A comparison of developments in natural vs. synthetic graphite production

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A comparison of developments in natural vs. synthetic graphite production

1. What are the main markets for natural and synthetic graphite?

2. What are the main differences in properties?

3. Challenges and developments in production processes
About Imerys Graphite & Carbon – Product range

Products in Imerys Portfolio

- **Graphite**
  - Powders
    - Primary synthetic graphite
    - Natural graphite
  - Dispersion
    - Water-based dispersion

- **Carbon black**
  - Powder
    - Conductive carbon black
1. What are the main graphite markets?

(or at least some of them...)
Graphite markets

Graphite
2.5 M ton/y

Natural Graphite
1 M ton/y
- Amorphous
  600 kton/y
- Flake
  400 kton/y

Synthetic Graphite
1.5 M ton/y
- Powders
  > 100 kton/y
- Bodies
  (Electrodes)
  < 1.4 M ton/y
Graphite markets

Natural Flakes
400 kton/y

- Ordinary Flakes
- Special Flakes
- Processed Naturals

Synthetic Powders
> 100 kton/y

- Primary Synthetic Powders
- Secondary Synthetic Powders (Scraps)
Graphite markets

Refractories & Metallurgy

Typical customers in this application group:

- Metal Producers: use Graphite as recarburizer
- Refractory Producers: use Graphite in Bricks, Monolithics, Crucibles

Products used by these industries:

- Natural Graphite Amorphous and Secondary Synthetic Powders are used as Recarburizer
- Natural Graphite Ordinary Flakes are used for Refractories and Crucibles
Graphite markets

Engineering Materials

Typical customers in this application group:

• Producers of Carbon Brushes, Powder Metallurgy & Hard Metals, Friction, Foils, etc.

• Producers of Lubricants, Catalysts, Synthetic Diamonds, Pencils, Ceramics.

Products used by these industries:

• Natural Graphite Special Flakes, Processed Natural Graphite Powders

• Primary Synthetic Powders, some Secondary Synthetic Powders
Mobile Energy

Typical customers in this application group are producers of:

- Primary batteries: Alkaline, Zn-C, etc.
- Rechargeable batteries: Li-ion, NiCd, NiMH, Lead-acid, etc.
- Fuel Cells
- Super-Capacitors

Products used by these industries:

- Processed Primary Synthetic Graphite
- Processed Natural Graphite Powders
- Graphite Water-based Dispersions
NISSAN LEAF: World’s Best-Selling EV

Nissan LEAF sales

Winning more than 30 awards

Source: NISSAN (AABC Asia 2014)
Potential customers in new applications:

• Producers of Thermal Conductive Polymers
• Producers of New Carbon Materials like Fullerene, Nanotubes, Graphene
• etc. etc. etc.

Products likely to be used by these industries:

• Processed Primary Synthetic Graphite
• Processed Natural Graphite Powders
In few words…

Just a tiny part of the graphite produced on earth is suitable for the high end markets of today … … and just after complex production processes!
In few words... For the high end markets of tomorrow, a carbon precursor (natural or primary synthetic or other) will be needed... ...but in any case just **combined** with complex production processes!
2. The Graphite Properties
Graphite properties

A high degree of graphitization is characterized by:

- Crystalline size (Lc and La)
- Interlayer distance (c/2)
- Real density (Xylene density)

A perfect graphitic structure:

- Interlayer distance of c/2 = 0.3354 nm
- Large Lc, generally > 100 nm
- Xylene density of 2.24 - 2.27 g/cm³
<table>
<thead>
<tr>
<th>Graphite Type</th>
<th>Crystal Size</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary synthetic graphite</td>
<td>Lc ranging from 50 to more than 200 nm, depending on graphite type and particle size distribution</td>
<td></td>
</tr>
<tr>
<td>Secondary synthetic graphite “SCRAP”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural graphite macrocrystalline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural graphite microcrystalline “Amorphous”</td>
<td></td>
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</tr>
</tbody>
</table>

