Post Fire Materials Identification by Confocal Raman Microscopy:

Improved Fire Modelling and Investigation

Tanya Kerr, Keith Duncan, Leary Myers

Materials Science Research Group

Department of Physics, UWI (Mona)

The Weekly News Item

The Fire Situation

Jamaica

80% of cause unknown

Source: JFB

USA

36.4 % of house fires; 47% of fatal fires; cause unknown

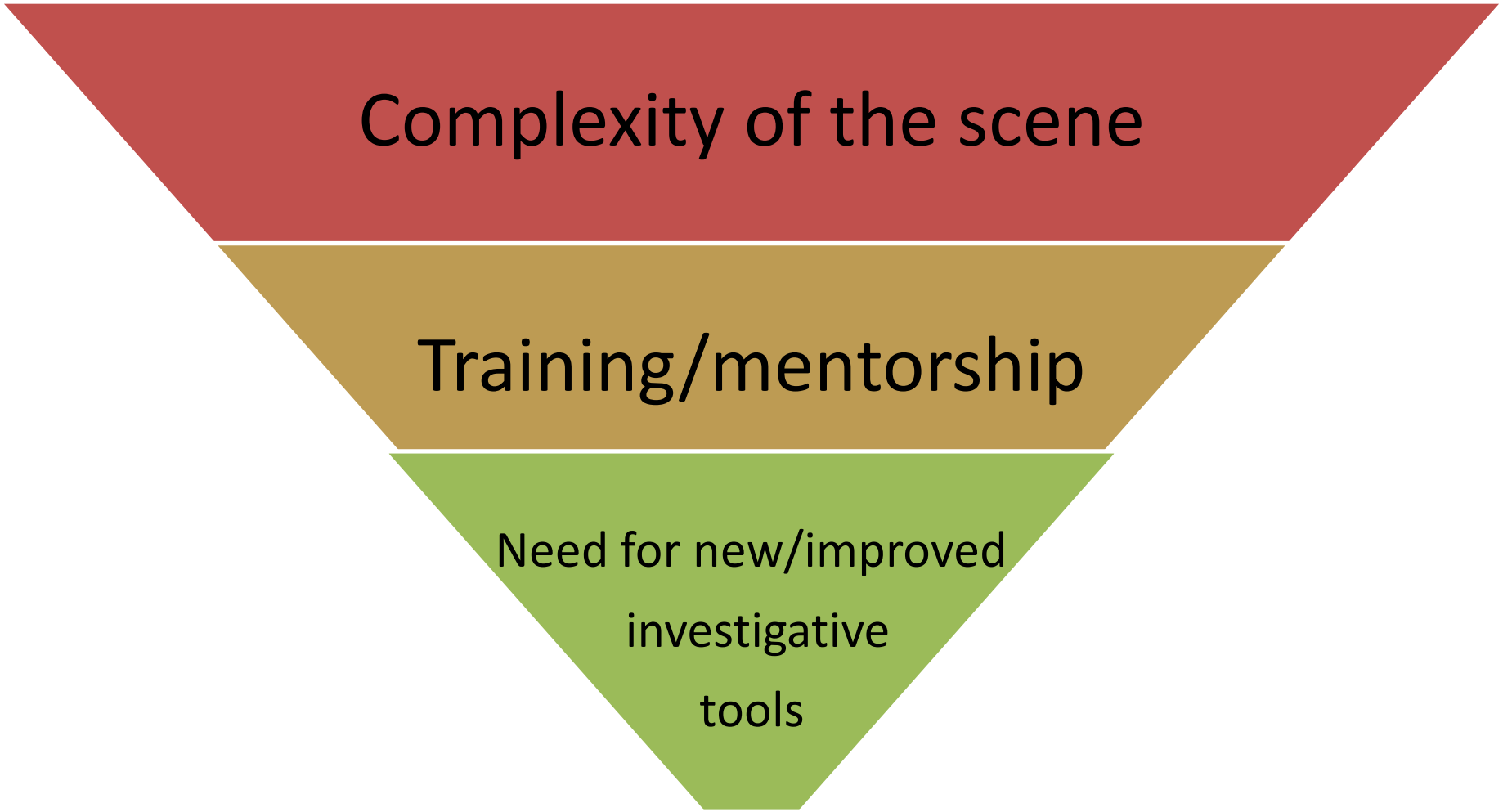
Source : USFA

Canada

16% cause of ignition unknown; 58% location of origin unknown; 15% first material ignited unknown

