SELF-ASSEMBLY OF SOME NANOSTRUCTURES

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Self-assembly is coordinated action of independent entities under distributed (i.e., noncentral) control to produce a larger structure or to achieve a desired group effect

Carries out many of the difficult steps in nanofabrication

- atomic-level modification of structure, using highly developed techniques of synthetic chemistry

• Inspiration from a wealth of examples in biology

- Proteins, DNA, cell-membrane etc.

• Target structure is thermodynamically stable

- structures are relatively defect-free and self-healing

Understanding is still at a very elementary level

- ”molecular shape”

- Enthalpy vs. Entropy

- nature of non-covalent forces

Forces used in self-organization processes:

- Covalent bonds (”normal chemistry”)

- Electrostatic forces (salts, ionchannels, synapses)

- Hydrophilic/hydrophobic forces (oil/water, cell membranes)

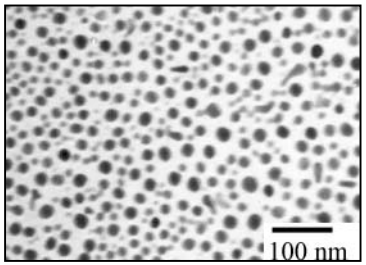
- Hydrogenbonds (DNA, proteins)

- Thermal effects

β-Cyclodextrin mediated Self-assembly of Sb_2Se_3 nanostructure

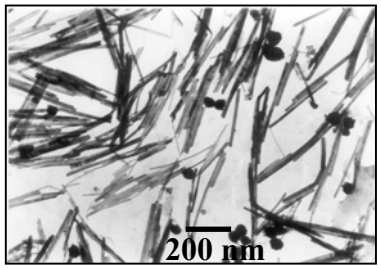
POTASIUM ANTIMONY OXIDE TARTRATE + SORBITOL+ SODIUM SELENOSULFATE IN AQUOUS MEDIUM

