Ionic liquid CIL-313 as antistatic agent for ESD grade masterbatches

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Properties of ionic liquids

1. Thermally stable
2. Electrochemically stable
3. Low vapor pressure
4. Non-volatile
5. Non-inflammable
6. Electrically conductive
7. Miscible with many kinds of organic solvents
Application of ionic liquids

As a chemical for
- Fuel cells
- Electrodeposit on metals
- Solar cells (as electrolyte of dye sensitized solar cells)
- Sensors
- Super capacitors (as electrolyte of EDLC)

In Polymer Chemistry
- Antistatic Additives for resin compounds or masterbatch
Synthesis & Catalysis
- Immobilization of catalyst
- Solvents for organic reactions

Thermodynamic
- Thermal fluids
Molecular structures of some ionic liquids

Imidazolium type  Pyridinium type  Ammonium type

CIL-313
Chemical Name: 1-Butyl-3-Methylpridinium-Trifluoromethanesulfonate
Chemical Formula of CIL-313: C11H16F3NO3S
Molecular weight: 299.3 g/mol
Flash point: 275°C
Decomposition temperature: 315°C
Refractive index: 1.44~1.45 @25°C
Viscosity: 70 ~ 80 mPa • s @25°C
* Not applicable for injection moldings of which temperature is higher than 270°C
* CIL-313 complies with the RoHS
Mechanism of conduction

High electrical conductivity appears when CIL-313 is used with IDP.
⇒ high ion mobility along with IDP polymer chain.

IDP: Inherently dissipative Polymer (resin w/ high polarity)
⇒ example: poly(ether ester amid) (Permanent antistatic agent)

* CIL-313 will not bleed out because CIL-313 has strong interaction with IDP.
1. Carbon fiber (typically used)
   - Stable control of resistance is difficult.
   - It gives you black color only.
   * Typical surface resistance for ESD purpose is $10^6 \sim 10^9 \Omega$.

2. IDP+CIL-313
   - Use IDP only (15% addition to base resin) \( \Rightarrow 10^{10} \sim 10^{12} \Omega \)
   - Use IDP and CIL-313 \( \Rightarrow 10^7 \sim 10^9 \Omega \) (ESD grade).
   Possible to have transparent or color compound for ESD grade.

**Example of IDP (Permanent anti-static agent) manufacturer**

Company name (product name)
BASF (Irgastat), Dupont (Entira), Arkema (Pebax), Lubrizol (Stat-rite)
Sanyo chemical industry (Pelestat and Pelectron)
Examples of Blending

① For use with vinyl chloride (PVC)
Add CIL-313 0.3wt% only ⇒ surface resistance $10^9\Omega$
* Since PVC is high polarity resin, IDP assistance is not necessary.

② For use with PP, PE, PS, PC, PBT, POM, PMMA, PA6, PET-G, TPU
Add CIL-313 0.5wt% and IDP 10wt% ⇒ surface resistance $10^7 \sim 10^9\Omega$
* The molding processing temperature must be lower than 270℃.
(thermal resistance of CIL-313 is up to 270℃)

† CIL-313 can NOT be used for food and medical packaging.
(CIL-313 is not approved by FDA.)
Industrial use only (e.g. used for electric parts packing etc.)
1. CIL-313 has been used in a major chemical company in combination with ABS in Japan.

* CIL-313 can not be used with ABS only because of patent right in Japan.
* Other resin compounds and polymer alloy with ABS have no such issue.

2. CIL-313 is used by U.S. based chemical company for ESD grade color PC and TPU compound in Singapore.

* Surface resistance required for ESD was achieved for PMMA, PA6, PET-glycol in this company.
### Cost comparison of permanent anti-static agents

<table>
<thead>
<tr>
<th></th>
<th>Carbon Black</th>
<th>Carbon Fiber</th>
<th>IDP + CIL-313</th>
<th>IDP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit price / kg</strong></td>
<td>USD3</td>
<td>USD28</td>
<td>IDP USD28 CIL USD450</td>
<td>USD28</td>
</tr>
<tr>
<td><strong>Amount of addition</strong></td>
<td>18wt%</td>
<td>10wt%</td>
<td>IDP 10wt% CIL 0.5wt%</td>
<td>15wt%</td>
</tr>
<tr>
<td><strong>Anti-static agent cost / resin-1kg</strong></td>
<td>USD0.5</td>
<td>USD3</td>
<td>USD5</td>
<td>USD4</td>
</tr>
<tr>
<td><strong>Surface resistance</strong></td>
<td>$10^3$~$10^5\Omega$</td>
<td>$10^6$~$10^8\Omega$ ESD grade</td>
<td>$10^7$~$10^9\Omega$ ESD grade</td>
<td>$10^{10}$~$10^{12}\Omega$</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>black only</td>
<td>black only</td>
<td>Colorable or Transparent</td>
<td>Colorable or Transparent</td>
</tr>
</tbody>
</table>

* The costs shown above are typical examples.

* This method is suitable when colorable or transparent ESD compound is indispensable.
✔ OA machine parts,
✔ carrying trays for HDD platters and other parts, Si wafers,
✔ equipment for semiconductor fabs,
✔ electronic parts packing,
✔ parts of explosion-proof equipment for use in mines etc.
1. New permanent antistatic agent for masterbatch.
   (Compound of base resin, IDP and CIL-313)

2. New ESD grade transparent or color compound master batch.
   (Compound of base resin, IDP and CIL-313)
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