



# **RDX-based Nanocomposite Materials for Significantly Reduced Shock Sensitivity**

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# Motivation and Challenge for Nanocrystals of High Explosives

- **Nanocrystals of high explosive (HE) demonstrated reduced sensitivity**
  - RDX nanocrystals\*
  - HNS nanocrystals\*\*
- **Nanocrystals have significant handling, processing, and safety/environment issues:**
  - Easy to form agglomeration, difficult to formulate
  - Sticking to the wall of reactor/container during formulation
  - Prone to become airborne
  - High potential of rapid uptake by biological system

\* V. Stepanov, Ph.D Dissertation, Chemical Engineering, New Jersey Institute of Technology, 2008

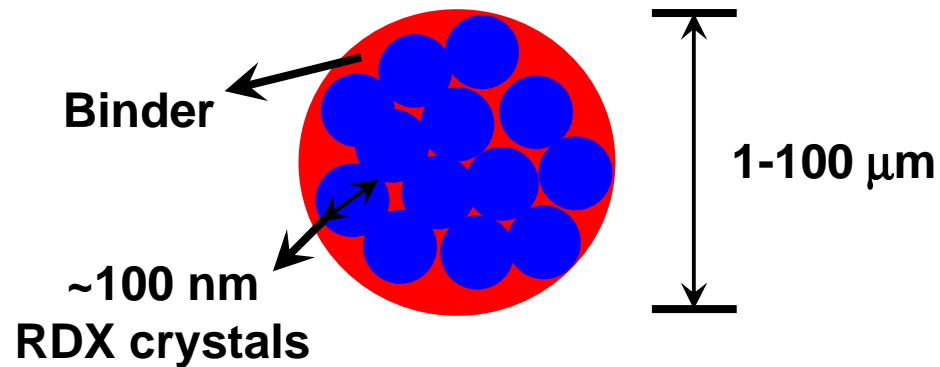
\*\* R. Setchell, Combustion and Flame, 56 (1984) 343.



# Goal, Ideal Structure, and Benefits

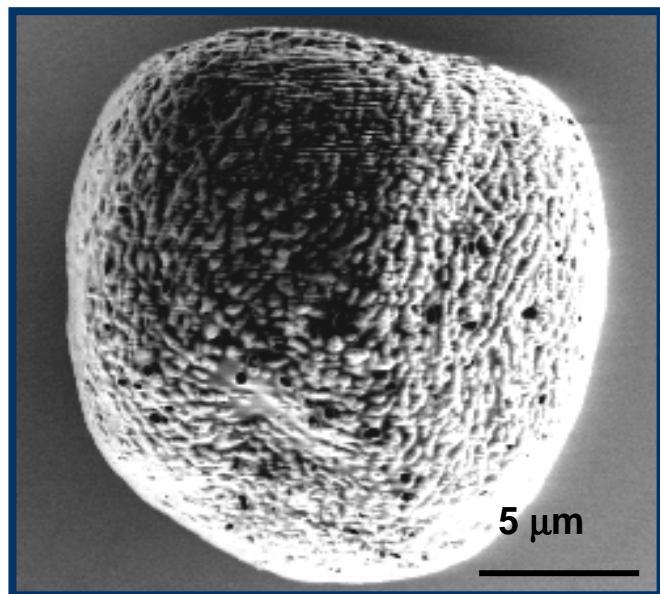


- **Goal:**
  - Achieve reduced sensitivity of energetic materials (RDX) by synthesizing RDX nanocomposite granules.
- **Ideal Structure**



- **Expected benefits from nanocomposite granules:**
  - Providing reduced sensitivity
  - No handling and safety/environment issues
  - Compatible with conventional powder processing
  - Ready for direct use!

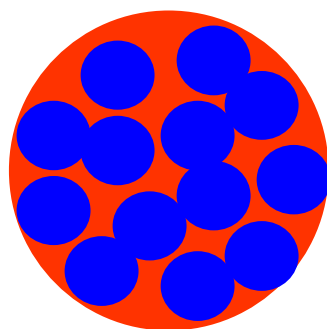
# One-Step Manufacturing of Energetic Nanocomposite Granules



