Overview

Nofia phosphonates are excellent flame retardants (FRs) for polyethylene terephthalate (PET) applications that need to pass FR tests requiring permanent FR performance. Sample testing protocols include: UL94 V0 and VTM0, NF P92-507 ("M1 test"), DIN 4102-1, ASTM D6413, NFPA-701A, ASTM E162 and E84, US and Canadian Rail standards, EN45545, FAR 25:853, FMVSS 302, and ASTM E648-99 / NFPA-253.

Features and Benefits of Nofia phosphonates

- Melt processable
- Permanent, does not migrate
- In fibers
  - Flexibility of addition level of FR (higher than 6,000ppm P)
  - Flexibility of base polymer (e.g. use recycle PET, PTT)
  - No limitation in fiber diameter
  - No deterioration of fiber properties
- In films
  - Can maintain transparency in film applications

Applications

- Staple fibers, nonwovens
- FDY, POY, and PTY fibers
- Bulk continuous fibers
- Monofilament fibers (industrial and synthetic hair)
- Biaxial oriented films (BOPET)
- Foam
Product Offerings: Nofia HM1100, HM9000, and HM5000

Nofia phosphonates are offered as products with different chain lengths, expressed as grades having different MVRs, with Nofia HM1100 having the highest molecular weight and Nofia HM5000 having the lowest molecular weight. They are used at various levels of addition to pass a variety of applications where FR performance is needed. The typical properties of grades that are recommended for PET applications are shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Nofia HM1100</th>
<th>Nofia HM9000</th>
<th>Nofia HM5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVR [ml/10 min]</td>
<td>10 (240°C/1.2kg)</td>
<td>10 (200°C/1.2kg)</td>
<td>13 (145°C/1.2kg)</td>
</tr>
<tr>
<td>Phosphorus [wt%]</td>
<td>10.6</td>
<td>10.6</td>
<td>10.6</td>
</tr>
<tr>
<td>Tg [°C]</td>
<td>105°C</td>
<td>105°C</td>
<td>90°C</td>
</tr>
<tr>
<td>Appearance</td>
<td>Clear pellets</td>
<td>Clear pellets</td>
<td>Irregular pellets / Granular</td>
</tr>
</tbody>
</table>

Fiber Applications

FR fibers made from polyesters containing Nofia phosphonates can be used in a number of applications:

- Fabric for upholstery and draperies in commercial buildings
- Floor and wall coverings
- Mass transportation fabrics
- Monofilament for braidings for wire and cable applications
- Synthetic hair for wigs and extensions
- Carpets

Fabrics prepared from polyester yarns containing Nofia phosphonates are permanently flame retardant. However, some auxiliary agents, used in the various process steps from fiber spinning to finished fabric, may decrease the flame retardant properties. In particular, the process lubricants (spin finish, coning oils, warp sizes, warp waxes and other applied finishes) are known to reduce fabric flame retardant properties. These auxiliary agents are wholly, or in part, aliphatic hydrocarbon based compounds and can be flammable. Proper scouring procedures need to be implemented in order to remove these compounds from the fabric.

The following table lists types of FR polyester fiber applications and recommended addition levels of Nofia product. The actual levels will need to be optimized depending on specific customer conditions and requirements.
Nofia Phosphonates in PET Applications – Technical Bulletin

Non-Fiber Applications

Nofia phosphonates can be used in a number of PET applications other than fibers

- Biaxial oriented PET film (BOPET) for electronics and building and construction materials
- Floor and wall laminates
- Laminates without FR adhesive layers
- Foam cores - lightweight building and construction and transportation applications

The following table lists types of other polyester applications than fibers and recommended addition levels of Nofia product. The actual levels will need to be optimized depending on specific customer conditions and requirements.

<table>
<thead>
<tr>
<th>Application</th>
<th>Standard</th>
<th>FR Criteria</th>
<th>Wt% Nofia FR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET Foam</td>
<td>NF P92-507, DIN 4102-1</td>
<td>M1, B1</td>
<td>&lt;10</td>
</tr>
<tr>
<td>BOPET Film</td>
<td>UL94</td>
<td>VTM0 (&lt;125 micrometer)</td>
<td>15 - 20</td>
</tr>
<tr>
<td>PET Sheet</td>
<td>UL94</td>
<td>V0 (1-3 mm)</td>
<td>20 - 22</td>
</tr>
</tbody>
</table>
Drying Guidelines for Nofia Phosphonates

Nofia phosphonates are hygroscopic materials and quickly absorb moisture from the atmosphere. The presence of moisture will hydrolyze the polymer in the melt phase, reducing the molecular weight. Therefore, it is critical that the material is thoroughly dried prior to melt processing (<50 – 200 ppm moisture). For recommendations on drying, please refer to FRX Polymers’ Technical Bulletin “Nofia Phosphonates Drying Recommendations”.

Twin screw extruder recommended for compounding to obtain better mixing at high Nofia phosphonate loading (e.g. > 10wt%).

Higher IV PET grades make processing (e.g. compounding, spinning) more forgiving.