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(54) Title: A POLYPROPYLENE-BASED COMPOSITION WITH IMPROVED TRANSPARENCY, IMPACT VISCOSITY AND HARDNESS FOR INJECTION MOLDED THIN-WALLED ARTICLES, A METHOD FOR PREPARING SUCH COMPOSITION AND ARTICLES MADE THEREFROM

(57) Abstract: The present invention is related to a polypropylene-based composition for making injection molded articles, comprising, based on the total weight of the composition: (A) from 53.8 to 79.8 wt. % of crystalline isotactic polypropylene, (B) from 10 to 20 wt. % of elastomer based on copolymer of ethylene with -olefin comprising 4 to 10 carbon atoms, and (C) from 10 to 25 wt. % of one or several homopolymers of ethylene and/or random thermoplastic copolymers of ethylene with -olefins comprising 3 to 10 carbon atoms; and also (D) a modifying system comprising from 0.04 to 0.64 wt. % of organic peroxide (D1) and from 0.04 to 0.64 wt. % of co-agent (D2), that is a vinyl monomer with three or more acrylate functional groups, and (E) from 0.05 to 1.0 wt. % of nucleating agent and optional additives. The composition is made by a two-stage method comprising a stage of providing a modified concentrate composition by mixing and compounding the components in a melt using mixing equipment and extruder. The obtained polypropylene-based composition has an optimal balance of properties, in particular increased flowability, improved impact resistance and hardness, and also transparency. The invention is also related to use of the polypropylene-based composition for making injection molded articles and also to an article based on the obtained composition.

WO 2020/091621 A1

A POLYPROPYLENE-BASED COMPOSITION WITH IMPROVED TRANSPARENCY, IMPACT VISCOSITY AND HARDNESS FOR INJECTION MOLDED THIN-WALLED ARTICLES, A METHOD FOR PREPARING SUCH COMPOSITION AND ARTICLES MADE THEREFROM

Field of the invention

The present invention is related to polypropylene (PP) based compositions that possess an optimal balance of properties, in particular, improved flowability, improved impact resistance and hardness and also transparency. The polypropylene-based composition obtained according to the claimed method is meant for injection molding of thin-walled articles used as packages and for storage of various materials including at temperatures below freezing point, for manufacture of thin-walled vessels for liquid and bulk materials, and also for lamination of various surfaces.

Description of related art

It is known that the important characteristics for the polypropylene-based composition used for injection molding of thin-walled articles are: high flowability and good mechanical properties, in particular, hardness and impact resistance. The flowability requirement is important for providing high processability of the manufacture of articles based on the polypropylene composition. The mechanical properties of the composition such as hardness and impact resistance provide the articles with resistance to damage, e.g. at mechanical compression or fall.

Apart from that, an important requirement fora polypropylene-based composition is optical characteristics, namely, transparency. However, improvement of the optical properties of a polypropylene-based composition often leads to deterioration of mechanical properties and vice versa. High degree of crystallinity of the polypropylene comprised in the composition provides good mechanical properties to the articles based thereon, in particular, hardness; however, it thus adversely affects transparency. Decrease in the degree of crystallinity, due to, e.g. increase in the amount of comonomer contained in the propylene copolymer facilitates improvement of optical properties of the compositions and articles based thereon; however, a significant deterioration of hardness thus occurs. In this connection, it is important to maintain an optimal ratio of mechanical and optical properties of the obtained composition.

Polypropylene-based compositions, the articles made of which are characterized by transparency are known from the art. For example, patent CN 103709518 discloses a composition based on the polypropylene random copolymer with propylene unit content from 87 to 99 wt.%. Ethylene and α-olefin containing 4 to 8 carbon atoms are used as comonomers in this composition, they are introduced into the copolymer in an amount from 0.5 to 3.5 wt.% and from 0.5 to 9.5 wt.%, respectively. The composition also comprises a nucleating agent, which is represented by sorbitol derivatives or aromatic phosphates. The melt flow index (MFI) of the composition varies in the range from 0.5 to 20 g/10 min. The composition is characterized by good transparency: the haze value is less than 10%; however, it does not possess the required level of impact strength characteristics required in the number of cases, especially at low temperatures and at high MFI value.

A number of patents described further discloses formulation and technological solutions allowing to increase the impact resistance of the polypropylene-based composition, including at low temperatures with maintaining of the optical properties (transparency). The said balance of the mechanical and optical properties is achievable due to the composition based on the binary mixture of highly crystalline (co)polymer of propylene with an elastomer, wherein the elastomer has good compatibility with the propylene (co)polymer and is preferably an amorphous copolymer of propylene with relatively high contents of ethylene comonomer or α-olefin with 4 to 8 carbon atoms. Production of such copolymers is often carried out using metallocene catalytic systems according to two- or multi-stage reactor technology.

