

# Control of phase composition in the hydrothermal synthesis of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$



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$\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$  - a complex perovskite, interesting piezoelectric and ferroelectric properties

**Hydrothermal synthesis** - enables production of **nanosized highly crystalline powders** from a variety of **inexpensive precursors** under **moderate temperature conditions**

- Aim**
- study of reaction mechanisms
  - acquirement of the correlations between the chemical-thermodynamic parameters applied and the formation of NBT and secondary phases

## Experimental

DI - H<sub>2</sub>O  
NaOH  
TiO<sub>2</sub> - anatase  
Bi(NO<sub>3</sub>)<sub>3</sub>·5H<sub>2</sub>O

mixing  
30 % filling

Hydrothermal synthesis  
Temperature : 120 - 240 °C  
Time : 0.5 - 96 h

washing  
drying

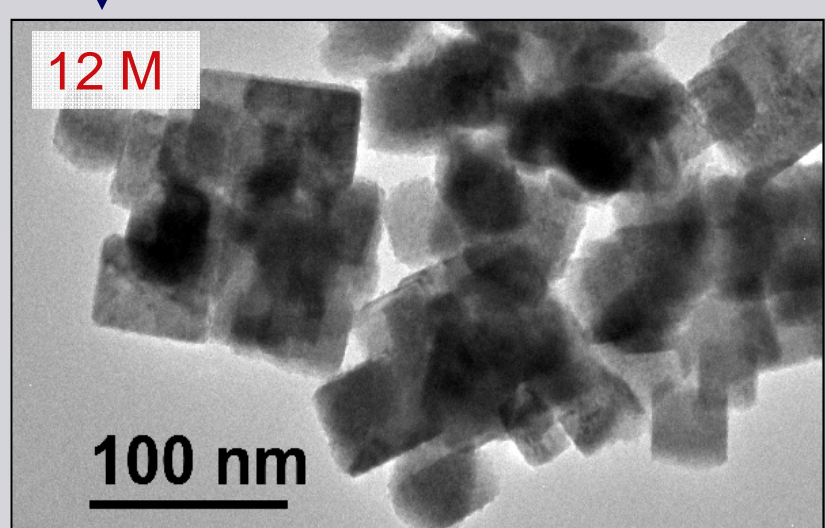
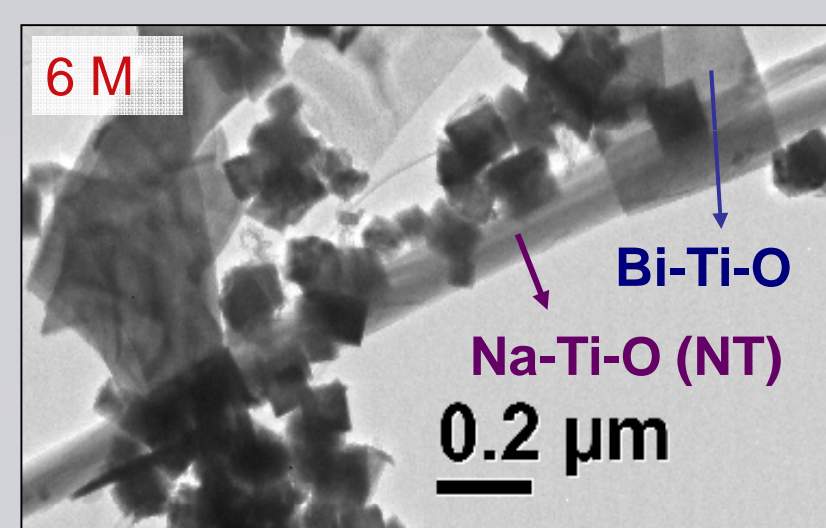
NBT  
powder

