

# Agglomeration in Solid Propellants Containing AP-Coated Aluminum

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## Introduction

Composite solid propellants consist of an oxidizer and additives bound by a polymer that serves as both binder and fuel. The long ignition delay of aluminum leads to agglomerate formation, causing incomplete combustion, performance losses, and potential motor damage. Therefore, shortening aluminum ignition time is assumed to result in reduced agglomeration. One well-known method to reduce agglomeration in by using coated aluminum powders. In this work, we use an oxidizer – coated aluminum

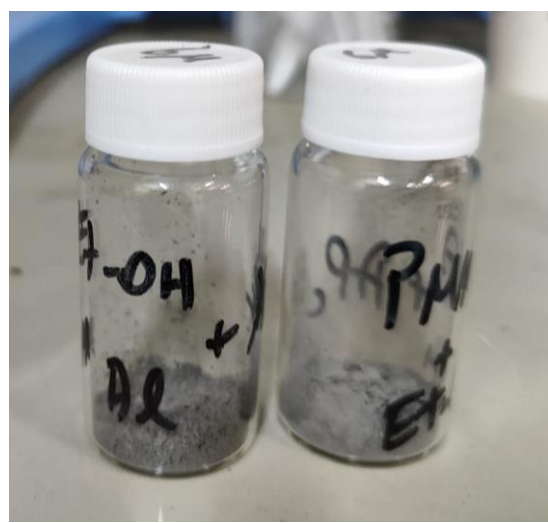
## Objective

This work investigates the effects of coating aluminum particles in AP (ammonium perchlorate) on the agglomeration in solid rocket propellants.

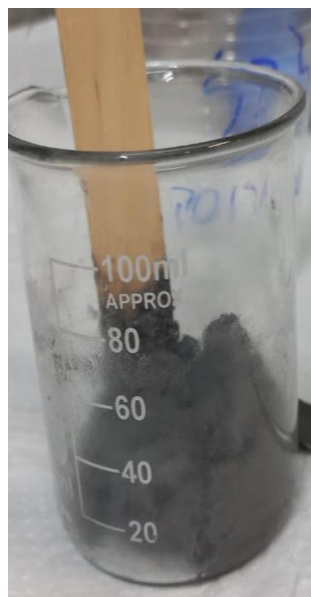
## Methods

### AP – coated Al Preparation process:

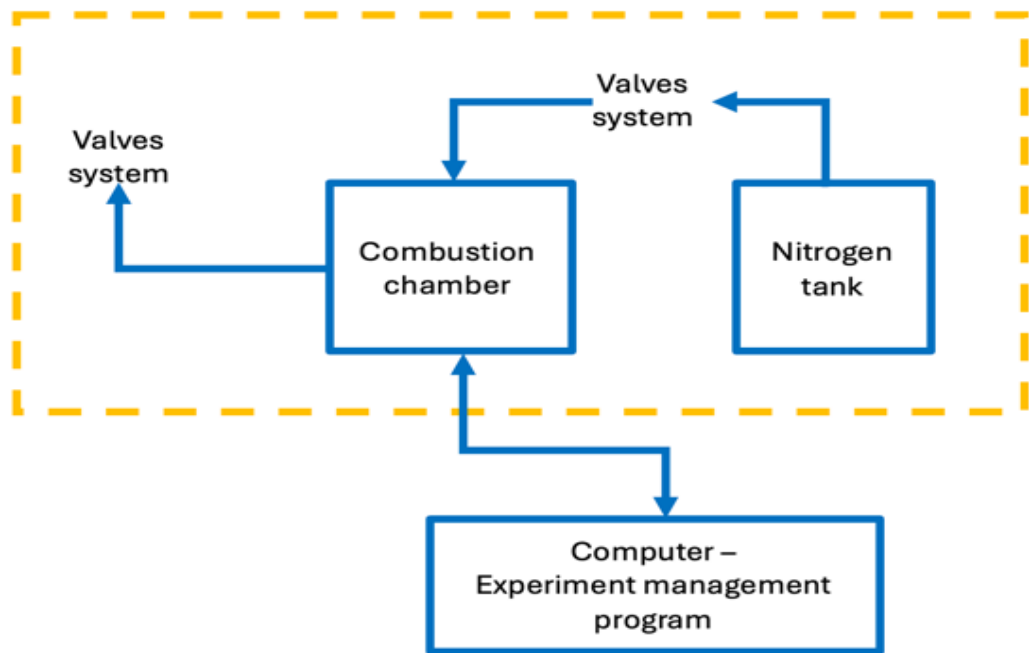
- Petri dishes were cleaned by sequential washing with water and ethanol (Et-OH) three times and dried prior to use.
- Al powder was ground to reduce agglomeration.
- For Sample 1: 1 g of Al was dispersed in 30 mL of Et-OH.
- For Sample 2: 1 g of Al was dispersed in a mixture of 29 mL Et-OH and 1 mL of 4 M PMMA solution ( $M_w \approx 950$  kDa).
- The suspensions were sonicated for 10 min to ensure homogeneous dispersion.
- The resulting dispersions were poured onto Petri dishes placed on a shaker.
- The solvent was allowed to evaporate under continuous shaking to form uniform Al layers.
- A saturated AP solution was prepared by dissolving 20 gr of AP in 50 mL of water.
- AP was deposited onto the dried Al layers by manual pump-spray coating.
- Solvent evaporation was carried out at 30–35 °C to obtain the final AP-coated samples.



