Kiwan Park

Pondering Piezo Particles
What we’ll talk about today

- Fun Facts
- The Fundamentals
- Applications
- The How's
  - How is Lead Zirconate Titanate (PZT) manufactured?
  - How is particle sizing crucial?
    1. Lead (IV) Oxide
    2. Lead (II) Oxide
    3. Lead Zirconate
    4. Lead Zirconate Titanate (PZT): soft and hard
- Q&A
Fun Facts

• “Piezo”, derived from the Greek *piezein*, which means to squeeze or press
• It’s pronounced as pee-eh-zo, it has nothing to do with a pie
• **Piezoelectricity** was discovered in 1880 by French physicists Jacques and Pierre Curie.
• **Radioactivity** was discovered by Marie Curie, Pierre Curie’s wife
• 5 Nobel Prizes
The Fundamentals

- Direct piezoelectric current
- Inverse piezoelectric current
- Cyclic
Application – DPI

Inspiratory air flow

De-agglomerated particles

Pierced holes

Sealed blister

Piezo Actuator

Attached cover

Dose counter

Thumb grip

Mouthpiece/dose release level hidden inside the cover

Image source: https://upload.wikimedia.org/wikipedia/commons/a/ae/Asthma-medication.png
Application – Ultrasound

- Power cable
- Acoustic insulator
- Piezoelectric crystals
- Electrodes
- Plastic membrane
- Backing material
- Metal case

CPU
Application - Igniter

https://upload.wikimedia.org/wikipedia/commons/0/02/Lighter_diagram.PNG

Mechanical pressure
Piezoelectric crystals
Nozzle
Gas
Electrical current
Flame

Tire pressure monitoring systems (TPMS) embedded inside
How is PZT manufactured?

1. **Incoming raw materials**
2. Weighing per formulation
3. **Milling/blending**
4. Calcining (e.g. PZT)
5. **Back to Milling**
6. **Spray-dry (e.g. PZT powder)**
7. Pressed/sintered to various shapes (various resonance)

**Particle sizing required | Particle size and shape required**
Measurement Method

- Laser diffraction
- Mie Scattering theory
- Dispersion method: water with surfactant (e.g. 0.1wt% of Darven C or 0.1wt% of Sodium Pyrophosphate solution)
- Refractive Index @ 650nm: 2.32-3.22
- RI is important for particles <50um (ISO13320)
Lead (II) oxide
Lead (II) oxide

Before applying ultrasonics energy

1 min ultrasonics; fully dispersed

- $D(v, 0.9)$
- $D(v, 0.5)$
- $D(v, 0.1)$

Data name:

<table>
<thead>
<tr>
<th>Lead II Oxide AS Average</th>
<th>$D(v, 0.1)$</th>
<th>$D(v, 0.5)$</th>
<th>$D(v, 0.9)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead II Oxide AS Average</td>
<td>3.09786 (µm)</td>
<td>5.87333 (µm)</td>
<td>9.92249 (µm)</td>
</tr>
</tbody>
</table>
Lead (IV) oxide

Data name: Lead IV Oxide Final Average

- D(ν,0.1) = 1.58223 (μm)
- D(ν,0.5) = 2.64958 (μm)
- D(ν,0.9) = 4.09606 (μm)
Lead Zirconate

Data name
Lead II Zirconate AS Average

D(v, 0.1) 4.30065 (µm) 2.63919 (µm) 1.15700 (µm)
Soft PZT / Hard PZT

- **“Hard” PZT**
  - “hard” because its dipole or domain is restricted by composition.
  - Can withstand high electrical, high temperature and mechanical stresses.
  - Used in applications when high power is required. E.g. welders, ultrasound cleaners.

- **“Soft” PZT**
  - “Soft” because dipole or domain isn’t restricted by composition
  - Has high permittivity, high coupling, high Curie temperature.
  - Used in applications when high sensitivity is required. E.g. medical ultrasound, gas igniters.
Hard PZT

![Graph showing comparison between Hard PZT and Soft PZT](image)

<table>
<thead>
<tr>
<th>Diameter (µm)</th>
<th>D(v,0.1)</th>
<th>D(v,0.5)</th>
<th>D(v,0.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>µm</td>
<td>1.85297</td>
<td>3.18659</td>
<td>4.94832</td>
</tr>
</tbody>
</table>

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RI Assessment

Calculation optimization

Imaginary Refractive Index Wizard - Result -

Step 6. Choose the best value
Please select the parameter listed below which provides the best particle size distribution.
If you would like assistance choosing the best value, please click the help symbol to the right.
Please choose the best value.
Acknowledgment

Special thanks to Wayne Lee of Harris Corp for providing general knowledge of the PZT manufacturing process

www.exelispzt.com
Q&A

Email us your questions: Labinfo@horiba.com


View our full range of particle characterization analyzers: www.horiba.com/us/particle
Thank you very much for your attention.
Thank you

감사합니다
Câm ơn
ありがとうございます
Dziękuję
धन्यवाद
Grazie
Merci
谢谢
מַהֲרַט
ขอบคุณครับ
ありがとうございました
धन्यवाद
நன்ற
Cảm ơ
mơ
Obrigado
Σας ευχαριστούμε
شكرا
Tack ska ni ha
Большое спасибо
Danke
Gracias