No Cyclodextrin



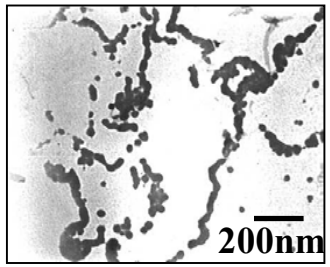
S1

2 mM Cyclodextrin



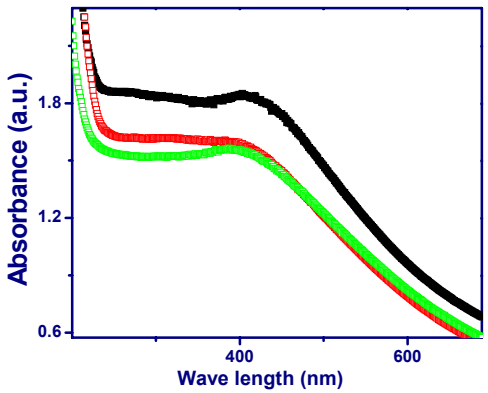
S2

5mM Cyclodextrin

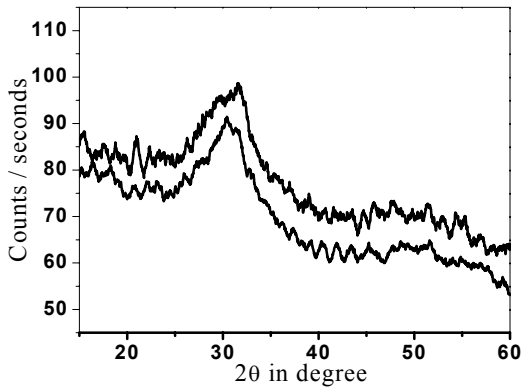


S3

TEM MICROGRAPH OF THE SAMPLES



UV-VIS absorbance spectra of S1, S2, S3

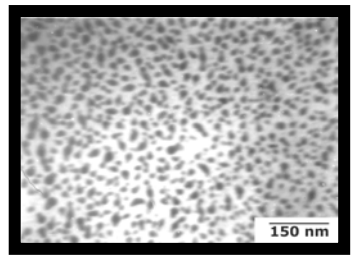


XRD SPECTRA OF S1 & S2

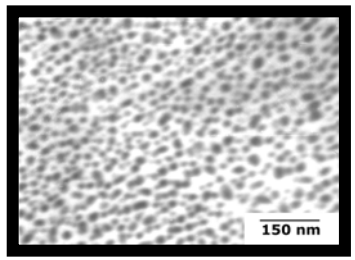
Self-Assembly of Bi_2Se_3 nanostructure

Controlled release of Bismuth ion from Bismuth ammonium citrate (.5 gm) and Se ion from sodium selenosulfate (5ml) in aquous medium(70ml H_2O) gives Bi_2Se_3 nanoparticle which assembled in network like agregates in presence of β-cyclodextrin

