Novel Solution

Using our own proprietary technology

GRAFTAMID™

NANOSTRUCTURED COPOLYMERS

Bring flexibility and good thermo-mechanical properties to your materials with GRAFTAMID™. With GRAFTAMID™ we combine separate material’s best properties with co-continuous nano morphology. Enhance your existing materials or use it as a standalone material for chemical resistance and good barrier properties.
Nanostructured copolymers

Generally, one phase is soft (low Tg, low E-modulus) or hydrophilic, while other phase is rigid (high modulus).
Graftamid™– Grafted copolymers

Graftamid® grafted copolymers:
Copolyolefin main linear chain, with grafted linear lateral chain
Co-continuous morphology

Proper choice of chemistry & process leads to co-continuous structure
Thermoplastic processability

Grafted copolymer with micellar structure
Grafted copolymer with co-continuous structure

Co-continuous structure for thermo-mechanical resistance of Graftamid®
MAIN ADVANTAGES

- Transparency
- Processability
- Thermo-mechanical and oxidation resistance
- Chemical resistance
- Compatibility with polyolefins (and polyamids)
**GRAFTAMID™ - Main Products Range**

- **EB-PA 01506**
- **EB-PA 01566**
- **EB-PA 02046**
- **EB-PA 02012**

**GRAFTAMID™ EB-PA** - is based on EBA matrix, and polyamide 6/66/46 and 12, with increased thermo-mechanical properties. Offers good barrier properties, chemical resistance, low moisture uptake and easy processing. Can be used as compatibilizer for PA blends/compounds or as a standalone materia.

**Special products:**

**Additives may be introduced during grafting process**

- *Fire retarded grades* (HFFR with UL 94 V0 or V2 ranking, brominated FR with high thermal resistance)
- *PEG grafted PO* (with high water permeation rate and high water uptake)
- Tailor-made grades possible

**Wide range of melt flow index available:**

- possible extrusion (blow/cast/calendar), injection / injection blow moulding...
GRAFTAMID™ - Possible Applications

_Graftamid in automotive_
- Thermal protection for cable, multilayers...

_Graftamid in special films_
- Transparency and adhesion in photovoltaic films,
- Thermo-mechanical and adhesion in multilayers adhesive films

_Fire retarded Graftamid grades_
- Cable, corrugated tubings for fire and thermal protection

_Graftamid as an additive_
- Thermo-mechanical and adhesion in polyolefins or TPV’s,
- Impact strength in polyamids
- Hot melt adhesives
GRAFTAMID™ Applications in automotive

Automotive:
- Thermal protection for tubing, cables
  - T4 (3000h @ 150° C)
  - Graftamid® homologated in automotive cables

Graftamid® performances:
- heat ageing & impact performances
- hydrolysis, oil and ZnCl₂ resistance
- easier processing than traditional TPV (coex versus 2-step process)
- can often be used at lower thickness (i.e. 1 mm versus + 1.5 mm)
- can be used in multilayer structures with PA without tie layer
GRAFTAMID™ - Impact resistance

«Guillotine » impact test (RSA D42 1235)

0.25 - 2 kg
H = 25 - 150 cm

Radius = 1 mm

1mm Graftamid
2,5mm competitor A
1,2mm competitor B

Determination of maximum impact energy to break a tube
GRAFTAMID - chemical & ageing resistance

Excellent ageing resistance in
- Water at 100° C
- Water/glycol mixture at 130° C
- ZnCl₂ aqueous solution at room temperature

Good resistance to occasional oil contact for all grades.

AUTOMOTIVE: thermal protection layer

High temperature heat shield cover

Protection from thermal and hydrolytic attack:
- Graftamid little affected by heat ageing
- Graftamid shows water/glycol oil / ZnCl₂ resistance
- Graftamid adheres to and protects polyamide
- Easy thermoforming
- HFFR versions available

Application examples (automotive)
- Outer protective layer (Fuel lines)
- Outer / inner protective layer (Cooling lines)

<table>
<thead>
<tr>
<th>Application</th>
<th>Fuel lines</th>
<th>Cooling lines</th>
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<tbody>
<tr>
<td>Outer Layer</td>
<td>Graftamid</td>
<td>Graftamid or PA12</td>
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<tr>
<td>Inner Layer</td>
<td>PA12</td>
<td>PA12 or Graftamid</td>
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</table>
GRAFTAMID - for special films

