Dispersing at its best

TEGOMER® Dispersants for Masterbatches and Compounds

Evonik Nutrition & Care GmbH
IM Interfaces & Performance
Technical Service Polymers
World Masterbatch Demand in 2009 and Distribution ~ 2.5 Mio t/a

Volume in 1,000 metric tones
Average of various sources
Masterbatches – Requests and Demands

TEGOMER® Dispersants
will bridge the gap
- by cost reduction
- and by product
differentiation

High pigment price
Energy consumption
Cost and price pressure
Low cost qualities
Improved color strength
Higher Pigment or Filler loading
Fewer blockages No clogging

Universal Compatibility
Homogeneous distribution of pigments
Reproducible hue
No visible specks
Improved processability
Higher through-put
Improved color strength
Higher Pigment or Filler loading
Fewer blockages No clogging

Energy consumption
Cost and price pressure
Low cost qualities
Improved color strength
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# Dispersing Additives – In Use

| **Waxes**                  | Natural waxes, Montanic acid ester  
<table>
<thead>
<tr>
<th></th>
<th>Synthetical waxes, Polyolefin waxes</th>
</tr>
</thead>
</table>
| **Organic acid derivatives** | Fatty acids, Stearinic acid  
|                            | Fatty acid ester/amide, EBS  
|                            | Saponified fatty acids  
|                            | Zinc stearate  
|                            | Sorbitanic acid ester  
|                            | Glycerol ester  |
| **Oligomeric derivatives**  | Polyacrylates, Polyether structures  
|                           | Polyester condensation products  |
TEGOMER® – Amphiphilic Additives Mode of Action

Due to their special chemical nature they -

- are highly temperature stable.
- will compatibilize the pigment/filler to the polymer matrix.
- are compatible to polyolefins and technical polymers.
- can interact with the pigment surface and will form a stable layer on it.

TEGOMER® Dispersants allow high flexibility in application and excellent efficiency due to high temperature stability and amphiphilic character.
Advantages of TEGOMER® in the Processing

1. **Fast Wetting**
   - Allows higher processing speed
   - Allows higher loadings

2. **Enhanced Grinding**
   - Less agglomerates / lower specks
   - Higher color strength

3. **Excellent Stabilizing**
   - Prevention of reagglomeration
   - Easy dilutability and compatibility of the masterbatches in the final application
   - Exact color matching

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**Mode of Action**

- **Motor**
- **Hopper**
- **Screw**
- **Heating elements**
- **Pigment particle**
- **TEGOMER dispersing additive**
TEGOMER® Dispersing Additives –
Product Overview I

TEGOMER® E 525

- For PE based color concentrates and compounds
- For colorizing POM and PVC
- For carbon black, transparent iron oxides, inorganic fillers
- Outstanding clarity and reduction of specks in film applications
- Enhanced productivity and throughput in highly filled compounds
- For direct coloration of compounds

Food contact status

**GB 9685:** TEGOMER® E 525 may be used in plastics based on PE, PP, PS, AS, ABS, PET, PC and PVC.

**European Regulation 10/2011:** TEGOMER® E 525 may be used in compliance with the EU-Regulation 10/2011 up to 3.2 % w/w in polyolefin materials and articles.

**FDA Regulations:** TEGOMER® E 525 may be used in compliance with FDA Regulation 21 CFR 177.1520 (Olefin polymers).
TEGOMER® Dispersing Additives – Product Overview II

TEGOMER® P 121

- For PP and technical polymers, e.g. PA, PBT/PET
- For all kind of pigments in demanding masterbatch application, e.g. blow films (PP, PA and PET) or molded appliances (PA, PBT, ABS)
- For carbon black and color pigments which are difficult to disperse used in masterbatches for dyeing of spin fibers
- For direct coloration of compounds
- Excellent thermal and color stability

Food contact status

**GB 9685**: Less than 50 % of TEGOMER® P 121 may be used in in compliance with the GB 9685-2008 when used in adhesives. All other components may be used in plastics based on PE, PP, PS, AS, ABS and PC up to a level of 2.5 % and in PET up to a level of 0.5 % in compliance with the Chinese guideline GB 9685-2008.