Powder X-ray diffraction - XRD  
Transmission electron microscopy - TEM

## Characterization

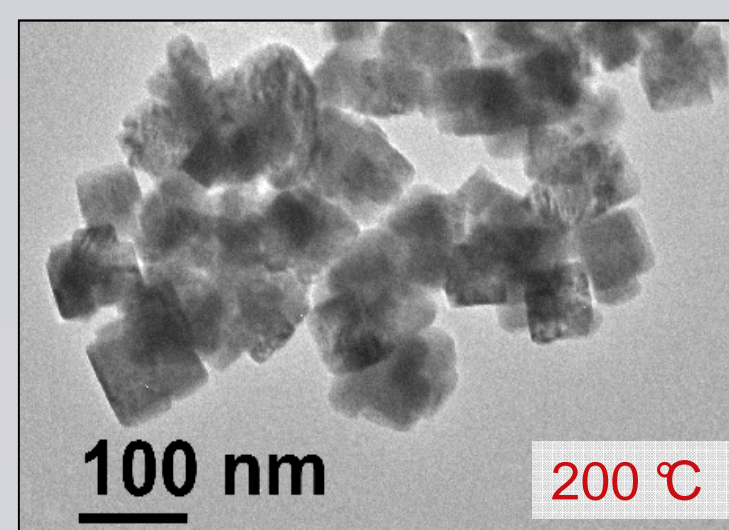
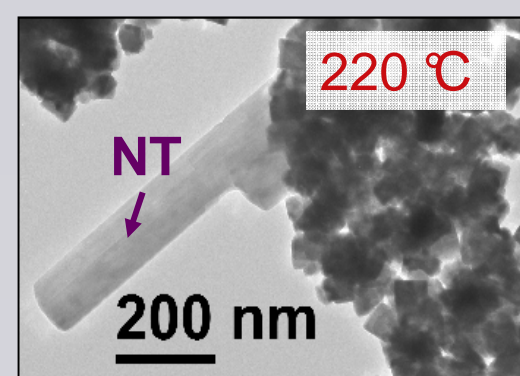
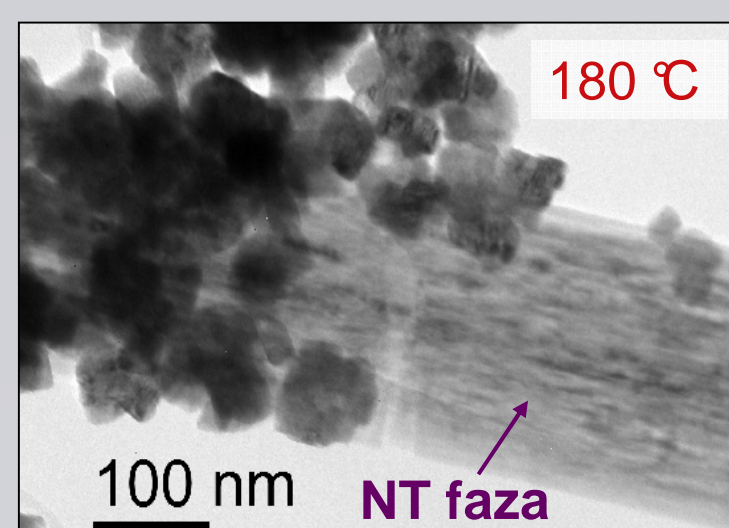
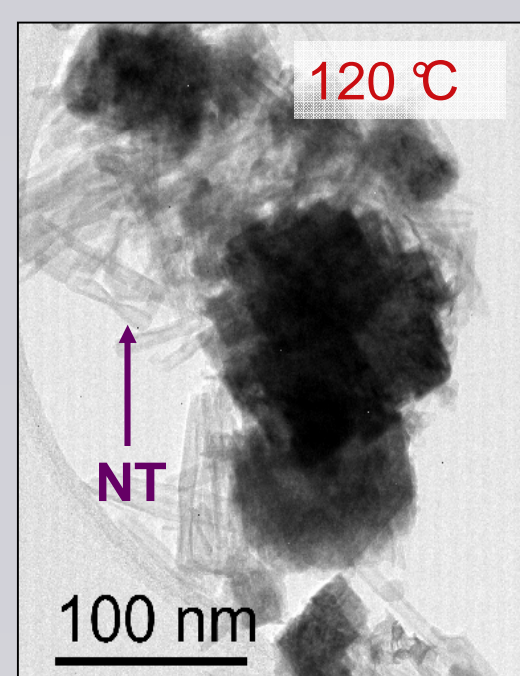
## Results

