Zoltek Carbon Felt Electrode Materials - An Overview

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Zoltek Carbon Felt
Electrode Materials - An Overview

Agenda

I. Zoltek Product Introduction
II. Redox Flow Battery Electrodes Features & Supply Chain
III. Electrode Physical Properties
IV. Activated Cell Performance & Electrode Characterization
V. Summary

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# ZOLTEK PRODUCTS

<table>
<thead>
<tr>
<th>ZOLTEK PX30</th>
<th>ZOLTEK PX35</th>
<th>ZOLTEK OX</th>
</tr>
</thead>
<tbody>
<tr>
<td>99% Carbon Content for Extreme Heat &amp; Harsh Environments.</td>
<td>Superior Strength to Weight Performance.</td>
<td>Outperforms All Other Organic Flame Resistant Fibers.</td>
</tr>
</tbody>
</table>

**CARBON YARN**

**CARBON 50K TOW CHOPPED, PLATE**

**CARBON FABRIC**

**CARBON FABRIC, FELT**

**TOW**

**STAPLE**

**YARN**

**FELT, FABRIC**

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**Locations**

Hungary
Mexico
United States

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Redox Flow Battery Electrodes
Features & Supply Chain

**REDOX FLOW BATTERY ELECTRODE FEATURES**

- 95% carbon content
- Corrosion resistant
- Optimized for best quality
- Good permeability
- Elasticity - compressibility
- Electrically conductive
- Thermally stable
- Customizable - activation
- High production capacity

**Supply Chain**

1. PAN FIBER
2. OX FIBER
3. STAPLE OX FIBER
4. OX FELT
5. CARBONIZING
6. CARBON FELT
7. ACTIVATING
8. ACTIVATED CARBON FELT

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# Electrode Physical Properties

<table>
<thead>
<tr>
<th>Electrode Property (PAN based CF)</th>
<th>PXFB PW03</th>
<th>PXFB SW08</th>
<th>PXFT FT50</th>
<th>PXFT FT300</th>
<th>PXFT FT450</th>
<th>PXFT FT540</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fabric or Felt Type</strong></td>
<td>Woven</td>
<td>Spunlace</td>
<td>Needled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Areal Weight, g m⁻²</strong></td>
<td>122</td>
<td>339</td>
<td>50</td>
<td>301</td>
<td>446</td>
<td>538</td>
</tr>
<tr>
<td><strong>Thickness, mm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 0.02 MPa compression</td>
<td>0.39</td>
<td>1.04</td>
<td>0.52</td>
<td>2.7</td>
<td>3.5</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>Felt bulk density, g cm⁻³</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Areal weight / thickness at 0.02 MPa compression</td>
<td>0.32</td>
<td>0.33</td>
<td>0.096</td>
<td>0.11</td>
<td>0.13</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Electrical resistivity, Ω mm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 1 A current for 30x30 mm sample, 20% compression, thickness direction</td>
<td>8.0</td>
<td>7.3</td>
<td>86</td>
<td>6.3</td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Open Porosity, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated as 1 - ( \frac{w_a}{d \cdot \rho_c} ), ( w_a ) felt areal weight, ( d ) felt thickness and ( \rho_c ) is the fiber density (1.78 g cm⁻³)</td>
<td>82</td>
<td>82</td>
<td>95</td>
<td>94</td>
<td>93</td>
<td>94</td>
</tr>
</tbody>
</table>
Electrode Cell Performance

Flow field: Through pass (Plate), 90 cm$^3$ min$^{-1}$ @ 0.8 A cm$^{-2}$
- Carbonized
- Activated

VRFB output voltage improved, after activation for all PXFT and PXFB electrode types.
Zoltek’s activation process has little impact on electrical resistivity or water permeability of the electrode.
Zoltek can supply carbonized felts and fabrics which can be customized for RFB applications requiring electrodes between ~0.4 mm to ~5 mm thick.

Zoltek’s electrode activation process improves output voltage in VRFB applications.

Carbon felt and fabric parameters continued to be optimized to maximize RFB performance.

Thank you for your attention
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