Title: A THERMOPLASTIC COMPOSITION WITH IMPROVED FLOW RATE

Abstract: A thermoplastic composition comprising poly butylene adipate-co-terephthalate (PBAT) and 2 - 50% of polycapro-lactone with an average molecular weight in the range 20.000 to 120.000.
A THERMOPLASTIC COMPOSITION WITH IMPROVED FLOW RATE.

The present invention refers to a thermoplastic composition having improved flow rate through lower viscosity and hence higher MFI where quite surprising effects have been achieved.

Thermoplastic materials are used for a multitude of articles today. The predominant methods for manufacturing products from thermoplastic materials are extrusion, injection molding, calendaring, vacuum molding and blow molding. In all of these methods the thermoplastic material is heated, given the desired shape and then allowed cool. Thermoplastic materials will have a specific viscosity at a specific temperature and shear rate. This viscosity is depending on type of thermoplastic material and molecular weight. Typically high molecular weight will render a higher viscosity. As most thermoplastic materials are in some sense amorphous, the viscosity can be brought down by further heating. However, overheating will cause breakdown of the molecular chains. The viscosity of the thermoplastic material is defined as Melt Flow Index (MFI) in accordance with ISO 1133. Very low MFI values, say below 2 - 5, are highly viscous at the maximum molding temperature and suitable only for blow molding, vacuum molding and calendaring. These low MFI materials are accordingly not very suitable for injection molding. The problem when using low MFI materials in injection molding is that it will be very difficult to fill a mold with long and narrow flow paths. Narrow flow paths and high injection pressures and speed will cause friction and this friction will cause enough heat to cause breakdown of the polymer. Accordingly, a molded part with thick goods is possible to produce but such an article will consume an unnecessary amount of plastic material just to be able to mold the article. Furthermore, a thick walled article will require longer cycle times since the time for cooling will have to increase. This
will of course make the article unnecessary costly. There is still a desire to use plastic materials with high molecular weight as these provide higher mechanical strength than high MFI materials.

Similar problem also applies to blow molding and film-blowing. Thermoplastic film can be made in many different ways. The predominant one is film-blowing which can be described as combination of extrusion and blow molding. Also calendaring and stretch-molding are known methods for producing thermoplastic film. A thermoplastic film is typically below 1 mm in thickness and can be as thin as 5 - 10 μm. Thicker films are often used for producing so called blister packaging through vacuum molding or blow molding.

These blister packages are predominantly used for one way packages that are discarded ones used. A well-known problem today is that plastic materials not recovered through the recycling industry will end up in nature causing several environmental problems. One an example of such a problem is thermoplastic articles of all kinds ending up in our oceans. These discarded materials will over time be fractioned by mechanical forces, to some extent also by UV-light. They will however not degrade completely. There is today increased findings of fish being hampered and also suffocated by small plastic particles clogging intestinal tract as well as their gills just to mention one example.

There is accordingly a desire to obtain bio-degradable plastic materials. One such bio-degradable thermoplastic material is poly butylene adipate-co-terephthalate (PBAT). This material is indeed very useful; however, the viscosity is a bit on the high side for some applications.

Accordingly, the present invention relates to a thermoplastic composition having improved flow rate through lower viscosity and hence higher MFI. Quite surprising effects have been achieved. The thermoplastic composition comprises poly butylene adipate-co-terephthalate
(PBAT) and the invention is characterised in that the composition comprises 2 - 50% of polycaprolactone with an average molecular weight in the range 20,000 to 120,000.

According to one embodiment of the invention the thermoplastic composition comprises 5 - 40% of polycaprolactone.

According to another embodiment of the invention the thermoplastic composition comprises 5 - 35% of polycaprolactone.

According to yet another embodiment of the invention the thermoplastic composition comprises 10 - 30% of polycaprolactone.

The polycaprolactone suitably has an average molecular weight of 35,000 to 100,000, more preferably an average molecular weight of 50,000 - 80,000.

Poly butylene adipate-co-terephthalate is on its own merits known to be biodegradable which is a desired property. We have however found that the rate of biodegradation is improved by adding polycaprolactone in accordance with the present invention which improves the biodegradation in soil, compost or by adding soil or marine microorganisms.

Accordingly, in accordance to one embodiment of the invention the biodegradability of the thermoplastic material is improved by at least 5% compared to pure PBAT. In accordance to this embodiment of the invention the time for bio-degradation of the composition is shortened by at least 5% compared to pure PBAT.

At an amount of 10 - 30% of polycaprolactone mixed with poly butylene adipate-co-terephthalate the time for bio-degradation of the composition is shortened by at least 10% compared to pure PBAT.
The present invention is further explained with reference to enclosed embodiment Examples, which are to be construed as illustrative and not limiting in any way.

