SPECIALTY CARBONS FOR ADVANCED LEAD ACID BATTERIES

TIMREX®
TIMCAL Graphite

SUPER P®
TIMCAL Carbon Black

ENSACO®
TIMCAL Carbon Black
WHO ARE WE?
IMERYS Graphite & Carbon has a strong tradition and history in carbon manufacturing. Its first manufacturing operation was founded in 1908. Today, IMERYS Graphite & Carbon facilities produce and market a large variety of synthetic and natural graphite powders, conductive carbon blacks and water-based dispersions of consistent high quality. Adhering to a philosophy of Total Quality Management and continuous process improvement, all Imerys Graphite & Carbon manufacturing plants comply with ISO 9001:2008. IMERYS Graphite & Carbon is committed to produce highly specialized graphite and carbon materials for today’s and tomorrow’s customers needs. IMERYS Graphite & Carbon belongs to IMERYS, the world leader in mineral-based specialties for industry.

WHERE ARE WE LOCATED?
With headquarters located in Switzerland, IMERYS Graphite & Carbon has an international presence with production facilities and commercial offices located in key markets around the globe. The Group’s industrial and commercial activities are managed by an experienced multinational team of more than 430 employees from many countries on three continents.

For the updated list of commercial offices and distributors please visit www.imerys-graphite-and-carbon.com

WHAT IS OUR MISSION?
To promote our economic, social and cultural advancement with enthusiasm, efficiency and dynamism by offering value, reliability and quality to ensure the lasting success of our customers.

WHAT IS OUR VISION?
To be the worldwide leader and to be recognized as the reference for innovative capability in the field of carbon powder-based solutions.
Carbon additives in the negative electrode

| FINAL BATTERY APPLICATIONS | 1. Automotive (micro HEV, e-bikes)  
| 2. Energy storage  
| 3. Industrial (fork-lifts, back-up systems, medical devices) |
| OBJECTIVES | 1. Improve cycle life  
| 2. Improve charge acceptance |
| CARBON REQUIREMENTS | 1. Good wettability for paste processing and electrolyte supply into the negative electrode  
| 2. High affinity to lead for an efficient lead plating onto the negative active mass (NAM) skeleton  
| 3. Good electrical conductivity to reduce electrode resistivity and to represent active electrode component  
| 4. Sufficient BET specific surface area (SSA) and double layer capacitance for dynamic charge acceptance (capacitor effect)  
| 5. Sufficient purity to reduce gassing and self-discharge  
| 6. Balanced particle size distribution for homogeneous incorporation into electrode structure |
| SOLUTIONS PROPOSED IN LITERATURE | 1. Low surface area carbon (graphite/expanded graphite mixed with low SSA carbon black)\[a\]  
| 2. High surface area carbon (graphite/expanded graphite mixed with high SSA carbon black)\[b\]  
| \[a\] D.P. Boden et al, J. Power Sources 195 (2010) 4470  
| \[b\] D. Pavlov et al, J. Power Sources 196 (2011) 5155 |

![Image](a.png) \[a\] ENSACO® 350G  

![Image](b.png) \[b\] SUPER P®  

![Image](c.png) \[c\] TIMREX® CyPbrid™

Figure 1: Images from contact angle measurements on dry powder of different carbon additives with water: (a) ENSACO® 350G, (b) SUPER P®, and (c) TIMREX® CyPbrid™.

The hydrophilic nature of TIMREX® CyPbrid™ is demonstrated. Consequently, TIMREX® CyPbrid™ is easily mixed into the active material paste. In addition, the electrolyte supply into the negative electrode plate is assured.
**Table 1: physio-chemical properties of different carbon materials**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>CONTACT ANGLE (WATER) (degree)</th>
<th>BET SURFACE AREA (m²/g)</th>
<th>OIL ABSORPTION NUMBER (m/l/100g)</th>
<th>SCOTT DENSITY (g/cm³)</th>
<th>PARTICLE SIZE DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMREX® CyPbrid™&lt;sup&gt;TM&lt;/sup&gt;</td>
<td>&lt;30 (ultra-hydrophilic)</td>
<td>&gt;180</td>
<td>&lt;100</td>
<td>0.33</td>
<td>Micron-sized aggregates of sub-micron particles</td>
</tr>
<tr>
<td><strong>Conductive carbon black</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUPER P&lt;sup&gt;®&lt;/sup&gt;</td>
<td>95 (mild-hydrophobic)</td>
<td>62</td>
<td>290</td>
<td>0.06</td>
<td>Agglomerated aggregates of nano-sized primary particles</td>
</tr>
<tr>
<td>ENSACO® 350G</td>
<td>130 (hydrophobic)</td>
<td>770</td>
<td>320</td>
<td>0.11</td>
<td>Agglomerated aggregates of nano-sized primary particles</td>
</tr>
<tr>
<td><strong>Expanded graphite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMREX® BNB90</td>
<td>&lt;30 (ultra-hydrophilic)</td>
<td>28</td>
<td>180</td>
<td>0.03</td>
<td>Micron-sized particles</td>
</tr>
</tbody>
</table>