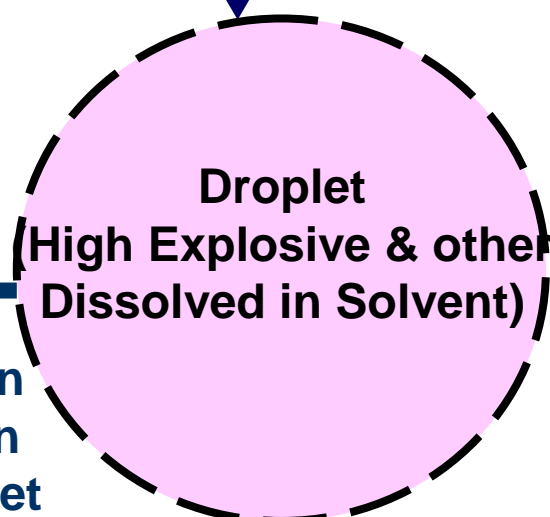
**RDX/PVAc Nanocomposite Granule**



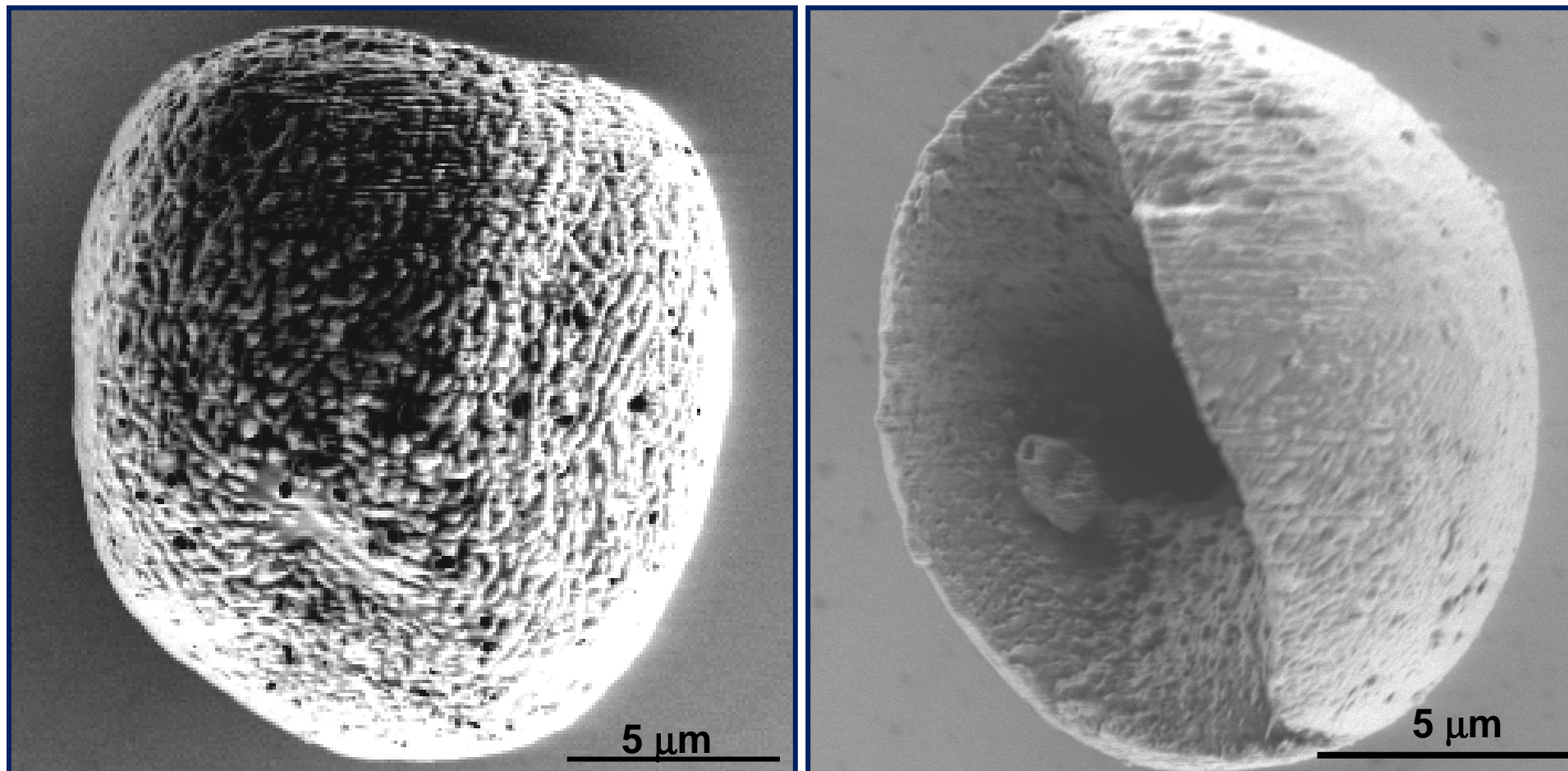
**Spray  
Dryer**



**Co-precipitation  
Confined within  
Shrinking Droplet**



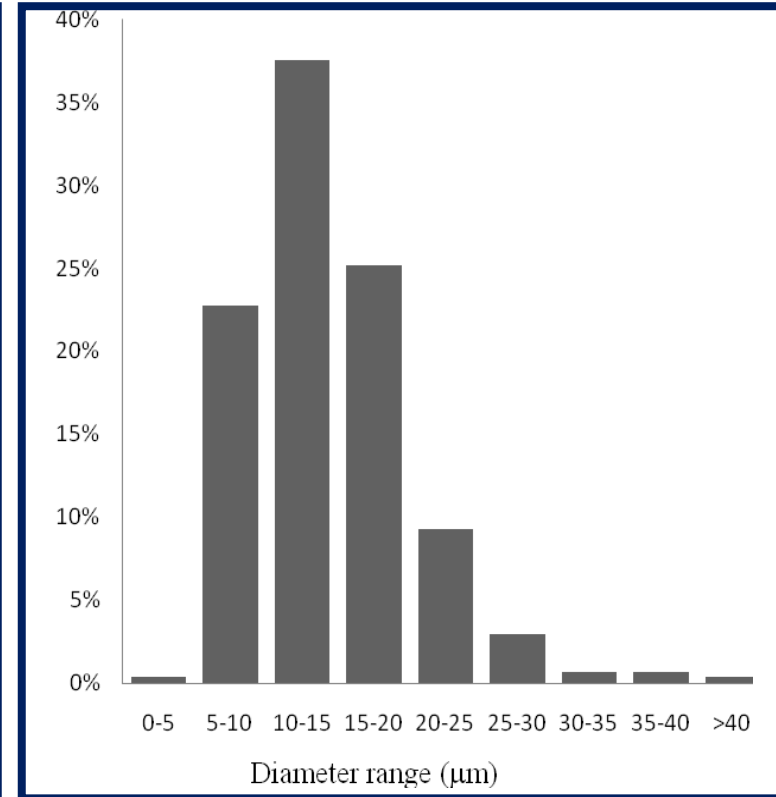
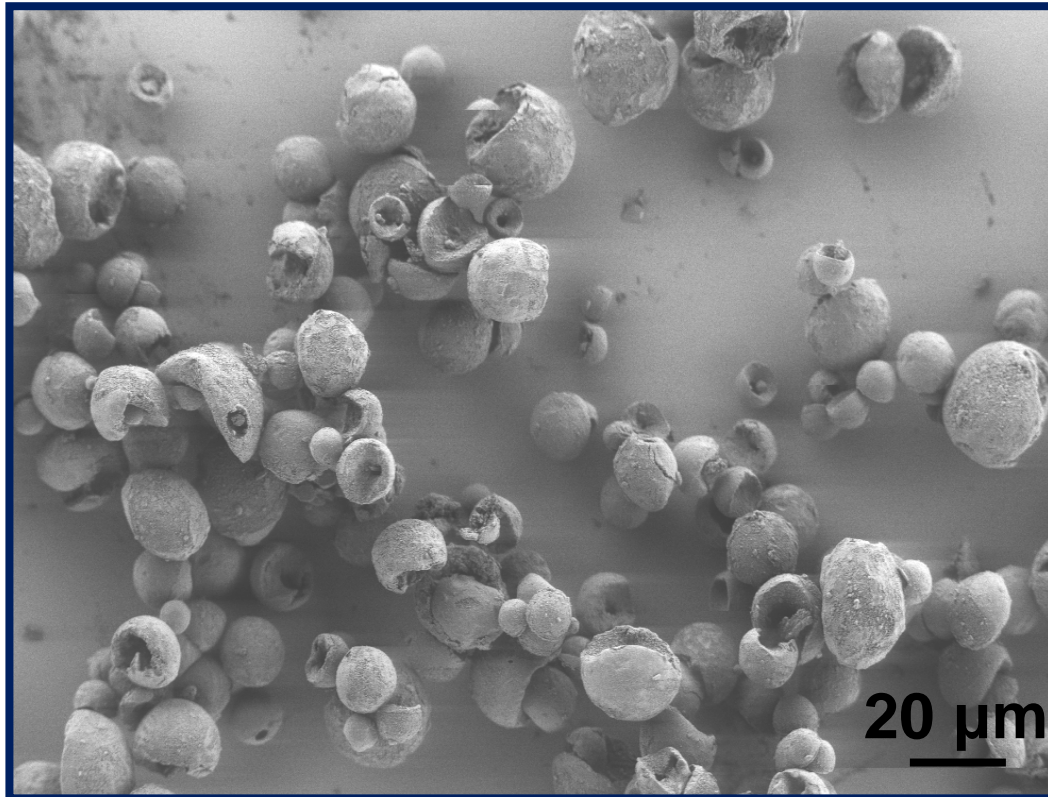
# Surface Morphology of RDX Nanocomposite Granules