**Photovoltaic films**
- Encapsulation of PV modules (flexible panels, CIGS modules...)

**Special films**
- Adhesive properties
- Protection
- Thermal ageing  Electrical insulation, UV protection
- Provide thermal resistance to PE based film
  Multilayers PE/Graftomid/PE, with improved creep resistance
  (+20/30° C) Multilayer Graftamid/PE/Graftamid, with improved adhesion performances
GRAFTAMID - for PV encapsulation

Transmittance at 560nm
Measurements on 400μm films

Yellow Index evolution during UV ageing in Sepap 12/24

 Resistivity dry

{(23°C, 85%RH) Moisture Vapor Transmission Rate

Graftamid Solar - Cross-linked EVA - Other theroplastic
GRAFTAMID adhesive properties

- Good intrinsic adhesion properties of many Graftamid grades
- Graftamid can be used as a material or as an additive to improve other materials like polyolefins

**Chart:**
- Graftamid laminated on glass
- Bi-injected, without surface treatment

**Table:**
<table>
<thead>
<tr>
<th>Peel strength (N/cm)</th>
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<tbody>
<tr>
<td>HDPE</td>
<td>51</td>
<td>10</td>
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<tr>
<td>PA12</td>
<td>66</td>
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<td>PA6</td>
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<td>TPU 59 Shore D</td>
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<tr>
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<td>1</td>
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<tr>
<td>POM</td>
<td>&lt; 1</td>
<td>ND</td>
</tr>
<tr>
<td>PET</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>

**Legend:**
- **Graftamid® + adhesive master batch ageing at 85°C, 90% RH**
Development Graftamid HFFR and FR grades:

- **Graftamid HFFR standard grades**: cable, automotive
  - Cable sheathing, thermal protection, corrugated tubes
    - No halogen, UL94-V0, LOI up to 41%
    - Low fume toxicity (F1/I2 NF F 16101)
    - Glow wire test: GWFI up to 920°C

- **Graftamid LC HFFR transparent grades**:
  - Technical films
  - No halogen, UL94-V2

- **Graftamid FR (brominated) grades**:
  - Automotive applications
  - Can be selected for superior mechanical & thermal resistance
    - Possible UL94-V2 grades without antimony trioxide (no labelling)
GRAFTAMID - as an additive

In Polyolefins or in TPV

- Possible dilution in HDPE, LDPE, ethylene copolymers and even in PP based formulations
- Twin screw extruders / single screw dilution possible
- Adhesion enhancement on nylon, glass, metal...
- Thermal properties enhancement (higher dosage):
  - Possible > 10 / 20 °C increased thermal creep resistance
- Example: over-moulding of modified TPV on PA + GF

In Polyamids

- Impact modifier
- Low viscosity increase compared to conventional MAH modified additives
- Can also act as a co-additive, for instance compatibilizer for metallocene low density copolyolefins

In Hot Melt Adhesives - HMA (FPO or PA based)

- Adhesion enhancement
- Thermal properties enhancement (saft, ring & ball temperatures)

Note that HFFR are “ready-to-use” materials
Formulation of HMA with GRAFTAMID

Graftamid + EVA/EMA/EBA/EEA base resin

Example:

40% of \{Graftamid + EBA28BA175 (high flow)\} mixtures
15% Novares TN150
15% Dertopline P125
30% fillers (calcium carbonate)
0.5% anti-oxidant

- Saft: 145–115
- Ring & ball: 190–160

Graftamid for high performance HMA
GRAFTAMID Summarize

- A new class of nanostructured materials
- Co-continuous structure stable during processing

Graftamid shows synergistic performances:
- Flexibility and adhesion properties of Soft functional PolyOlefins
- Thermo-mechanical and chemical resistance of PolyAmids

Graftamid main performances
- Flexibility without plasticizer, modulus from 35 MPa to 1 GPa possible, Hardness 80 Shore A to 50 Shore D
- Good impact properties, ductile / brittle transition from -60°C to -20°C
- Thermomechanical resistance, heat resistant up to 180°C under moderate loading
- Good chemical resistance (water, oil, salt, glycol...)
- Low density (< 1 except HFFR grades < 1.1)
- Adhesion on various substrates (polyolefin, polar polymers, metals, glass)
- Melting point adjustable up to 220°C
- Transparency (for natural grades)
- Electrical insulation
- FR or HFFR grades possible, UL94 V0, with high LOI and low fume tox
- Large ranges of viscosity: MFI (230°C, 2.16 Kg) = < 1 to 40 g/10 mn, possible extrusion (blow/cast/calendar), injection moulding, injection blow moulding...
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