



# U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

Synergetic Effect of the Chemical Compositions in an Energetic Device

Zhaohua Luan

Chemical Engineer

Advanced Materials Technology (FCDD-ACM-AP )

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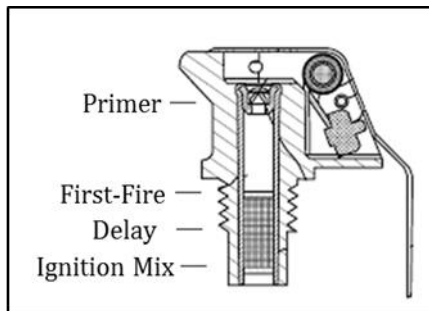


# INTRODUCTION



## BACKGROUND:

- A pyrotechnic device or subsystem, such as a well-known M201A1 fuze shown below, is constructed typically with a number of energetic compositions.
- Once triggered, it undergoes a series of self-sustained exothermal reactions for distinctive pyrotechnic effect or to initiate a main pyrotechnic charge such as a smoke grenade.



**Figure 1.** Typical compositions in a M201A1 fuze.

## THE CHALLENGES:

- However, the occurrence of those energetic events in between those compositions has been found hardly sequential, and deserves some close examination.

## OBJECTIVES:

- This work will, for the first time, presents strong evidence of some secondary reaction in between those energetic compositions which appears in much stronger intensity in terms of heat or energetic output.
- Those findings provide invaluable technical insight for the design and test of those pyrotechnic devices for failure mode analysis and improved performance.



# EXPERIMENTAL - CHEMISTRY

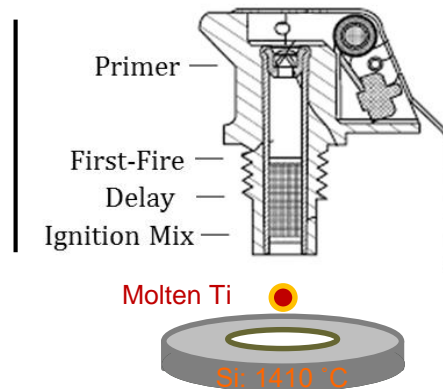


## Starter-slug ignition process:

1 - Heat generation

2 - Heat transport

3 - Heat absorption - **ignition**



## Chemistry and Prototyping

Delay Mix (500 mg)	(wt%)	Reaction – Ignition composition ( TPP Control):
BaCrO4	60	$\text{Ti (s)} + \text{KClO}_4 \text{ (s)} \longrightarrow \text{TiO}_2 \text{ (s)} + \text{KCl (g)} + \text{Ti (l)}$ <p>21.0 (6.2)    9.0                    10.4            4.8            14.8 mg</p>
KClO4	14	
ZrNi	26	



# RESULTS



**TABLE 1: Heat of Combustion Measured for the Titanium-Potassium Perchlorate Mix**

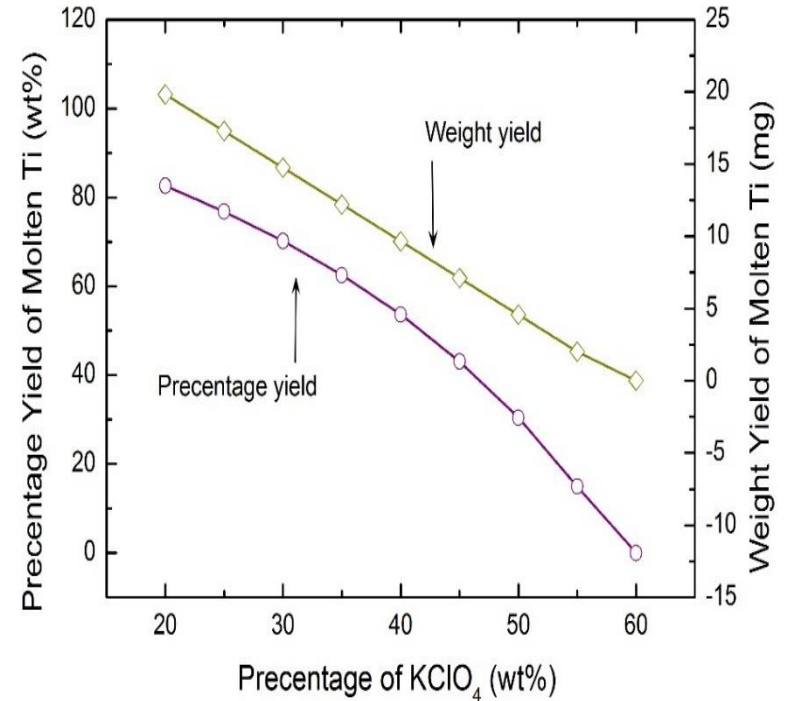
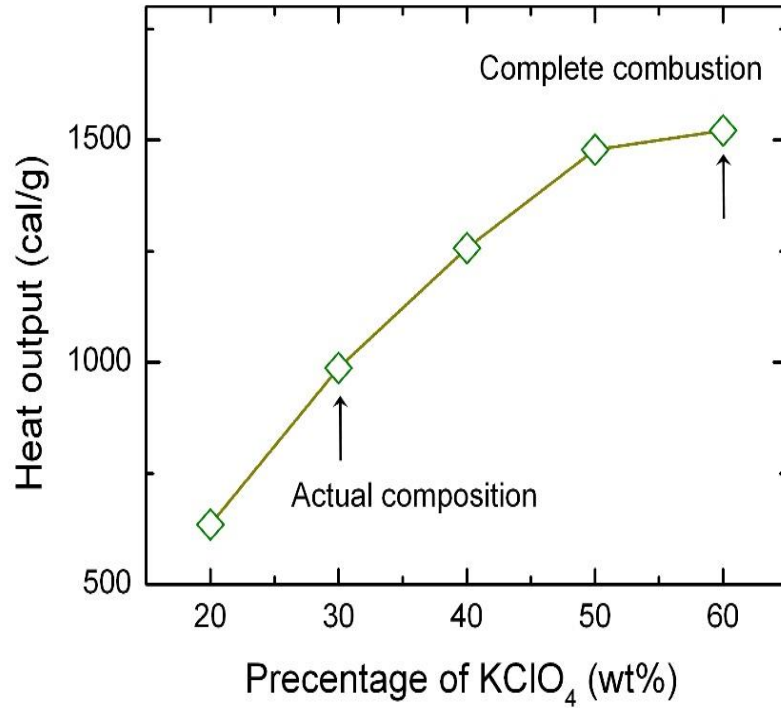
Composition (%KClO <sub>4</sub> )	Heat of Combustion (cal/g)		Products
	Calculated*	Measured	
30	941	987	Grey powder