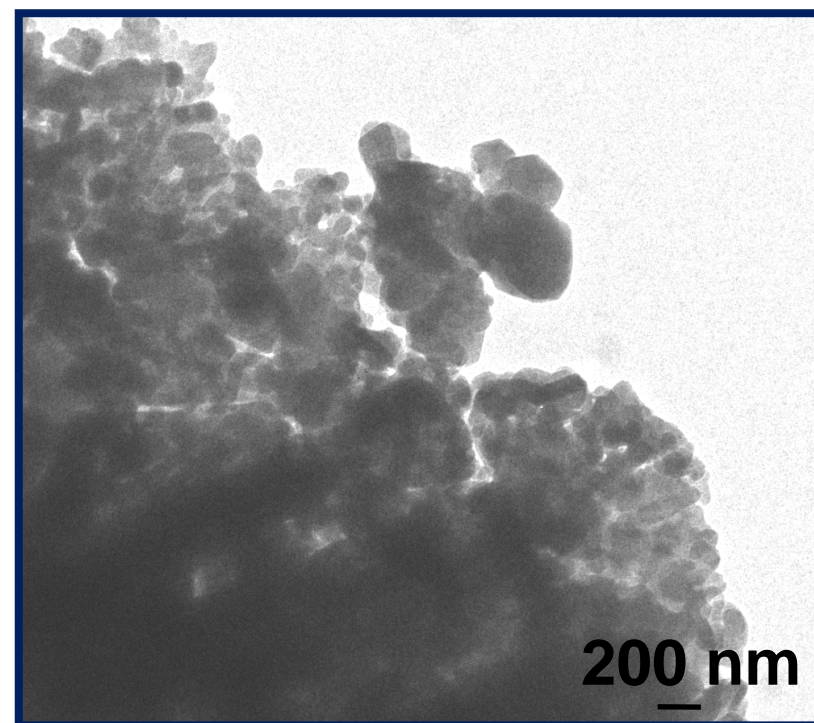
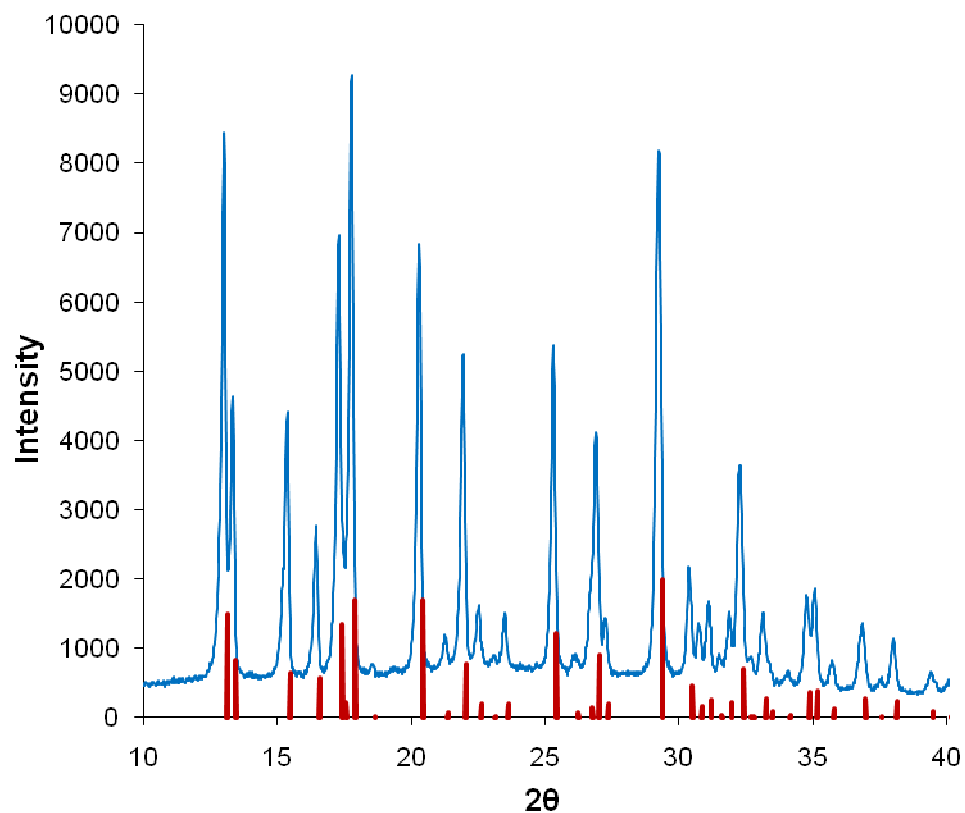
RDX\_PVAc\_acetone



