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(54) **FIBRE-REINFORCED PLASTIC OBJECTS**

(57) This invention relates to fibre-reinforced plastic objects comprising a rest fraction from plastic recycling comprising more than 95 wt% polyolefins. The invention further relates to methods of producing said fibre-reinforced plastic objects and the use of fibres to improve the mechanical properties of recycled plastic objects comprising said rest fraction from plastic recycling. The addition of mineral fibres, particularly glass wool fibres or stone wool fibres, to a rest fraction from polymer recycling greatly improves the otherwise inferior mechanical properties such that the resulting fibre-reinforced plastic objects find interesting applications.

FIBRE-REINFORCED PLASTIC OBJECTS

FIELD OF THE INVENTION

The invention relates to fibre-reinforced plastic objects, more particularly to fibre-reinforced plastic objects comprising a rest fraction from plastic recycling comprising more than 95 wt% polyolefins. The invention further relates to methods of producing said fibre-reinforced plastic objects and the use of fibres to improve the mechanical properties of recycled plastic objects comprising said rest fraction from plastic recycling.

BACKGROUND OF THE INVENTION

The huge amounts of plastic waste resulting from industrial and domestic use presents our society with major challenges. Due to the very limited economically feasible options for processing plastic waste into valuable products, a large fraction of the plastic waste is incinerated along with other industrial and domestic waste streams or ends up at landfill sites. Even large parts of the plastic waste collected separately is incinerated. The fraction that is not incinerated is typically sorted out into different useful fractions that are processed into different products and a rest fraction. This rest fraction from plastic recycling, which amounts to up to 60 wt% of the plastic waste collected separately, can as such, due to its heterogeneity, not be processed into useful products and cannot be efficiently separated further into valuable fractions. Typically, this rest fraction comprises more than 95 wt% polyolefins of which the major part consists of polyethylene and polypropylene. Apart from the polyolefins, the rest fraction typically comprises additives used in the production of the plastics such as plasticizers, colorants and fillers.

It is known in the art to reinforce virgin thermosetting polymers, and sometimes also thermoplastic polymers, with fibres. The resulting fibre-reinforced polymers or fibre-reinforced plastics are composite materials made of a polymer matrix with fibres embedded therein. The fibres are usually glass, carbon or aramid fibres, although other fibres such as paper, wood, or asbestos have also been applied. The reason for adding the fibres is to improve mechanical properties such as strength, stiffness or toughness of virgin plastics to make them for example suitable as a substitute for infrastructure components that are constructed of traditional civil engineering materials such as concrete and steel. In this respect, reference is made to M.A. Masuelli, *Introduction of fibre-reinforced polymers – polymers and composites: concept, properties and processes*, 2013, open access article available via http://dx.doi.org/10.5772/54629.

GB1,095,700A relates to the reinforcement of virgin plastics obtained from polymers of α-olefins such as polypropylene and polyethylene with mineral fillers such as glass fibres, asbestos fibres or mica. GB1,095,700A discloses an embodiment wherein glass fibres coated with the reaction product of γ-aminopropyl triethoxysilane and a copolymer of ethylene and glycidyl methacrylate are compounded with virgin polypropylene. A reinforcement factor, defined as the ratio of the tensile modulus of the reinforced virgin polypropylene at a given strain to that of unreinforced virgin polypropylene, of about 1.5 was reported.

The term 'virgin polymer' as used herein relates to polymer that has never been put into a finished product. It is the 'new' polymer that a factory uses directly from the polymer manufacturer. Likewise, the term 'virgin plastic' relates to plastic or a plastic article comprising only virgin polymer. On the other hand, 'recycled plastic' is, at least partially, made of plastic material that has been made into a finished product before. Virgin plastics already find many commercially interesting applications and reinforcement of virgin polymers with fibres to form plastic composite materials even extends this range of applications.

As will be understood by those skilled in the art, a rest fraction from plastic recycling comprises different grades of polyethylene, polypropylene and further recycled plastics. These recycled plastics may be partially degraded due to impact of weather and thermal processing. Moreover, these recycled plastics may contain all kinds of additives commonly used in the production of plastic consumer products such as colorants, plasticizers, fillers, antimicrobials and the like. Consequently, the rest fraction from polymer recycling is a mixture of many diverse components which can in no way be compared to a virgin polymer or virgin plastic.

One of the problems that arises when one would process the rest fraction from polymer recycling into products is a (too) low tensile modulus and flexural modulus, a low elongation and a low impact strength. Because of these inferior mechanical properties, plastics objects obtained from the rest fraction of polymer recycling hardly find interesting applications.

Accordingly, there is a need for new processes for producing valuable products from the heterogeneous rest fraction obtained from plastic recycling. It is therefore an object of the invention to provide valuable products from the heterogeneous rest fraction obtained from plastic recycling. It is a further object of the invention to provide products from the heterogeneous rest fraction obtained from plastic recycling having improved tensile modulus, flexural modulus, elongation and/or impact strength.

SUMMARY OF THE INVENTION

The present inventors have found that the above objects can be met by adding mineral fibres to the rest fraction from plastic recycling and by processing the mixture into fibre-reinforced plastic products.

The present invention thus provides a fibre-reinforced plastic object comprising, based on the weight of the plastic object:

a) 65 - 99.9 wt% of a rest fraction from plastic recycling;

b) 0.1 - 30 wt% of mineral fibres;

c) 0 - 5 wt% of further additives;

wherein the rest fraction from plastic recycling comprises 10 - 90 wt% of recycled polyethylene, 10 - 90 wt% of recycled polypropylene, 0.1 - 3 wt% of further recycled plastics, and less than 2 wt% of inorganic impurities, based on the weight of the rest fraction.

