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Evaluating the Water Reactivity of Ash Resulting From the Ignition of Expired Propellants

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Treatability study to assess the reactivity of ash material

- **Client:** Department of Defense (DoD) ammunition plant
- **Sample description:** 14 samples, expired propellants from the DoD site required disposal
- **Scope of study:**
  to *evaluate ash reactivity upon contact with water* using a vented calorimeter to measure heat generation and off gassing and *characterize the water reactivity of the ash to facilitate proper disposal practices*

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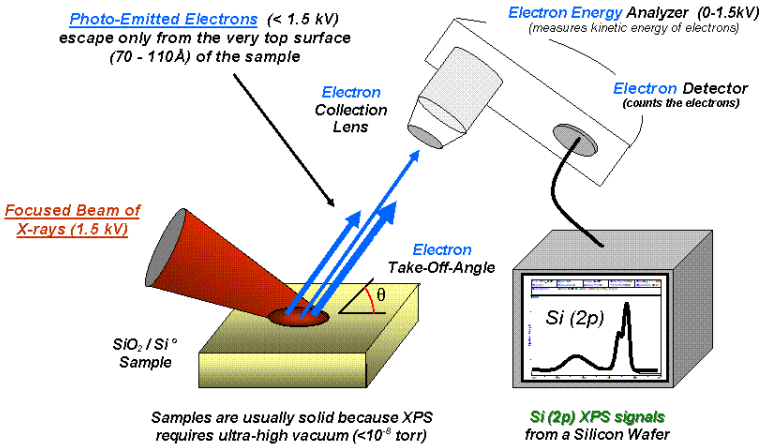
Sample Composition

- X-ray Photoelectron Spectroscopy indicated that the ash samples primarily consisted of:
- Carbon (C)
- Oxygen (O)
- Aluminum (Al)
- Notable traces of nitrogen (N)



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Theoretical Chemistry

aluminum hydroxide bayerite
Gibbsite - $Al(OH)_3$

- Metallic Al may undergo hydrolysis and yield hydrogen gas (H_2)

(1) $2Al + 6H_2O = 2Al(OH)_3 + 3H_2$
(2) $2Al + 4H_2O = 2AlO(OH) + 3H_2$
(3) $2Al + 3H_2O = Al_2O_3 + 3H_2$

aluminum hydroxide boehmite
Boehmite - AlO(OH)

- A reaction between aluminum and water will generate heat and off-gas H_2

aluminum oxide
Alumina - Al_2O_3

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Methods for Study

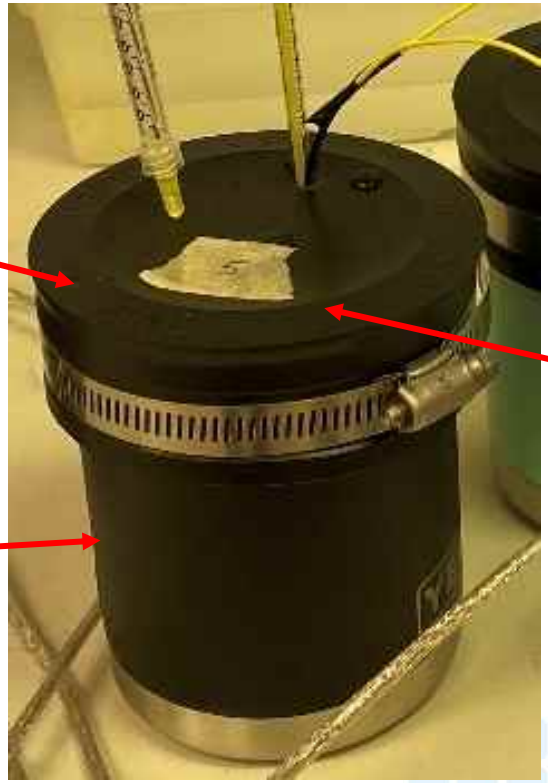
- Measure the moisture content of each sample prior to testing

