CHARACTERIZATION OF A NOVEL PHOTOSWITCH FOR DETECTING HOTSPOTS IN EXPLOSIVE COMPOSITES

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Penn WiP Conference, 2015

Background

Introduction

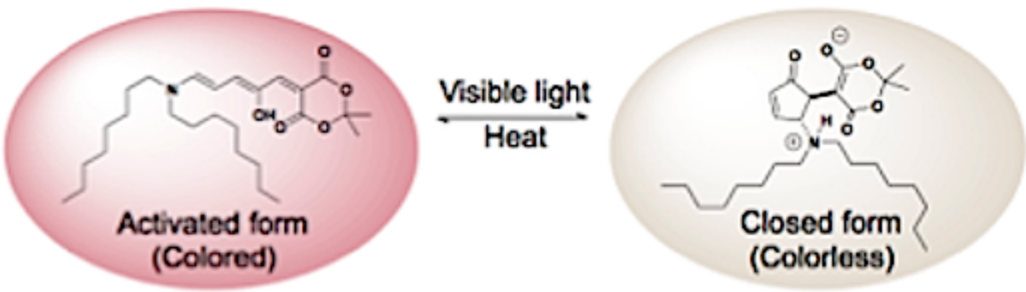
- Problem
  - Hotspots cause uncontrolled detonations
  - No viable way to study hotspots