Particularly, in the patent RU 2337114 a composition based on propylene copolymers for the production of fibers, films or molded articles is disclosed. The composition consists of A and B components obtained in separate reactors in the presence of metallocene catalytic system. The component A is a propylene homopolymer with isotactic structure. The component B is a propylene copolymer comprising from 12 to 18 wt.% ethylene. The composition may also optionally comprise other additives, such as stabilizers, lubricants, nucleating agents, antistatic agents, dyes and pigments. It is noted that A and B components are present in the form of separate phases, and the weight ratio of A to B is from 80:20 to 60:40. The composition described above is characterized by high transparency (haze is at most 30%) and Charpy notched impact resistance at room temperature (23°C) from 41.3 to

49.4 kJ/m^2, and from 12.6 to 28.9 kJ/m^2 at 0°C. However, at lower temperature of -20°C the impact resistance drastically decreases to the values of 2.1 to 2.6 kJ/m^2. Another drawback of the composition is low tension modulus of from 602 to 609 MPa.

In the patent US 8618220 a binary composition that is characterized by increased flexural modulus value is represented. The said composition consists of the propylene homopolymer (A), propylene copolymer (B) comprising from 10 to 35 wt.% of olefin other than propylene and, optionally, additives. According to the claimed invention the increase in flexural modulus is achieved due to broadening of the content variation ranges for the component B and olefin in the propylene copolymer. Thereby, the propylene homopolymer and propylene copolymer are obtained using Ziegler-Natta catalytic system. The increased values of flexural modulus for the polypropylene composition, reaching the level of 1100 MPa, nevertheless, adversely affect the value of impact resistance, which is from 3.5 to 9.0 kJ/m^2 at 23°C, and from 2 to 5 kJ/m^2 at 0°C.

Patent RU 2528425 also describes a binary composition based on polypropylene with improved transparency, and also a method for preparing such composition by polymerization in reactor or via extrusion technology. The said composition comprises: (A) from 60 to 90 wt.% of crystalline propylene copolymer comprising 3.5 to 10.0 wt.% units formed by ethylene, and (B) from 10 to 40 wt.% of propylene copolymer comprising from 18.5 to 23.5 wt.% units formed by ethylene. The MFI value of the composition varies in the range from 3 to 20 g/10 min. Thereby, the Izod notched impact resistance are relatively low and are as follows: from 33.8 to 51.0 J/m at 23°C, from 9.9 to 45 J/m at 0°C, and from 3.3 to 4.9 J/m at 20°C. Moreover, the composition is characterized by low values of the flexural modulus from 500 to 700 MPa.

Therefore, the common drawback of the binary compositions based on the mixture of polypropylene and its copolymers with ethylene and other α-olefins of various contents and microstructure are difficulties in achieving a good balance of such parameters as flowability, impact resistance and hardness at maintaining optimal optical properties (transparency). One of the possible methods of solving the said problem known from the art is the use of binary heterophase mixture of isotactic polypropylene and ethylene-α-olefin elastomer. However, in order to obtain compositions characterized by transparency, a certain combination of structure and properties of both phases of these components is required.

A patent EP 0603723 claims a heterophase composition based on polypropylene with good optical and improved impact strength properties. This composition comprises: (A) from 70 to 98 wt.% of crystalline homopolypropylene or propylene copolymer with 0.5 to 10.0 wt.% contents of units of ethylene or other olefin other than propylene; and (B) from 2 to 30 wt.% elastomer based on copolymer of ethylene with α-olefin comprising from 4 to 10 carbon atoms. It is noted that ethylene content in the copolymer (B) may vary from 60 to 85 wt.%. Thereby, the xylene-soluble fraction should possess intrinsic viscosity in the range from 0.8 to 1.1 dl/g.

The technical solution of a similar essence is known from patent RU 2043373 where a composition and a method for preparing a polypropylene composition with improved transparency and impact resistance, is disclosed. The known composition comprises: (A) from 87.0 to 92.5 wt.% of crystalline copolymer of propylene and ethylene, and (B) from 7.5 to 13.0 wt.% of the elastomer based on copolymer of ethylene and C_3-C_4-α-olefin. The composition is made by two-stage copolymerization. The content of ethylene units introduced at second stage of copolymerization using titanium-magnesium catalysts varies from 25 to 68.5 wt.%. The additional conditions are certain values of intrinsic viscosities of xylene-soluble fractions of components A and B and also certain ratio of ethylene units in elastomeric, xylene-soluble ethylene copolymer. A nucleating agent is further added to the composition. The composition properties, however, are not so good: the Izod notched impact resistance is 118 J/m at 23°C and from 30.4 to 45.0 J/m at 0°C, flexural modulus is from 780 to 880 MPa.

