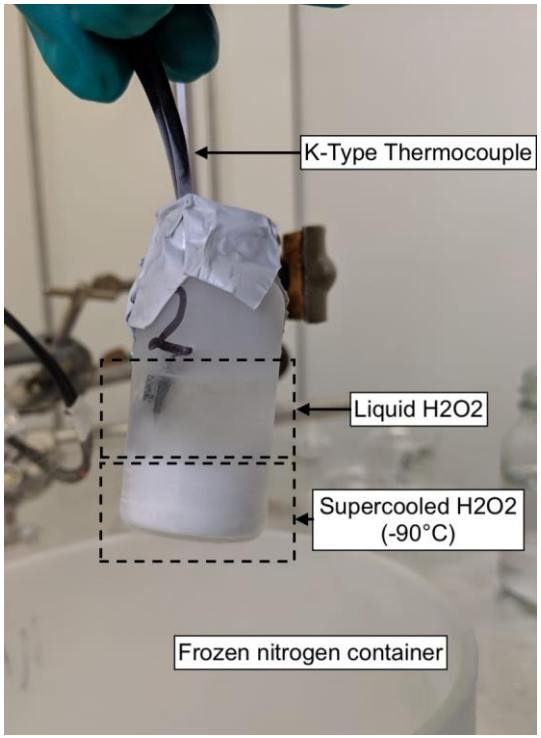
The Freezing Method

Propellant Procurement

Monopropellant: Thermal decomposition

Bipropellant: Pseudo-hypergolicity





Innovative Approach: Patent Results

Propellant Procurement

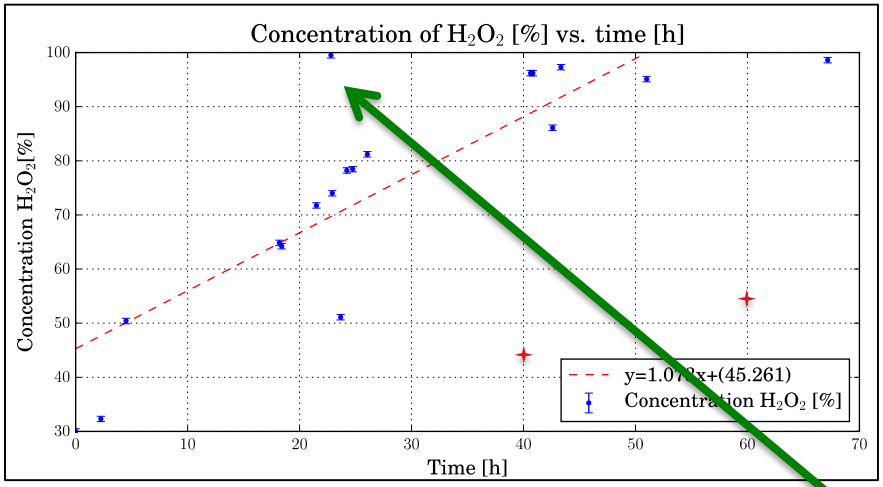
Patent

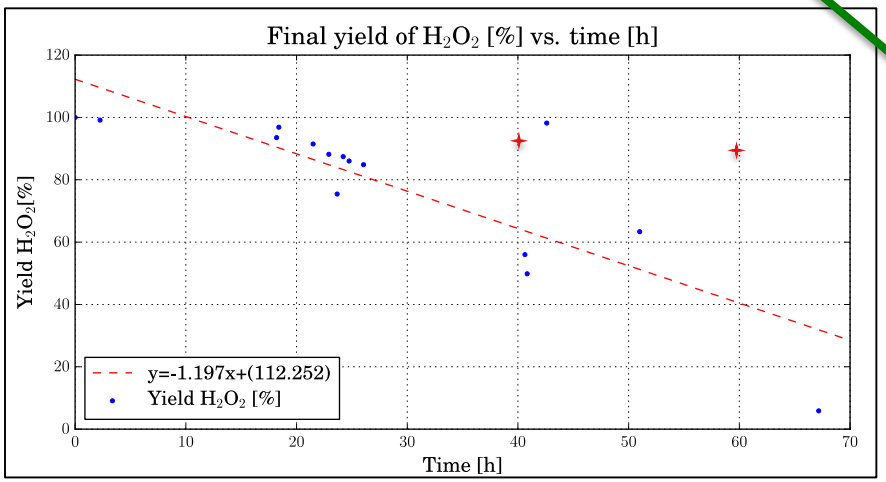
Monopropellant:

Thermal decomposition

Bipropellant:

Pseudo-hypergolicity





- ✓ Maximum concentration: **99.5%**
- ✓ Minimum initial concentration: **10%**
- ✓ Average of 1.1% increase per hour
- ✓ Fastest recorded: **99.5% in 23h**
- ✓ Order of magnitude **cheaper** than available systems
- ✓ Improvements show **reduction in time** and increase in yield

START-UP SPIN-OFF INCOMING

Monopropellant: Thermal Decomposition

1. **Temperature: needed and expected**
2. **Experimental setup**

1. **Methodology**

2. **Test results**

Propellant Procurement

Patent

Monopropellant:

Thermal decomposition

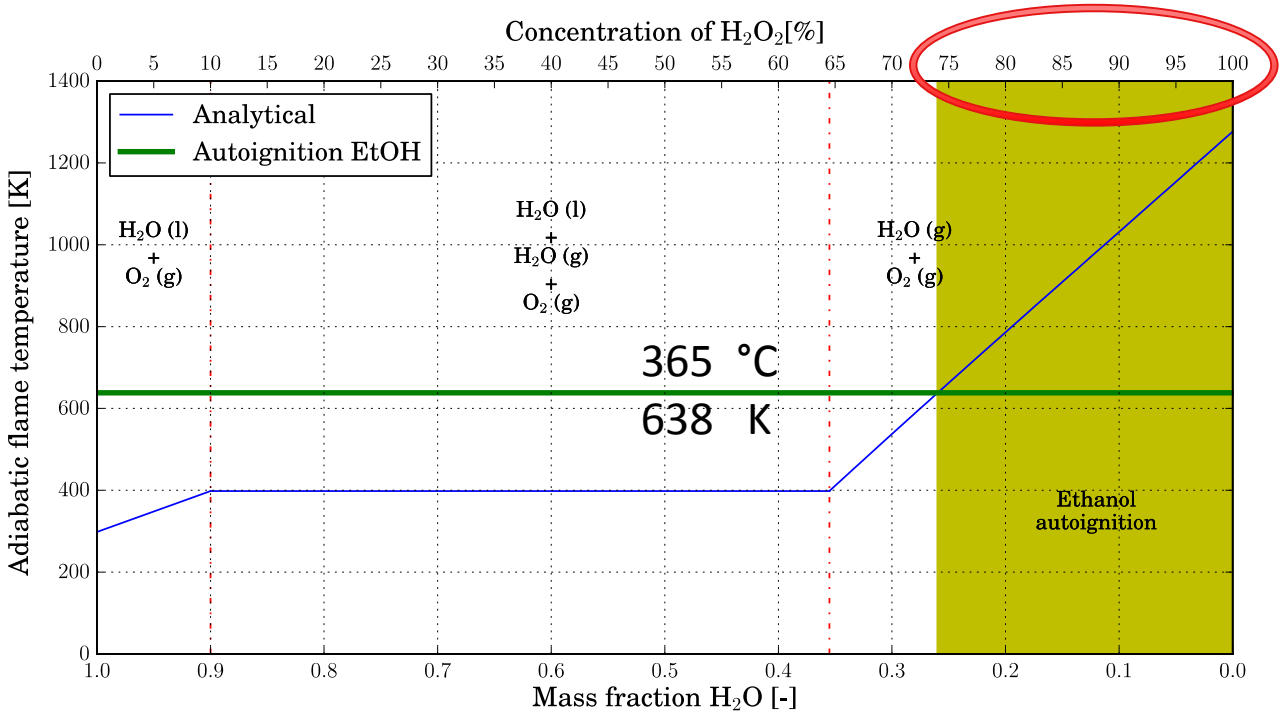
Bipropellant:

Pseudo-hypergolicity

Thermal Decomposition: Theory

$$H_2O_2(aq.) \longrightarrow H_2O(l) + \frac{1}{2}O_2(g) + \Delta H$$

- What temperature is expected to happen?
- ✓ Adiabatic flame temperature



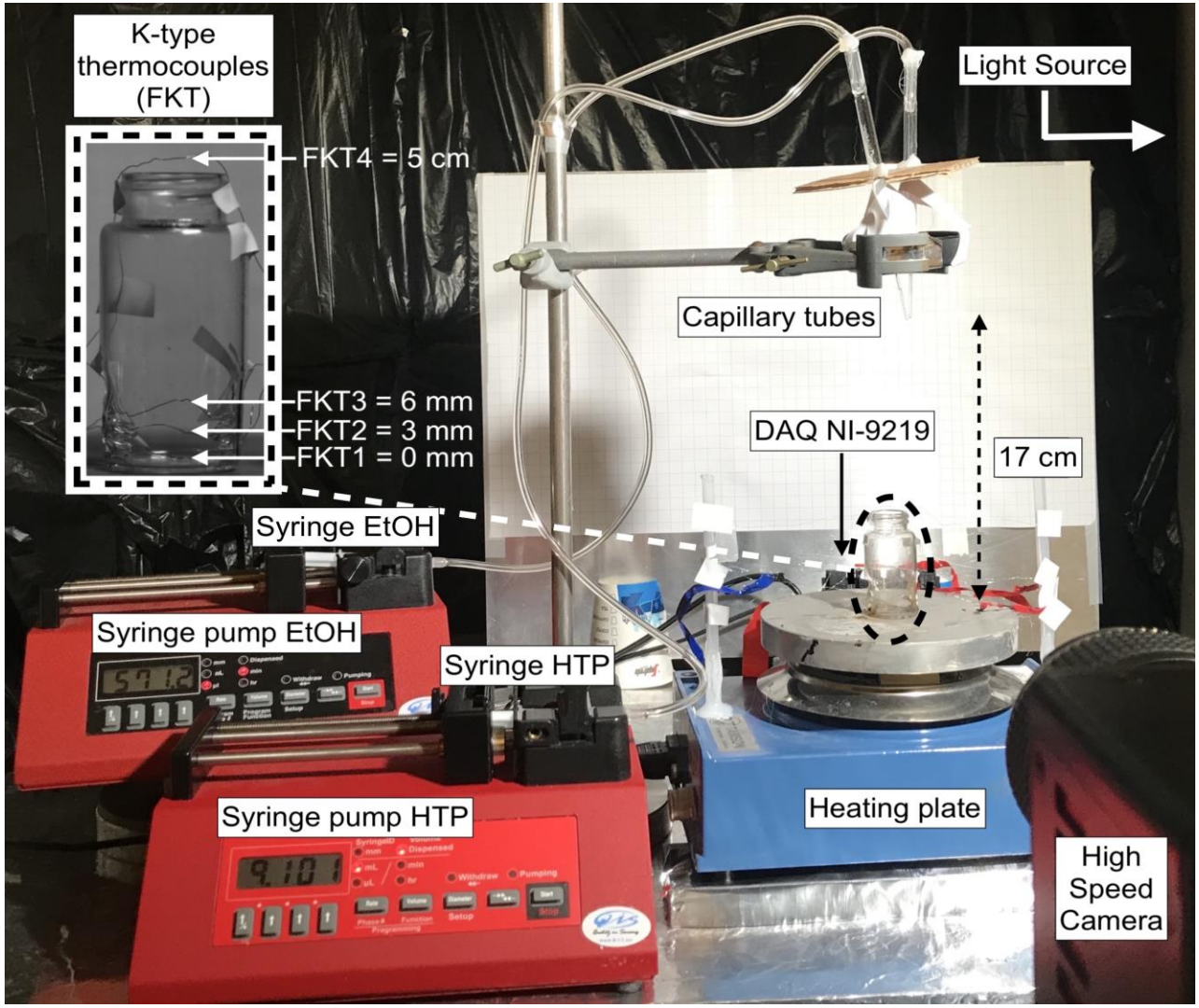
The Experimental Setup

Propellant Procurement

Patent

Monopropellant: Thermal decomposition

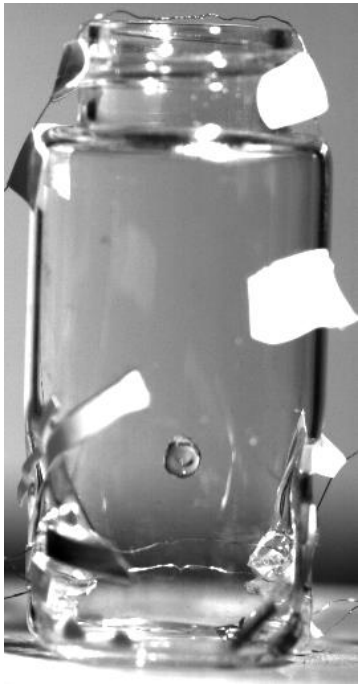
Bipropellant: Pseudo-hypergolicity



Methodology

- Concentrations: 75, 80, 85, 90, 95 %
- Heating plate: 50, 100, 150, 200, 250, *270* °C
- Droplet: 0.13 mL (H_2O_2)
- HSPC: 6,400 fps
- Thermocouples: (1-3) 55Hz

	Concentration [%±1%]				
T [°C±10 °C]	75	80	85	90	95
50	1	7	13	19	25
100	2	8	14	20	26
150	3	9	15	21	27
200	4	10	16	22	28
250	5	11	17	23	29
270	6	12	18	24	30