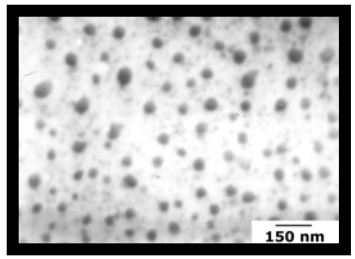
No cyclodextrin



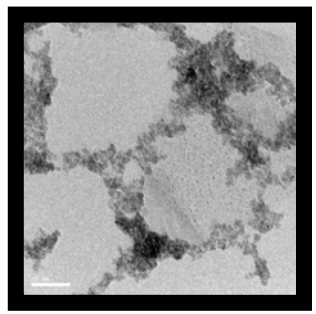
.483 gm cyclodextrin



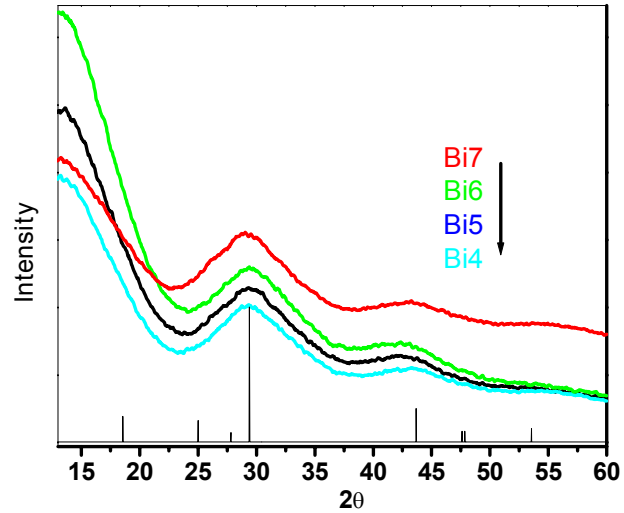
.96gm cyclodextrin

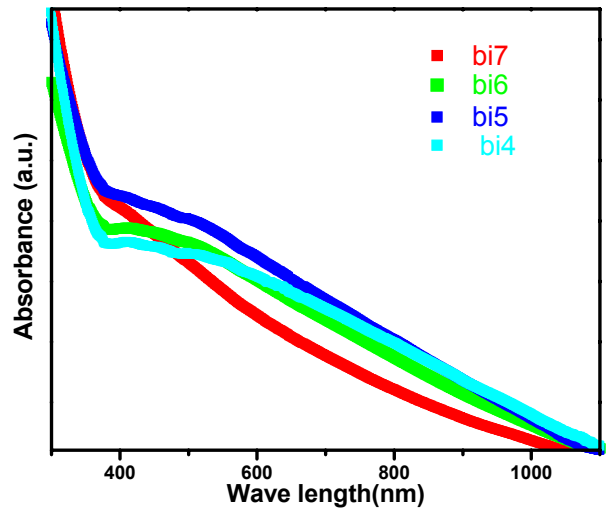


2 gm cyclodextrin



XRDspectra of the samples



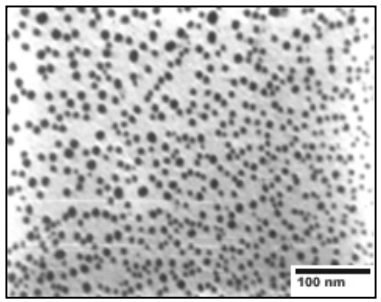


Metal ion mediated self-assembly of Ag_2Se nanoparticle

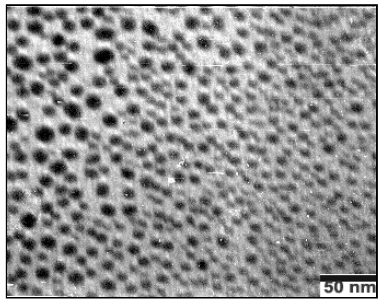
1mM $AgNO_3$ Aquous Sol + excess NH_4OH (final pH 12.8) +

x mM Se^{2-} ion source (Na_2SO_3Se)