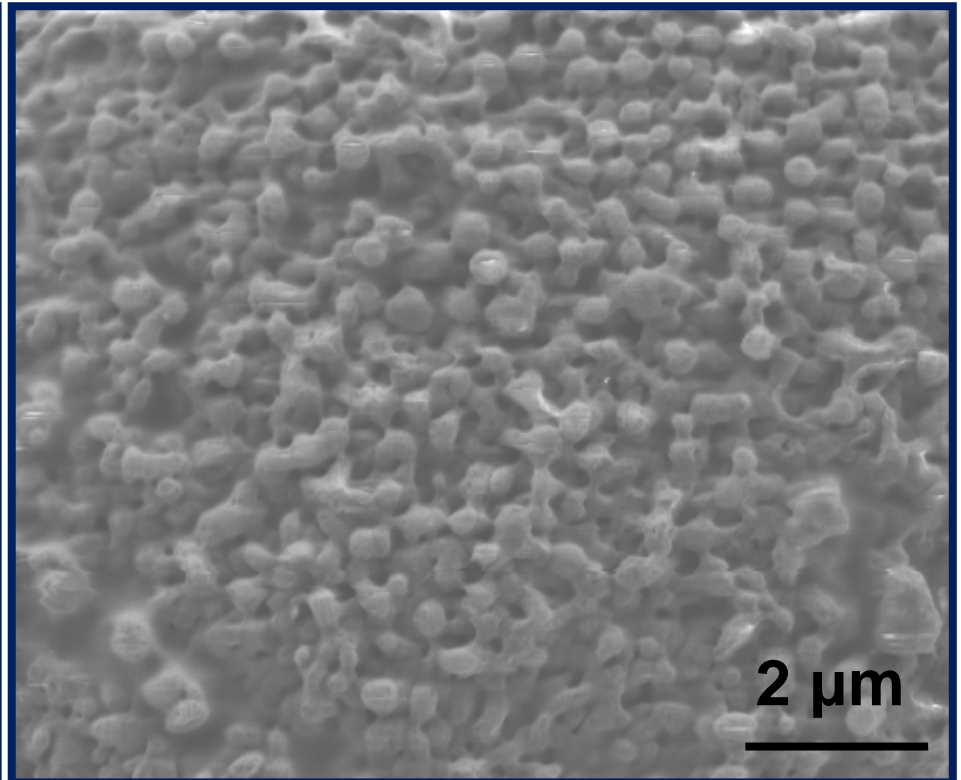
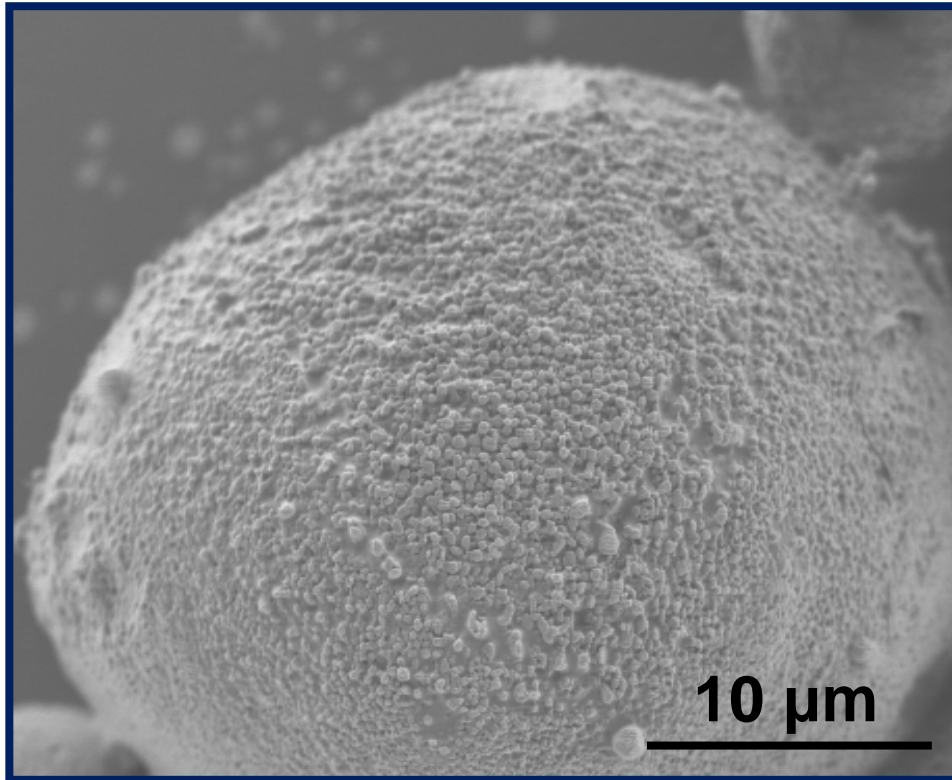
# Granule Size and Size Distribution



# RDX Nanocrystals

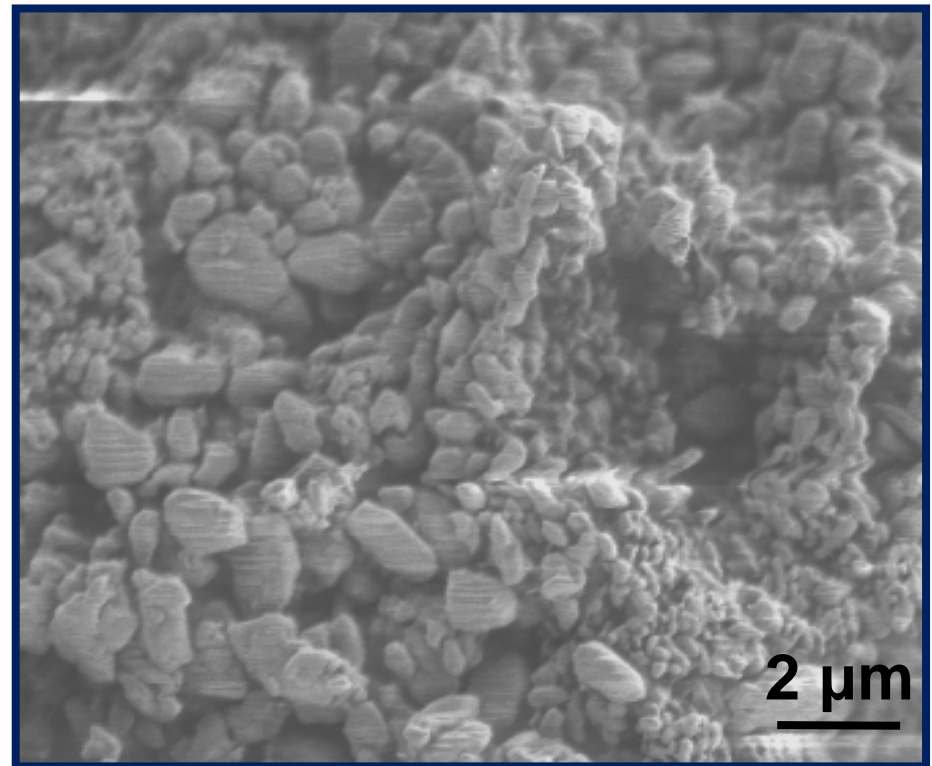
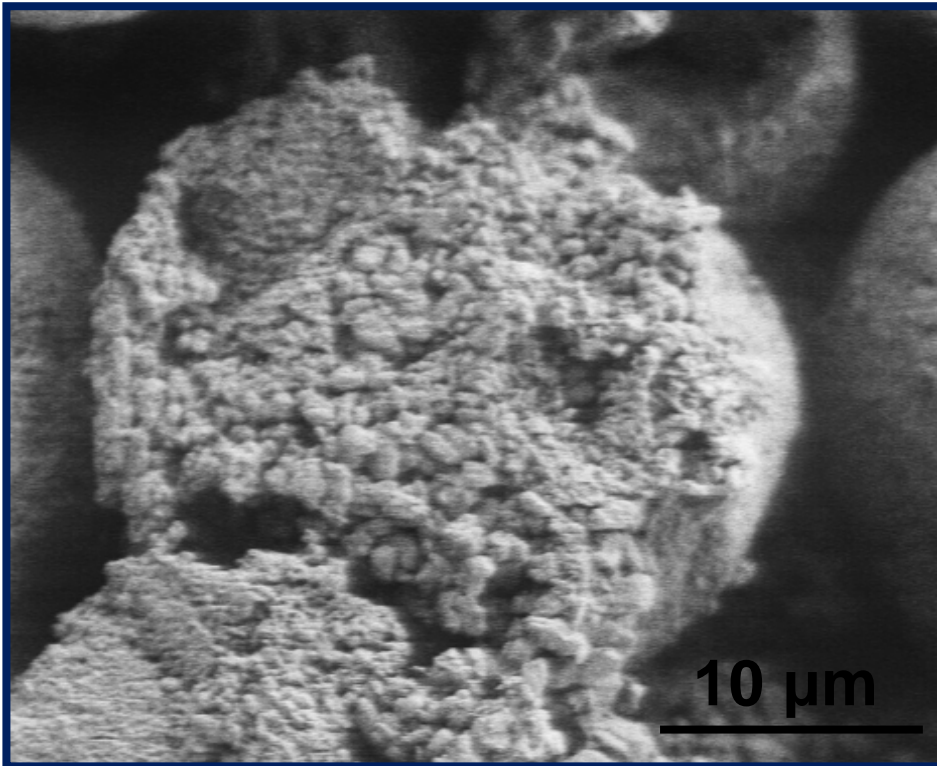