AP – coated aluminum (samples 1 and 2)



Composition preparation process



Experimental system

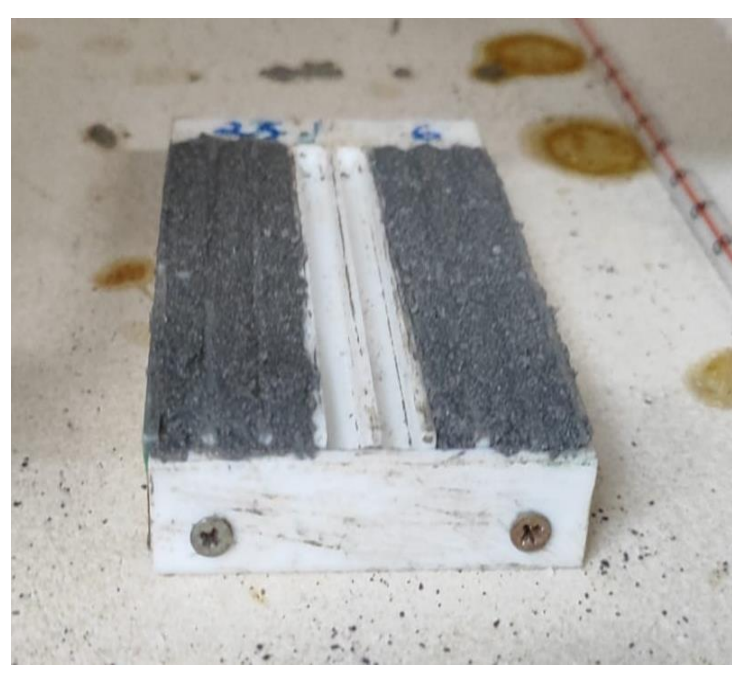
Dimensions of all solid propellant strands in this work:

Length: 80 [mm]

