

Fire Dynamics and Explosion Risks of Li-Ion batteries

21. May 2024

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and

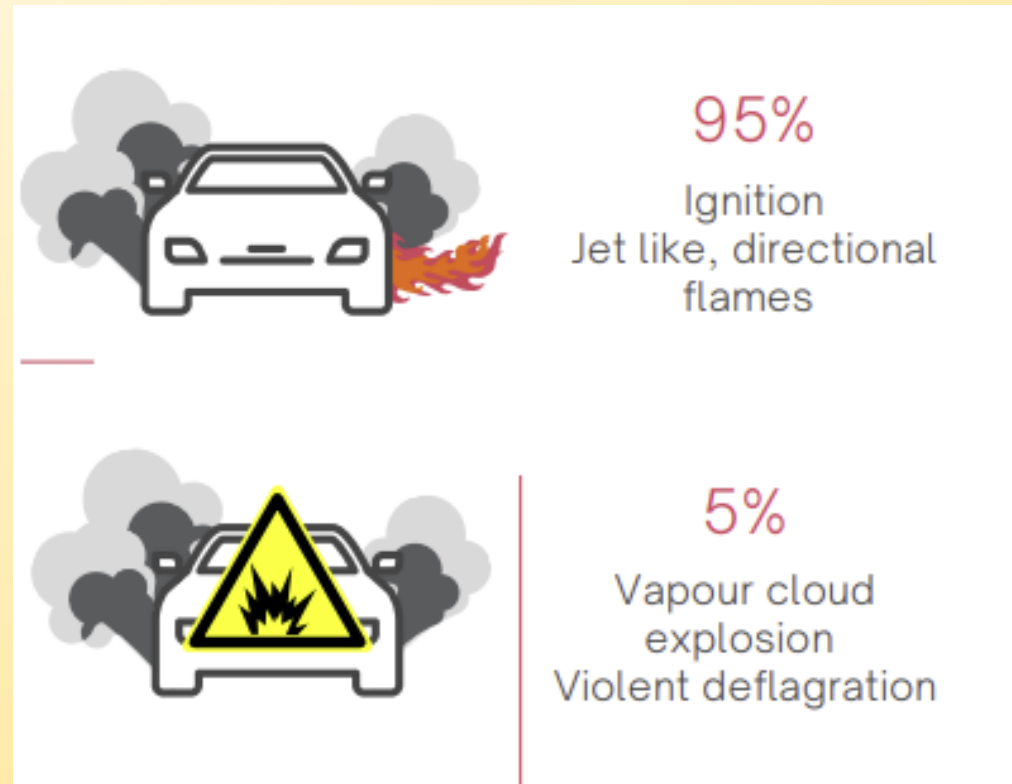


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Fire Dynamics/Statistics



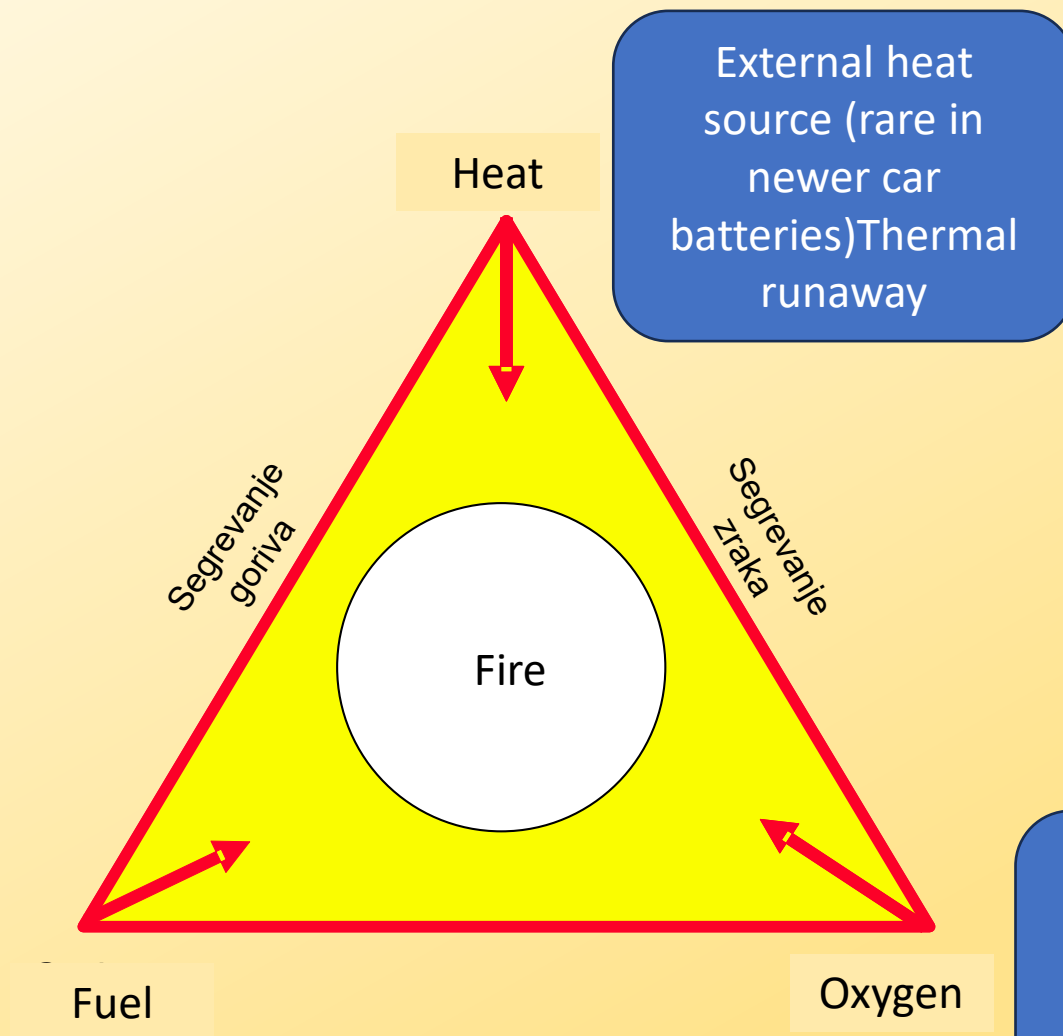
Viri: evfiresafe.com, Research Europe, 2023

Li-ion Batteries as Fuel



Batteries are a combination of solid and gaseous fuels. The gases released contain flammable components consisting of hydrocarbons (ethane, ethene, ethene), carbon monoxide and hydrogen. In addition, in addition to the casing (plastic parts), solid particles of carbon, aluminum and copper are present during combustion.