The present inventors have established that the addition of glass wool fibres to a rest fraction from polymer recycling greatly improves the otherwise inferior mechanical properties such that the resulting fibre-reinforced plastic objects find interesting applications. The inventors have further unexpectedly found that the addition of stone wool instead of glass wool further improves mechanical properties of the fibre-reinforced plastic object.

The present invention further provides a method for producing a fibre-reinforced plastic object as defined herein before, said method comprising the steps of:

a) gravimetric of volumetric feeding 65 - 99.9 wt%, based on the weight of the plastic object, of a rest fraction from plastic recycling, 0.1 - 30 wt% of mineral fibres and 0 - 5 wt% of further additives, all as defined herein before, to a hopper of a melt homogenization device;

b) feeding the components fed to the hopper to a feeding zone of the melt homogenization device wherein at least part of the air is removed and wherein the material is compacted;

c) conveying, heating, melting and homogenizing the compacted material from step b) at a temperature of between 170 and 230 °C; and subsequently

d) (i) cooling the homogenized material of step c) and collecting the fibre-reinforced plastic object in the form of a masterbatch or (ii) hot cutting the homogenized material of step c) and collecting the fibre-reinforced plastic object in the form of pellets or a granulate or (iii) feeding the homogenized material of step c) to the mould of an injection-moulding device to form an injection-moulded fibre-reinforced plastic object.

The present invention further relates to the use of mineral fibres, preferably stone wool fibres, to improve the mechanical properties of recycled plastic objects comprising a rest fraction from plastic recycling, said rest fraction from plastic recycling comprising 10 - 90 wt%

of recycled polyethylene, 10 - 90 wt% of recycled polypropylene, 0.1 - 3 wt% of further recycled plastics, and less than 2 wt% of inorganic impurities, based on the weight of the rest fraction.

DETAILED DESCRIPTION

In a first aspect of the invention, a fibre-reinforced plastic object is provided, said plastic object comprising, based on the weight of the plastic object:

a) 65 - 99.9 wt% of a rest fraction from plastic recycling;

b) 0.1 - 30 wt% of mineral fibres;

c) 0 - 5 wt% of further additives;

wherein the rest fraction from plastic recycling comprises 10 - 90 wt% of recycled polyethylene, 10 - 90 wt% of recycled polypropylene, 0.1 - 3 wt% of further recycled plastics, and less than 2 wt% of inorganic impurities, based on the weight of the rest fraction.

The term recycled polyethylene as used herein encompasses different kinds of polyethylene that may appear in waste streams such as ultra-high-molecular-weight polyethylene (UHMWPE), ultra-low-molecular-weight polyethylene (ULMWPE or PE-WAX), high-molecular-weight polyethylene (HMWPE), high-density polyethylene (HDPE), medium-density polyethylene (MDPE), linear low-density polyethylene (LLDPE), low-density polyethylene (LDPE), very-low-density polyethylene (VLDPE), and polyethylene-polypropylene random or block copolymers.

The term recycled polypropylene as defined herein encompasses different kinds of polypropylene that appear in waste streams such as isotactic, syndiotactic and atactic polypropylene, high crystalline polypropylene (HcPP) and expanded polypropylene (EPP).

The 0.1 - 3 wt% of further recycled plastics typically comprise cross-linked polyethylene (PEX or XLPE), high-density cross-linked polyethylene (HDXLPE), polyamides, polyethylene terephthalate and/or thermosetting plastics. In a preferred embodiment, the amount of further recycled plastics is between 0.15 and 2 wt%, more preferably between 0.2 and 1 wt%, based on the weight of the rest fraction from plastic recycling.

Typical examples of inorganic impurities are sand, glass and metals, such as aluminium. In a preferred embodiment, the amount of inorganic impurities is less than 1 wt%, in a more preferred embodiment less than 0.5 wt%, based on the weight of the rest fraction from plastic recycling. Obviously, the amounts of these inorganic impurities can be further reduced by enhanced separation techniques. However, the better the separation, the higher the costs and at

some point, the separation costs do not outweigh the commercial value of the fibre-reinforce plastic objects anymore.

As will be understood by those skilled in the art, the recycled polyethylene, recycled polypropylene and further recycled plastics are so-called postconsumer plastics that have been produced and possibly also used for a specific application. Hence, these recycled plastics may contain all kinds of additives commonly used in the production of plastic consumer products such as colorants, plasticizers, fillers, antimicrobials and the like. Consequently, the rest fraction from polymer recycling may comprise small amounts of many diverse components.

The rest fraction of polymer recycling as defined herein before is a typical rest fraction obtained from industrial and domestic plastic waste streams after separating off the otherwise useful fractions. Although the overall composition of industrial and domestic plastic waste streams may depend on time and location, it is possible to obtain a rest fraction having a composition as defined herein before using separation techniques that are well-known in the art of plastic recycling. In this respect, reference is made to J. Brandrup, M. Bittner, W. Michaeli, G. Menges, Eds., *Recycling and recovery of plastics*, Hanser, Munich, Germany, 1996 and to V. Goodship, *Introduction to plastics recycling*, Smithers Rapra Press, 2nd edition, 2008.

In a preferred embodiment, the rest fraction from plastic recycling as used in the fibre-reinforced plastic object as defined herein before comprises 30 - 70 wt% of recycled polyethylene, 30 - 70 wt% of recycled polypropylene, and 0.1 - 3 wt% of further recycled plastics, and less than 2 wt% of inorganic impurities, based on the weight of the rest fraction.

In another preferred embodiment, the rest fraction from plastic recycling as used in the fibre-reinforced plastic object as defined herein before comprises 40 - 60 wt% of recycled polyethylene, 40 - 60 wt% of recycled polypropylene, and 0.1 - 3 wt% of further recycled plastics, and less than 2 wt% of inorganic impurities, based on the weight of the rest fraction.