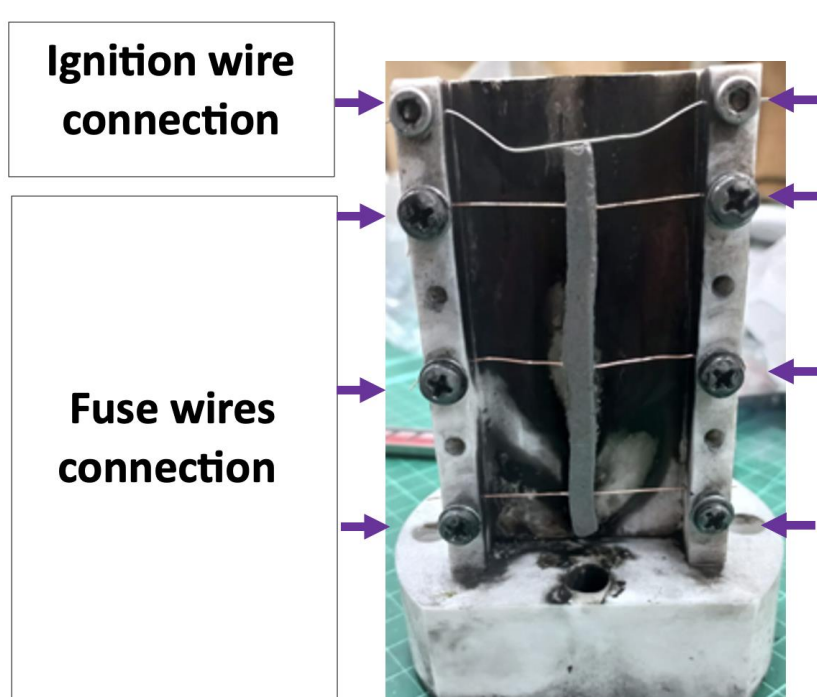
Cross section of 5x5 [mm<sup>2</sup>]

The experimental setup used in this study includes:

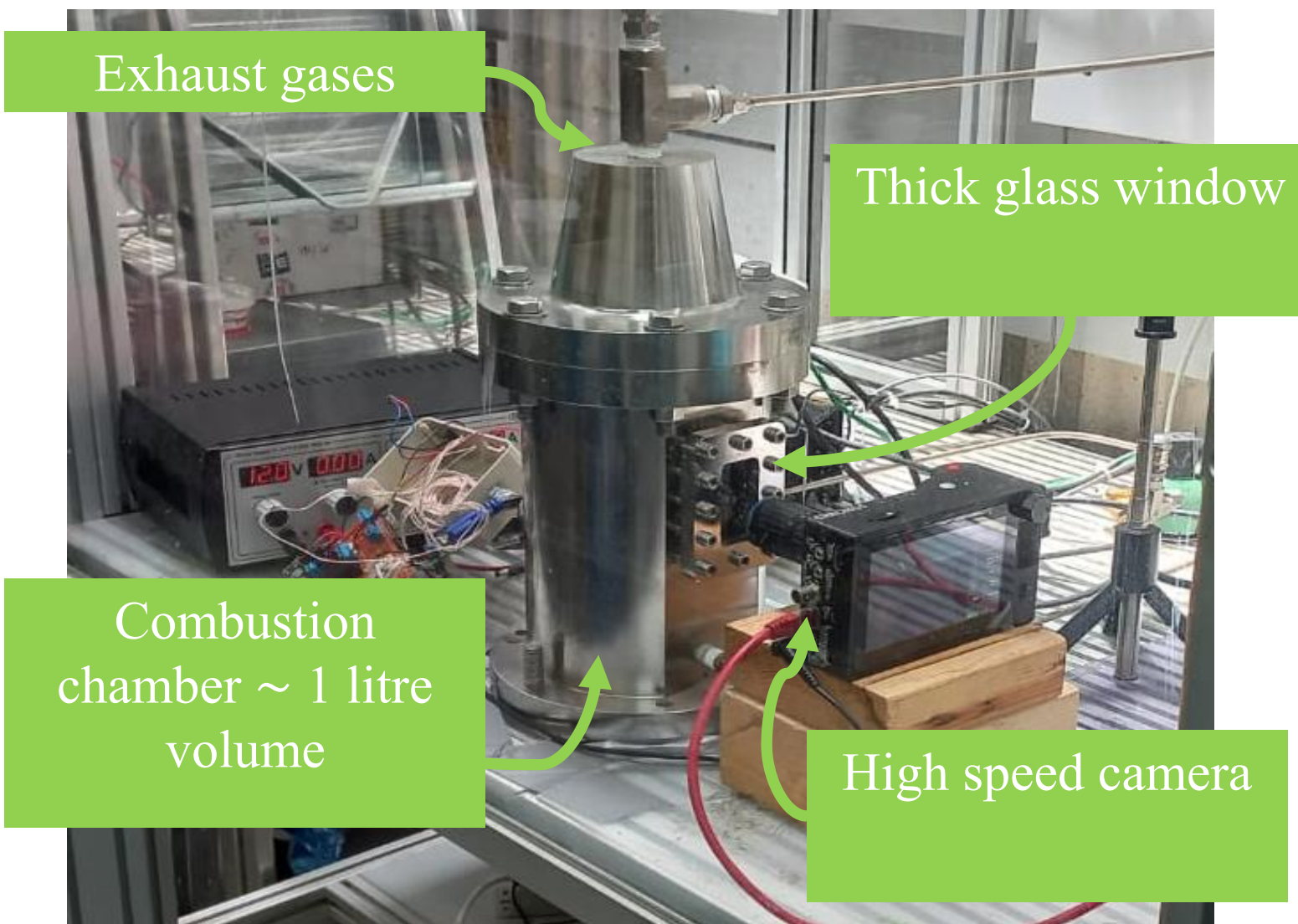
- A windowed pressure chamber
- Solid propellant holder
- High speed camera at up to 5400 fps (chronos 2.1)