The Combustion Theory

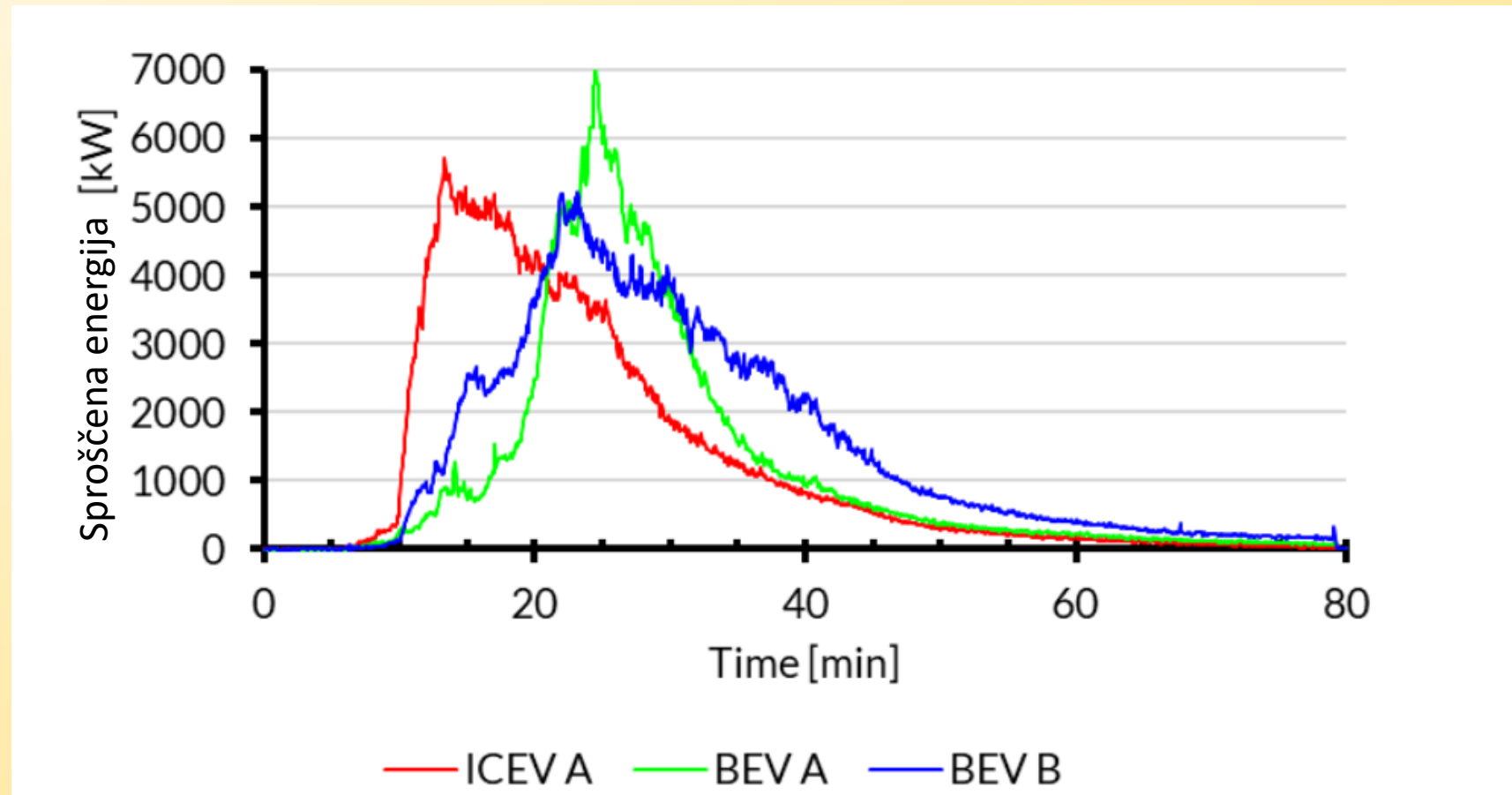


External heat source (rare in newer car batteries) Thermal runaway

Lithium - flash point: 500 °C
Hydrogen - flash point: 560 °C