- Construct calorimeters to measure temperature and off gas production

Methodology - Calorimeter

PVC Flexible Cap

10 oz Yeti cup



Insulating Foam

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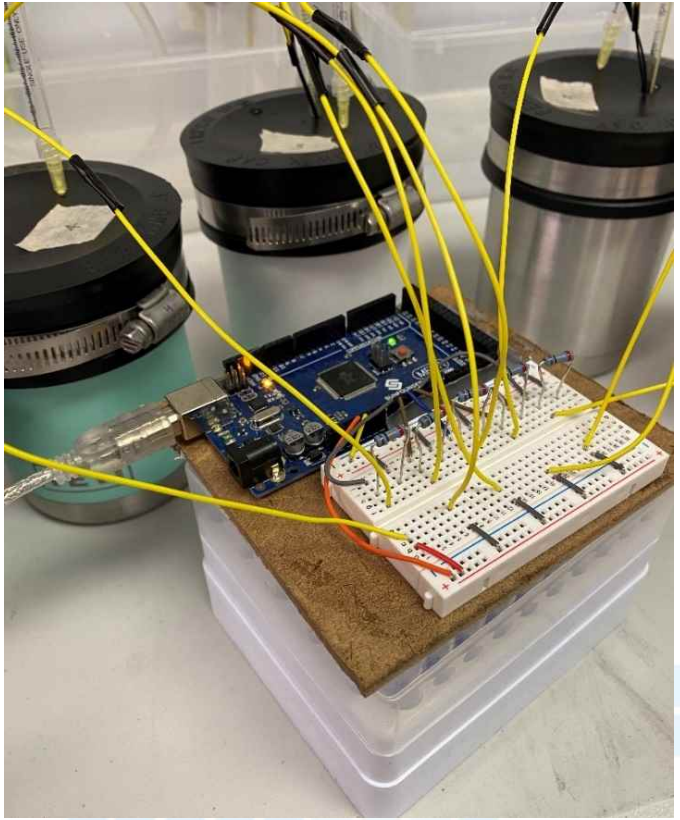
Calorimeter Construction and Data Collection

- Thermistors were coupled to an Arduino microcontroller board to monitor temperature in real time
- Injection port
- Gas vent



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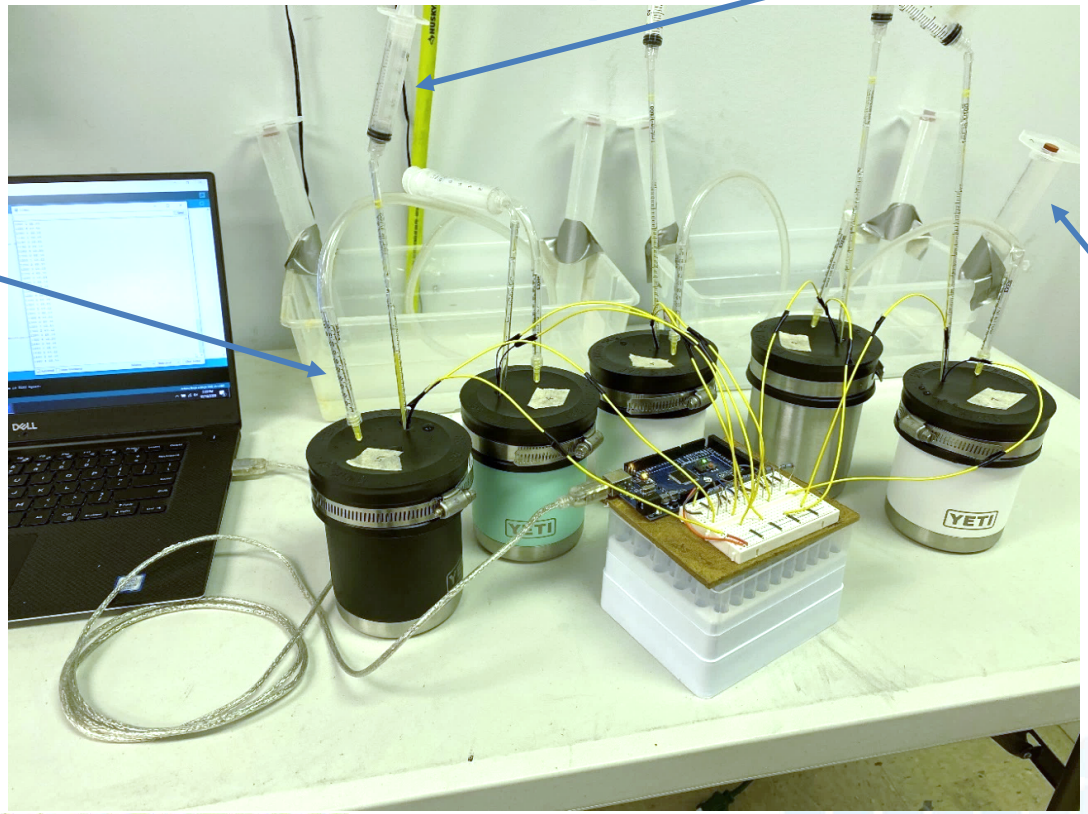
Experimental Setup