- Proposition
  - Thermochromic molecular photoswitches

Vietnam USS Forrestal: 134 deaths and 161 injuries

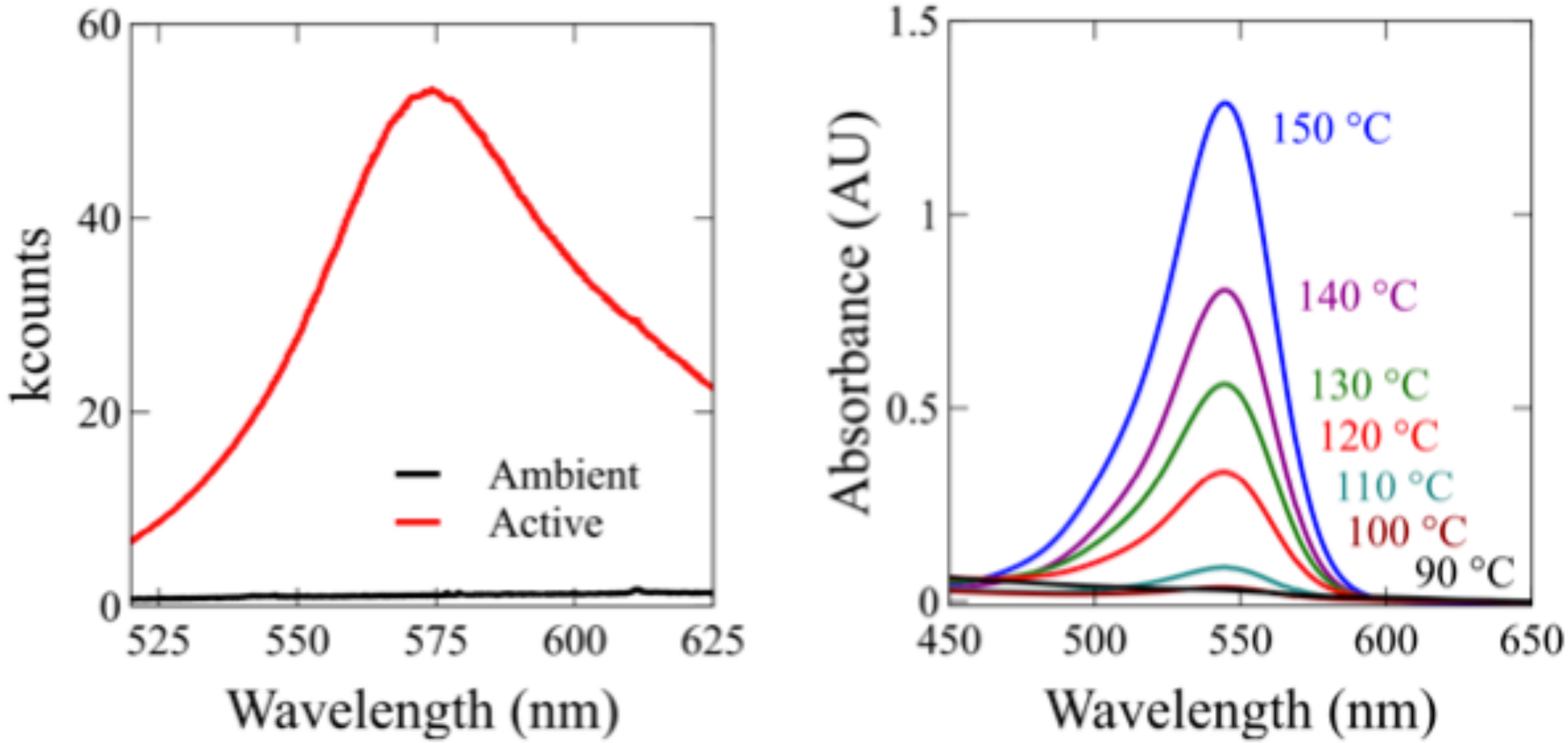
DASA Photoswitch

Donor-acceptor Stenhouse adduct photoswitch (DASA) in hydroxyl-terminated polybutadiene (HTPB) polymer