# Surface Morphology after Removal of Binder

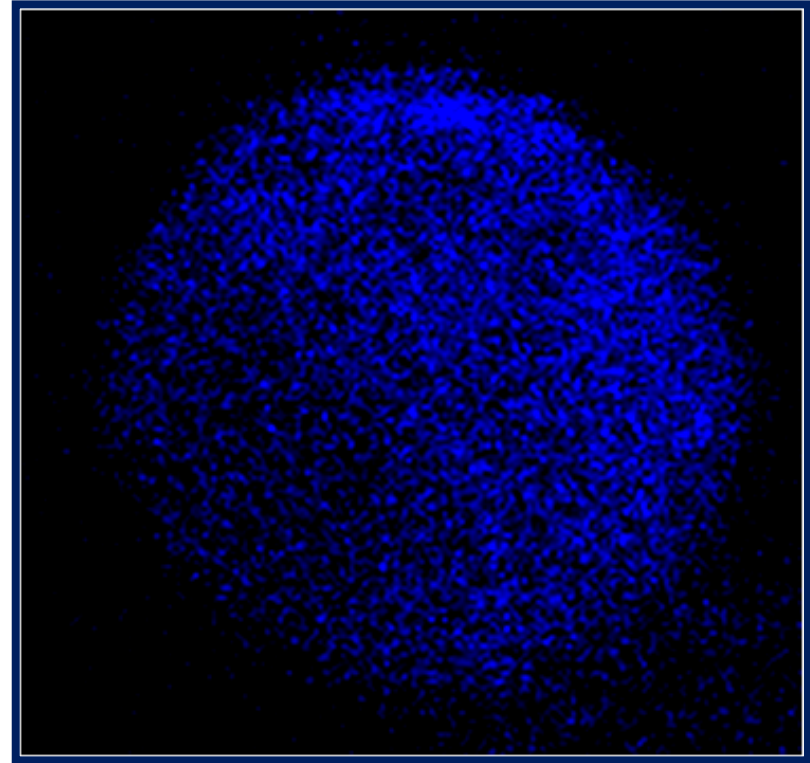
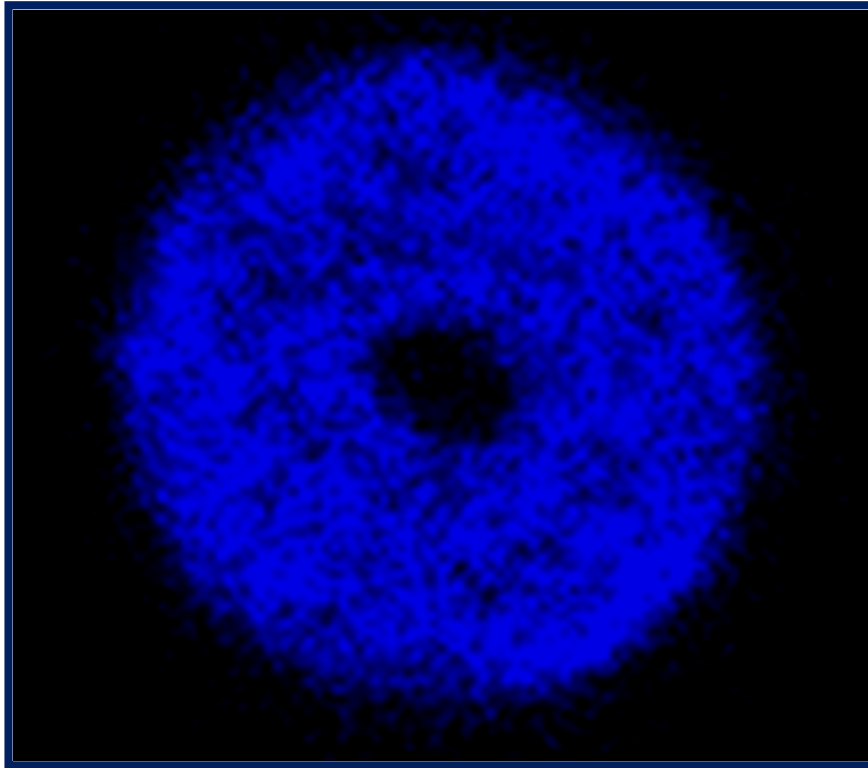




