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Combustion of aerosols: droplet sizing study in microgravity

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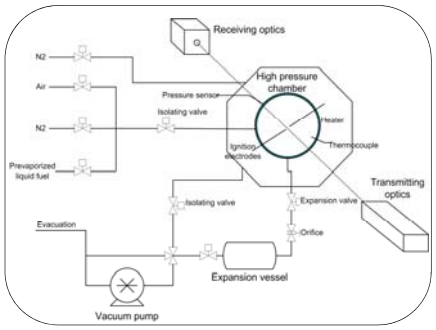
INTRODUCTION

Our objective is the experimental determination of the flame propagation velocity in aerosols.
The first step was to characterize experimentally the size of droplets composing the aerosol.
This characterization was performed using a laser diffraction particle size analyzer "Sympatec-HELOS".
After ground tests, three parabolic flight campaigns were conducted.

METHOD

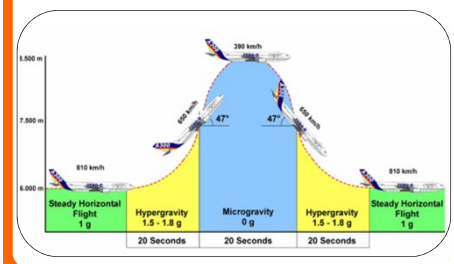
1. Experimental approach

The experimental approach consists of introducing a fuel-oxidizer mixture (liquid / gas) into the combustion chamber.
Aerosol mixtures are prepared by a condensation technique of expansion cooling (Wilson cloud chamber technique) [1].



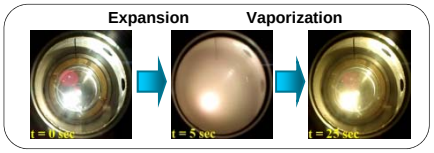
2. Microgravity environment

The interest of microgravity is the possibility of creating aerosols without sedimentation effects.



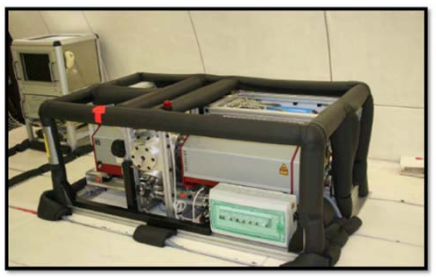
3. Aerosol

During the experiment, the temporal evolution of droplet's growth and evaporation is followed.
Experiments in normal and microgravity conditions are conducted both for ethanol and isooctane droplets.



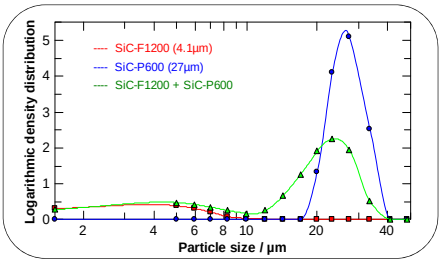
4. Diffraction laser particle size analyzer

Laser Particle Size Analysis consists in measuring the size of particles (powders, suspensions and emulsions) using the diffraction and diffusion of a laser beam.
For smaller particles , especially for transparent ones, it is appropriate to use **Mie Theory** [2].



5. Validation of the measurement system

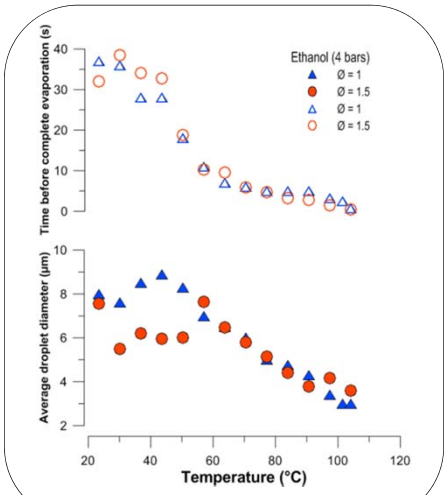
The system of measurements was validated by using reference calibrated particles.
The efficiency of the particle size analyzer is tested in microgravity.