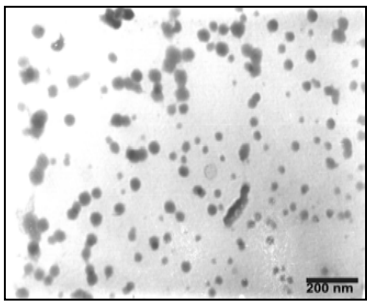
X=.5 | X=.3 | X=.075 | X=.032



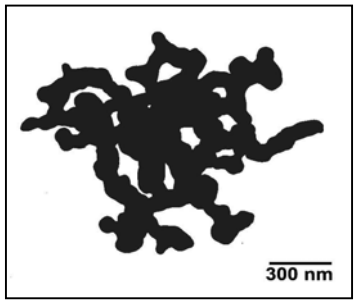
P5



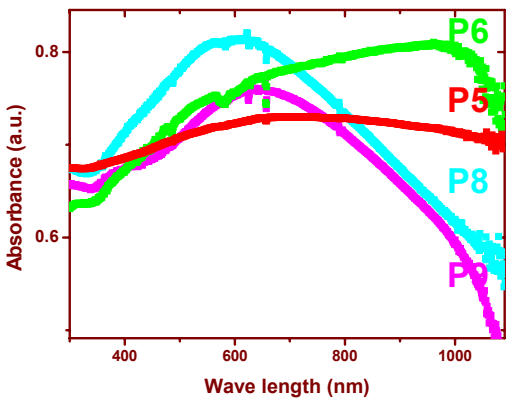
P6



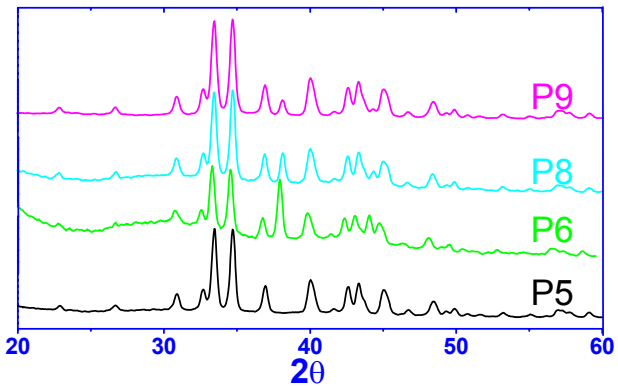
P8



P9



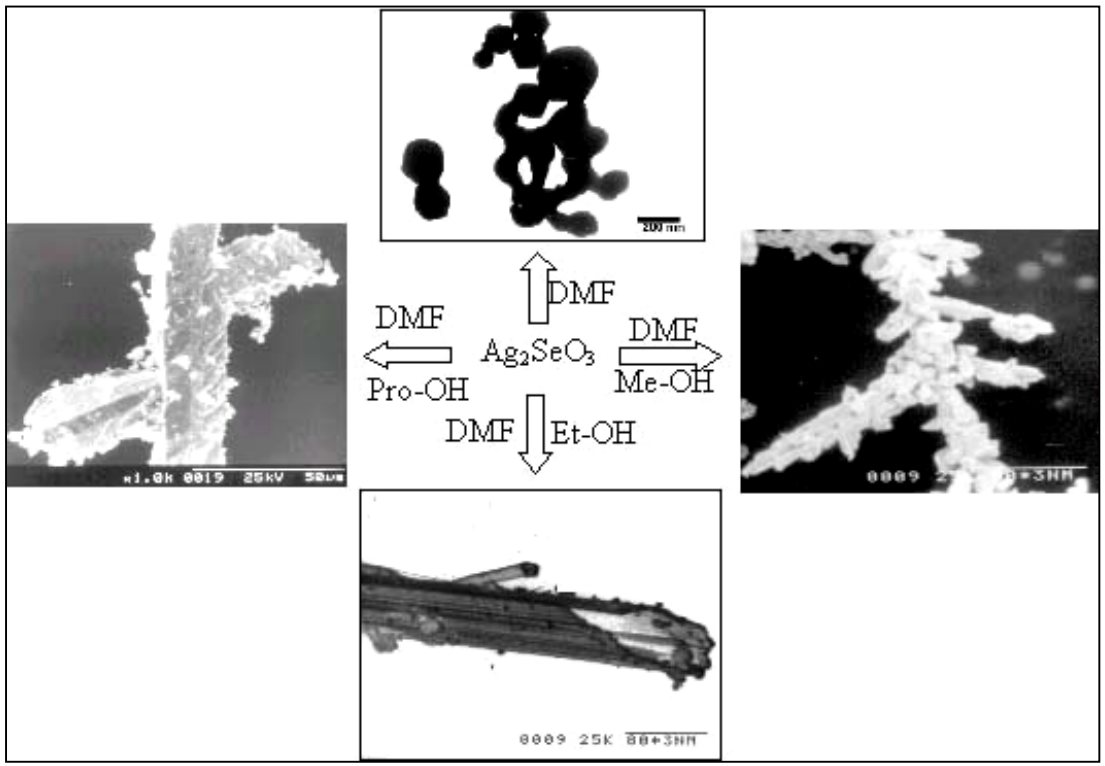
UV-VIS spectra of the samples



XRD spectra of the samples

Micro-patterns of Ag_2Se nanocrystals

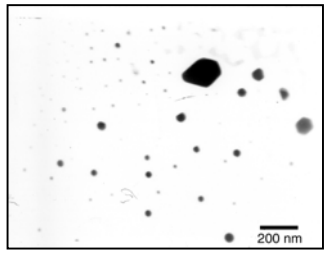
Silverselenide (Ag_2Se) nanocrystals were synthesized solvothermally using a single source precursor silver selenite (Ag_2SeO_3) in presence of dimethyl formamide (DMF) in an autoclave. Mixed solvent of DMF and a few aliphatic alcohols [1:1 (V/V), at 165^0 C for 24 h] yielded novel microstructures



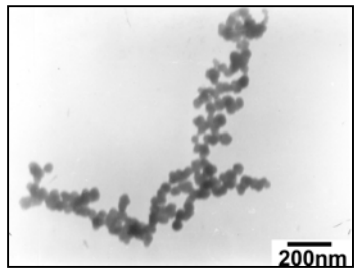
Formation of Bi_2Se_3 nanotube

Bismuth Ammonium citrate ($C_{24}H_{20}Bi_{14}O_{28}$,$6NH_3$,$10H_2O$)+ elementary selenium (Se) + DMF heat treated at autoclavic condition at 165^0C with different time