Strand preparation

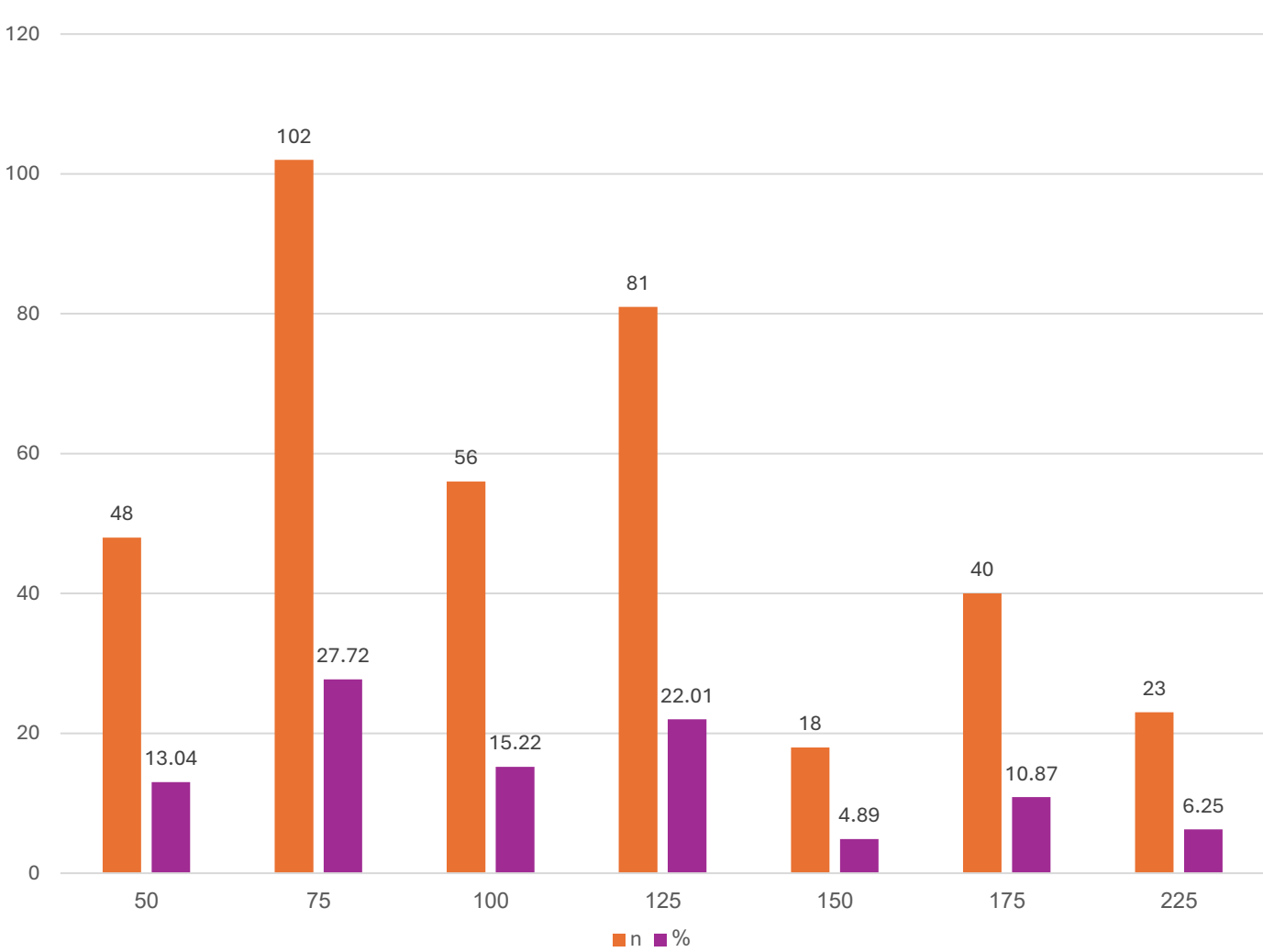


Solid propellant holder