THERMAL CHARACTERIZATION

Absorption and Emission

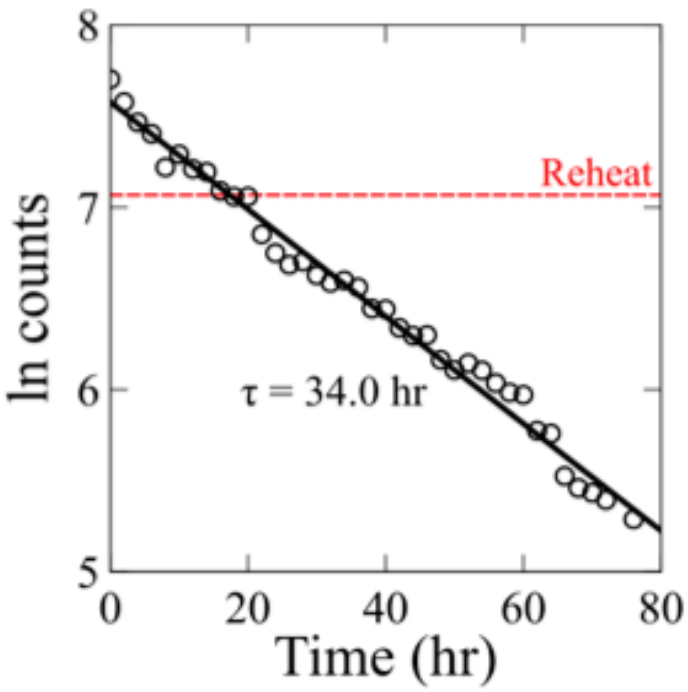


Reconversion

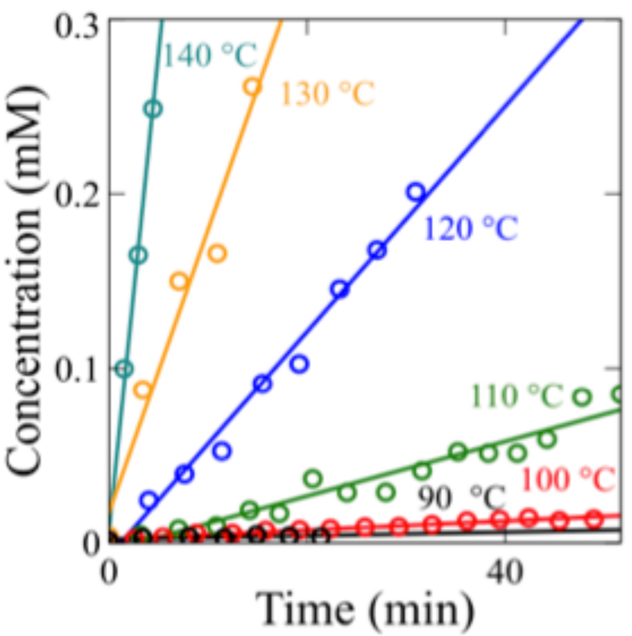
Exponential reconversion

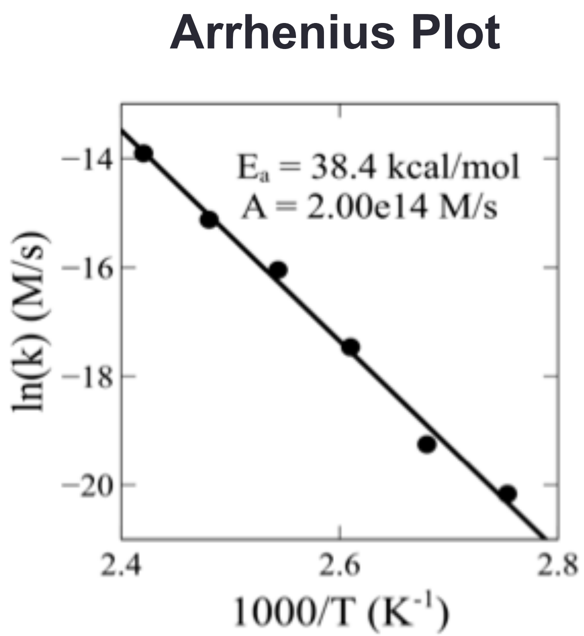
Decay constant is 34 hours

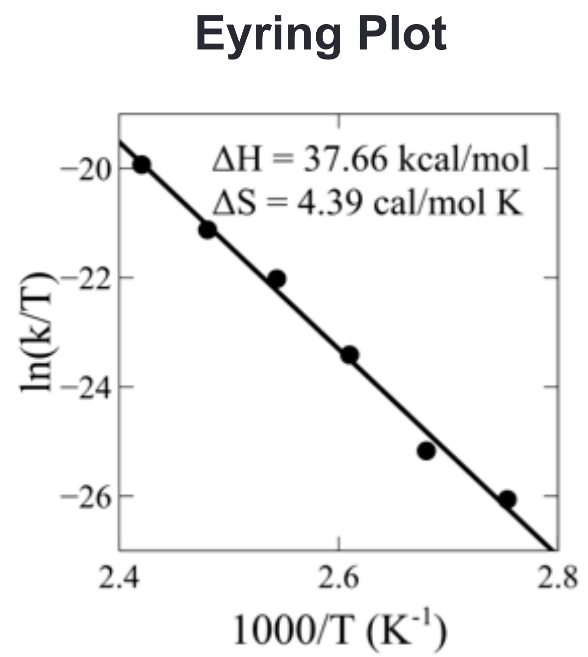
Reactivated to 92% of initial counts



Kinetics


0.3
0.2
0.1
0
Concentration (mM)
140 °C
130 °C
120 °C
110 °C
100 °C
90 °C
0
40
Time (min)


Arrhenius Plot
E_a = 38.4 kcal/mol
A = 2.00e14 M/s
ln(k) (M/s)
−14
−16
−18
−20
2.4
2.6
2.8
1000/T (K^{-1})


Eyring Plot
ΔH = 37.66 kcal/mol
ΔS = 4.39 cal/mol K
ln(k/T)
−20
−22
−24
−26
2.4
2.6
2.8
1000/T (K^{-1})

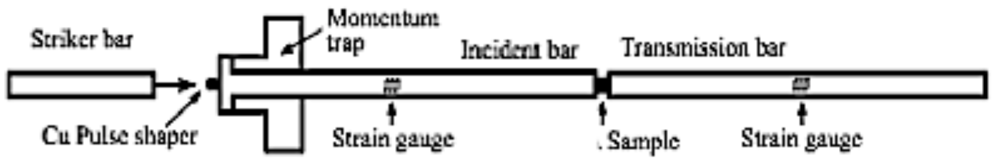
MECHANICAL STRESS TESTS

Uniform Temperature Fluorescence Maps

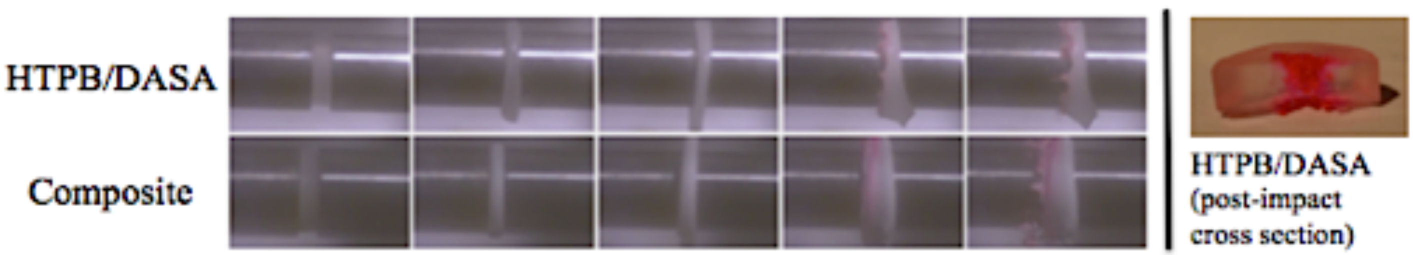
- Method
  - Uniformly heated sample of DASA with HTPB
  - Raman microspectrometer mapping at 100 nm scale