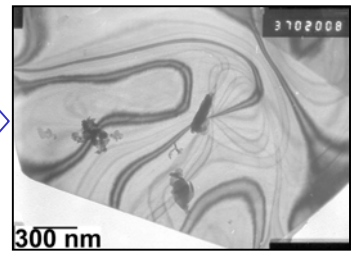
5 hr

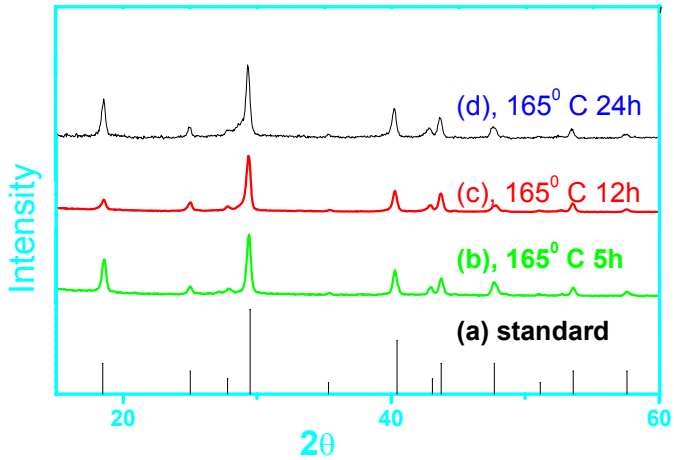


10 hr



24 hr





XRD spectra of the samples

Probable path way:

$(CH_3)_2NCHO + Se^0 \rightarrow Se^{2-}$

$C_{24}H_{20}Bi_{14}O_{28}$,$6NH_3$,$10H_2O \rightarrow Bi^{3+}$

$Se^{2-} + Bi^{3+} \rightarrow Bi_2Se_3$

Self-assembly of Selenium: nanoparticle to microtube

Reduction of SeO_2 by DMF produces Se.

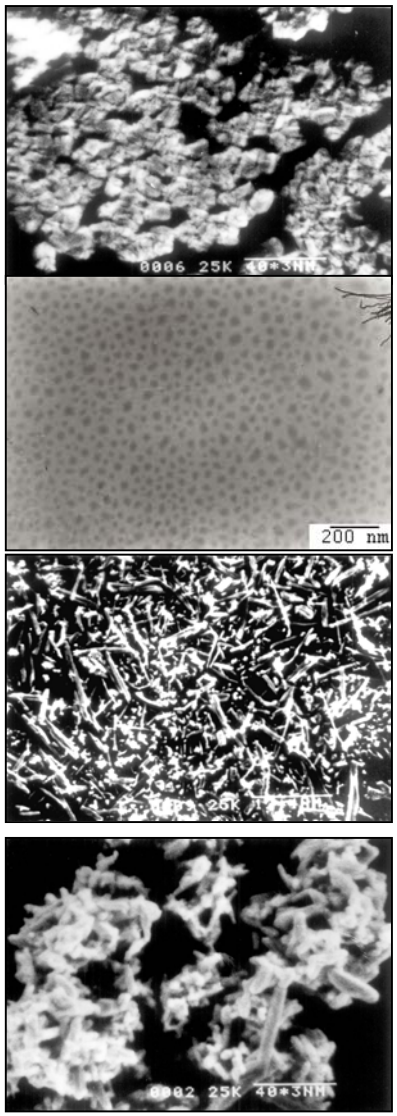
Morphology depends on the reaction temperature