Propellant Procurement

Patent

Monopropellant: Thermal decomposition

Bipropellant: Pseudo-hypergolicity

Results: Valid Combinations and Profile

Propellant Procurement

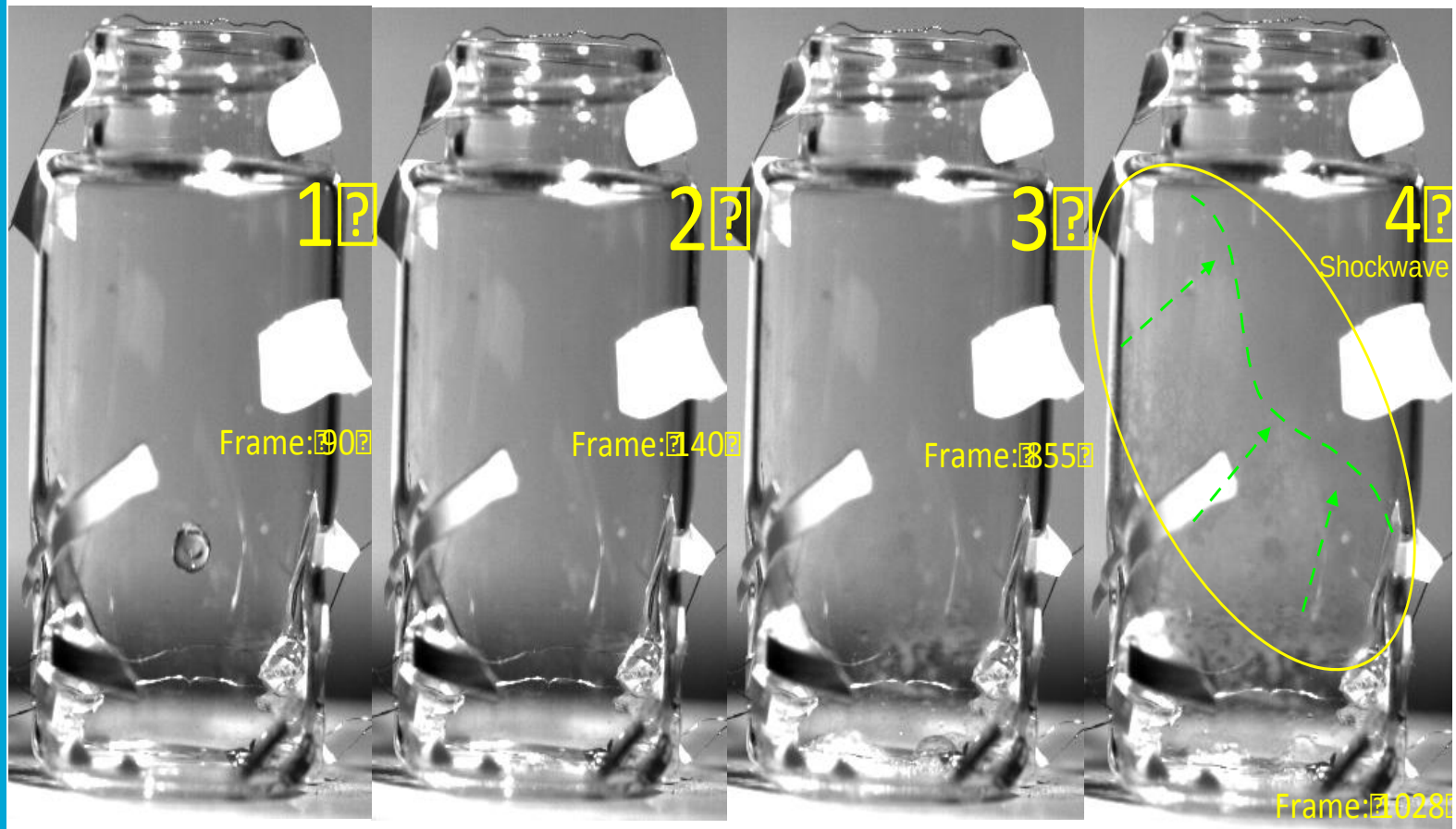
Patent

Monopropellant:

Thermal decomposition

Bipropellant:

Pseudo-hypergolicity



80% HTP on 270°C

Results: Maximum Temperature

Propellant Procurement

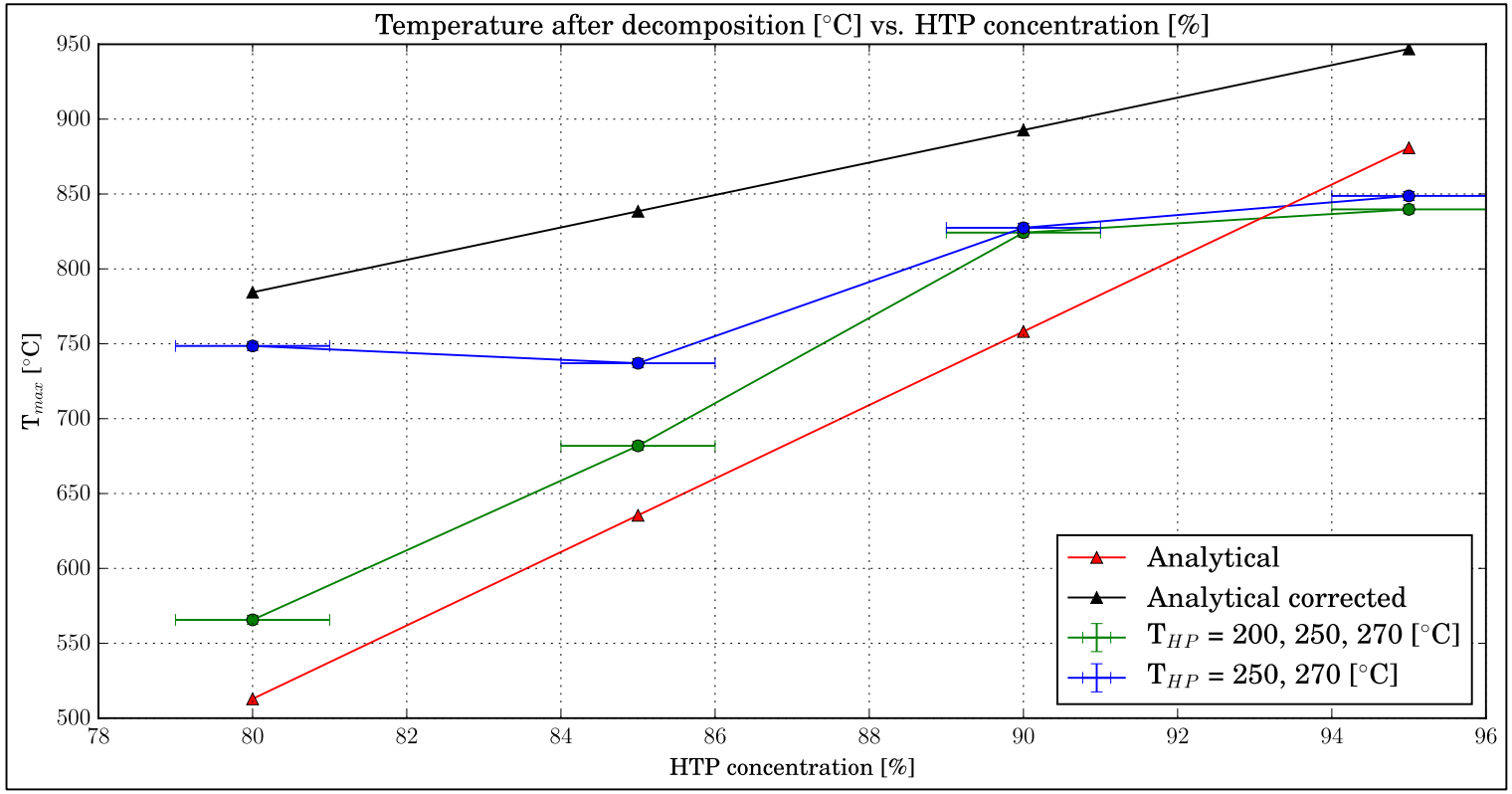
Patent

Monopropellant:

Thermal decomposition

Bipropellant:

Pseudo-hypergolicity



Results: Decomposition Time Delay

Propellant Procurement

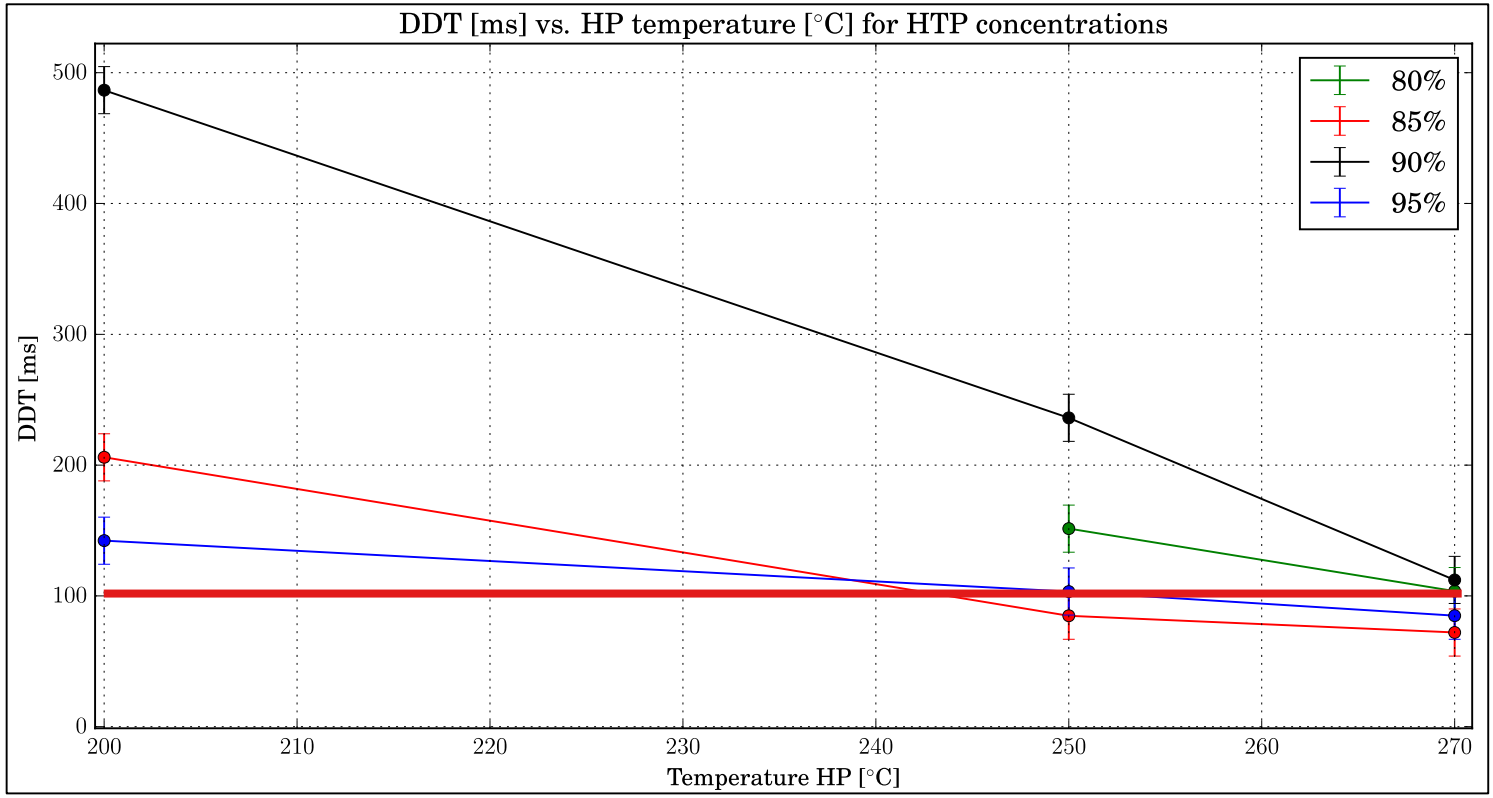
Patent

Monopropellant:

Thermal decomposition

Bipropellant:

Pseudo-hypergolicity



Decomposition Lessons

- Minimum of 200 °C and 80% HTP is needed to decompose
- All combinations from 80% HTP and 200 °C can auto ignite ethanol
  - Tmax increases with concentration
- DDT decreases with temperature
  - Heating element at 270 °C gives less than 100 ms
- **Thermal approach is possible for monopropellant**