Lithium salts are an oxidant - they do not need oxygen from the surroundings to burn.

Fire Curve - Not Electric/Electric Vehicles



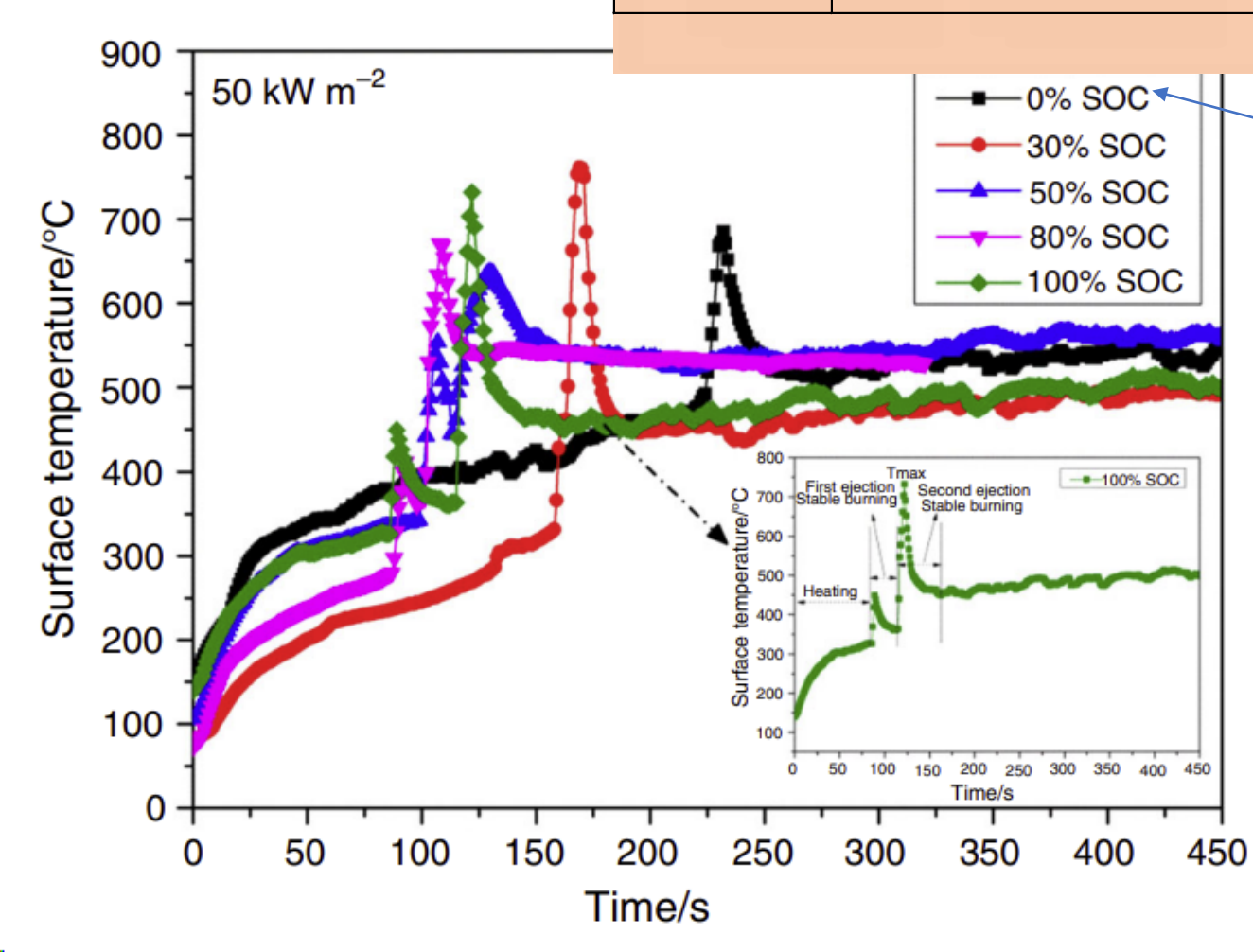
Internal combustion v.