Source: Branz Ltd

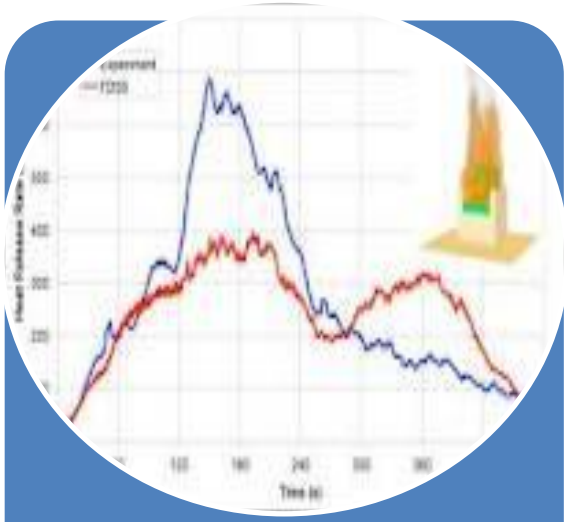
Why So Many Undetermined Cases



The Investigation

- Systematically examine compartment fire patterns
- Excavate and determine fire origin
- Come up with 2 or 3 hypotheses as to cause by application of fire science
- Verify cause by application of fire dynamics

Hypothesis Testing and Verification

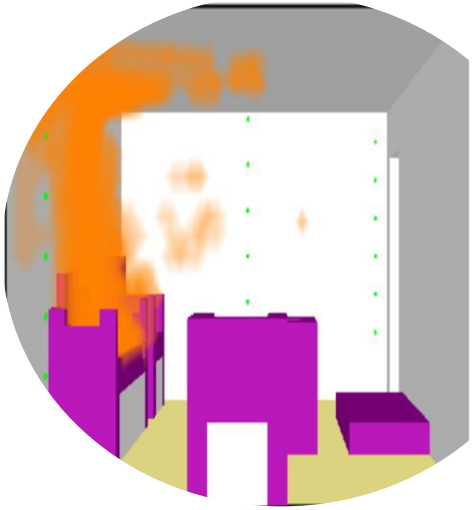


Interpretation of Fire Dynamics

Physical Reconstruction

Fire Modelling

Fire Modelling Requirements



Effects of Material Properties on Model Outcome

Chen et al. 2010

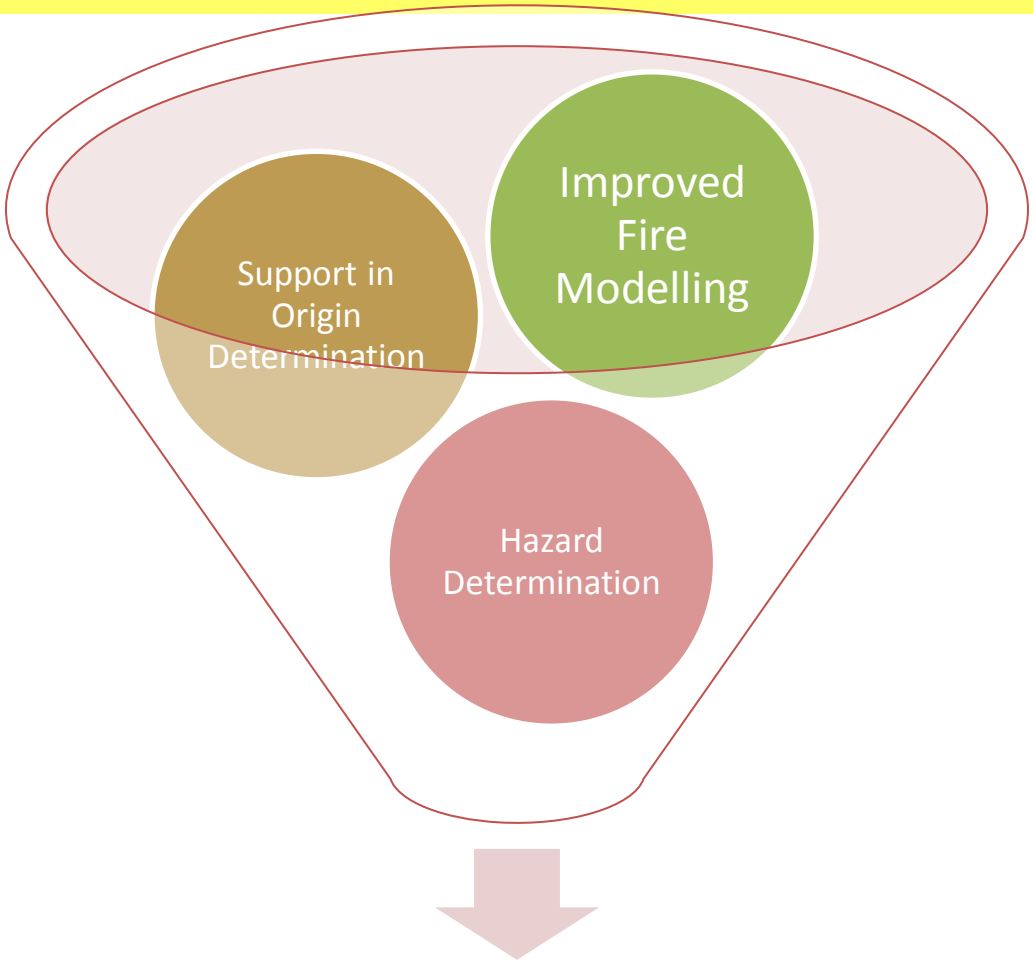
Spruce

- Heat release rate in compartment increased more rapidly in the compartment showing a very rapid fire growth and spread

Plywood