The solution directed to producing a composition with optimal balance of mechanical and optical properties is disclosed in the patent RU 2315069. The content of elastomer in the composition is increased to the values from 30 to 45 wt.%, the xylene-soluble fraction content being at most 35 wt.%, preferably at most 30 wt.%. The obtained composition is characterized by combination of high flowability and impact resistance, expressed via the ductile-to-brittle transition temperature and Izod notched impact resistance. Thus, the impact resistance at room temperature reaches the value of 39.5 kJ/m^2 in such composition. The ductile-to-brittle transition temperature is at most -35°C. The MFI value of the composition is $\geq$ 15 g/10 min. A drawback of the composition is the low value of the flexural modulus: from 600 to 770 MPa.

Patent EP 2471858 represents a composition of a more complex content, comprising: (A) from 30 to 60 wt.% of homopolypropylene; (B) from 30 to 60 wt.% of random copolymer of propylene with α-olefins comprising 4 to 8 carbon atoms; (C) from 2 to 15 wt.% of the elastomer based on copolymer of ethylene with α-olefins comprising 4 to 8 carbon atoms; (D) homo- or copolymer of ethylene with the density from 0.905 to 0.920 g/cm^3 and (D) from 0.001 to 1.0 wt.% nucleating agent. The compositions is made according to multi-stage technology in several reactors. The obtained composition has a tension modulus from 100 to 1600 MPa. A drawback of this composition is low Charpy notched impact resistance that is from 4 to 7 kJ/m^2 at room temperature and from 2.5 to 3.0 kJ/m^2 at 0°C.

More ample opportunities for varying the structure and properties of the impact-resistant and transparent compositions based on polypropylene are provided by the use of three-component composition. Thus, patent US 8779064 proposes contents and method for making polypropylene compositions with good impact resistance and transparency. The composition contains a mixture of three components of different structure and properties. The main component (A) comprised in the composition in an amount of from 50 to 95 wt.% is a random copolymer of propylene comprising from 0.5 to 10 wt.% of ethylene or other α-olefin. Its production is carried out in a reactor according to suspension technology using Ziegler-Natta catalytic systems or metallocene catalysts. Further, the reaction mass obtained in the said reactor is fed to another reactor wherein at the second stage the B component is obtained, the content of which in the final composition may vary from 5 to 49 wt.%. The B component is an elastomer based on copolymer of propylene comprising from 20 to 70 wt.% of ethylene and/or butene units. Further, the obtained product (A + B) is mixed with component (C) via extrusion processing. The component (C) is a copolymer of ethylene with α-olefin comprising 4 to 10 carbon atoms, and its content in the composition is from 1 to 45 wt.%. The density of the component C may be varied in the range from 0.870 to 0.955 g/cm^3; therefore, both amorphous elastomers and plastomers and more crystalline (co)polymers of ethylene (LLDPE, MDPE and HDPE) may be used. The composition may also comprise nucleating agents and other standard additives. The required properties of the composition are achievable by varying the amount of the components (A + B + C) in the mixture, ratio of their viscosities, and also nature of each component. The properties of the obtained compositions outlined in the specific invention embodiment examples are varied in the following ranges: MFI is from 2.4 to 2.6 g/10 min, flexural modulus is from 930 to 1000 MPa, Izod notched impact resistance is from 550 to 570 J/m at 23°C and from 28 to 30 J/m at -20°C. A drawback of the composition is a sophisticated method for making thereof and also low flowability and insufficiently high impact resistance at low temperatures.

Another, more simplified technological approach consisting in producing formulations of compositions based on polypropylene with improved transparency and impact resistance via extrusion technology, is described in the patent EP 0557953. The composition comprises (A) a highly crystalline random copolymer of propylene with ethylene and/or α-olefin with 4 to 8 carbon atoms. Thereby, the said copolymer comprises from 85 to 99 wt.% of propylene, from 1 to 5 wt.% of ethylene, from 1 to 6 wt.% of α-olefin. The density of the copolymer (A) can be varied in the range from 0.885 to 0.910 g/cm^3. The B component, content of which in the composition is from 40 to 75 wt.%, is a binary mixture of elastomer (B1) based on copolymer of ethylene with α-olefin comprising 3 to 8 carbon atoms, with a density from 0.855 to 0.865 g/cm^3 (Mooney $ML(1+4)_{125}^{0}$ from 10 to 100 relative units) and component (B2) which is a polyethylene thermoplast (LDPE, LLDPE or HDPE or mixture thereof) with a density from 0.910 to 0.965 g/cm^3. A required condition for making transparent compositions is compliance with the density ratio, $d_{B1}/d_{B2} = 0.980 - 1.015$. A drawback of the proposed composition is an insufficiently good balance of impact resistance and flexural modulus. At the ductile-to-brittle transition temperature of less than –40°C the flexural modulus is from 200 to 600 MPa. At the achievable values of the flexural modulus of above 600 MPa the ductile-to-brittle transition temperature drastically increases to -15°C.