### NaOH concentration



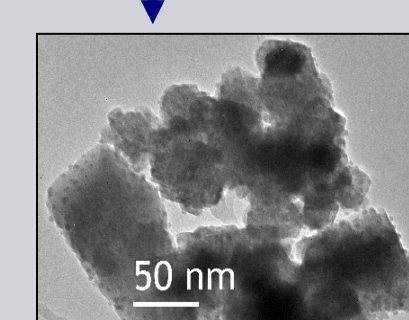
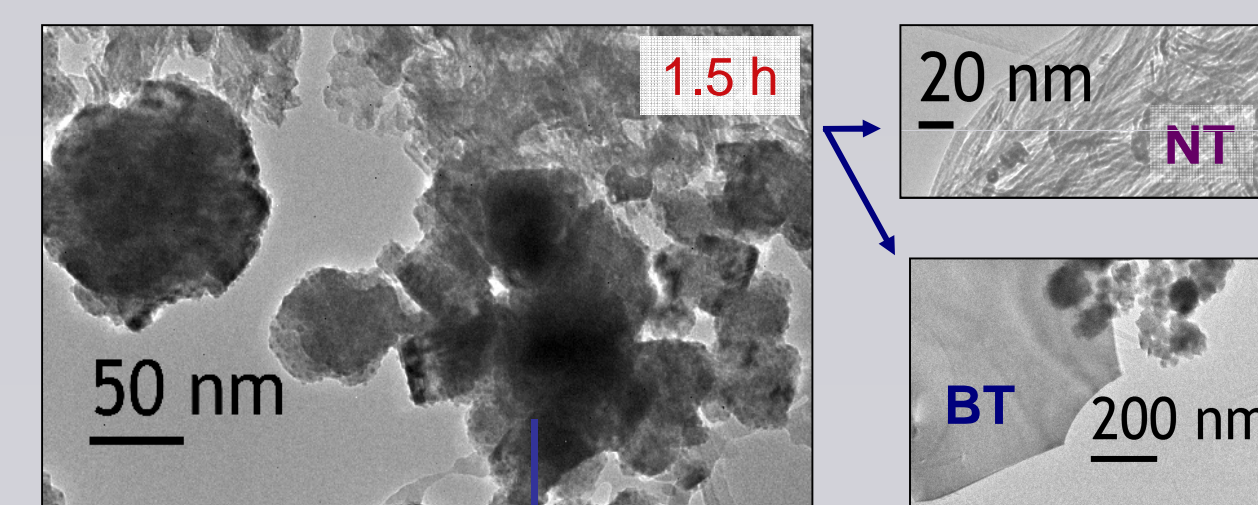
$c(\text{Bi}^{3+}) = 0.1 \text{ M}, T = 200 \text{ °C}, 12 \text{ M NaOH}$