- There was a significant delay in the peak heat release rate in the compartment and that there was a much slower fire growth and spread

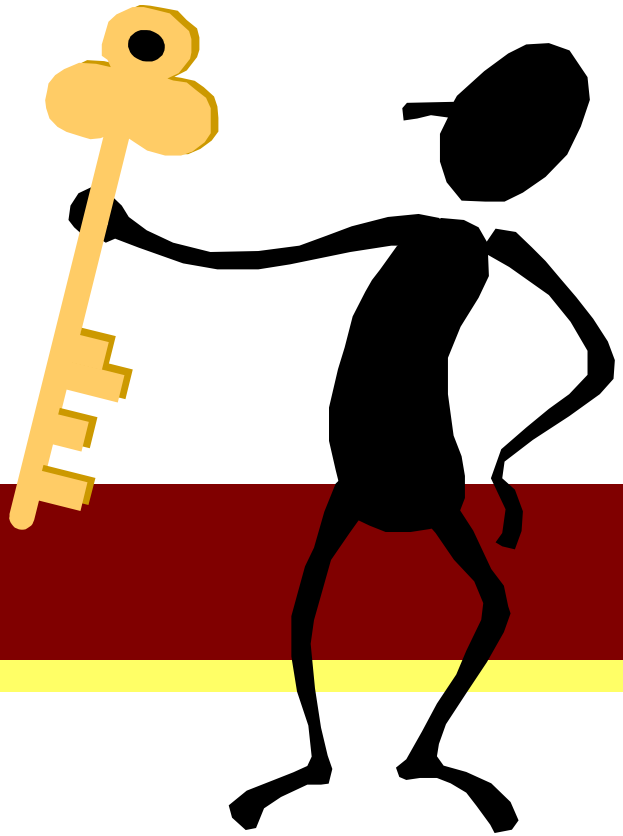
Material ID from Fire Debris



Comprehensive Fire Investigation

How do we identify them?

Solution



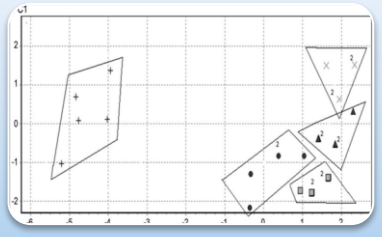
Materials Identification

Gonzalez-Rodriquez et al. 2011

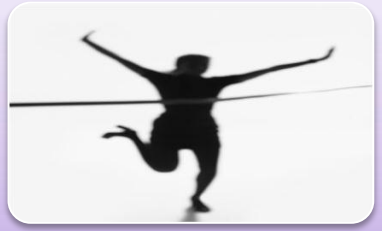
Identify the Original Material and the accelerant used by Raman Spectroscopy of the Fire Debris

Polypropylene, polystyrene and Nylon

After burning with accelerants collected new Raman Data for burnt samples



Use of chemometric, **principal component analysis** (PCA) to show material discrimination



Had some success, but results were plagued by sample fluorescence, so not many peaks for discrimination