Combustion chamber

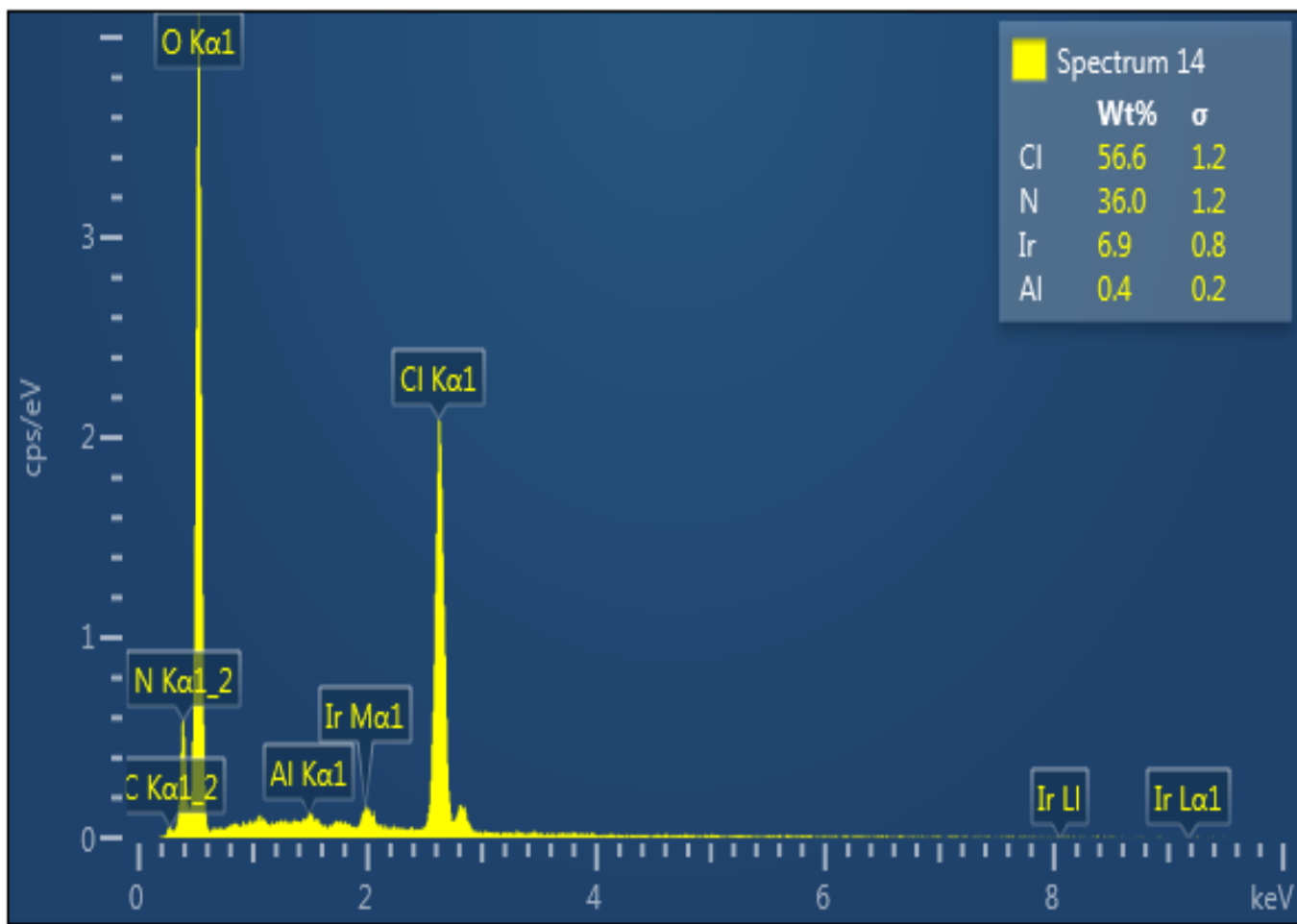
## Results