The 0 - 5 wt% of further additives typically comprise colorants such as dyes or pigments, preferably pigments, compatibilizers, emulsifiers, fillers, antimicrobials, waxes, stabilizers, flame retardants and antioxidants. The rest fraction of polymer recycling is in fact a waste stream. As will be understood by those skilled in the art, further additives increase the price of the plastic object obtained from the rest fraction of polymer recycling. Hence, the amount of further additives is preferably kept as low as possible. In a preferred embodiment, the fibre-reinforced plastic object comprises, based on the weight of the plastic object, 0 - 4 wt% of further additives, more preferably 0 - 3 wt%, still more preferably 0 - 2 wt%.

It is known in the art that mixtures of different types of polyethylene and polypropylene can be miscible, partially miscible or immiscible dependent on their relative concentration. In this

respect, reference is made to L.A. Utracki, Thermodynamics of Polymer Blends, *Polymer Blends Handbook* (2003), page 123-201, Kluwer Academic Publishers. Homogeneity of the rest fraction from polymer recycling in the fibre-reinforced plastic object is very important for obtaining good mechanical properties. Hence, the rest fraction from plastic recycling may comprise based on the weight of the plastic object and as part of the further additives, between 1 and 5 wt% of a compatibilizer. Preferred examples of compatibilizers are chosen from the group consisting of ionomers, ethylene vinyl acetate, elastomers such as EPDM, LLDPE and polyethylene-polypropylene grafts. As will be appreciated by those skilled in the art, a compatibilizer is only needed in case the rest fraction from polymer recycling show macroscopic phase separation in the melt. In a preferred embodiment, no compatibilizer is used.

The fibre-reinforced plastic objects according to the invention can be coloured using colorants such as dyes or pigments. Hence, in a preferred embodiment, the rest fraction from plastic recycling comprises based on the weight of the plastic object and as part of the further additives, between 1 and 5 wt% of a colorant. Pigments are preferred colorants because of their better lightfastness.

The fibre-reinforced plastic objects according to the invention can further comprise one or more emulsifiers or wetting agents for improving the wetting of the mineral fibres by the rest fraction from plastic recycling and for improving the adhesion between the mineral fibres and the rest fraction from plastic recycling. Hence, the plastic object may comprise based on the weight of the plastic object and as part of the further additives, between 1 and 5 wt% of one or more emulsifiers and/or wetting agents. Preferred examples of emulsifiers or wetting agents are glycol and glycerol. Surprisingly, the inventors found that sufficient wetting and adhesion can be obtained when no wetting agents or emulsifiers are used. In a preferred embodiment, no emulsifiers or wetting agent is used.

Preferred examples of fillers that can be applied in the plastic object are calcium carbonate and talc.

Preferred examples of antimicrobials that can be applied in the plastic object are silver-based antimicrobials.

The fibre-reinforced plastic object according to the invention can further comprise one or more waxes. Waxes may be applied to lower the melt flow index (mfi) of the plastic material during injection moulding. The mfi is a measure of the ease of flow of the melt of a thermoplastic polymer. It is defined as the mass of polymer, in grams, flowing in ten minutes through a capillary of a specific diameter and length by a prescribed pressure at a prescribed temperature. The melt flow index should be high enough that the molten polymer can be easily

formed into the intended article. Preferred examples of waxes that can be applied in the plastic object are paraffin, polyolefin waxes and amide waxes. For injection moulding and extrusion mfi-values of 1 or higher are required.

In a preferred embodiment, the fibre-reinforced plastic object comprises, based on the weight of the plastic object, 0.2 - 15 wt% of mineral fibres, preferably 0.4 - 10 wt%, more preferably 0.6 - 6 wt%.

In another preferred embodiment, the mineral fibres are chosen from the group consisting of glass wool fibres, stone wool fibres, or combinations thereof. In a more preferred embodiment, the mineral fibres are glass wool fibres. In an very preferred embodiment, the fibre-reinforced plastic object comprises, based on the weight of the plastic object, 0.8 - 10 wt% of glass wool fibres, preferably 0.9 - 6 wt%.

Most preferably, the mineral fibres are stone wool fibres. Stone wool is also called rock wool in the art. Both terms are considered interchangeable herein. In a very preferred embodiment, the fibre-reinforced plastic object comprises, based on the weight of the plastic object, 0.4 - 10 wt% of stone wool fibres, preferably 0.6 - 6 wt%, more preferably 0.7 - 3 wt%, even more preferably 0.8 – 2.5 wt%.

Stone wool can be manufactured from various types of diabase rock, mainly basalt, which is melted at high temperature. Through the furnace product of molten rock at a temperature of about 1600 °C, air or steam is blown. More advanced production techniques are based on spinning molten rock in high-speed spinning heads. The final product typically is a mass of fine, intertwined fibres with a typical diameter of 2 to 6 μm. Nowadays, the main application of stone wool is for thermal and/or sound isolation of buildings. For this purpose, small quantities of binding agents are added to bond the individual fibres together, the binder is cured and the resulting wool is processed by cutting it to the required size and shape, for example into rolls or boards. The binding agent typically is a thermosetting resin such as phenolic resins, like phenol formaldehyde resins or phenol formaldehyde urea resins.

In order to reduce costs, it would be advantageous if the mineral fibre that is applied in the rest fraction from polymer recycling is a waste stream. The inventors have found that the offcuts resulting from the production of stone wool isolation material can be used in the fibre-reinforced plastic object as defined herein before. These offcuts mainly consist of intertwined stone wool fibres comprising small amounts of cured binder. Hence, in a preferred embodiment, the mineral fibres are stone wool fibres in the form of offcuts resulting from the production of stone wool isolation. These stone wool fibres may comprise small amounts of binder. However, stone wool fibres without binder can also be applied in the plastic objects according to the invention.