### Temperature

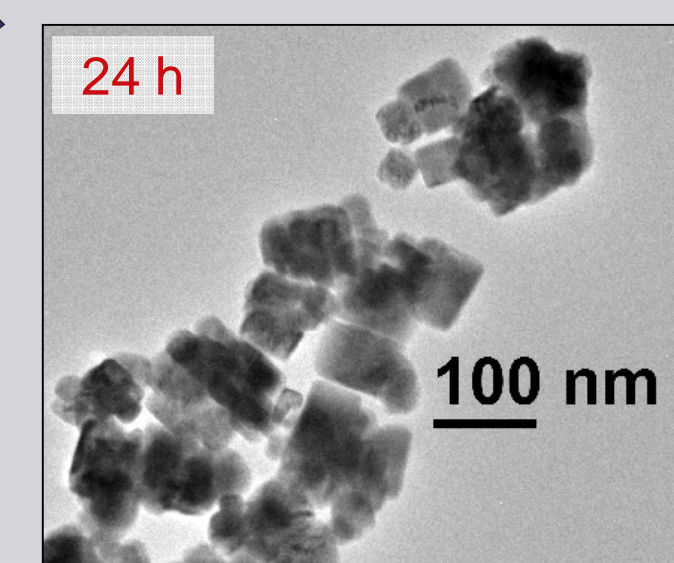


$c(\text{Bi}^{3+}) = 0.1 \text{ M}, 12 \text{ M NaOH}, 48 \text{ h}$

### Reaction time

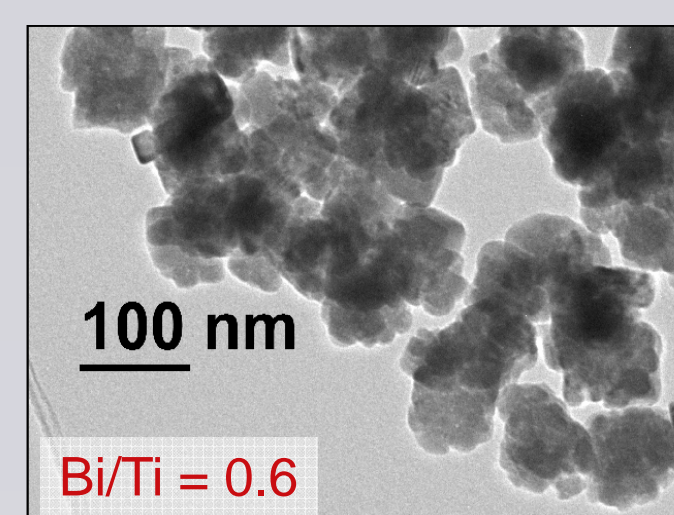
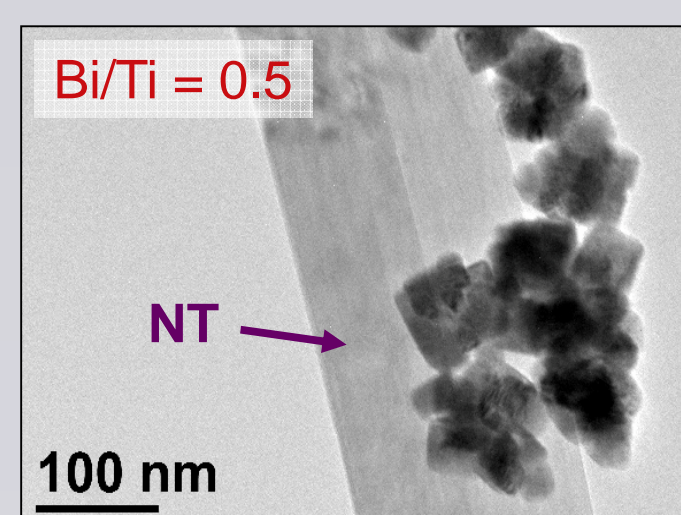


poorly crystallized NBT phase, secondary phases



$c(\text{Bi}^{3+}) = 0.1 \text{ M}, T = 200 \text{ °C}, 12 \text{ M NaOH}$

### Bi/Ti ratio



$c(\text{Bi}^{3+}) = 0.05 \text{ M}, T = 200 \text{ °C}, 12 \text{ M NaOH}, 48 \text{ h}$

## Summary

Control over the crystallization process and thus the final phase composition can be attained by managing parameters that ultimately define the solubility of chosen precursors and the stability of NBT phase under applied conditions.

### Future work

- synthesis of NBT-based solid solution
- employment of NBT/NBT-based ceramic particles in thin films through polymer-assisted assembly

### Final product

- *lead-free piezoelectric powder materials*
- *NBT thin films, composite thin films, multicomponent systems*

### Applications

- piezoelectric components  
sensors, resonators, transducers, actuators,...
- voltage-tunable capacitors, phase shifters, electronic components