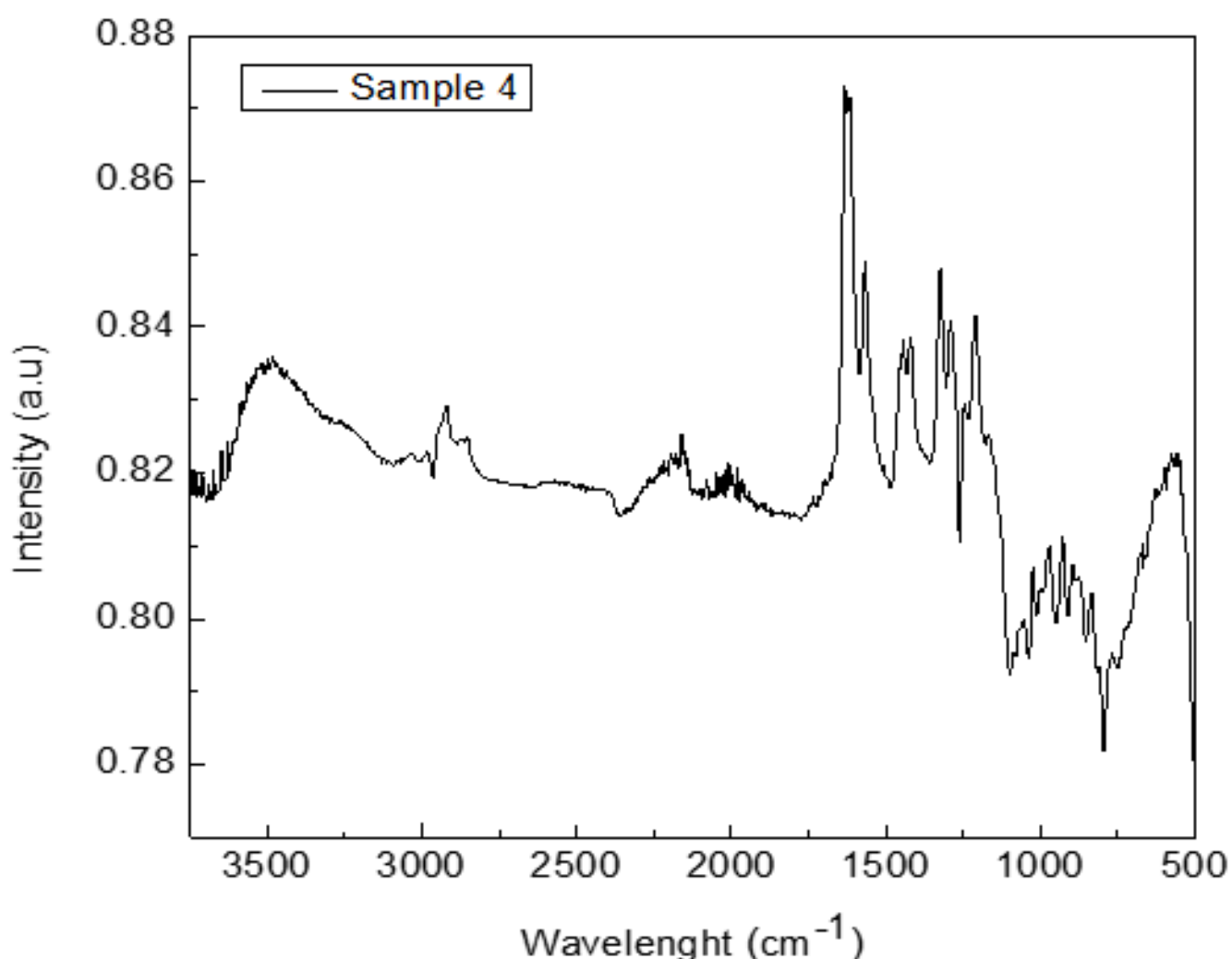
Agglomerate quantity in uncoated aluminum



