

# XANES and STXM Studies of Ceramic Biomaterials for Drug Delivery

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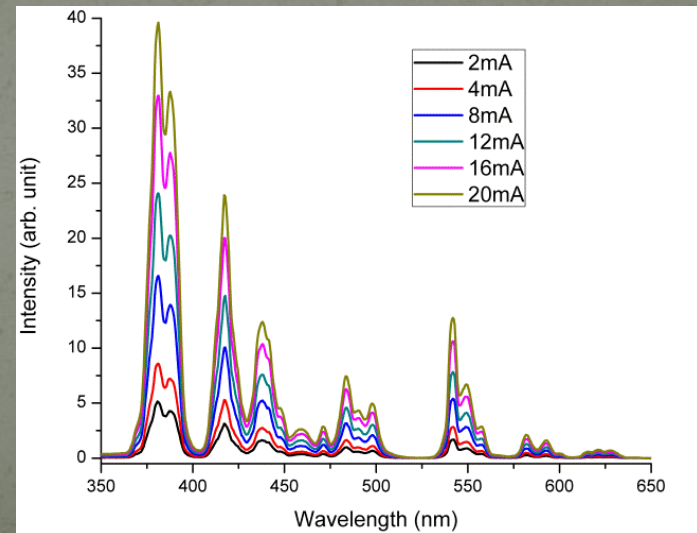
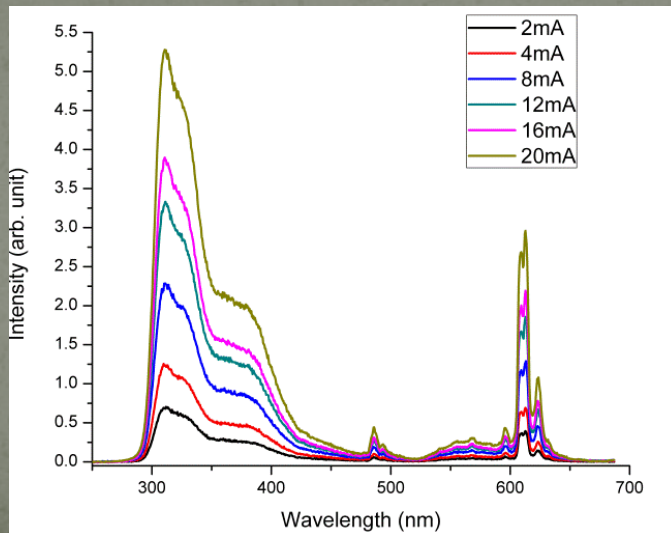
Group Workshop

April 15<sup>th</sup>, 2013

Vince Xiaoxuan Guo

# Research Topics

- Ceramic Biomaterials Drug Delivery
  - Calcium Silicate Hydrate (CSH)
  - Hydroxyapatite (HAp)
- Mesoporous Silica
  - Luminescence
  - Drug Delivery
- Rare Earth Elements Luminescence in Calcium Scandium Silicate ( $\text{Ca}_3\text{Sc}_2\text{Si}_3\text{O}_{12}$ )

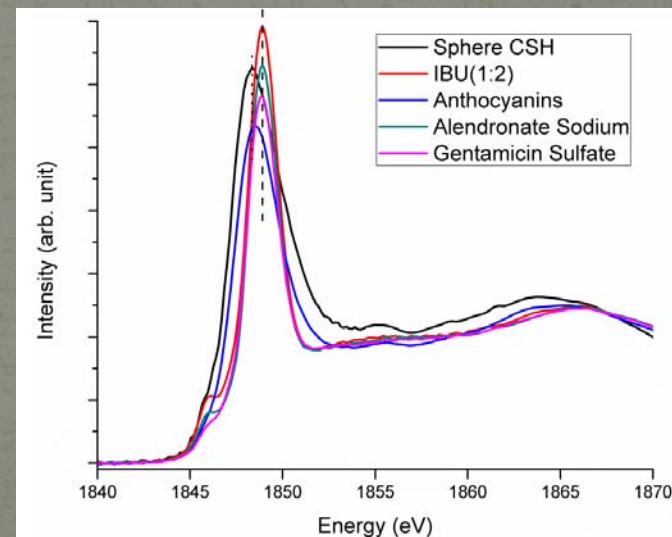
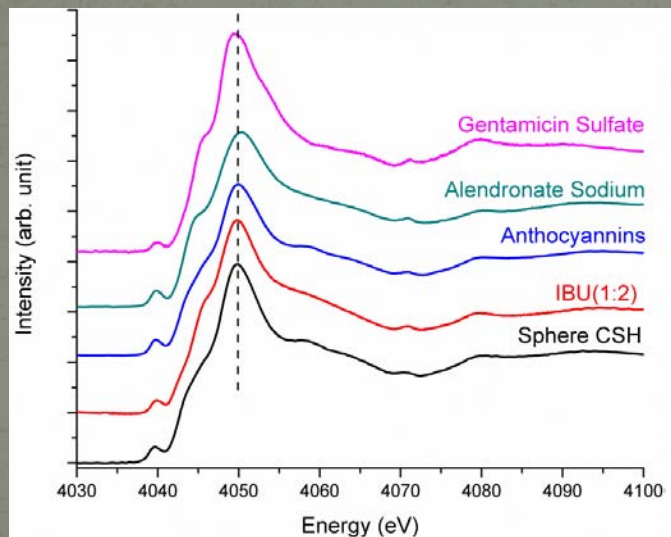


