Properties of Functional Carbon

Carbon materials have diverse structures and are used in a wide range of applications, such as electrodes for lithium ion secondary cells, electrodes and separators for fuel cells, and electrodes for capacitors, etc. The properties of carbon can be analyzed and evaluated from various angles. The following introduces analysis of surface functional groups, which control electrical properties (capacity, resistance) and are also considered to affect the life of batteries.

Analysis Methods

JFE-TEC performs multi-faceted measurement and analysis work, including chemical analysis, physical structure analysis, organic structure analysis, etc., as part of a comprehensive analysis of the properties of carbon depending on differences in the amounts of surface functional groups.

- Acid-base titration method: Boehm method
- Semi-quantitative analysis by XPS
- Semi-quantitative analysis by FT-IR

Clients can also take advantage of other JFE-TEC analysis technologies such as iodine and methylene blue adsorption performance evaluation, etc. in evaluations of carbon material pore structures, which are thought to contribute to electric capacity and response characteristics.

Example of Analysis: Analysis of Carbon Surface Functional Groups by Acid-Base Titration Method (Boehm Method)

Sodium hydroxide and sodium hydrogen carbonate are added separately to the sample, and back titration (under an inert atmosphere) is performed using a hydrochloric acid solution by an automatic potentiometric titrator.

1. Total content of acid functional groups (total acid content): Consumption of hydrochloric acid solution under condition of added sodium hydroxide.
2. Content of strongly acidic functional groups (carboxyl group content): Consumption of hydrochloric acid under condition of added sodium hydrogen carbonate.
3. Content of weakly acidic functional groups (phenolic hydroxyl group content): Total acid content – Content of carboxyl group.

⇒ Measurement of the contents of surface functional groups of a carbon material not only makes it possible to determine the characteristics of the functional material, but is also effective in product control in production processes.

Example of measurement (Table 1)

In comparison with the conventional product A, improved carbons B and C have higher total acid contents and display high electrical reactivity.

Table 1 Analysis of surface functional groups of carbon by Boehm method

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total acid content [mmol/g]</th>
<th>Phenolic hydroxyl group [mmol/g]</th>
<th>Carboxyl group [mmol/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Conventional product</td>
<td>0.18</td>
<td>0.17</td>
<td>0.01</td>
</tr>
<tr>
<td>B: Improved product</td>
<td>0.44</td>
<td>0.34</td>
<td>0.10</td>
</tr>
<tr>
<td>C: Improved product</td>
<td>0.52</td>
<td>0.40</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Phenolic hydroxyl group

Representative surface functional groups of carbon

Carboxyl group