EV



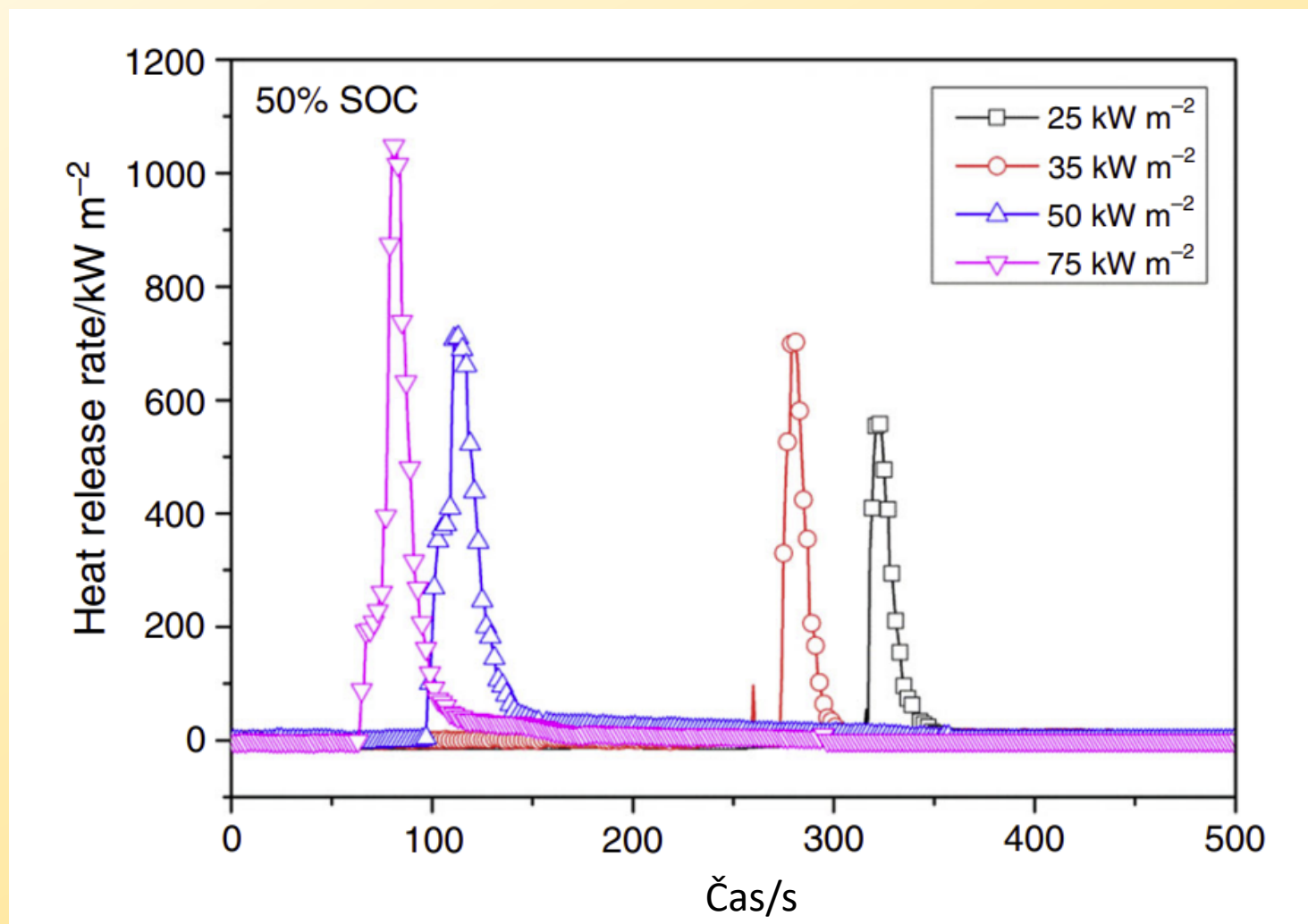
Time to Ignition

Heat flux (kW/m ²)	Equipment	Impacts
		Humans
60-200	Flame surface	
20	Flashover	100% dead in one minute Major injuries within 10 seconds
12,5	Minimum heat energy to ignite wood with flame, plastic pipes melt	1% dead in one minute 1st degree burns after 10 seconds
4		Causes pain if exposure is longer than 20 seconds
1,6		No effect on human well-being after prolonged exposure