**European Regulation 10/2011**: TEGOMER® P 121 in compliance with the EU-Regulation 10/2011 up to 4.5 % in the finished article.

**FDA Regulations**: TEGOMER® P 121 may be used as a dispersant for colorants at a maximum level of 0.166 % in polyolefin, in contact with all types of food, except foods containing greater than 13 % alcohol under conditions of use B ("Boiling water sterilized") through H ("Frozen or refrigerated storage: Ready-prepared foods intended to be reheated in container at time of use").
TEGOMER® Dispersing Additives – Product Overview III

TEGOMER® P 122

- Comparable application profile to TEGOMER® P 121:
- For PP and technical polymers, e.g. PA, PBT/PET
- For all kind of pigments in demanding masterbatch application, e.g. blow films (PP, PA and PET) or molded appliances (PA, PBT, ABS)
- For carbon black and color pigments which are difficult to disperse used in masterbatches for dyeing of spin fibers
- For direct coloration of compounds
- Excellent thermal and color stability
- It is delivered as a free flowing micro granulate for easy handling and quick dust free feeding

Food contact status

**GB 9685:** TEGOMER® P 122 may be used in plastics based on PE, PP, PS, AS, ABS and PC up to a level of 5% and in PET up to a level of 0.5%.

**European Regulation 10/2011:** TEGOMER® P 122 may be used without a specific migration limit (SML-value) in the Regulation 10/2011/EU

**FDA Regulations:** TEGOMER® P 122 may be used as a dispersant for colorants at a maximum level of 2 % in polyolefins. In all other types of plastics TEGOMER P 122 may be used as a dispersing additive up to 400 mg/sqm food contact area (e.g. 0.4% in a film with 100 g/sqm).
TEGOMER® E 525 – Perfect Distribution of Pigment

PE Masterbatches

- Standard wax
  - Poor distribution of pigment with agglomerates
  - Desired color needs high pigment loading

- TEGOMER® E 525
  - Perfect dispersing of pigment particles
  - Lower pigment loading to achieve desired color
  - Excellent clarity and reduction of speck formation

First choice for PE masterbatches and direct coloration of PE film, injection molding and highly filled PE compounds
TEGOMER® E 525 – Effect on Inorganic Pigment

Formulation
Additive: 0 - 5 %
Iron Oxide Red P.R. 101: 20 %
PE-LD (MFI 15): 75 - 80 %

Concentrate was heightened with TiO$_2$ to determine the color strength Pigment:TiO$_2$–ratio 1:10

TEGOMER® E 525 – highly efficient even at low dosages
**TEGOMER® E 525 for CB Printex® 85**

Formulation

- TEGOMER® E 525: 0 - 25 %
- Carbon Black Printex® 85: 30 %
- PE-LD (MFI 15 g/10 min.): 40 - 70 %

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Concentrate was heightened with TiO₂ to determine the color strength

Pigment:TiO₂-ratio 1:10
TEGOMER® P 121 & P 122 - Designed for use in Masterbatches and Films

Masterbatches

- TEGOMER® P 121/ P 122
  - Higher pigment loadings
  - Improved color strength
  - Positive influence on rheology
  - Excellent thermal and color stability even in technical polymers

Outstanding performance in masterbatching and direct coloration of technical polymers and PP

PP Films

- TEGOMER® P 121/ P 122
  - Speck free and high transparent films are obtained
  - No reflockulation in down streaming
  - Avoid film fracture
TEGOMER® P 121 & P 122 - Designed for Colorizing Technical Polymers

Mass dyeing of Polyester fibers

TEGOMER® P 121/ P 122

- Improved color strength
- Reduced fiber fracture
- Low pressure index values

Colorizing of PET

TEGOMER® P 121/ P 122

- Excellent clarity with no haze
- High color yield

First choice for PP and all kinds of technical polymers in high demanding applications where a superior pigment dispersion is essential
By using TEGOMER® P 121 a tremendous reduction of the pressure index value (< 2 bar/g for fiber grades) and a significant increased color strength is obtained.