# Internal RDX Crystals

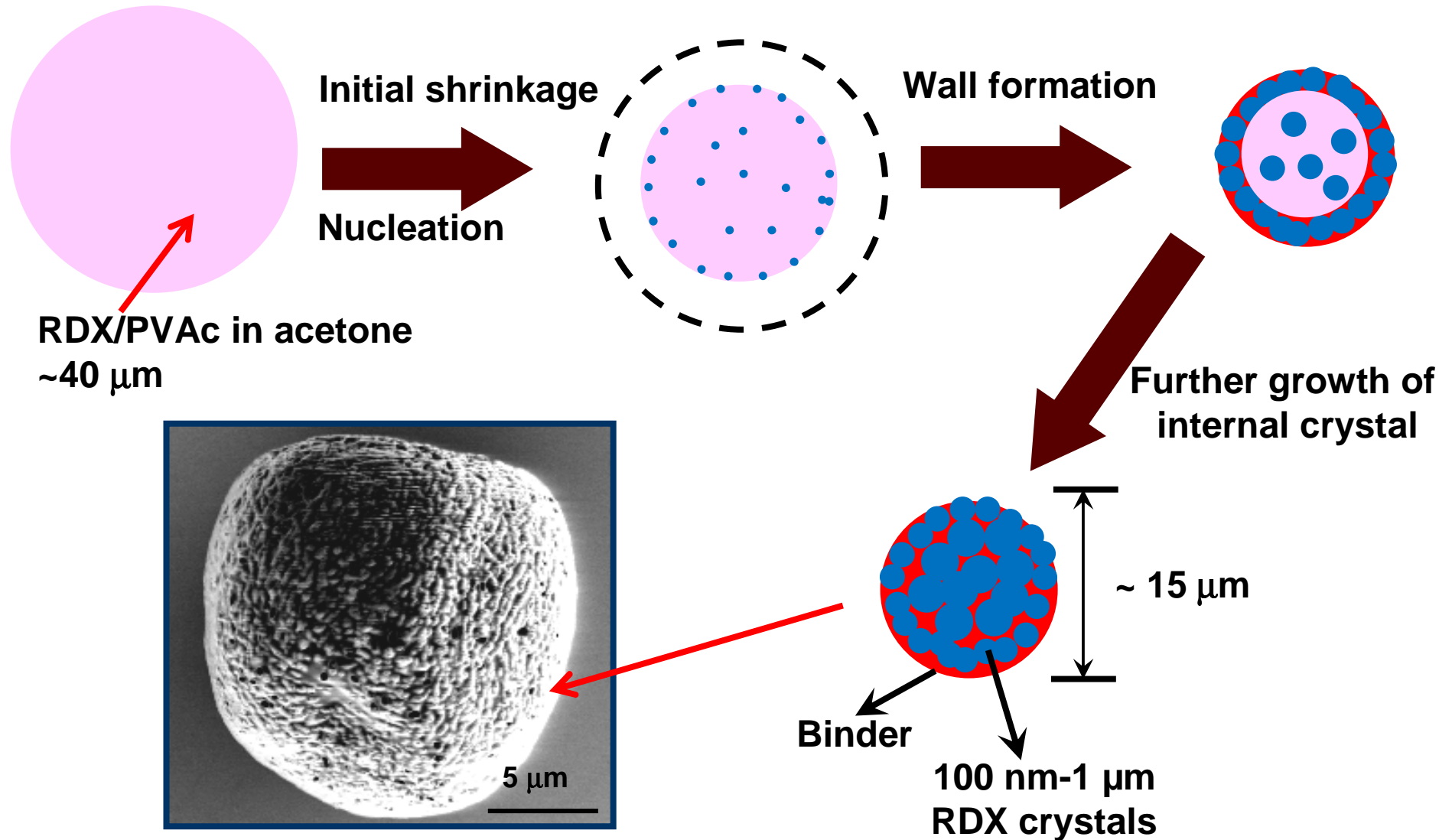


# Granules with Dye under Confocal Microscopy



**Uniform distribution of polymer**

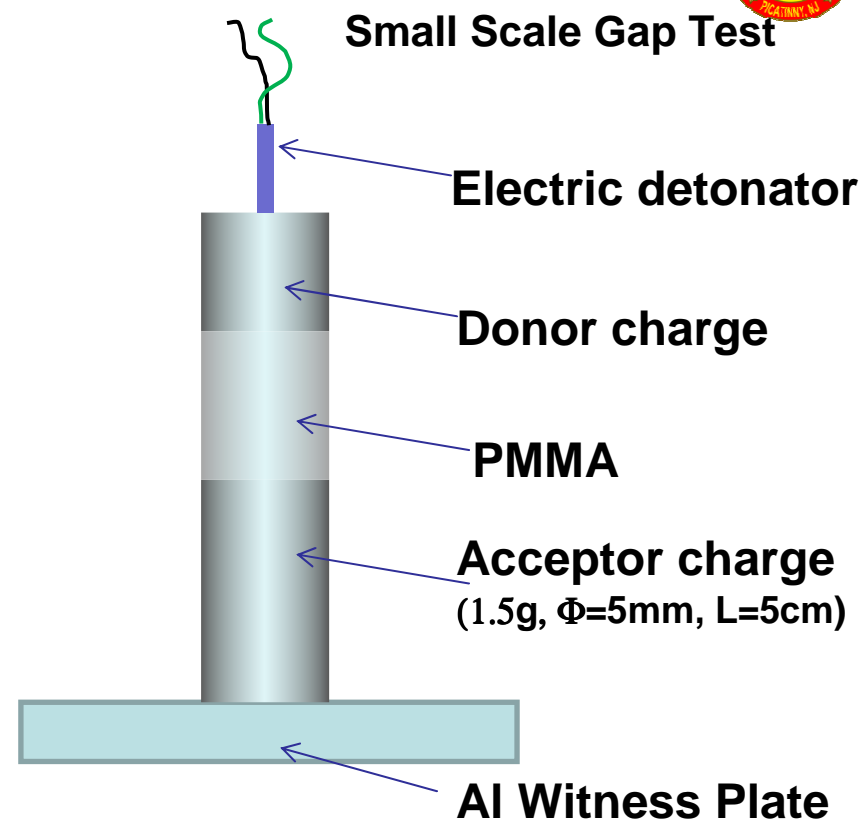
# Formation of the RDX Nanocomposite Granules