- Results
  - No observed spatial variation in activation of uniformly heated samples

Split Hopkinson Pressure Bar

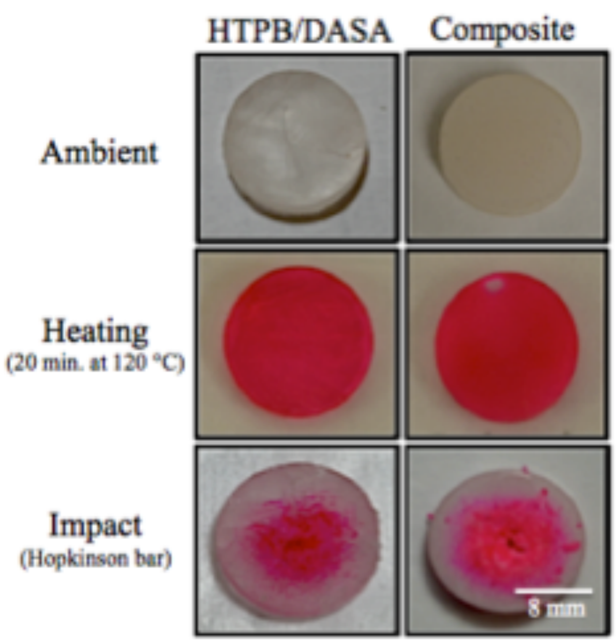


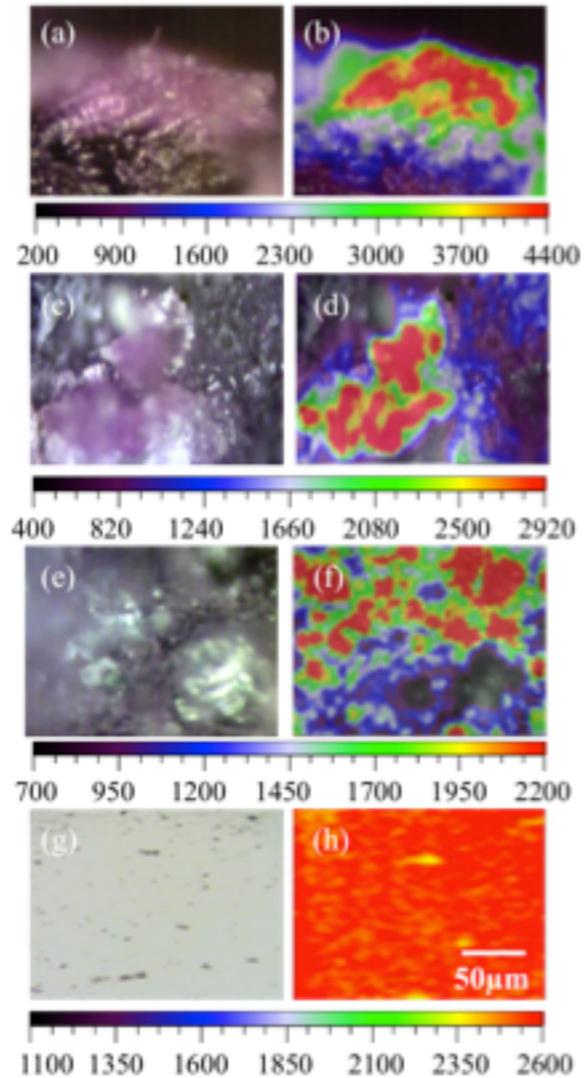
Schematic



150 microsecond compressive loading

Mechanical Stress Data





A/B: Plain HTPB with DASA

C/D: Sugar Composite

E/F: Inactivated sugar granules in impacted sugar composite

G/H: Uniformly heated sample with no spatial variation

Results

- Confirm the existence of hotspots
- DASA has suitable properties for the intended application
- Weapon System Explosives Safety Review Board use case

Next

- New photoswitch
  - Different activation barrier
  - Different fluorescent signature

- Extract hotspot properties
  - Temperature
  - Duration

Acknowledgements

Funding: Defense Threat Reduction Agency

Mentor: Joseph P. Hooper, Naval Postgraduate School

Collaborators:

- Brian P. Mason
  - Department of Chemistry and Biochemistry, University of California, Santa Barbara, California

- James R. Hemmer, Sameh Helmy and Javier Read de Alaniz
  - Research Department, Naval Surface Warfare Center, Indian Head, Maryland