Supercritical carbon dioxide (scCO$_2$) processing of Ceramic Materials

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Contents

• Introduction to scCO$_2$
• Potential and applications of scCO$_2$ processing
• Research in ceramic materials group
What is supercritical CO$_2$
Supercritical CO$_2$ (sccO$_2$)

**Gas-like** ↔ *Properties from both* ↔ **Liquid-like**

- High diffusivity & mass transfer
- Flowing properties (e.g. viscosity)
- No surface tension
- High density

**Flow properties & Diffusion through structures**

**scCO$_2$**

**Better solvability & Tunable solvability**

Other processing benefits:

- Inexpensive
- Easily available
- Low supercritical point
- Non-toxic
scCO$_2$ application areas

Extraction

Coffee beans

Decaffeinated Coffee beans

Nanomaterial synthesis and preparation

Other areas:
- Polymer/chemical synthesis
- Carbon storage
- Pharmaceuticals
- Dry cleaning
- Etc…
Our equipment

System 1

System 2
scCO$_2$ research in Ceramic Group

1. SiO$_2$ Aerogel drying
2. Artificial zinc patina
   a) Pretreatment for painting
   b) Conversion to ZnO
3. Laser ablation of Titanium target
1. SiO$_2$ aerogel drying

- No aging
- Porosity ~ 97 v-%
- Surface area 598 m$^2$/g
2. Artificial zinc patina: a) Pretreatment for painting
2. Artificial zinc patina:
   a) Pretreatment for painting

Galvanized steel

Dense patina

Porous patina

scCO$_2$ treatment
2. Artificial zinc patina

b) Conversion to ZnO

Zinc patina
\( \text{Zn}_x(\text{CO}_3)_y(\text{OH})_z \)

Release of \( \text{CO}_2 \) and \( \text{H}_2\text{O} \)

Zinc oxide
\( \text{ZnO} \)

300°C

DS Solar cells

Gas sensor

Energy harvesting

Applications

Flexible Nanogenerator
3. Pulsed laser ablation in scCO$_2$

Photoactive nanoparticles & Functionalized surfaces

Amandeep Singh

Ti$_x$O$_y$ Nanoparticles

CO$_2$ Pump

scCO$_2$ (50 °C, 10 MPa)

Laser

Outlet

High Pressure Vessel

Ablated surface (Functionalized)

Unablated surface (Original)
$\text{Ti}_x\text{O}_y$ Nanoparticles
Functionalized $\text{Ti}_x\text{O}_y$ surface

Possibility to make variable surface profiles by selecting laser parameters
Conclusions

• Supercritical carbon dioxide is a versatile processing method with utilization potential in various industries
  • Food
  • Pharmaceutical
  • Materials processing
  • Ceramic processing
  • Chemical engineering

• Green processing method that utilizes already produced carbon dioxide (no extra emissions)
  • In some applications reduces emissions

• New application areas emerging constantly
Thank you for your attention!

Advanced ceramic materials group
Figure references:

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