Making Materials with Flames

Dr. Frank Ernst
ernst@ptl.mavt.ethz.ch
phone: 044 632 25 10

Office hour:
Thursdays after the lecture

Department of Mechanical and Process Engineering
ETH Zurich, www.ptl.ethz.ch
<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture/Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THU 06.12.</strong></td>
<td><strong>Lecture 1: Particle Formation in Flames</strong></td>
</tr>
<tr>
<td><strong>MON 10.12.</strong></td>
<td>Exercise 1: Particle growth (solution)</td>
</tr>
<tr>
<td></td>
<td>Exercise 2, 3 - hand out</td>
</tr>
<tr>
<td><strong>THU 13.12.</strong></td>
<td><strong>Lecture 2: Particle Design and Scale-up Production</strong></td>
</tr>
<tr>
<td><strong>MON 17.12.</strong></td>
<td>Exercise 2, 3: Monodisperse and polydisperse coagulation (solution)</td>
</tr>
<tr>
<td></td>
<td>Exercise 2, 3 - hand in at beginning of exercise</td>
</tr>
<tr>
<td><strong>THU 20.12.</strong></td>
<td><strong>Lecture 3: Production – Nanoparticles and Cement</strong></td>
</tr>
<tr>
<td></td>
<td>Lab tour (optional) from 11:45 to 12:30</td>
</tr>
<tr>
<td></td>
<td>Return feedback on exercises</td>
</tr>
</tbody>
</table>
Documentation available

Lecture presentations as well as exercise problems and solutions are available for n.ethz users on the PTL website

www.ptl.ethz.ch
Outline and Topics

Lecture + Exercise for each topic

- Application of flame-made materials
- Fundamentals of particle formation in flames
- Particle formation in premixed flames and diffusion flames
- Particle morphology control and scale-up
- Nanoparticles: State-of-the-art in flame synthesis
- Industry scale combustion processes for material production: Cement production
Flames in material synthesis

Flames as heat source and reactor
Example: Nanoparticle production

Flames as heat source
Example: Cement production
Production of cement (3 billion t/y worldwide)

limestone containing raw material

Temperature 1450° C

Cement = clinker + additives
Lampblack first was produced in quantity by the ancient Chinese

Attic black-figure amphora, 540-530 BC, Museum of Cycladic Art, Athens, Greece

Ulrich, 1984
Particle Technology Laboratory at ETHZ
From Fundamental Understanding to Final Performance

- Fuel Cells
- Catalysts
- Batteries
- Sensors
- Pigments
- Flavour Retention
- Dental Filler

Particle Synthesis & Characterization, Process Diagnostics & Modeling
Examples for FSP materials

**Metal oxides**
SiO$_2$, TiO$_2$, Al$_2$O$_3$, Bi$_2$O$_3$, CeO$_2$, ZnO

**Mixed metal oxides**
SiO$_2$/TiO$_2$, V$_2$O$_5$/TiO$_2$, ZnO/SiO$_2$, Zn$_2$SiO$_4$, BaTiO$_3$, Ce$_x$Zr$_{(1-x)}$O$_y$

**Noble metals on oxides**
Au, Pt, Pd on TiO$_2$, SiO$_2$, Al$_2$O$_3$

**Core-shell morphology**
SiO$_2$ on Ag
CB on LiFePO$_4$