# Shock Insensitivity Improvement



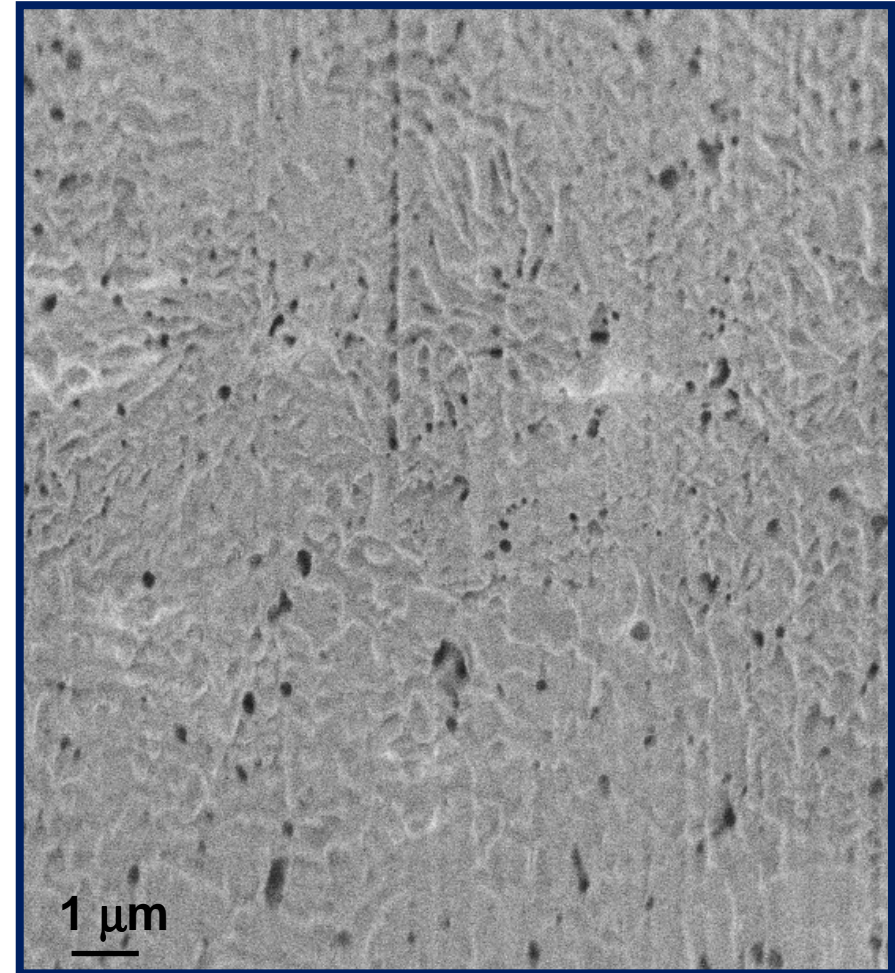
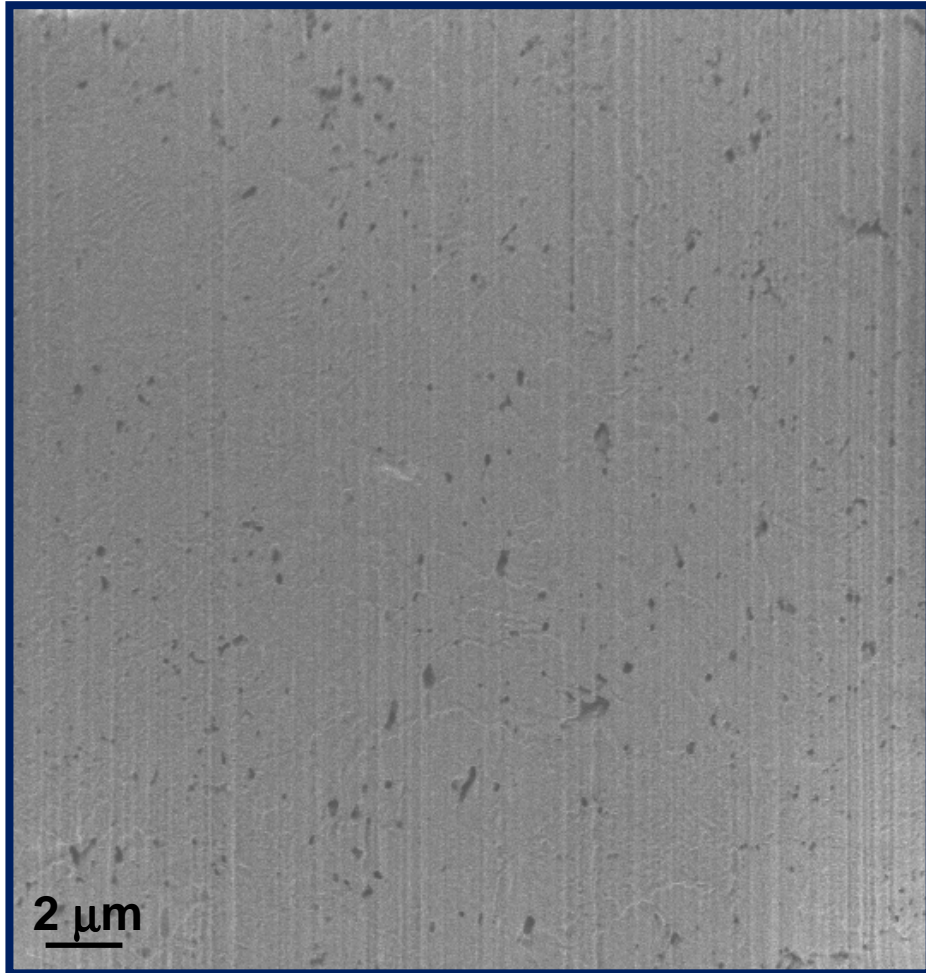
- **RDX/PVAc or VMCC**
  - HE: 83%
  - Avg. size:  $\sim 15 \mu\text{m}$
- **Pressing conditions:**
  - 16000psi
  - Room temperature
- **Mechanism**
  - Elimination of large pores due to existence of nano RDX as well as intimate nanoscale mixing between RDX and polymer



| Composition                               | Shock Sensitivity (GPa) | Density (g/cm <sup>3</sup> ) | % TMD | Binder wt. % | HMX wt. % |
|---|-------------------------|------------------------------|-------|--------------|-----------|
| RDX/PVAc (Spray Dried)                    | 4.0                     | 1.58                         | 91.9  | 17           | 4         |
| RDX/VMCC (Spray Dried)                    | 3.3                     | 1.62                         | 92.5  | 17           | 9         |
| 4- $\mu\text{m}$ RDX/VMCC (Slurry coated) | 2.5                     | 1.64                         | 93.7  | 17           | 9         |