The mechanical properties of the fibre-reinforced plastic objects as defined herein before are sufficient for the production of different plastic products. In a preferred embodiment, the plastic object as defined herein before is an injection-moulded product, preferably a pallet, bin, container, paver, tube or garden furniture. Relevant mechanical properties for such injection-moulded products are E-modulus, flexural modulus and impact strength. The minimum preferred values for the mechanical properties of such injection-moulded products are an E-modulus of at least 450 MPa, as determined in accordance with ISO 527-1 (version 1996), a flexural modulus of at least 450 MPa, as determined in accordance with ASTM D790 (version 1995), and an impact strength (unnotched) of at least 60 kJ/m^2 as determined in accordance with ISO 179-1 (version 2001).

In a preferred embodiment, the fibre-reinforced plastic object as defined herein before has one or more of the following mechanical properties:

a) an E-modulus, as determined in accordance with ISO 527-1 (version 1996), of at least 450 MPa, more preferably at least 900 MPa, even more preferably at least 950 MPa, still more preferably at least 1000 MPa;
b) a flexural modulus, as determined in accordance with ASTM D790 (version 1995), of at least 450 MPa, more preferably at least 780 MPa, even more preferably at least 790 MPa, still more preferably at least 800 MPa; and
c) an impact strength (unnotched), as determined in accordance with ISO 179-1 (version 2001), of at least 60 kJ/m^2, more preferably no fracture resulting from said impact strength test.

In a more preferred embodiment, the fibre-reinforced plastic object as defined herein before has all of the following mechanical properties:

a) an E-modulus, as determined in accordance with ISO 527-1 (version 1996), of at least 450 MPa, more preferably at least 900 MPa, even more preferably at least 950 MPa, still more preferably at least 1000 MPa;
b) a flexural modulus, as determined in accordance with ASTM D790 (version 1995), of at least 780 MPa, more preferably at least 785 MPa, even more preferably at least 790 MPa, still more preferably at least 800 MPa; and
c) an impact strength (unnotched), as determined in accordance with ISO 179-1 (version 2001), of at least 60 kJ/m^2, more preferably no fracture resulting from said impact strength test.

In another preferred embodiment, the fibre-reinforced plastic object is an intermediate product that takes the form of pellets, a granulate or masterbatch that can be used in injection-moulding processes to produce further fibre-reinforced plastic objects.

The fibre-reinforced plastic objects as defined herein before can also be applied in multi-layer plastic products. In such a product, a fibre-reinforced plastic object as defined herein before in the form of a layer is combined with one or more layers of virgin plastic. In a preferred embodiment, a multi-layer plastic object is provided, said multi-layer plastic object comprising a fibre-reinforced plastic object as defined herein before in the form of a first layer and a second plastic layer comprising virgin plastic attached to a first side of said first layer. In another preferred embodiment, a multi-layer plastic object is provided, said multi-layer plastic object comprising a fibre-reinforced plastic object as defined herein before in the form of a first layer and a second plastic layer comprising virgin plastic attached to a first side of said first layer and a third plastic layer comprising virgin plastic is attached to a second side of said first layer.

In a second aspect of the invention, a method for producing a fibre-reinforced plastic object as defined herein before is provided, said method comprising the steps of:

a) gravimetric of volumetric feeding 65 - 99.9 wt%, based on the weight of the plastic object, of a rest fraction from plastic recycling, 0.1 - 30 wt% of mineral fibres and 0 - 5 wt% of further additives, all as defined herein before, to a hopper of a melt homogenization device;
b) feeding the components fed to the hopper to a feeding zone of the melt homogenization device wherein at least part of the air is removed and wherein the material is compacted;
c) conveying, heating, melting and homogenizing the compacted material from step b) at a temperature of between 170 and 230 °C; and subsequently
d) (i) cooling the homogenized material of step c) and collecting the fibre-reinforced plastic object in the form of a masterbatch or (ii) hot cutting the homogenized material of step c) and collecting the fibre-reinforced plastic object in the form of pellets or a granulate or (iii) feeding the homogenized material of step c) to the mould of an injection-moulding device to form an injection-moulded fibre-reinforced plastic object.

In a preferred embodiment, the melt homogenization device is a compounder or an injection-moulding device.

In another preferred embodiment, the injection-moulded fibre-reinforced plastic object is chosen from the group consisting of pallets, bins, containers, pavers, tubes and garden furniture.

Too much mechanical burden during melt homogenization leads to undesirable break-up of the mineral fibres and plastic degradation. It is within the skills of the artisan to adjust the screw geometries in such devices in order to minimize mechanical burden and plastic degradation. In

this respect, reference is made to B. Jakob *et al.*, Relevant Process Parameters for Twin Screw Compounding, Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany, Application Notes LR-70, 2012, to T. Sakai, Screw extrusion technology – past, present and future, *Polimery*, 2013 (58), pp 847-857, to K. Ramani *et al.*, Effect of screw design on fibre damage in extrusion compounding and composite properties, *Polymer Composites*, 1995 (16), pp 258-266, and to A. L. Kelly *et al.*, The effect of screw geometry on melt temperature profile in single screw extrusion, *Polymer Engineering & Science*, 2006 (46), pp 1706-1714.

In a preferred embodiment, the total residence time of the material in the melt homogenization device is less than 60 seconds.

The highest temperature in the melt homogenization device must be above the melting point of the highest melting component in the rest fraction from polymer recycling. Typically, the highest temperature in the melt homogenization device is between 200 and 230 °C.

Since the mineral fibres may break up into smaller fibres during processing steps such as compounding and/or injection moulding, it is preferred that the initial length of the fibres is as long as possible without negatively influencing the processability. Preferably, at least 90 wt% of the mineral fibres before melt homogenization have a length of between 30 and 70 mm, more preferably between 40 and 60 mm.