Concentrate was heightened with TiO₂ to determine the color strength Pigment:TiO₂–ratio 1:10
By using TEGOMER® P 121 a tremendous reduction of the pressure index value (< 2 bar/g for fiber grades) and a significant increased color strength is obtained.
**TEGOMER® P 121 - in Comparison to Waxes with Pigment Yellow 155**

**Formulation**

- Additive: 15 %
- Pigment Yellow 155: 30 %
- PP (MFI = 50 g/10 min.): 55 %

**Graph:**

- **Pressure index [bar/g]**
  - TEGOMER® P 121 enables to reduce the pressure index value below 2 bar/g which is essential for spun fine fiber qualities

- **Color strength [%]**
  - Concentrate was heightened with TiO₂ to determine the color strength Pigment:TiO₂–ratio 1:10
The Evaluation of Dispersing Additives’ Performance is Based on Color Strength

1. Color strength of a masterbatch with known pigment concentration and standard dispersant PP wax is measured and set to 100
2. PP wax is replaced by our dispersant and color strength is measured
3. Reduction of pigment & dispersant concentration at constant ratio (e.g. 2:1), parts to 100 filled with base polymer
4. Color strength of each masterbatch is measured and formulation with color strength 100 is identified
5. Cost of original and new formulation with color strength 100 are calculated and compared (see next slides)

⇒ Calculation directly shows which benefit our customers can expect
Cost Saving by Pigment Reduction - PG 7 in PP with TEGOMER® E 525

Pigment reduction by 33%, dispersant reduction by 33%, increase of base polymer by 15%
TEGOMER® E 525 - Cost Saving by 15% Example
Pigment Green 7

Cost distribution by component

<table>
<thead>
<tr>
<th>Raw Material Cost [€/kg]</th>
<th>Wax Formulation share [%]</th>
<th>TEGOMER® E 525 Formulation share [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigment Green 7</td>
<td>9.00</td>
<td>30</td>
</tr>
<tr>
<td>Dispersing Additive</td>
<td>3.00</td>
<td>15</td>
</tr>
<tr>
<td>TEGOMER® E 525</td>
<td>5.25</td>
<td>10</td>
</tr>
<tr>
<td>PE-LLD</td>
<td>1.00</td>
<td>55</td>
</tr>
<tr>
<td>Total Cost [€/kg]</td>
<td>3.70</td>
<td>3.03</td>
</tr>
</tbody>
</table>

*Given price indications are no real sales prices. They are estimated to visualize the proof of concept.

- Only ~67% PG 7 was needed by using TEGOMER® E 525 to achieve the same color strength than with the reference wax

- **Cost benefit of 0.68 €/kg**
TEGOMER® P 121 - Cost Saving by 21% Example
Pigment Red 122

Cost distribution by component

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost [€/kg]</th>
<th>Wax Formulation share [%]</th>
<th>TEGOMER® P 121 Formulation share [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigment Red 122</td>
<td>38.00</td>
<td>25</td>
<td>17.5</td>
</tr>
<tr>
<td>Dispersing Additive</td>
<td>3.00</td>
<td>30</td>
<td></td>
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<tr>
<td>TEGOMER® P 121</td>
<td>6.80</td>
<td>21</td>
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</tr>
<tr>
<td>PP</td>
<td>1.20</td>
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<td>61.5</td>
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<tr>
<td>Total Cost</td>
<td>10.94</td>
<td></td>
<td>8.82</td>
</tr>
</tbody>
</table>

*Given price indications are no real sales prices. They are estimated to visualize the proof of concept.