# Voids in Pressed Sample

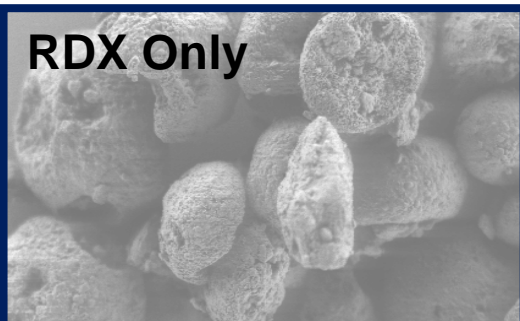




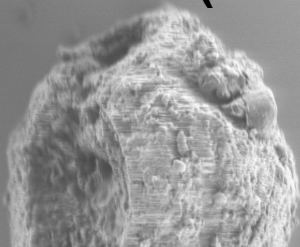


# Simple and Versatile Method for Producing Novel Energetic Materials

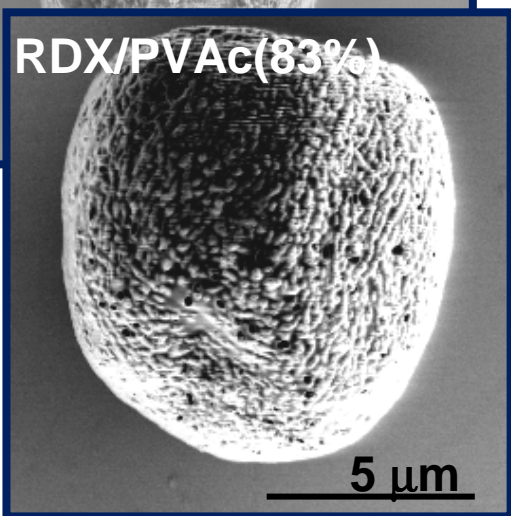
**RD<sub>X</sub> Only**



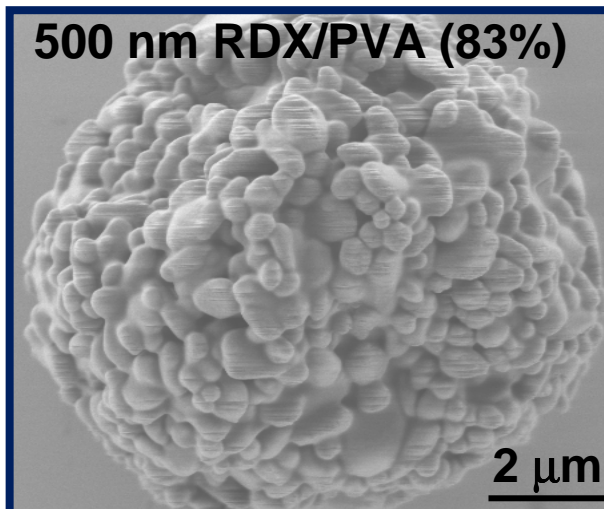
**RD<sub>X</sub>/VMCC(83%)**



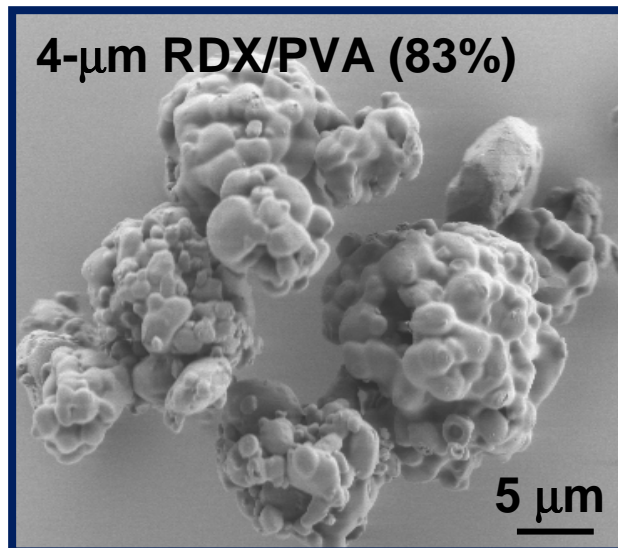
**RD<sub>X</sub>/PVAc(83%)**



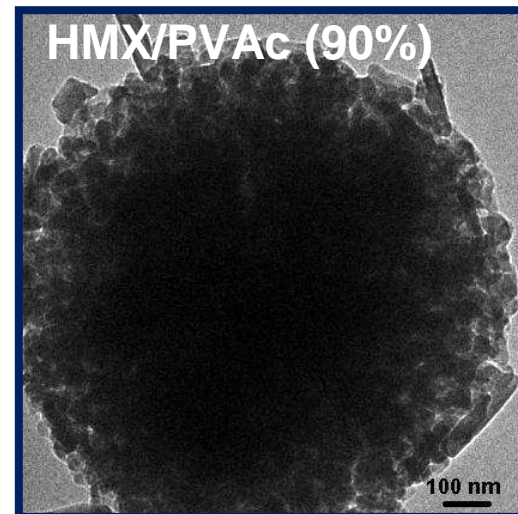
**500 nm RD<sub>X</sub>/PVA (83%)**



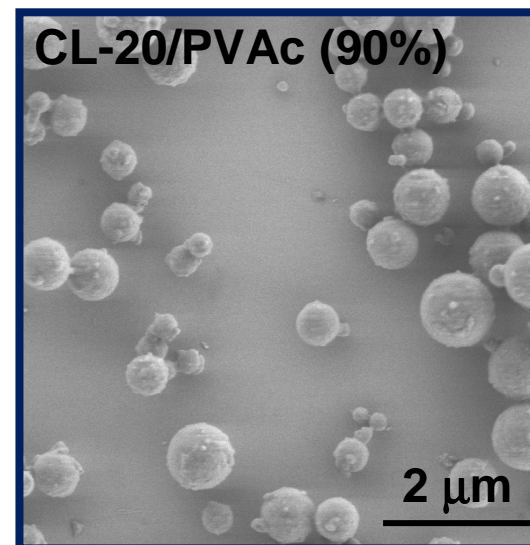
**4-μm RD<sub>X</sub>/PVA (83%)**



**HM<sub>X</sub>/PVAc (90%)**



**CL-20/PVAc (90%)**



# Summary

- **An one-step process for manufacturing RDX nanocomposite granules was developed**
- **Characterization shows that the granules have an average size of  $\sim 15 \mu\text{m}$  with  $100 \text{ nm}$ - $1 \mu\text{m}$  sized RDX nanocrystals and polymeric binder mixed uniformly inside**
- **Sensitivity test demonstrated that RDX nanocomposite has significantly reduced sensitivity**

# Acknowledgements

**Alex Chou and Matt Libera  
Helen Lee**

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Steven Nicolich**

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- **H. Qiu, V. Stepanov, A.R. Di Stasio, T. Chou, W.Y. Lee, RDX-based Nanocomposite Microparticles for Significantly Reduced Shock Sensitivity, Journal of Hazardous Materials (In Press)**