Preferably, the mineral fibres are applied as individual fibres and not as wool. Individual glass wool fibres or stone wool fibres of this length can be obtained by size reduction techniques such as cutting and/or shredding of glass wool, stone wool or offcuts resulting from the production of stone wool isolation.

In a third aspect, the invention relates to the use of mineral fibres, preferably glass wool fibres or stone wool fibres, more preferably stone wool fibres, to improve the mechanical properties of plastic objects comprising a rest fraction from plastic recycling, said rest fraction from plastic recycling comprising 10 - 90 wt% of recycled polyethylene, 10 - 90 wt% of recycled polypropylene, 0.1 - 3 wt% of further recycled plastics, and less than 2 wt% of inorganic impurities, based on the weight of the rest fraction. In further embodiments, said use encompasses the incorporation of further additives as defined herein before, the use of preferred mineral fibres as defined herein before and the use of preferred rest fraction compositions as defined herein before.

Thus, the invention has been described by reference to certain embodiments discussed above. It will be recognized that these embodiments are susceptible to various modifications and alternative forms well known to those of skill in the art.

Furthermore, for a proper understanding of this document and its claims, it is to be understood that the verb 'to comprise' and its conjugations are used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. In addition, reference to an element by the indefinite article 'a' or 'an' does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one of the elements. The indefinite article 'a' or 'an' thus usually means 'at least one'.

All patent and literature references cited in the present specification are hereby incorporated by reference in their entirety.

The following examples are offered for illustrative purposes only, and are not intended to limit the scope of the present invention in any way.

EXAMPLES

Example 1: preparation of plastic objects from recycled plastic

A rest fraction from polymer recycling was obtained from curbside collection. The composition of the rest fraction from polymer recycling as used in this example was determined using differential scanning calorimetry (DSC) in accordance with ISO 11357-1 (version 2009). The composition of the rest fraction from polymer recycling comprised 58 wt% polyethylene, 39 wt% polypropylene, 2wt% of other plastics and 1 wt% of inorganics.

Mineral fibres were milled to obtain a product containing fibres having a length of between about 30 mm and 70 mm. Such a milled product mainly consisting of individual fibres can be dosed more easily than a mineral fibre wool.

The rest fraction from polymer recycling was gravimetrically fed to a hopper of twin screw compounder (Collin ZK 25T SCD 15, Teachline Cooling WB 850T and granulator Teachline CSG 171T) without or with mineral fibres. The homogenized fibre-reinforced plastic material was obtained as an extruded strand which was subsequently cooled and cut into a granulate. The total residence time of the material in the twin screw compounder was 30 seconds.

The granulate thus obtained was used in an injection moulding device (BOY XS) to produce plastic objects for testing (thermo-)mechanical properties.

In total, 12 types of granulates and test samples were produced using the method described above. The first granulate and test sample consisted only of the rest fraction from polymer recycling. In addition, 3 granulates and test samples obtained therefrom, respectively having 1 wt%, 2 wt% and 5 wt% of glass wool fibres, based on the weight of the granulate, were produced. Moreover, 4 granulates and test samples obtained therefrom, respectively having 1 wt%, 2 wt%, 5 wt% and 10 wt% of stone wool fibres, based on the weight of the granulate, were produced. These stone wool fibres were offcuts resulting from the production of stone wool isolation (obtained from the wool fibre producing industry) and contained small amounts of cured binder.

The 4 stone wool fibre granulates and test samples were reproduced using stone wool in the form of offcuts resulting from the production of stone wool isolation from which the small amounts of cured binder had been removed.

Example 2: (thermo-)mechanical properties of test samples comprising glass wool fibres

Several (thermo-)mechanical properties of plastic test samples comprising glass wool fibres, produced in accordance with Example 1, are presented in Table 1. The sample not comprising glass wool fibres ('R + 0 wt%') is used as a reference. The property 'mfi' stands for melt flow index. The abbreviation 'R' stands for rest fraction from polymer recycling.

Table 1: (thermo-)mechanical properties of test samples comprising glass wool fibres

(Thermo-)mechanical property	R+0 wt%	R+1 wt%	R+2 wt%	R+5 wt%
E-modulus [MPa]	885	909	955	962
Tensile strength [MPa]	20	17	17	18
Elongation [%]	5	8	7	7.5
Impact strength, notched [kJ/m^2]	2	9.2	8.5	7.5
Impact strength, unnotched [kJ/m^2]	28	no fracture	no fracture	no fracture
Flexural modulus [MPa]	780	788	817	1000
Mfi [g/10 min]	4	2.3	2.6	2.3

The test methods used for determining the (thermo-)mechanical properties listed in Table 1 are indicated in Table 2.

Table 2: test methods used

(Thermo-)mechanical property	Test method
E-modulus	ISO 527-1, version 1996
Tensile strength	ISO 527-1, version 1996
Elongation	ISO 527-1, version 1996
Impact strength, notched	ISO 179-1, version 2001
Impact strength, unnotched	ISO 179-1, version 2001
Flexural modulus	ASTM D790, version 1995
Mfi	ISO 1133, version 2005

As can be inferred from Table 1, the test sample not comprising glass wool fibres ('R + 0 wt%') has a low E-modulus and impact strength. Such inferior mechanical properties do not enable the production of useful plastic products. The addition of glass wool fibres clearly improves E-modulus, impact strength and flexural modulus, while the influence of the addition of glass wool fibres on tensile strength and elongation is only limited.

Example 3: (thermo-)mechanical properties of test samples comprising stone wool fibres

Several (thermo-)mechanical properties of plastic samples comprising stone wool fibres (offcuts with small amounts of cured binder), produced in accordance with Example 1, are presented in Table 3. The properties were determined using the test methods indicated in Table 2. The composition of the rest fraction from polymer recycling was identical to the composition used in Example 2. Similar (thermo-)mechanical properties were obtained for stone wool fibres (offcuts) without cured binder.