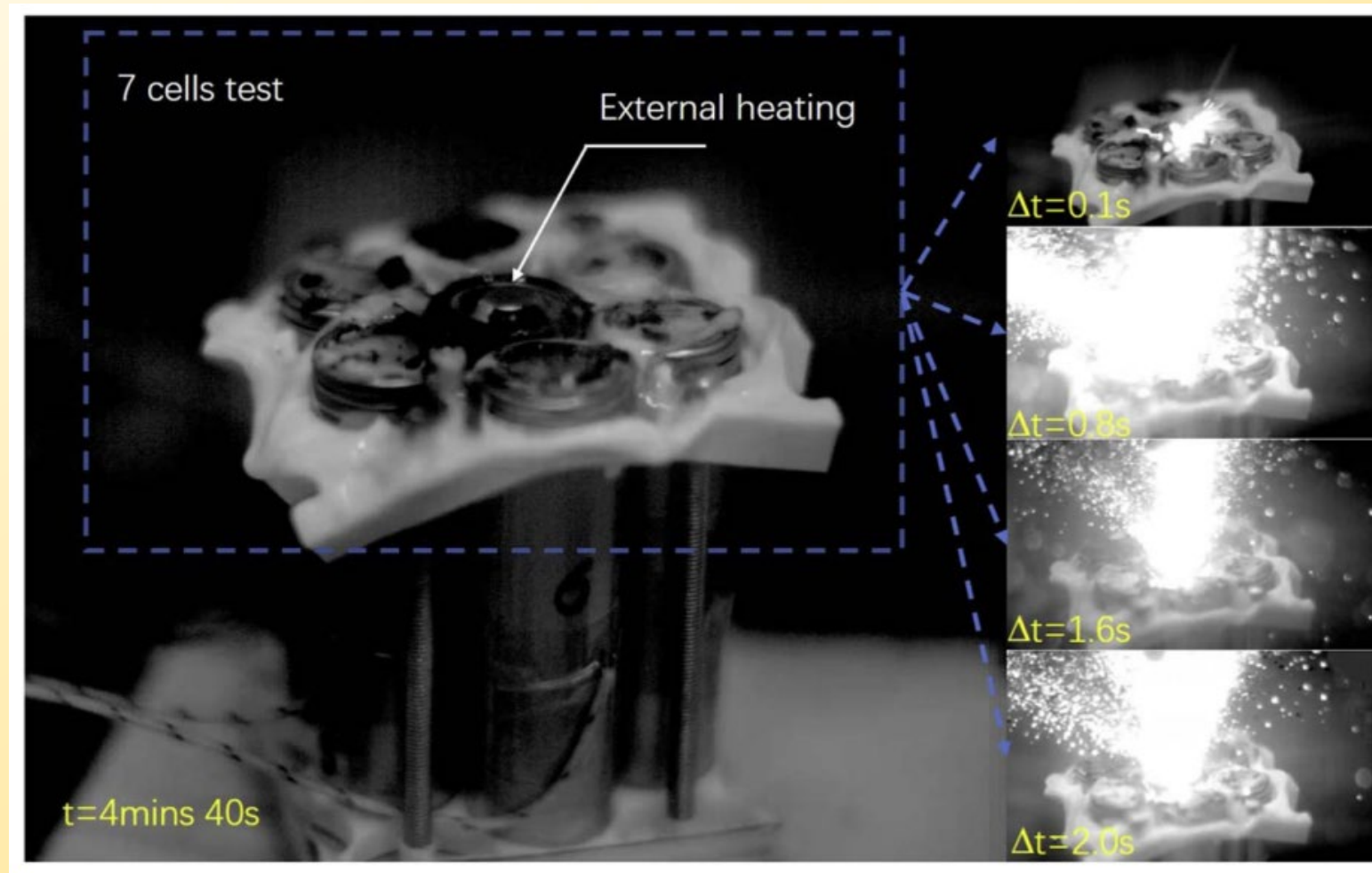


SOC – battery charge status

Amount of Energy Released



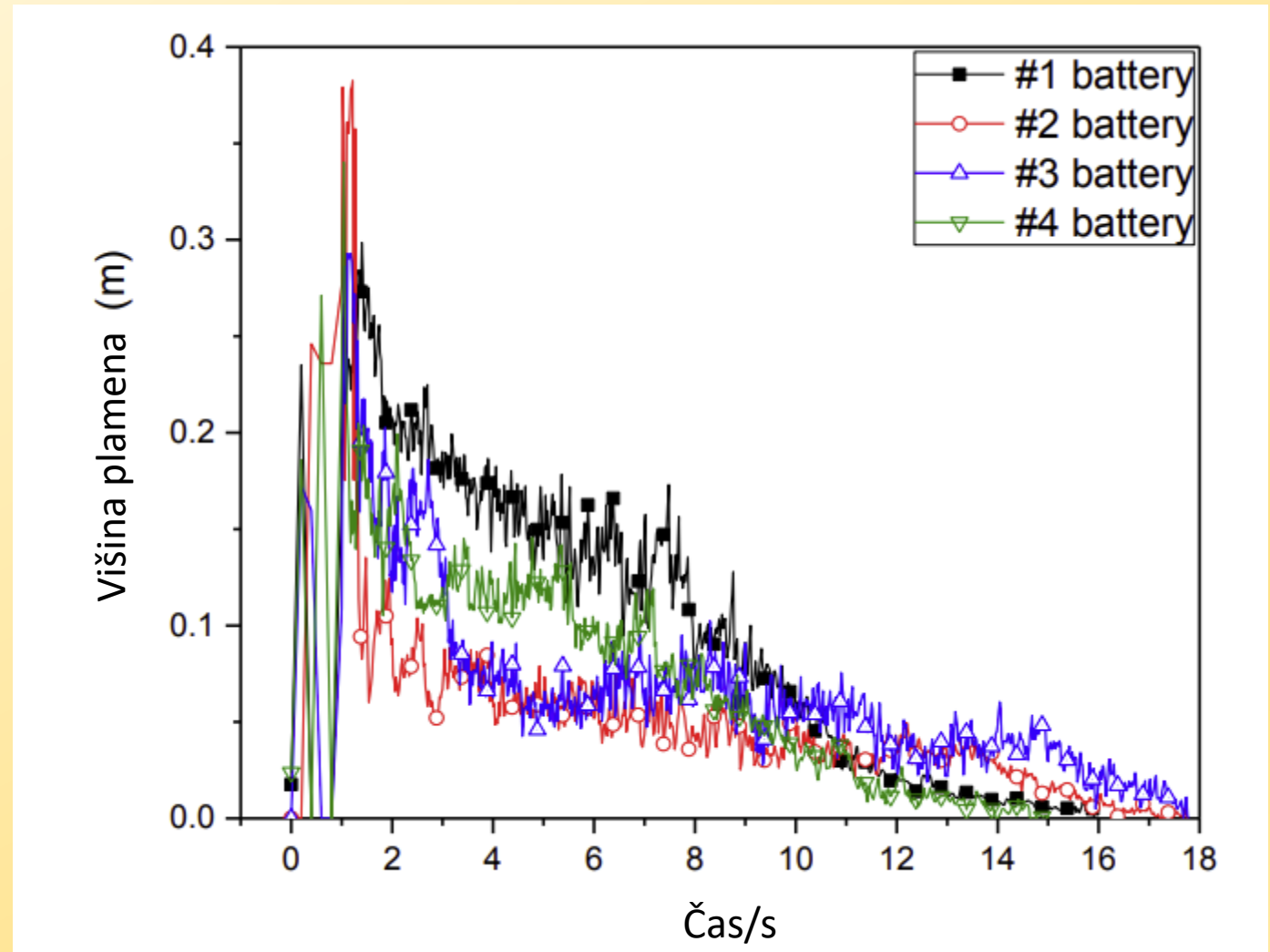
Jet Flame



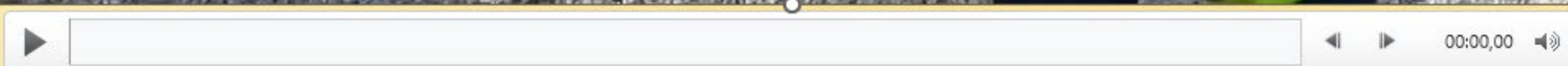
Flame Height



Li-ionska battery, type 18650



Fire Dynamics



Toxicity



In addition to the well-known combustion products that occur in a fire, the combustion of batteries also produces:

- hydrogen, ethylene carbonate, methyl carbonate,
- dimethyl carbonate, methane, ethene, ethane, ethene,
- lithium hexafluorophosphate, heavy metals (cobalt, nickel, manganese),
- hydrogen fluoride, phosphoric acid and phosphine.

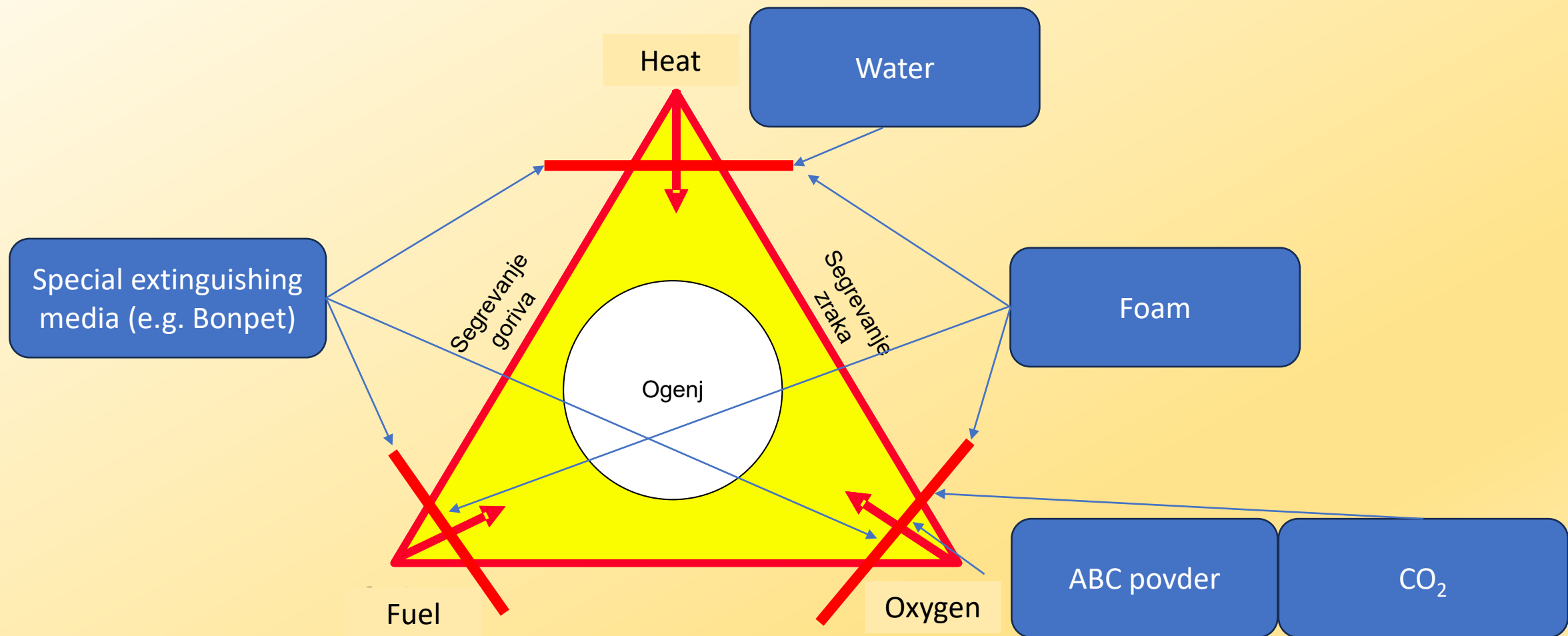
Explosion risks



- SOC dependent: There is a distinct change in the species composition of the vent gas at about 40% to 50% SOC.
- FAA study:
 - below 40% SOC flammable gases make up less than 25% of the volume, with the remainder being carbon-dioxide.
 - At 40% SOC, there is a sudden jump in the flammable gas volume and a decrease in the carbon-dioxide volume.
 - At 50% SOC, the flammable gas production is above 30% by volume and increases further as the SOC increases.