\* The calculated heat of combustion was based on the data given in a literature for titanium combustion and potassium perchlorate decomposition.

Composition (%KClO <sub>4</sub> )	Heat of Combustion (cal/g)		Products
	Calculated*	Measured	
60	1883	1522	White powder
50	1569	1478	Grey powder
40	1255	1257	Grey powder
30	941	987	Grey powder
20	628	635	Dark particles



# RESULTS



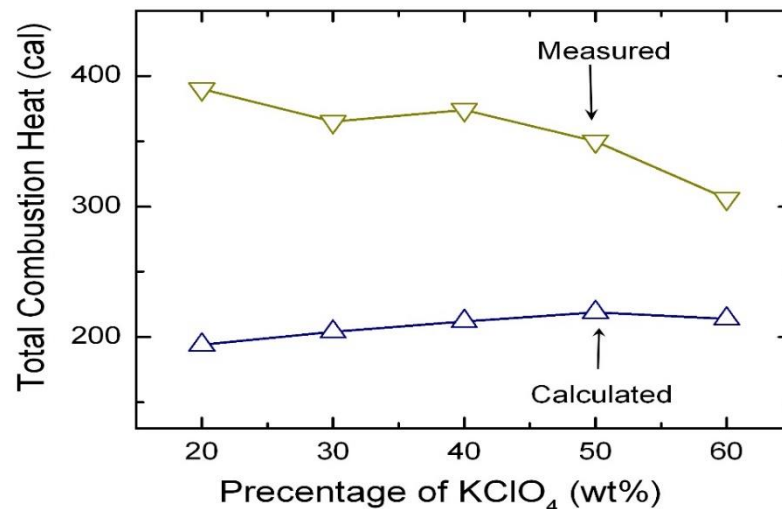
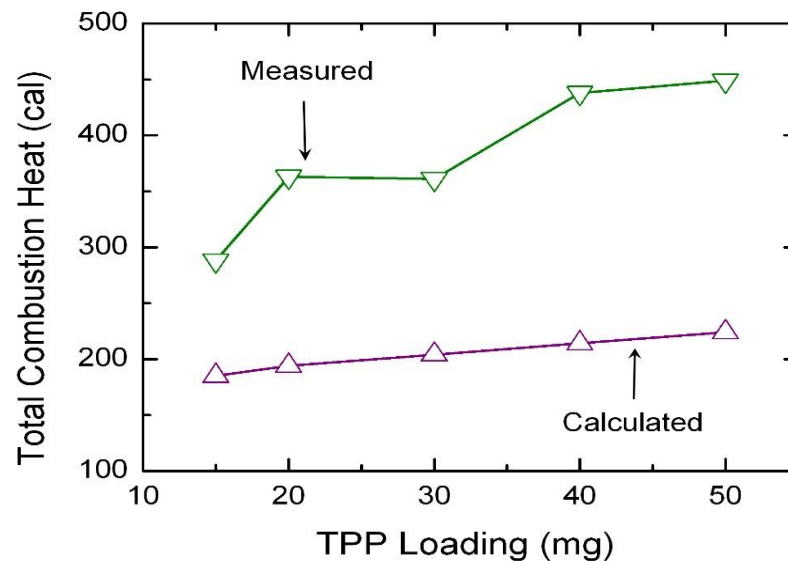


# RESULTS



**TABLE 1.** Bomb calorimetry of M201A1 fuzes.

Custom made Fuze		Total Combustion Heat (cal.)*	
		Calculated	Measured
TPP Loading (mg)	10	185	288
	20	194	364
	30	204	360
	40	214	438
	50	224	449
TPP Composition (% KClO <sub>4</sub> )	60	214	306
	50	219	350
	40	212	384
	30	204	360
	20	194	390





# RESULTS



## Function of TPP and secondary reaction

1. Open the delay tube
2. Provide molten Ti for secondary energetic event

w/o TPP



w TPP





## CONCLUSIONS



- M201A1 fuze prototypes with varying energetic composition and loading levels have been fabricated and evaluated.
- This work, for the first time, presents strong evidence of some secondary reaction in between those energetic compositions.
- The total heat or energetic output appears in much stronger in intensity as compared to sequential firing of each individual energetic compositions.
- Those findings provide invaluable technical insight for the design and test of those pyrotechnic devices for failure mode analysis and improved performance.