Table 3: (thermo-)mechanical properties of test samples comprising stone wool fibres

(Thermo-)mechanical property	R+0 wt%	R+1 wt%	R+2 wt%	R+5 wt%	R+10 wt%
E-modulus [MPa]	885	910	1000	1170	1325
Tensile strength [MPa]	20	22	23	23	23
Elongation [%]	5	180	120	80	10
Impact strength, notched [kJ/m^2]	2	12.5	12.3	8.6	7.9
Impact strength, unnotched [kJ/m^2]	28	no fracture	no fracture	no fracture	no fracture
Flexural modulus [MPa]	780	785	790	820	950

Mfi [g/10 min]	4	2	2	2	2

The addition of stone wool fibres clearly improves E-modulus, elongation, impact strength and flexural modulus, while the influence of the addition of stone wool fibres on tensile strength is limited. The improvement of these mechanical properties is much more pronounced than for glass wool fibres.

CONCLUSIES

1. Een vezelversterkt kunststof voorwerp omvattende, gebaseerd op het gewicht van het kunststof voorwerp:
   a) 65 - 99.9 gew% van een restfractie van kunststof recycling;
   b) 0.1 - 30 gew% minerale vezels;
   c) 0 - 5 gew% andere additieven;
   waarin de restfractie van kunststof recycling 30 - 70 gew% gerecycled polyethyleen, 30 - 70 gew% gerecycled polypropyleen, 0.1 - 3 gew% andere gerecyclede kunststoffen en minder dan 2 gew% anorganische onzuiverheden, gebaseerd op het gewicht van de restfractie, omvat.

2. Kunststof voorwerp volgens conclusie 1, omvattende, gebaseerd op het gewicht van het kunststof voorwerp, 0.2 - 15 gew% minerale vezels, bij voorkeur 0.4 - 10 gew%, bij sterkere voorkeur 0.6 - 6 gew%.

3. Kunststof voorwerp volgens conclusie 1 of 2, waarin de minerale vezels gekozen worden uit de groep bestaande uit glaswolvezels, steenwolvezels of combinaties daarvan, bij voorkeur steenwolvezels.

4. Kunststof voorwerp volgens één van de voorgaande conclusies 1 - 3, waarin de minerale vezels afsnijdsels zijn resulterend uit de productie van steenwol isolatiemateriaal.

5. Kunststof voorwerp volgens conclusie 1, waarin de restfractie van kunststof recycling 60 - 40 gew% gerecycled polyethyleen, 40 - 60 gew% gerecycled polypropyleen, 0.1 - 3 gew% andere gerecyclede kunststoffen en minder dan 2 gew% anorganische onzuiverheden, gebaseerd op het gewicht van de restfractie, omvat.

6. Kunststof voorwerp volgens één van de voorgaande conclusies 1 - 5, waarin de andere additieven gekozen worden uit de groep bestaande uit kleurmiddelen zoals kleurstoffen of pigmenten, bij voorkeur pigmenten, compatibilisatoren, emulgatoren, vulstoffen, antimicrobiële stoffen, wassen, stabilisatoren, vlamvertragers en antioxidanten.

7. Kunststof voorwerp volgens één van de voorgaande conclusies 1 - 6, waarin genoemd kunststof voorwerp een halffabricaat in de vorm van korrels, een granulaat of masterbatch is, welk halffabricaat gebruikt kan worden in spuitgietprocessen voor het vervaardigen van verdere kunststof voorwerpen.

8. Kunststof voorwerp volgens één van de voorgaande conclusies 1 - 6, in de vorm van een gespuitgiet product, bij voorkeur een pallet, bak, container, straatklinker, buis of tuinmeubilair.

9. Multilaags kunststof voorwerp omvattende het kunststof voorwerp volgens één van de voorgaande conclusies 1 - 6 in de vorm van een eerste laag en een tweede kunststoflaag omvattende niet eerder verwerkt kunststof, welke tweede kunststoflaag gehecht is aan een eerste zijde van genoemde eerste laag.

10. Multilaags kunststof voorwerp volgens conclusie 9 waarin een derde kunststoflaag omvattende niet eerder verwerkt kunststof gehecht is aan een tweede zijde van genoemde eerste laag.

11. Kunststof voorwerp volgens één van de voorgaande conclusies 1 - 10, welke één of meer van de volgende mechanische eigenschappen bezit:
    a) een E-modulus, als bepaald overeenkomstig ISO 527-1 (versie 1996), van ten minste 450 MPa, bij voorkeur ten minste 900 MPa, bij sterkere voorkeur ten minste 950 MPa, bij nog sterkere voorkeur ten minste 1000 MPa;
    b) een buigmodulus, als bepaald overeenkomstig ASTM D790 (versie 1995), van ten minste 780 MPa, bij voorkeur ten minste 785 MPa, bij sterkere voorkeur ten minste 790 MPa, bij nog sterkere voorkeur ten minste 800 MPa; en
    c) een slagvastheid (niet gekerfd), als bepaald overeenkomstig ISO 179-1 (versie 2001), van ten minste 60 kJ/m^2, waarbij de slagvastheidstest bij voorkeur niet in een breuk resulteert.