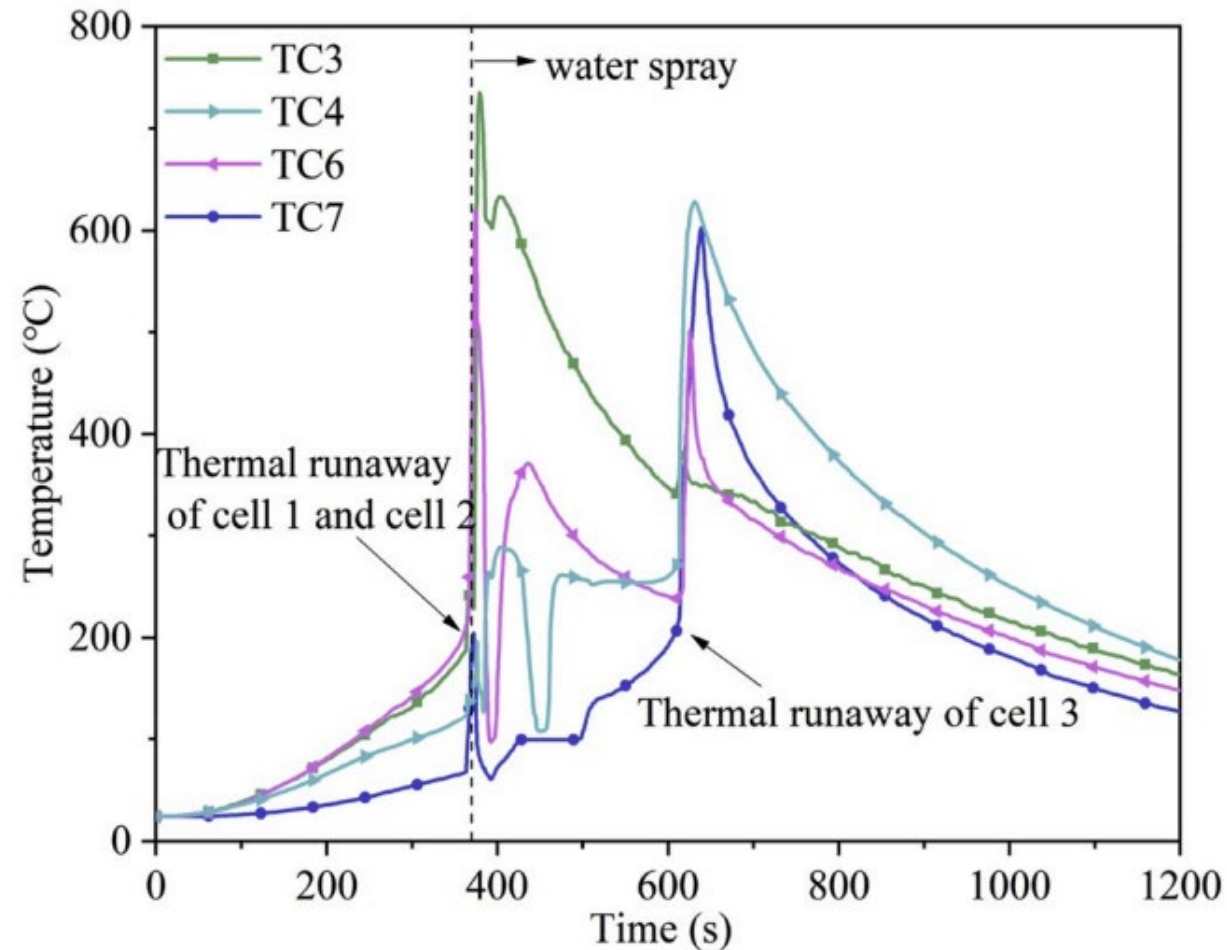
Supression

The extinguishing medium shall provide a cooling and damping effect.



Supression

The effect of water as an
extinguishing medium - water
mist (stable system)



Questions

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