The Current Work

- TO EXTEND THE WORK OF GONZALEZ- RODRIGUEZ ET AL. IN DEVELOPMENT OF A METHODOLOGY FOR POST FIRE MATERIALS IDENTIFICATION UTILIZING RAMAN SPECTROSCOPY.
- IMPROVE THE QUALITY OF RESULTS BY USING AN ADVANCED RAMAN SPECTROSCOPY METHOD, IE. ***CONFOCAL RAMAN MICROSCOPY.***
- TESTING OF MATERIALS OF INTEREST IDENTIFIED BY THE ***SOCIETY OF FIRE PROTECTION ENGINEERS*** AS THOSE WHICH CONTRIBUTE SIGNIFICANTLY TO THE FIRE LOAD OF A COMPARTMENT.
- CREATE BURN MATERIALS LIBRARY

Materials Listed by Society of Fire Protection Engineers

Polyethylene terepthalate (PET)

- Curtains
- Table Cloths

Ethylene Vinylacetate (EVA)

- Shower Curtains
- Baby Bibs

polypropylene

- DVD Cases
- Mats

Polystyrene

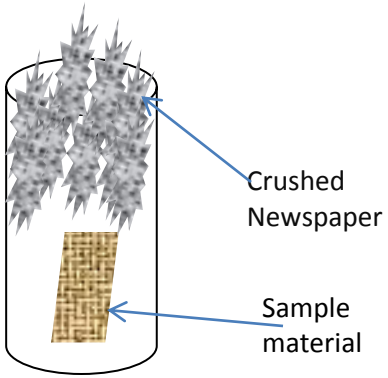
- CD Cases
- Plates

Nylon

- Stockings

Basic Methodology

- Collect Raman spectra for each material type in their original state
- 5 x 5cm squares of each sample was used for testing.

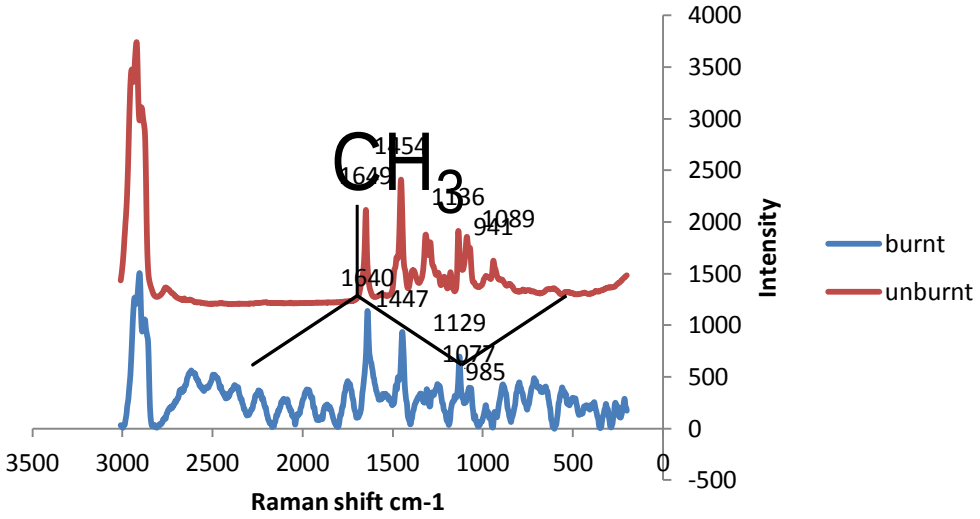


- Samples placed in to a metal can which was divided in two parts by metal mesh wire and burnt in air
- Raman spectra obtained at five points with an average of three replicates from the same spot.

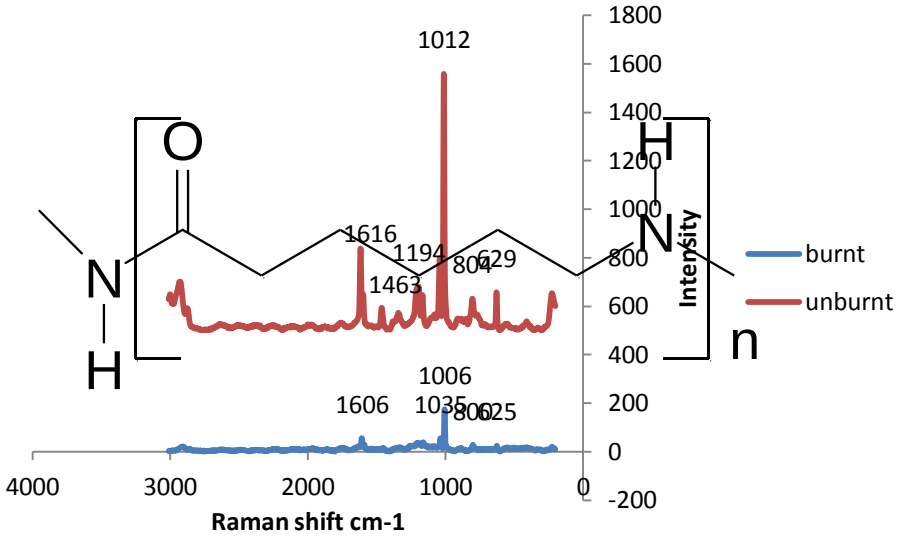
- Comparison of spectra to determine loss
- Apply PCA to the peaks after samples are burnt for discrimination between samples