**Graphite properties**

Berlin, December 2014
Graphite properties

Graphitization process: primary synthetic graphite

Temperature [1000°C] vs. Crystallite size [nm]

TIMREX® Coke
TIMREX® Graphite
Graphite properties

Basic graphite properties related to the applications:

- High electrical and thermal conductivity
- Insertion chemistry (intercalation)
- Chemical stability under acidic and alkaline conditions, inertness
- Lubricity
- Low weight
- Price / performance ratio
Graphite properties

Material bulk parameters

Purity
- Ash
- Moisture
- Carbon content

Crystalline structure

Particle size
Distribution & Shape

Texture & Porosity
Graphite properties

Surface parameters

Surface morphology

Surface group chemistry

$R = x \text{ mm}$
Graphite properties

In summary, graphite is defined through 8 main parameters:

- Purity
- Crystallinity
- Texture
- Porosity
- Particle Shape
- Particle Size Distribution
- Surface Morphology
- Surface Group Chemistry
By fine tuning these 8 main parameters, it is possible to impact the 6 main requested characteristics:

- High electrical and thermal conductivity
- Insertion chemistry (intercalation)
- Chemical stability under acidic and alkaline conditions, inertness
- Lubricity
- Low weight
- Price / performance ratio

...and obtain graphite grades custom tailored made for each final application.
TIMREX® KS graphite family

Scanning electron microscopy

10 μm

TIMREX® KS44
Scanning electron microscopy

TIMREX® MX25

TIMREX® M graphite family
Scanning electron microscopy

TIMREX® SLP50
Scanning electron microscopy

TIMREX® HSAG300
TIMREX® natural graphite family

Scanning electron microscopy

TIMREX®
3. The Production Processes
The big challenge is about having the “appropriate processing technology” for the most promising future markets. . .
Production processes

...and just in a second priority about having

“access to the appropriate carbon precursors”
Just being a carbon precursor producer is not enough to be successful in the high end graphite markets of tomorrow.
Of course, if you own appropriate and diversified graphite precursors reserves and you know about processing technologies... 

...you are very well placed!
Production processes

Primary Synthetic Graphite

- Carbon Precursor
  - selection, crushing, mixing
- Raw Material Mix

Natural Graphite

- Graphite Ore
  - crushing, grinding, flotation
- Raw Graphite (max. 98 % C)
  - Conditioning, grinding, classifying, mechanical / chemical treatment
  - Thermal / Chemical Purification
- Raw Purified Graphite (min. 99 % C)

Final Graphite Product
Environmental impact of naturals vs. Environmental impact of synthetics?
Production processes

Long term sustainability of naturals vs. Long term sustainability of synthetics?
Cost of naturals

vs.

Cost of synthetics?
About Imerys Graphite & Carbon

• Owns a plant to manufacture primary synthetic graphite in Switzerland

• Owns natural graphite reserves and already mines natural graphite in Canada

• Is the only one to be in a position to offer both natural and primary synthetic graphite powders
About Imerys Graphite & Carbon – Mine in Canada

• Exploitation of the present PIT nr. 6 will end during 2015

• Planning of next PIT nr. 2 will start in 2015

• Further explorations already ongoing, in order to define additional reserves for the future
About Imerys Graphite & Carbon - Locations

- Production Plants
- Commercial Offices
- Distributors / Agents
About Imerys Graphite & Carbon – A member of Imerys

Imerys, the world leader in mineral specialties for industry:
• Based in almost 50 countries at more than 250 industrial sites*
• 15,805 workers worldwide*
• M€ 3,698 in annual sales*  

* 2013 figures

Imerys products, finding applications in everyday life:
• Construction
• Personal care
• Paper
• Paints
• Plastics
• Ceramics
• Telecommunications
• Beverage filtration
Thank you for your attention