나노입자에서 관찰된 새로운 물성변화

Nanoparticles Melting Point

\[
\frac{T}{T_m} \quad \text{Number of Atoms}
\]

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## Applications of Nanosized Particles

<table>
<thead>
<tr>
<th>Property</th>
<th>Method</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Ozone</td>
<td>SnO₂, In₂O₃, Au, Carbon, Al₂O₃, SiO₂, TiO₂, YBa₂Cu₃O₇</td>
</tr>
<tr>
<td>Chemical</td>
<td>Electroless</td>
<td>TiO₂, Pb, Sn, Cu, Au, SiO₂</td>
</tr>
<tr>
<td>Magnetic</td>
<td>Magnetic Field</td>
<td>SiC, Si₃N₄, YSZ</td>
</tr>
<tr>
<td>Electrostatic</td>
<td>Electrostatic</td>
<td>Ti, Sn, Pb</td>
</tr>
<tr>
<td>Ceramic</td>
<td>Ceramics</td>
<td>SnO₂, Al₂O₃, WC, TiC, Si₃N₄, SiO₂</td>
</tr>
<tr>
<td>Optical</td>
<td>Optical</td>
<td>Ag, Au, Cu, AgCl, AgBr</td>
</tr>
<tr>
<td>Gas</td>
<td>Gas</td>
<td>Fe, Pt, Ni</td>
</tr>
</tbody>
</table>

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### 미세입자의 제조법

- **가스 전증법 (Gas Evaporation Method)**
- **가스 분출법 (Gas Filling Method)**
- **가스 분해법 (Gas Decomposition)**
- **가스 불화법 (Gas Drying)**

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고차구조형 유기재료

**Experimentals**

**Reaction Diagram**

**Step 1**
- Surfactant aqueous solution phase containing hydrazine
- Mixing and Stirring

**Step 2**
- Formation of stable Nucleus
- Adsorption of surfactant molecules on the particle surface

**Step 3**
- Formation of Ag nanoparticles stabilization by surfactant molecules (particle protected by surfactant molecules from further growth and aggregation)

**Metal particles by adsorption of surfactant on the surface of particles**

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Materials

Surfactants
- **Tween20** (polyoxyethylene (20) sorbitan monolaurate, Aldrich) - 0.01M
- **SDS** (sodium dodecyl sulfate, Aldrich 99.5%) - 0.01M
- **NP9** (polyoxyethylene (9) nonyl phenol ether, Ilchil Chemicals) - 0.01M
- **CTAB** (cetyl trimethyl ammonium bromide, Acros, Aldrich 99%) - 0.01M

AgNO₃ (silver nitrate, Aldrich, 99.995%) - 0.05M

Hydrazine Monohydrate (Aldrich, Assay 98%) - 0.1M

\[
N_2H_4 + 4Ag^+ + 4OH^- \rightarrow 4Ag^0 + 4H_2O + N_2
\]

Reducing agent

- Ethylene glycol (J. Mater. Chem. 6(4), 573(1996))
- Ethylene oxide group (Langmuir, 12, 3585(1996))
- **Hydrazine** (Langmuir, **15, 3050(1999)**)
- Sodium borohydride (J. dispersion Sci. and Tech. 20(6), 1569(1999))

Instrumentation

- UV-visible and fluorescence measurement
  (Shimazu UV-2101PC)
- Dynamic light scattering
  (Malvern Zetasizer Inc. – Wavelength 514.5nm of Ar-Ne)

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Absorption spectra of silver plasmon resonance

Silver plasmon band in the aqueous surfactant solution

UV-vis. absorbance of silver particles prepared in presence of various surfactants as stabilizers (about 3 hours after from reduction)
Particle size distribution

Particle size distributions of silver particles prepared in various surfactants as stabilizers
(a) SDS  (b) Tween20
(c) NP9  (d) CTAB

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Stabilization model for silver colloid

(a)

(b)

AdSORption of anionic surfactant on the particle surface
(SDS)

Particle stabilization mechanism by steric hindrance of surfactant with hydrated polyethylene in aqueous solution
(Tween20)

Absorption spectra showing different AgNO₃ conc.

Preparation of Ag particles in tween 20 (0.01M) aqueous solution

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Absorption spectra showing different reductant Conc.

(a) 
![Absorption Spectra 2:1](image)

(b) 
![Absorption Spectra 1:1](image)

Different mole ratio of Silver (0.006 Wt %) and Hydrazine in tween 20 (0.01M) aqueous solution
(a) 2:1 (b) 1:1

Absorption spectra showing different Tween20 conc.

(a) 
![Absorption Spectra Tween20 0.01M](image)

(b) 
![Absorption Spectra Tween20 0.02M](image)

Mole ratio of Silver (0.005 Wt %) and Hydrazine was 1:2 in Tween20 aqueous solution.
(a) Tween20 0.01M (b) Tween20 0.02M

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Summary

Stabilization Effect

**SDS** – Electrical repulsion caused by hydrophobic bonding.

**Tween20** – Steric hindrance effect cause by highly hydrated polyoxyethylene groups

(NP9 - Not enough quantity of polyoxyethylene groups)

**Particle size distribution**

Tween20 > SDS > NP9 > CTAB
Surfactant effects

1. Acts as particle stabilizer
2. Dissolves away the Ag ion from the particle surface to the bulk
3. Retards the rate of particle formation from Ag ion

Reductant effects

1. Act as reducing agent for Ag ion
2. Increases the reactivity of silver particle toward oxidation by oxygen

앞으로의 연구방향

- Morphology of metal particles in surfactants aqueous solution.
- Synthesis of composite metal colloid.
- Metal Surface Modification.