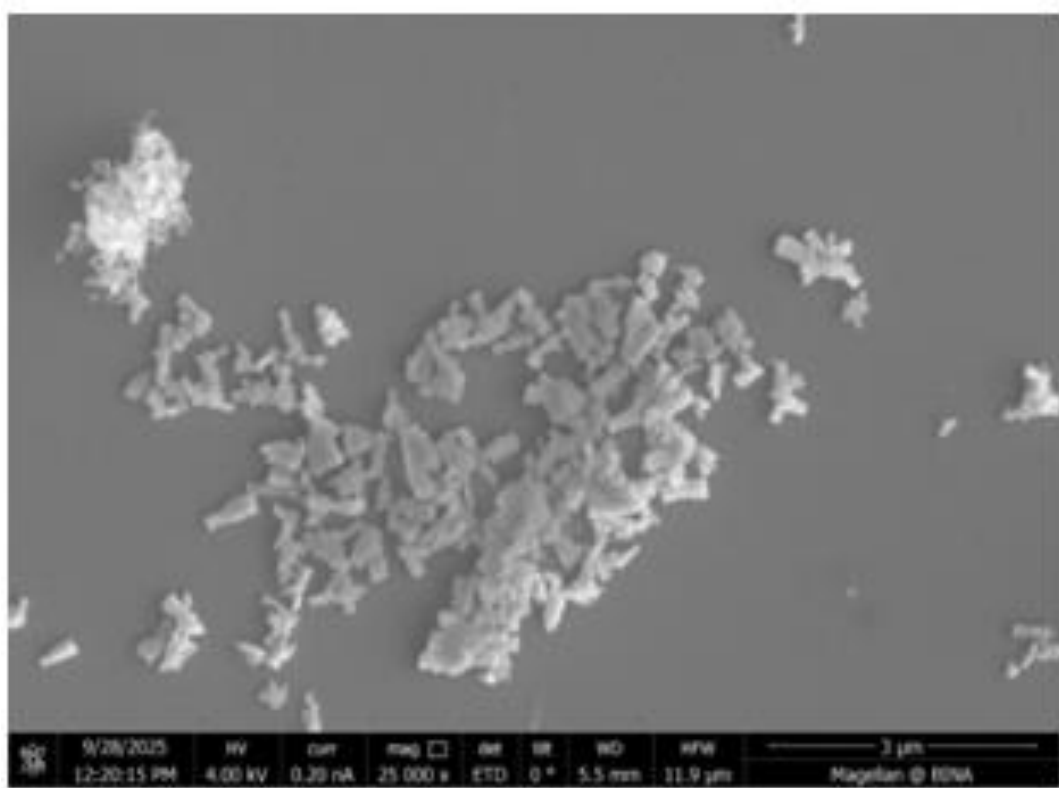
Agglomerate mean diameter in uncoated aluminum