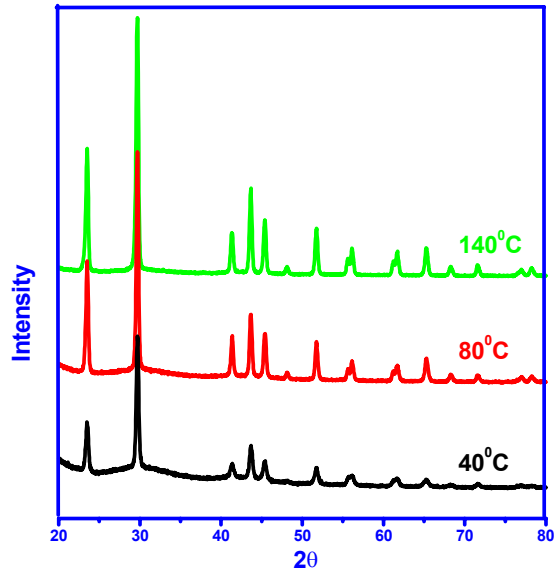
Room T

40^0 C

80^0 C

140^0 C





REACTION scheme

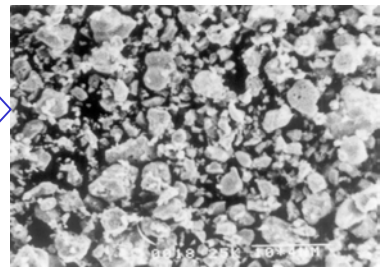
$$(CH_3)_2NCHO + SeO_2 \rightarrow (CH_3)_2NCOOH + Se$$

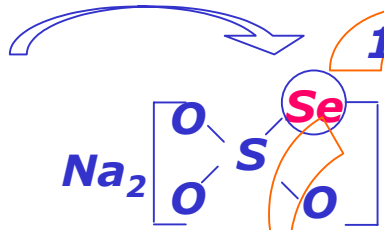
$$(CH_3)_2NCOOH \rightarrow (CH_3)_2NH + CO_2$$

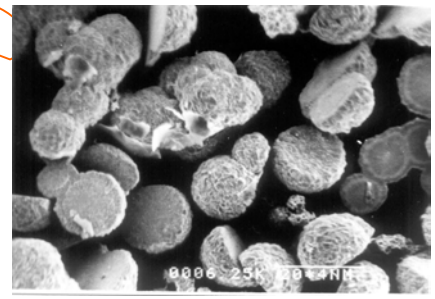
Self-assembly via Recrystalization

Bulk crystal → moleqular state → recrystalization with stabilization

Refluxing of Se in aquous Na_2SO_3 Solution

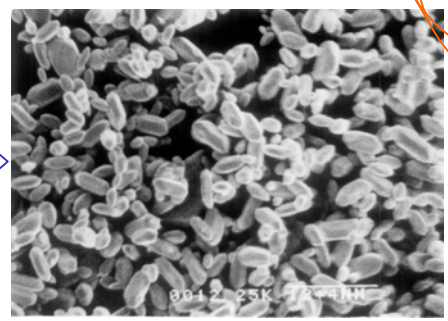


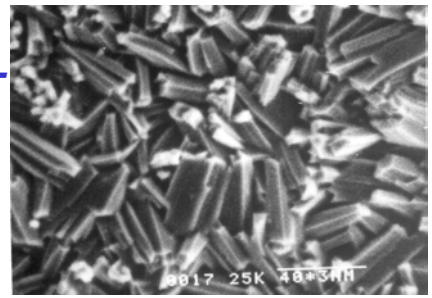




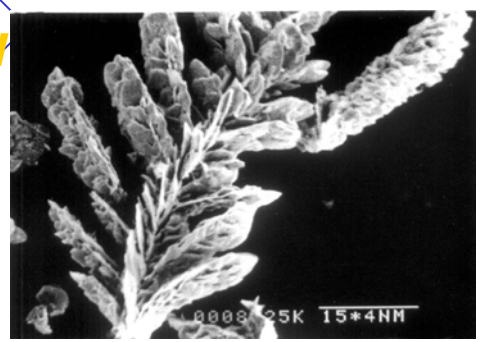
Reaction with DMF at 165^0 C in closed system

Direct evaporation of DMF





Solution grown crystal



SEM micrograph of Selenium microstructure

CONCLUSIONS

Self-assembly is nature's way of organizing smaller structures into larger ones

Recrystallization may be a promising tools for nano fabrication

Acknowledgement:

1. ***Professor C. Basu***
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