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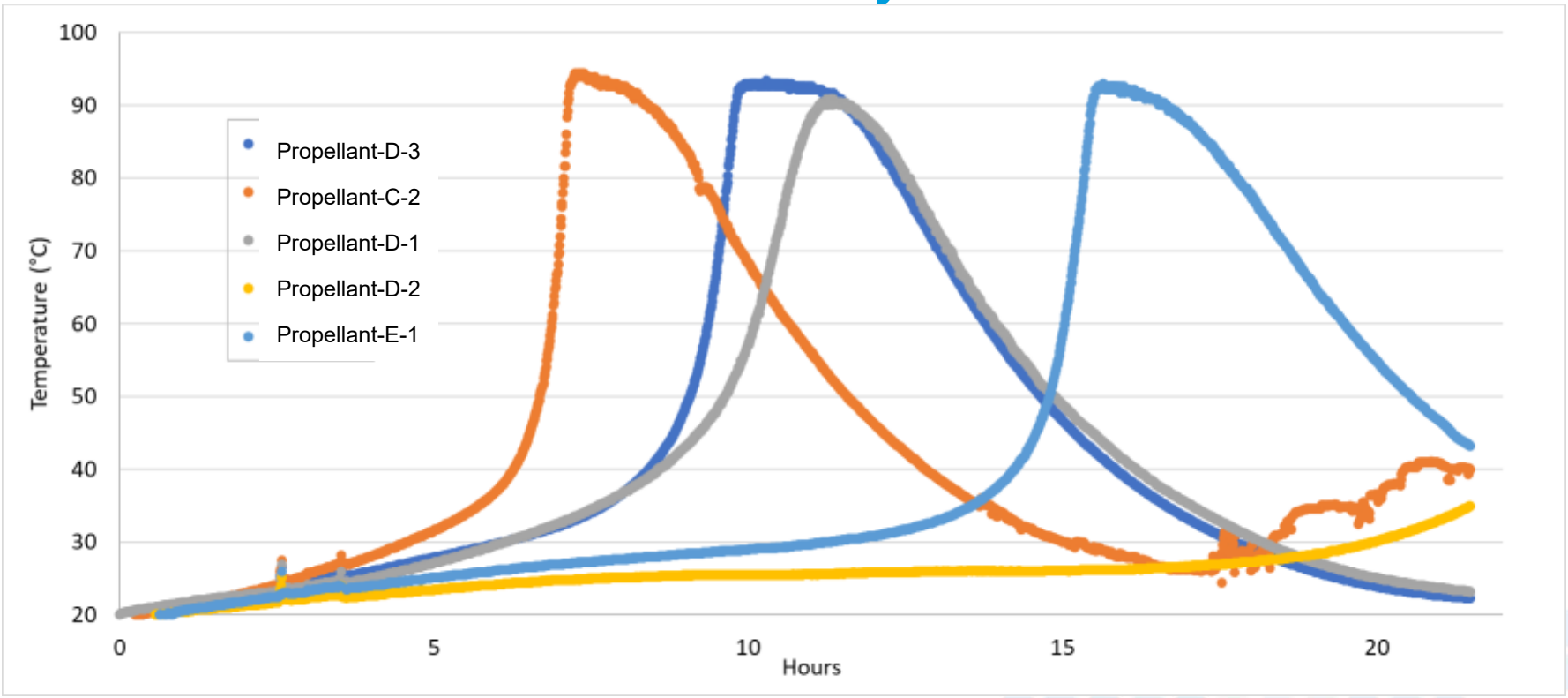
Results - Calorimetry



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Results - Calorimetry

Sample ID	Peak Temp (°C)	Time to Peak Temp (h)	Gas Produced	Approximate Concentration of H2 gas (ppmv)	Calorie Content (calories/g)
Propellant A-1	23.3	46.2	No	-	0
Propellant B-1	93.9	37.9	Yes, >150 mL	4.8E+05	72
Propellant B-2	49.9	35.3	Yes, >150 mL	3.6E+05	42
Propellant B-3	90.4	36.9	Yes, >150 mL	1.7E+05	109
Propellant C-1	95.9	11.2	Yes, >150 mL	7.1E+03	251
Propellant C-2	94.4	7.2	Yes, >150 mL	2.9E+04	223
Propellant C-3	31.5	26.9	No	-	22
Propellant D-1	98.5	5.1	Yes, >150 mL	4.0E+05	169
Propellant D-2	34.9	21.5	Yes, >150 mL	2.2E+05	45
Propellant D-3	93.5	10.3	Yes, >150 mL	1.7E+05	235
Propellant E-1	93.1	15.6	Yes, >150 mL	2.9E+05	222
Propellant E-2	21	5.1	Yes, >150 mL	2.8E+05	3
Propellant E-3	23.5	5.1	Yes, >150 mL	1.7E+05	15

Summary

- All *ash samples* except for Propellent-A-1 and Propellent-C-3 ***were highly reactive towards water***
- Reactivity (gas release) without heat generation was observed
- Time required to reach peak temperature varied by sample and dependent on the mass of ash
- Hydrogen and ammonia gas were generated
- Ammonia gas may have been generated due to the presence of a water-reactive nitrogen species
- ***The study indicated that the reactivity of the ash excludes it from being disposed of in a landfill setting***

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Questions?

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