# Objectives

- Drug Delivery Ceramic Biomaterials
  - No toxicity, good compatibility, bioactivity and biodegradability
  - Little is known on the interaction between drug carriers and drug molecules on the molecular level
    - Implications on the drug loading capacities
    - Hints to the following drug release mechanisms
- X-ray Absorption Near Edge Spectroscopy (XANES)
  - Elemental specific
  - Probe unoccupied states
- Scanning Transmission X-ray Microscopes (STXM)
  - Resolution: 30 nm
  - Drug Loading Distribution (mapping)

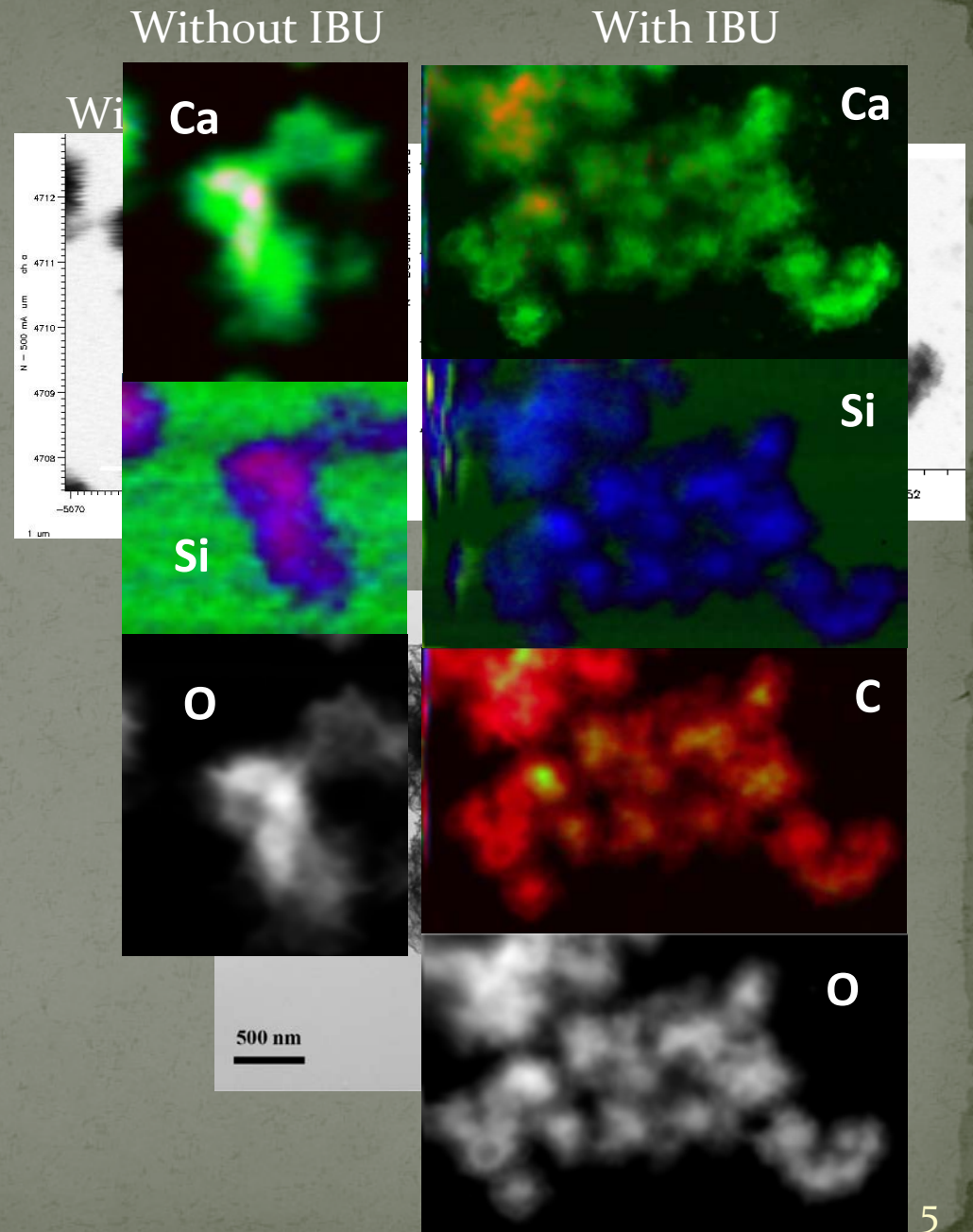
# Highlights

- Calcium Silicate Hydrates (CSH)
  - Amorphous, Nanosheets, Microspheres
  - Anhydrous nanosheets and microspheres
  - CSH nanosheets-polymer nano-composite
  - CSH microspheres loaded with different drug



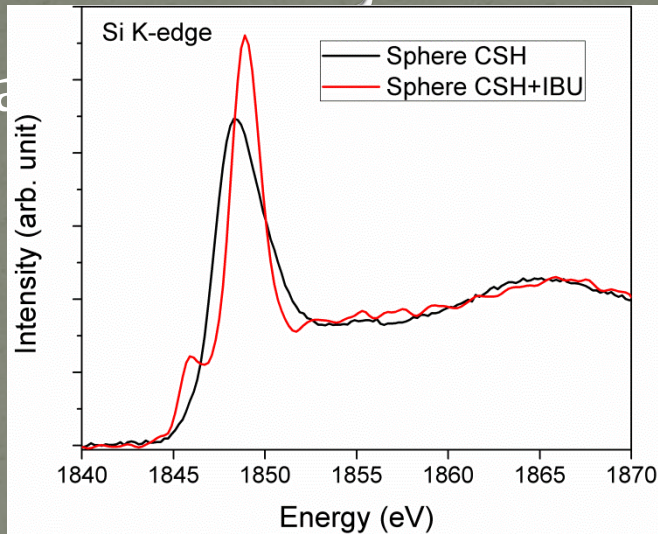
# STXM Mapping

- STXM stack images are almost the same as TEM image
- From carbon stack mapping, IBU is uniformly loaded on CSH microspheres

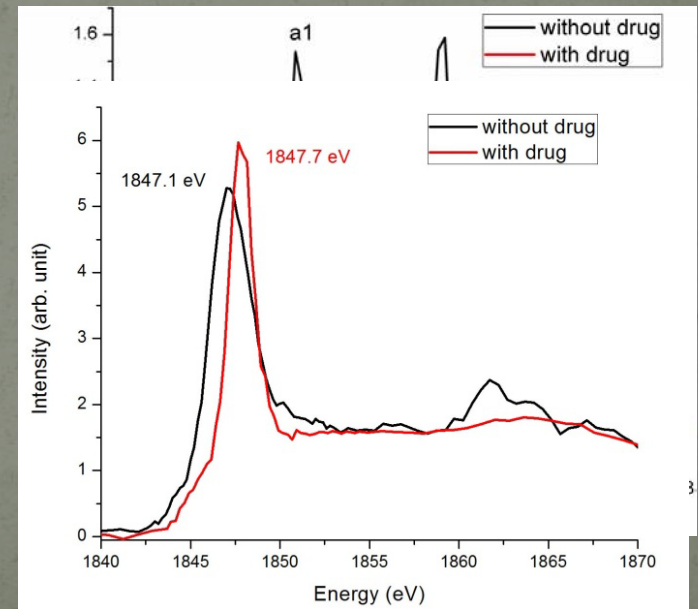
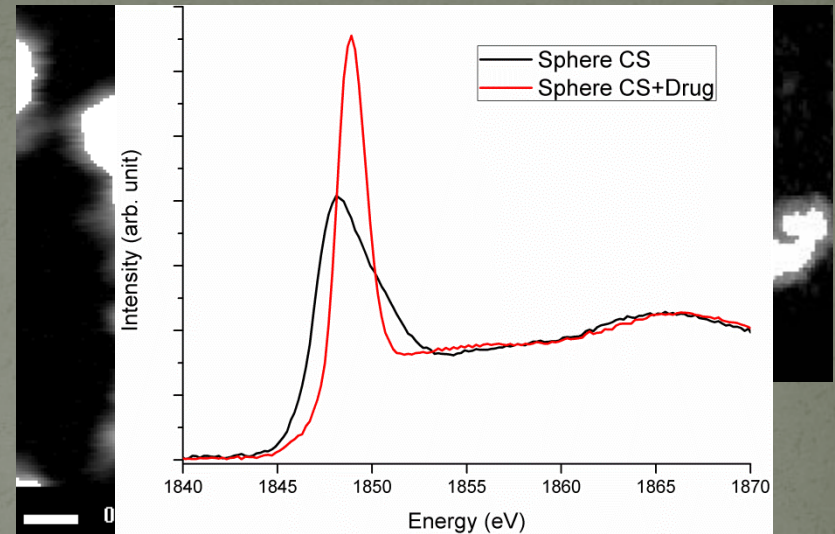