Typical values / Patent pending
Figure 2: Scanning electron microscope (SEM) images on lead plating activity for different carbon additives: (a) ENSACO® 350G, (b) TIMREX® BNB90, (c) TIMREX® CyPbrid™, and (d) TIMREX® synthetic graphite (high crystallinity; D90 = 6 micron). The lead plating is induced by a potential pulse on a pure carbon electrode in a 1M Pb(NO₃)₂ solution. The SEM analysis indicates nucleation and growth of homogeneously distributed fine lead particles on the surface of the TIMREX® CyPbrid™ (photo c) and the TIMREX® BNB90 (photo b) electrodes.
Figure 3: Electrical volume resistivity (2-point) for various carbon additives measured in dry powder form with increasing pressure increments of 50-450 kg/cm² at the corresponding sample density.

TIMREX® CyPbrid™ shows an intermediate behavior between the TIMREX® synthetic graphite (high crystallinity; D90 = 6 micron) and ENSACO® 350G.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>SPONTANEOUS Pb-uptake FROM Pb(NO₃)₂ SOLUTION (ppm)</th>
<th>SPECIFIC CAPACITANCE (F/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon hybrid material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMREX® CyPbrid™</td>
<td>5823</td>
<td>20</td>
</tr>
<tr>
<td>Conductive carbon black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUPER P®</td>
<td>700</td>
<td>5</td>
</tr>
<tr>
<td>ENSACO® 350G</td>
<td>8660</td>
<td>70</td>
</tr>
<tr>
<td>Expanded graphite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMREX® BNB90</td>
<td>1340</td>
<td>5</td>
</tr>
</tbody>
</table>

Typical values / Patent pending

Carbon particles exhibiting a high affinity to lead, i.e. high spontaneous lead uptake, are well incorporated into the lead skeleton during formation of the negative active material.

TIMREX® CyPbrid™ is the most suitable carbon additive for the negative electrode of an advanced lead acid battery, by combining the hybrid properties of a conductive carbon black and a graphite; resulting in excellent wettability for paste mixing, high affinity to lead for an efficient lead plating, and good electrical conductivity to improve cycle life and charge acceptance.
MAKE YOUR BATTERY WORK AT ITS BEST WITH DEDICATED IMERYS GRAPHITE & CARBON ADDITIVES
EUROPE

Imerys Graphite & Carbon Switzerland Ltd.
Group Head Office • Via Maito 8 • 6804 Bironico • Switzerland
Tel: +41 91 873 20 10 • Fax: +41 91 873 20 19 • graphiteandcarbon.ch@imerys.com

Imerys Graphite & Carbon Switzerland Ltd.
Strada Industriale 12 • 6743 Bodio • Switzerland
Tel: +41 91 873 20 10 • Fax: +41 91 873 20 19 • graphiteandcarbon.ch@imerys.com

Imerys Graphite & Carbon Belgium SA
Brownfieldlaan 19 • 2830 Willebroek • Belgium
Tel: +32 3 886 71 81 • Fax: +32 3 886 47 73 • graphiteandcarbon.be@imerys.com

ASIA-PACIFIC

Imerys Graphite & Carbon Japan K.K.
Kanagawa Science Park East Tower #206 • 3-2-1 Sakado • Takatsu-Ku • Kawasaki-city
Kanagawa 213-0012 • Japan
Tel: +81 44 299 7141 • Fax: +81 44 299 7143 • graphiteandcarbon.jp@imerys.com

South Korea Representative Office
4F Haesung 1st Bldg • 942 Daechi-dong • Gangnam-gu • Seoul 135-845 • Korea
Tel: +82 2 3450 1561 • graphiteandcarbon.kr@imerys.com

Shanghai Branch Office c/o Imerys
1438 Hong Qiao Road • Chang Ning District 8F • Gubei International Fortune Centre II
Shanghai 201103 • China
Tel: + 86 21 2223 0136 • Fax: + 86 21 2223 0199 • graphiteandcarbon.cn@imerys.com

AMERICAS

Imerys Graphite & Carbon Canada Inc.
990 rue Fernand-Poitras • Terrebonne (QC) J6Y 1V1 • Canada
Tel: +1 450 622 91 91 • Fax: +1 450 622 86 92 • graphiteandcarbon.ca@imerys.com

Imerys Graphite & Carbon is a trademark of the Imerys Group