Results

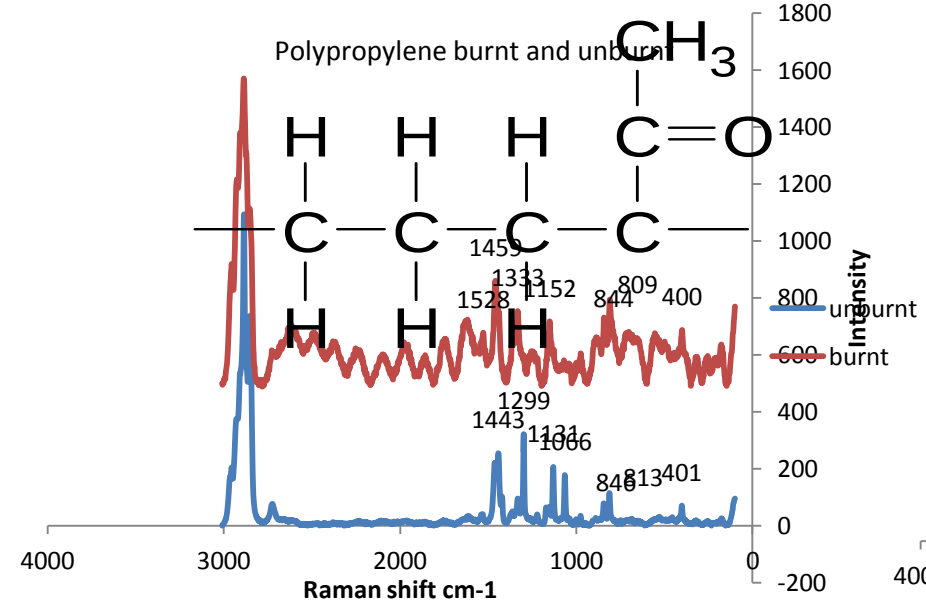
Nylon comparison spectra for burnt and unburnt



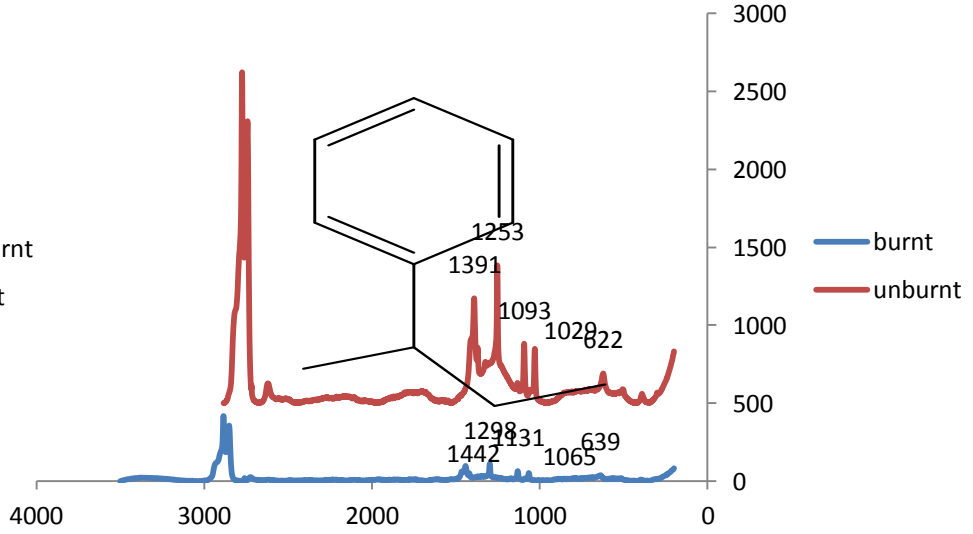
Raman Spectra before and after burning for polystyrene foam