12. Werkwijze voor het vervaardigen van een vezelversterkt kunststof voorwerp volgens één van de voorgaande conclusies 1 - 11, welke werkwijze de volgende stappen omvat:
    a) gravimetrisch of volumetrisch doseren van 65 - 99.9 gew% van een restfractie van kunststof recycling, 0.1 - 30 gew% minerale vezels en 0 - 5 gew% andere additieven,

gebaseerd op het gewicht van het kunststof voorwerp, in een hopper van een smelt-homogeniseringsapparaat;

b) toevoeren van de componenten welke in de hopper gedoseerd zijn aan een toevoerzone van het smelt-homogeniseringsapparaat waarin ten minste een deel van de lucht wordt verwijderd en waarin het materiaal wordt verdicht;

c) transporteren, verwarmen, smelten en homogeniseren van het verdichte materiaal uit stap b) bij een temperatuur tussen 170 en 230 °C; en vervolgens

d) (i) koelen van het gehomogeniseerde materiaal uit stap c) en verzamelen van het vezelversterkte kunststof voorwerp in de vorm van een masterbatch of (ii) heet opsnijden van het gehomogeniseerde materiaal uit step c) en verzamelen van het vezelversterkte kunststof voorwerp in de vorm van korrels of een granulaat of (iii) toevoeren van het gehomogeniseerde materiaal uit stap c) aan een mal van een spuitgietmachine om een gespuitgiet vezelversterkt kunststof voorwerp te vormen.

13. Werkwijze volgens conclusie 12, waarin het smelt-homogeniseringsapparaat een compounder of een spuitgietmachine is.

14. Werkwijze volgens conclusie 13, waarin het gespuitgiet vezelversterkt kunststof voorwerp gekozen wordt uit de groep bestaande uit pallets, bakken, containers, straatklinkers, buizen of tuinmeubilair.

15. Werkwijze volgens één van de voorgaande conclusies 12 - 14, waarin ten minste 90 gew% van de minerale vezels vóór smelt-homogenisering een lengte heeft tussen 30 en 70 mm, bij voorkeur tussen 40 en 60 mm.

16. Gebruik van minerale vezels, bij voorkeur steenwolvezels, voor het verbeteren van de mechanische eigenschappen van kunststof voorwerpen welke een restfractie van kunststof recycling omvatten, waarin genoemde restfractie van kunststof recycling 30 - 70 gew% polyethyleen, 30 - 70 gew% polypropyleen, 0.1 - 3 gew% andere gerecyclede kunststoffen en minder dan 2 gew% anorganische onzuiverheden omvat.

ABSTRACT

This invention relates to fibre-reinforced plastic objects comprising a rest fraction from plastic recycling comprising more than 95 wt% polyolefins. The invention further relates to methods of producing said fibre-reinforced plastic objects and the use of fibres to improve the mechanical properties of recycled plastic objects comprising said rest fraction from plastic recycling. The addition of mineral fibres, particularly glass wool fibres or stone wool fibres, to a rest fraction from polymer recycling greatly improves the otherwise inferior mechanical properties such that the resulting fibre-reinforced plastic objects find interesting applications.

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	P6059143NL
Nederlands aanvraag nr. **2016845**	Indieningsdatum **27-05-2016**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **IBR Consult B.V., et al**	
Datum van het verzoek voor een onderzoek van internationaal type **24-09-2016**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN67401**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

B29B17/00;B29K105/06;B29K309/08

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**B29B;B29K**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III. ☐ **GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES** (opmerkingen op aanvullingsblad)

IV. ☐ **GEBREK AAN EENHEID VAN UITVINDING** (opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2016845

A. CLASSIFICATIE VAN HET ONDERWERP
INV. B29B17/00
ADD. B29K105/06 B29K309/08

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)
B29B B29K

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X Y A	DE 198 30 913 A1 (FINACOR ANSTALT VADUZ [LI]) 13 januari 2000 (2000-01-13) * bladzijde 6, regel 61 - regel 66; conclusie 10; voorbeeld 3 *	1-3,7,9, 13-15,17 3,4 5,6,8, 10-12,16

X Y	US 5 635 551 A (LEE WHANJO [KR]) 3 juni 1997 (1997-06-03) * kolom 2, regel 38 - regel 40; voorbeeld 1 *	1,3,7,9, 17 3,4

Y	EP 0 526 733 A2 (HELLING WILHELM [DE]) 10 februari 1993 (1993-02-10) * kolom 5, regel 55 - regel 57 * * kolom 6, regel 51 - regel 52; conclusie 15 *	3,4

☐ Verdere documenten worden vermeld in het vervolg van vak C.

☒ Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

* Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
12 januari 2017	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kujat, Christian

Formulier PCT/ISA/201 (tweede blad) (Januari 2004)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek: NL 2016845

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)		Datum van publicatie
DE 19830913	A1 13-01-2000	GEEN		
US 5635551	A 03-06-1997	GEEN		
EP 0526733	A2 10-02-1993	AT	152661 T	15-05-1997
		DE	4122382 A1	14-01-1993
		DE	59208445 D1	12-06-1997
		DK	0526733 T3	01-12-1997
		EP	0526733 A2	10-02-1993
		ES	2102428 T3	01-08-1997
		GR	3024382 T3	28-11-1997
		JP	3350676 B2	25-11-2002
		JP	H05253932 A	05-10-1993
		US	5468431 A	21-11-1995

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN67401	27.05.2016		NL2016845

International Patent Classification (IPC)
INV. B29B17/00 ADD. B29K105/06 B29K309/08

Applicant
IBR Consult B.V., et al

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner
	Kujat, Christian

Application number

WRITTEN OPINION

NL2016845

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	2, 4-6, 8, 10-12, 16
	No:	Claims	1, 3, 7, 9, 13-15, 17
Inventive step	Yes:	Claims	5, 6, 8, 10-12, 16
	No:	Claims	1-4, 7, 9, 13-15, 17
Industrial applicability	Yes:	Claims	1-17
	No:	Claims	

2. Citations and explanations

see separate sheet

Application number

WRITTEN OPINION

NL2016845

Box No. VII Certain defects in the application

see separate sheet

Box No. VIII Certain observations on the application

see separate sheet

1 **Re Item V**

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1.1 Reference is made to the following documents:

D1 DE 198 30 913 A1 (FINACOR ANSTALT VADUZ [LI]) 13 januari 2000 (2000-01-13)

D2 US 5 635 551 A (LEE WHANJO [KR]) 3 juni 1997 (1997-06-03)

D3 EP 0 526 733 A2 (HELLING WILHELM [DE]) 10 februari 1993 (1993-02-10)

1.2 The features "restfractie van kunststof recycling", "gerecycled polyethyleen", "gerecycled polypropyleen" and "andere gerecyclede kunststoffen" in claims 1 to 17 are product-by-process features. The question to be answered is whether the claimed plastic materials are identical to known products. The burden of proof for an allegedly distinguishing "product-by-process" feature lies with the applicant, who has to provide evidence that the modification of the process parameters results in another product, for example by showing that distinct differences exist in the properties of the products.