Example 1

Poly butylene adipate-co-terephthalate in the form of EcoFlex® C1200 blend is mixed with polycaprolactone CAPA™ 6800 (80,000mw) in a twin screw extruder. 0, 10, 20 and 30% of the polycaprolactone was mixed in. The theoretical expected value was calculated in accordance with the formula \( \text{logMFI}_{\text{blend}} = \text{logMFI}_A + (1-a)\text{logMFI}_B \). The real Melt Flow Index (MFI) MFI 2,16kg, 190°C, g/lOmin was then measured and compared in table 1a and graph 1b below.

Table 1a

<table>
<thead>
<tr>
<th>EcoFlex /amount (%)</th>
<th>Capa 6800 (80,000mw) /amount (%)</th>
<th>MFI theoretical</th>
<th>MFI measured</th>
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<tr>
<td>100% 0%</td>
<td></td>
<td>3.7 *)</td>
<td>3.7</td>
</tr>
<tr>
<td>90% 10%</td>
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<tr>
<td>80% 20%</td>
<td></td>
<td>3.8</td>
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</tr>
<tr>
<td>70% 30%</td>
<td></td>
<td>3.8</td>
<td>6.1</td>
</tr>
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</table>

*) measured
The conclusion of the trial is that an unexpected and considerable improvement of the flow rate (decreasing viscosity as shown by increased melt flow index) of the thermoplastic material has been achieved.

Example 2

Poly butylene adipate-co-terephthalate in the form of EcoFlex® CI200 blend is mixed with polycaprolactone CAPA™ 6500 (50,000mw) in a twin screw extruder. 0, 10, 20 and 30% of the polycaprolactone was mixed in. The theoretical expected value was calculated in accordance with the formula \( \log MFI_{b,d} = a \log MFI_A + (1-a) \log MFI_B \). The real Melt Flow Index (MFI) MFI 2,16kg, 190 °C, g/10min was then measured and compared in table 1a and graph 1b below.
The conclusion of the trial is that an unexpected and considerable improvement of the flow rate (decreasing viscosity as shown by increased melt flow index) of the thermoplastic material has been achieved.

Graph 3 shows the results of biodegradation comparison over a 40 day period for CAPA 6800, poly butylene adipate-co-terephthalate (PBAT) and a composition in accordance to one
embodiment of the invention with 70% poly butylene adipate-co-terephthalate (PBAT) and 30%, CAPA 6800. The biodegradation test was performed in accordance with EN 13432.

Graph 3
Biodegradation according to EN 13432

The conclusion of the study is that biodegradation of PBAT is improved by adding CAPA 6800.
CLAIMS

1. A thermoplastic composition comprising poly butylene adipate-co-terephthalate (PBAT), wherein the composition comprises 2 - 50% of polycaprolactone with an average molecular weight in the range 20.000 to 120.000.

2. A thermoplastic composition according to claim 1, the composition comprises 5 - 40% of polycaprolactone.

3. A thermoplastic composition according to claim 1, wherein the composition comprises 5 - 35% of polycaprolactone.

4. A thermoplastic composition according to claim 1, wherein the composition comprises 10 - 30% of polycaprolactone.

5. A thermoplastic composition according to any of claims 1 - 3, wherein the polycaprolactone has an average molecular weight of 35.000 to 100.000.

6. A thermoplastic composition according to any of claims 1 - 3, wherein the polycaprolactone has an average molecular weight of 50.000 - 80.000.

7. A thermoplastic composition according to any of claims 1 - 3, wherein the material is bio-degradable.

8. A thermoplastic material according to claim 7, wherein the rate of bio-degradability is improved at least 5% compared to pure PBAT.

9. A thermoplastic material according to claim 7, wherein the time for bio-degradation of the composition is shortened by at least 5% compared to pure PBAT.

10. A thermoplastic material according to claim 4, wherein the composition is bio-degradable and the time for bio-degradation of the composition is shortened by at least 10%, compared to pure PBAT.
### INTERNATIONAL SEARCH REPORT

**International application No.**

PCT/SE2015/000054

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### A. CLASSIFICATION OF SUBJECT MATTER

**IPC:** see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

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### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**IPC:** C08G, C08J, C08L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, BIOSIS, CHEM ABS Data, MEDLINE, PUBCHEM, XPSPRNG

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>WO 201201 0401 A2 (BILLERUDS AB ET AL), 26 January 2012 (2012-0-01-26); page 33, line 9 - page 33, line 20; claims 11, 12</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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* Special categories of cited documents:
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Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Document member of the same patent family

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Date of the actual completion of the international search

17-1 2-201 5

Date of mailing of the international search report

18-1 2-201 5

Name and mailing address of the ISA/SE Patent- och registreringsverket

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Form PCT/ISA/210 (second sheet) (January 2015)
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International Patent Classification (IPC)

C08L 67/02 (2006.01)
C08L 67/04 (2006.01)
C08G 63/08 (2006.01)
C08G 63/183 (2006.01)
C08J 5/8 (2006.01)
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