# STXM Analysis

- Ca
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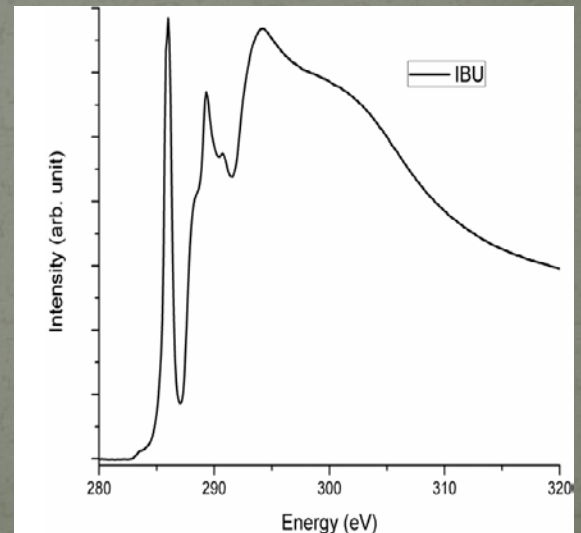
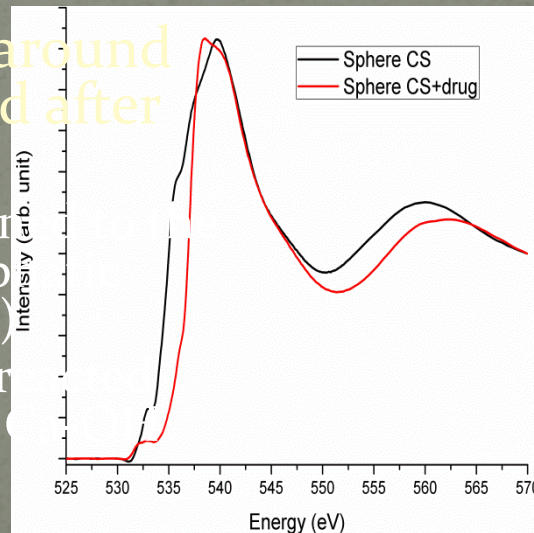
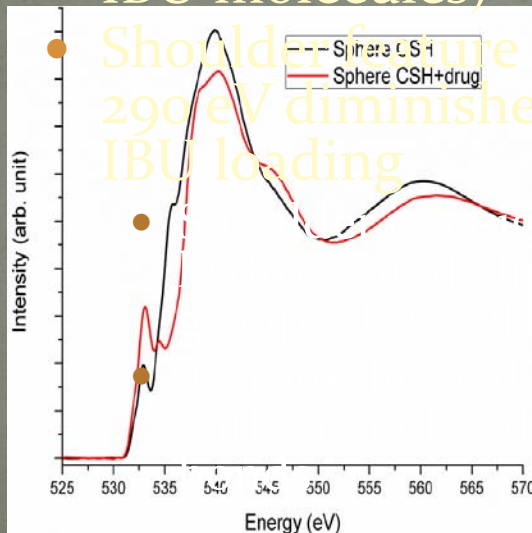
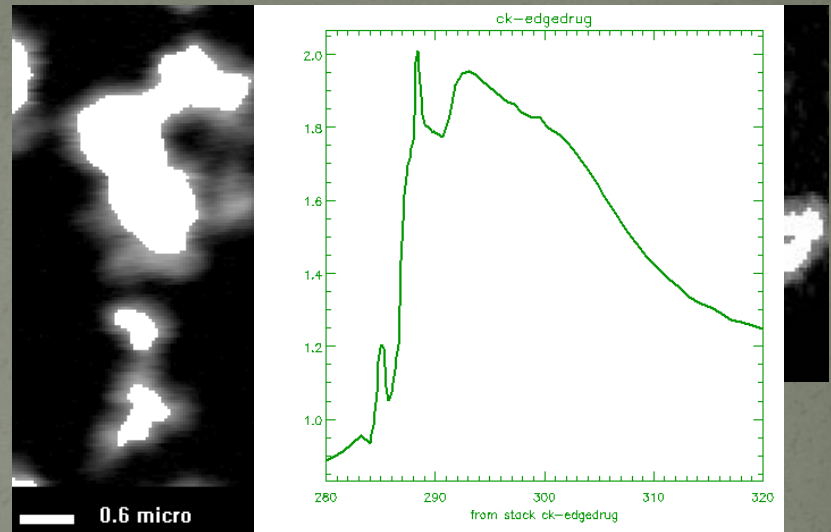