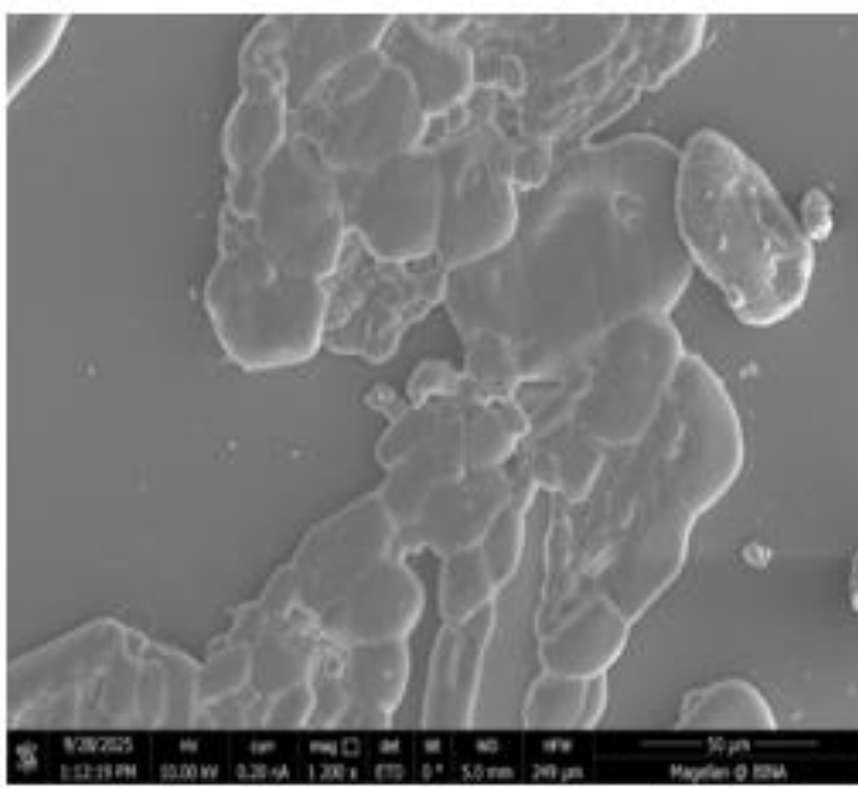
EDS analysis for AP – coated aluminum



FTIR analysis for AP – coated aluminum

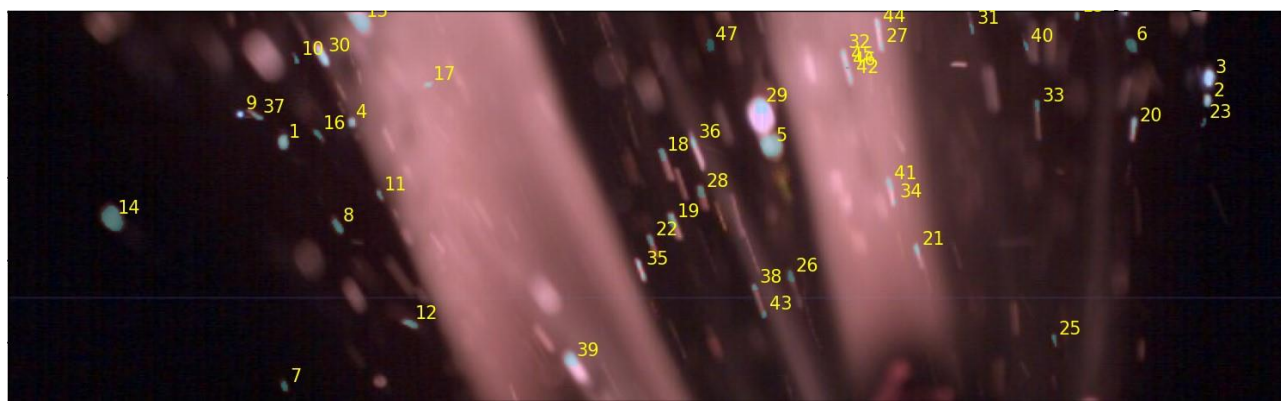


(a)



(b)

E-SEM micrographs of (a) Al coating (spin coating), and (b) AP coating on Al (spray granulation)



Machine learning model analysis of agglomerate quantity and diameter



Burning experiment frame

## Summary and Conclusions

- According to the E-SEM, EDS and FTIR analysis, AP was successfully deposited on top of the aluminum layer.
- From the total particle mass, approximately 90% corresponds to AP and 10% to the aluminum core.

## Future Work

- Reducing AP fraction within coated particle
- Combustion experiments for coated aluminum in various pressures to determine agglomerates quantity and mean diameter, using high speed photography.