Pseudo-hypergolic demonstration

Propellant Procurement

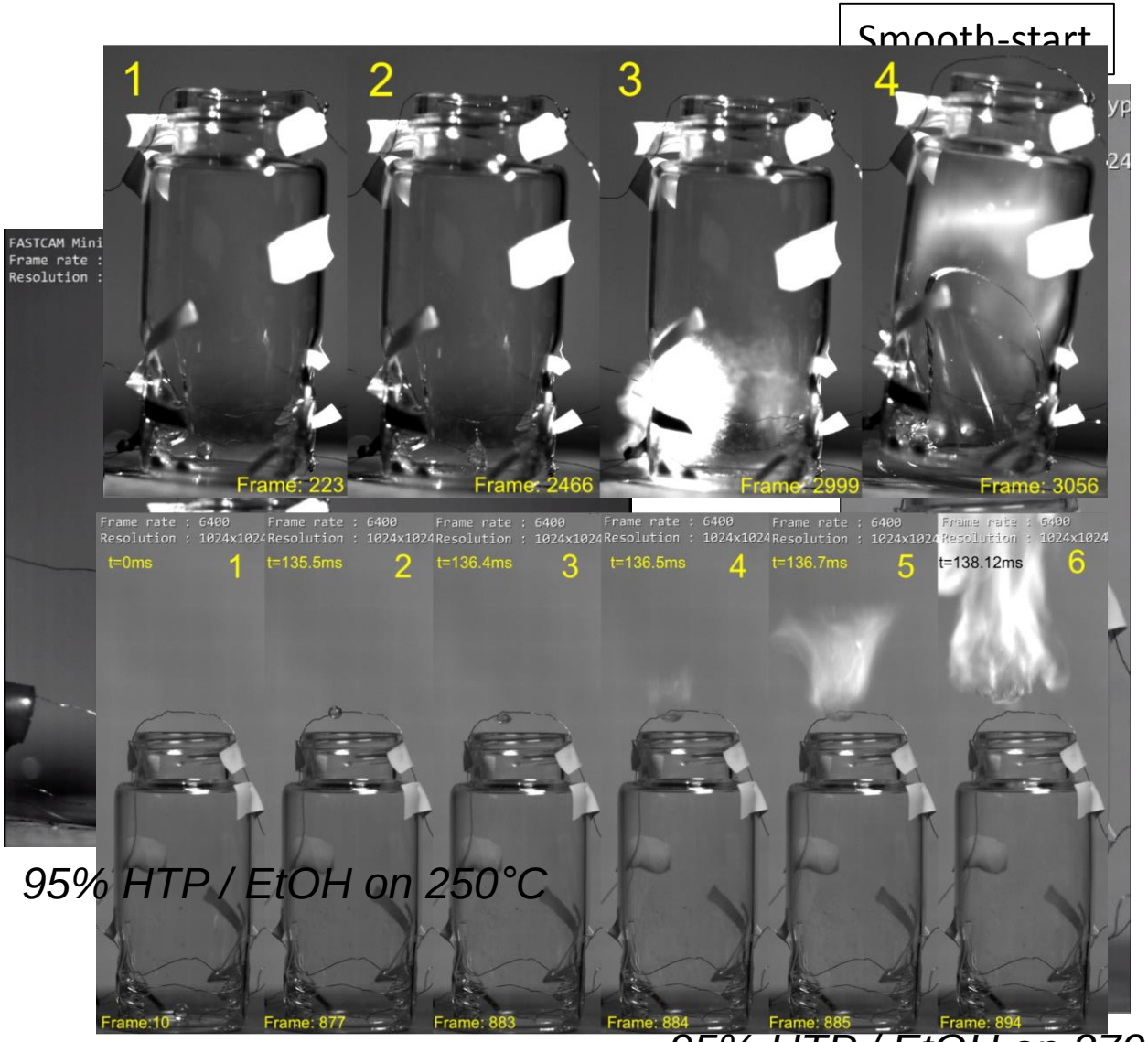
Patent

Monopropellant: Thermal decomposition

Proved

Bipropellant: Pseudo-hypergolicity

Start-Up Spin-Off incoming



95% HTP / EtOH on 250°C

95% HTP / EtOH on 270°C

Conclusions and **recommendations**

- Study on the **purity of the HTP** in terms of stabilizers
- Larger funding for setup with close chamber: **pressure variations**
  - Color-mode equipment
  - Impinging mechanism
- Test the approach on a **flow of hydrogen peroxide**
- Detail study on the exact **liquid-to-vapor ratio** prior to decomposition for better modeling of the approach
- Vary the **height** of the setup to mimic different injector situations

Thank you for your attention!

Questions?