- Only ~70% PR 122 is needed by using TEGOMER® P 121 to achieve the same color strength than with the reference wax

- **Cost benefit of 2.12 €/kg**
TEGOMER® E 525 - Cost saving by 7% Example Pigment Blue 15:1

Cost distribution by component

<table>
<thead>
<tr>
<th>Raw Material Cost* [€/kg]</th>
<th>Wax Formulation share [%]</th>
<th>TEGOMER® E 525 Formulation share [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigment Blue 15:1</td>
<td>10.50</td>
<td>30</td>
</tr>
<tr>
<td>Dispersing Additive</td>
<td>3.00</td>
<td>15</td>
</tr>
<tr>
<td>TEGOMER® E 525</td>
<td>5.25</td>
<td>12</td>
</tr>
<tr>
<td>PE-LLD</td>
<td>1.00</td>
<td>55</td>
</tr>
<tr>
<td>Total Cost [€/kg]</td>
<td>4.15</td>
<td>3.79</td>
</tr>
</tbody>
</table>

*Given price indications are no real sales prices. They are estimated to visualize the proof of concept.

- Only ~80% PB 15:1 was needed by using TEGOMER® E 525 to achieve the same color strength than with the reference wax
- **Cost benefit of 0.36 €/kg**
TEGOMER® Dispersants – Test Methods

- Color Strength measurement
- Gloss
- Transparence
- Microscopy examination
- Filter pressure value
- Speck evaluation
  - On blow films and molded plates
  - Press out method
- Mechanical properties
  - Impact strength
  - Elongation/ tensile strength…etc.
## TEGOMER® Dispersants – Polymer Recommendation

<table>
<thead>
<tr>
<th>Product</th>
<th>Polymer types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PE / EVA</td>
</tr>
<tr>
<td>TEGOMER® E 525</td>
<td>■</td>
</tr>
<tr>
<td>TEGOMER® P 121</td>
<td>○</td>
</tr>
<tr>
<td>TEGOMER® P 122</td>
<td>○</td>
</tr>
</tbody>
</table>

- ■ highly recommended
- ○ suitable
# TEGOMER® Dispersants - Application Recommendation

<table>
<thead>
<tr>
<th>Product</th>
<th>Pigment and Fillers</th>
<th>Masterbatches and Compounds</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inorganic Pigments</td>
<td>Monomasterbatches</td>
<td>Moulding</td>
</tr>
<tr>
<td></td>
<td>Organic Pigments</td>
<td>Multiple Pigment Masterbatches</td>
<td>Film Applications</td>
</tr>
<tr>
<td></td>
<td>Carbon Black</td>
<td>Colored Compounds</td>
<td>Fibre/Filament Production</td>
</tr>
<tr>
<td></td>
<td>Fillers</td>
<td>Filler Compounds</td>
<td></td>
</tr>
<tr>
<td>TEGOMER® E 525</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>TEGOMER® P 121</td>
<td>□</td>
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<tr>
<td>TEGOMER® P 122</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

- □: highly recommended
- ○: suitable
# TEGOMER® Dispersants – General dosage recommendations

<table>
<thead>
<tr>
<th>Product</th>
<th>Suitable Polymers</th>
<th>Dosage in [%] AOP*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEGOMER® E 525</strong></td>
<td>PE, EVA, POM and PVC</td>
<td>30-50</td>
</tr>
<tr>
<td><strong>TEGOMER® P 121</strong></td>
<td>PP, PA, PET/PBT, ABS/PS and other technical polymers</td>
<td>30-50</td>
</tr>
<tr>
<td><strong>TEGOMER® P 122</strong></td>
<td>PP, PA, PET/PBT, ABS/PS and other technical polymers</td>
<td>30-50</td>
</tr>
</tbody>
</table>

* % AoP: Additive calculated on Pigment in parts by weight
Highly effective TEGOMER® dispersing additives based on uniquely designed chemistry