In the present case, there does not seem to be any difference between virgin polyethylene and recycled polyethylene, between virgin polypropylene and recycled polypropylene, and between virgin plastic materials and recycled plastic materials.

Further, claim 1 is directed to the resin object *per se*. Further, claim 17 is directed to the use of mineral fibers with plastic materials *per se*, i.e. not restricted to the use in recycled plastic materials.

The same consideration applies to the feature "afsnijdsels resulterend uit de productie von steenwol isolatiemateriaal", which is construed as being directed to any stone wool material, either virgin or recycled.

1.3 The present application does not meet the criteria of patentability, because the subject-matter of claim 1 is not new.

D1 discloses:

Een vezelversterkt (page 7, line 44: "30 Gew.% Glasfasern") kunststof voorwerp (page 6, lines 38, 39, 42 to 46: the resulting products) omvattende, gebaseerd op het gewicht van het kunststof voorwerp:
a) 65 - 99.9 gew% (page 7, line 44: 100%-30%=70%) van een restfractie van kunststof recycling (non-limiting feature, disclosed on page 6, lines 61 to 66: "Windsichterfraktion", "Schwimmfestfraktion");
b) 0.1 - 30 gew% (30%) minerale vezels (Glasfasern);
~~c) 0 - 5 gew% andere additieven~~; (non-limiting feature due to the inclusion of 0%)

waarin de restfractie van kunststof recycling 10 - 90 gew% gerecycled polyethyleen (page 6, lines 61 and 62: 80% LDPE + 5%HDPE), 10 - 90 gew% gerecycled polypropyleen (page 6, line 62: 10%), 0.1 - 3 gew% andere gerecyclede kunststoffen (page 6, lines 62 and 63: "2% PS") ~~en minder dan 2 gew% anorganische onzuiverheden~~ (non-limiting feature due to the inclusion of 0%; D1 does not refer to any impurities, i.e. 0%), gebaseerd op het gewicht van de restfractie, omvat.

1.4 The present application does not meet the criteria of patentability, because the subject-matter of claim 1 is not new.

D2 discloses:

Een vezelversterkt (example 1: glass wool) kunststof voorwerp (column 3, lines 37 and 38) omvattende, gebaseerd op het gewicht van het kunststof voorwerp:
a) 65 - 99.9 gew% (50% pulverized tire + 14.25% PP + 14.25% LDPE + 11.11 % HDPE) van een restfractie van kunststof recycling (non-limiting feature, disclosed in column 2, line 38);
b) 0.1 - 30 gew% (example 3: 5.63 %) minerale vezels (glass wool);
~~c) 0 - 5 gew% andere additieven~~; (non-limiting feature due to the inclusion of 0%)

waarin de restfractie van kunststof recycling 10 - 90 gew% gerecycled polyethyleen (14.25% + 11.11 %), 10 - 90 gew% gerecycled polypropyleen (14.25%), 0.1 - 3 gew% andere gerecyclede kunststoffen (unclear feature due to an amount exceeding 100%; see item VIII below for details) ~~en minder dan 2 gew% anorganische onzuiverheden~~ (non-limiting feature due to the inclusion of 0%; D2 does not refer to any impurities, i.e. 0%), gebaseerd op het gewicht van de restfractie, omvat.

1.5 The present application does not meet the criteria of patentability, because the subject-matter of claim 13 is not new.

Due to the disclosure of injection moulding in D1 and D2, each of the documents also discloses a method with all the features of claim 13.

1.6 The present application does not meet the criteria of patentability, because the subject-matter of claim 17 is not new.

Each of D1 and D2 disclose the use of mineral fibers for improving the mechanical properties of plastic materials. See the passages discussed above.

1.7 Dependent claims 2-4, 7, 9, 14, 15 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of novelty and/or inventive step, see D1 to D3.

In particular, stone wool according to claims 3 and 4 is rendered obvious by D3 (column 6, line 52). A compatibilizer and a pigment according to claim 7 is disclosed in D1 (page 5, line 32) and in D2 (example 1).

2 **Re Item VII**

Certain defects in the application

2.1 Independent product claim 1 is not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble and the remaining features being included in the characterising part.

2.2 The relevant background art disclosed in D1 is not mentioned in the description, nor is this document identified therein.

3 **Re Item VIII**

Certain observations on the application

3.1 The amounts for the feature "restfractie" in claims 1 and 17 exceed 100%, since 10% of polyethylene 90 % of polypropylene (or 90% of polyethylene and 10 % of polypropylene) do not leave any room for the 0.1-3% of other recycled plastics.

Similar objections apply to claims 5 and 6.

3.2 The statement on page 11 (lines 8 and 9) does not meet the requirements for incorporations by reference.

3.3 The feature "slagvastheid (niet gekerfd)" does not meet the requirements for features in brackets.

3.4 As explained below, some of the features in the apparatus claim [...] relate to a method of using the apparatus rather than clearly defining the apparatus in terms of its technical features. The intended limitations are therefore not clear from this claim.