- Si K-edge
  - Made agreement with the results of SXRMB
  - Main resonance turned sharper and shifted  $\sim 0.6$  eV
  - Hydrates seemed to had replaced by IBU



# STXM Analysis

- O K-edge
  - Once again, Spectrum after IBU loading is similar to that of sphere CS+IBU (Hydrates were replaced)
- C K-edge
  - Peak located 286 eV decreased dramatically (due to the orientation of IBU molecules)

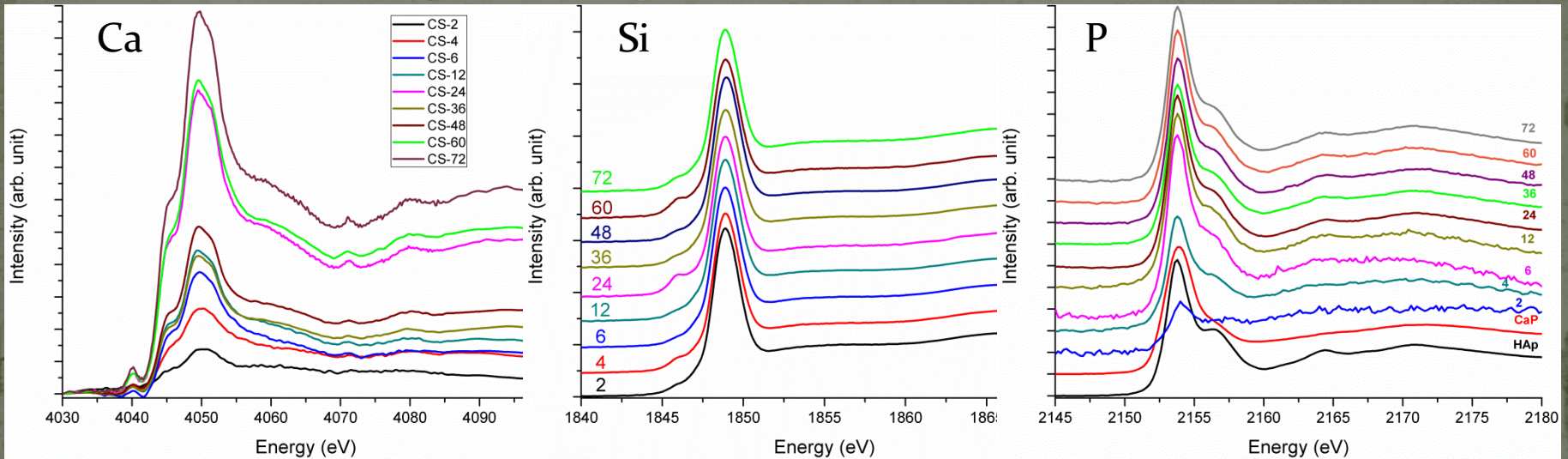


# Future Plan

- Make or repeat part of experiments to complete the analysis
  - FLY of Sphere CS, Sphere CS+IBU
  - O K-edge of Drug Delivery System (Photodiode as background)
- Europium doped in CSH microspheres (XANES and XEOL)
- Drug Release Study
  - CSH microspheres without drug in SBF
  - CSH microspheres +IBU (1:2/1:4) release in SBF
  - CS microspheres+ IBU (1:2) release in SBF



# Preliminary Drug Release Data



- After 6 hours, CSH has been transformed to HAp from Ca and P K-edge
- Even after 3 days, still observed Si signal
  - Peak intensity around 1846 eV varied

Thank you very much!