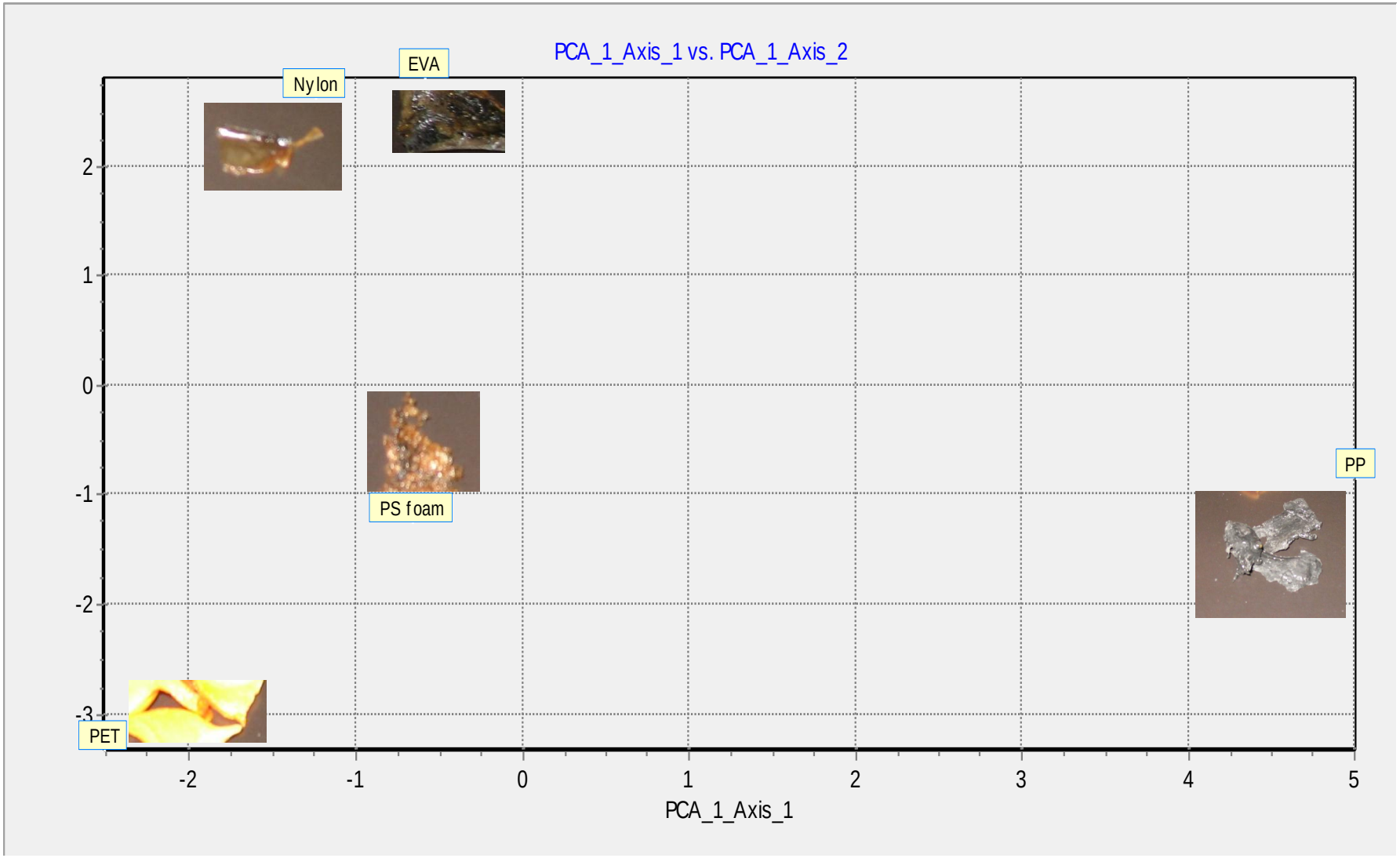
Polypropylene burnt and unburnt



Burnt EVA and unburnt comparison



Materials Discrimination - PCA



Conclusion

Fluorescence is still an issue to be resolved for burnt debris

Materials can be identified by Confocal Raman Spectroscopy

More accurate data can be provided for fire modelling

Burnt materials have unique spectra

Further Work

- Determine the best method for minimizing fluorescence for burnt debris
- Examine material combinations, Raman Mapping
- Gathering Raman spectra for burnt materials at different time frames
- Exposure time assignment
- Compartment mapping