RESULTS

1. Temperature effect on droplets diameter & evaporation

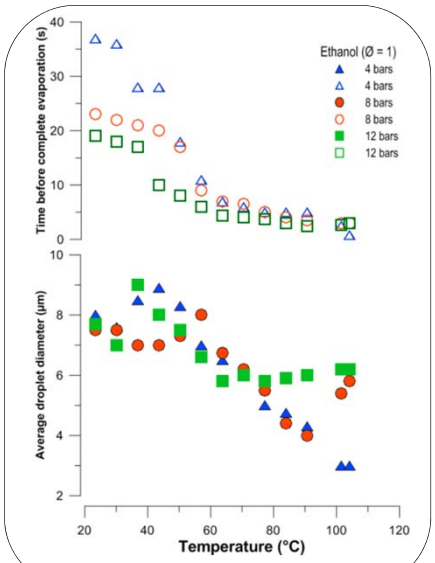
The initial temperature of the mixture reduces the droplets size, in particular for high temperature values (>60°C).
The vaporization rate increases with increasing initial temperature.



Ethanol at P = 4 bars and Ø=1, 1.5

2. Pressure effect on droplets diameter & evaporation

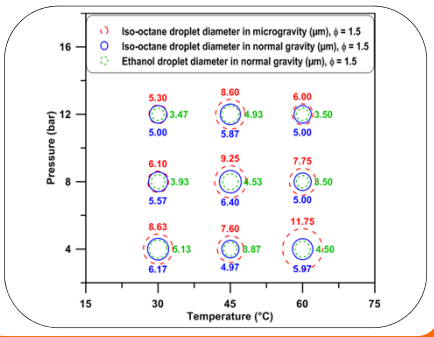
Increasing pressure reduces the vaporization time and produces a higher rate of vaporization, especially for small values of initial temperature.
There is no clear effect of initial pressure on the droplets size.



Ethanol at P = 4, 8, 12 bars and Ø=1

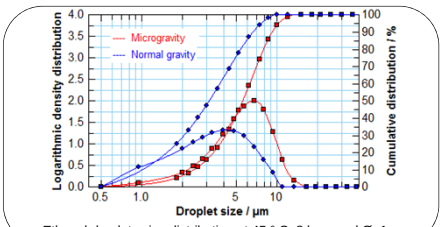
3. Average droplet diameters

The reduced gravity conditions allow obtaining larger droplets sizes.
The comparison between ethanol and isooctane fuels shows larger droplet sizes for isooctane droplets under the same conditions.



4. Droplets size distribution

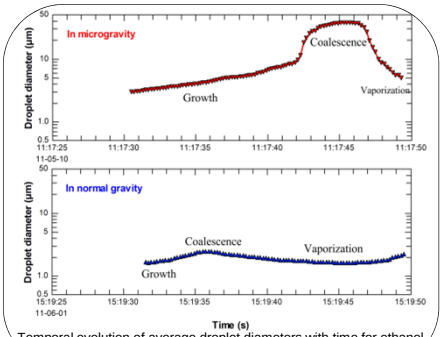
The cumulative curve in normal gravity covers a wider size range. The distribution curve is narrower in microgravity, showing that the aerosol is more mono-disperse.
The droplet sizes in microgravity are larger.



Ethanol droplets size distribution at 45 ° C, 8 bars and Ø=1

5. Temporal evolution

Three main steps:
Growth, Coalescence and Vaporization.



Temporal evolution of average droplet diameters with time for ethanol at 45 ° C, 8 bars and Ø=1

CONCLUSIONS AND PERSPECTIVE

- **T**he effects of initial temperature, initial pressure and global equivalence ratio are investigated.
- **U**nder microgravity conditions, larger droplet sizes are obtained together with more homogeneous and more mono-disperse aerosol mixtures.
- **I**sooctane droplet diameters are always larger than ethanol droplet sizes under the same conditions.
- ❖ **D**uring the next step of our research, we plan to produce the aerosol at higher initial pressures and more varied equivalence ratios before moving to combustion experiments.

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[1] Lawes, M., Lee, Y., Marquez, N., Combustion and Flame 144: 513-525 (2006).
[2] Nai-Ning, W., Hong-Jian, Z., Xian-Huang, Y., Advanced Powder Technology 3: 7-14 (1992).

Acknowledgements

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