The closest in the technical essence to the claimed invention is the patent EP 2338657, which discloses a composition based on polypropylene with improved balance of impact resistance and transparency meant for use as a film material or for injection molded thin-walled articles used for packaging and storage of frozen products. In accordance with said invention a multi-component composition is proposed comprising a mixture of highly crystalline components: (A) from 30 to 60 wt.% of homopolypropylene; (B) from 10 to 50 wt.% of random copolymer with comonomer content of up to 5 wt.%; (C) from 10 to 20 wt.% of a mixture of two different elastomers based on ethylene copolymers differing in content of ethylene units and viscosity, (D) from 5 to 25 wt.% of homo- or random thermoplastic ethylene copolymer with a density of from 0.905 to 0.925 g/cm^3. Mixing of all said components is carried out in a melt. The obtained composition is characterized by the following properties: MFI ≥ 20 g/10 min, Charpy notched impact resistance from 7.0 to 12.0 kJ/m^2 (from ~70 to ~120 J/m) at 23°C, from 1.8 to 4.0 kJ/m^2 (from ~18 to ~40 J/m) at -20°C, the haze of 2 mm thick injection molded samples is from 70 to 80%. Drawbacks of this composition include sophisticated contents, insufficiently high impact resistance both at room and at decreased temperatures.

As it follows from prior art, the main problem of the proposed solutions remains an infeasibility of optimal balance of the main characteristic of the polypropylene-based compositions used for producing packaging films, containers and other injection molded thin-walled articles. Therefore, there is a need to produce a polypropylene-based composition, which, retaining good impact resistance, including at low temperature, has improved flowability, namely a high melt flow index and high hardness and transparency.

The aim of the present invention is to provide a polypropylene-based composition that is characterized by high flowability and optimal combination of mechanical and optical properties, in particular, hardness, impact resistance and transparency.

The technical result of the present invention consists in increasing impact strength and physical and mechanical properties of the polypropylene-based composition, while maintaining optimal optical properties, namely, transparency. Thus, the Izod notched impact resistance of the polypropylene-based composition is increased to the values from 150 to 517 J/m at 23°C and from 41 to 52 J/m at -20°C. Moreover, the composition has increased hardness, expressed via flexural modulus, which is from 910 to 1200 MPa. Thereby, the melt flow index of the composition is at the level of at least 20 g/10 min.

The additional technical result is simplifying the contents of the composition with respect to the prototype, which makes a method for making the composition more efficient.

There are several features essential for achieving the technical result according to the present invention:

1) The use of the polymer components selected from crystalline isotactic polypropylene, elastomer based on ethylene and thermoplastic polymer based on ethylene and/or copolymer thereof in the composition;

2) The use of the modifying system based on organic peroxide and co-agent that is a vinyl monomer with three or more acrylate functional groups the composition; and

3) The use of a nucleating agent.

The said technical result consisting in achieving the best transparency, is achievable at using an elastomer and a thermoplastic polymer at such weight ratio to each other, wherein the density of their mixture would be close or equal to the density of isotactic polypropylene; thereby, the elastomer content in the composition should be at least 10 wt.%. Moreover, high values of the composition transparency are provided at using the nucleating agent, preferably, a “brightener”.

The required flowability parameters and, simultaneously, high impact resistance and hardness parameters are achievable due to the use of crystalline isotactic polypropylene and also due to chemical modification of polymer components by modifying system comprising an organic peroxide and a co-agent, a vinyl monomer with three or more acrylate functional groups.

Thereby, in order to maintain an optimal ratio between optical and mechanical properties of the composition, it should be obtained using a two-stage method comprising a stage of making a modified concentrate composition and subsequent stage of mixing the obtained concentrate with a nucleating agent and, optionally, other additives, wherein the crystalline isotactic polypropylene used at the first stage and polypropylene used at the second stage differ from each other in melt flow index.

Description of the invention

In accordance with the present invention, a claimed composition comprises, based on the total weight of the composition:

(A) from 53.8 to 79.8 wt.% of crystalline isotactic homopolypropylene,

(B) from 10 to 20 wt.% of an elastomer based on copolymer of ethylene with α-olefins comprising 4 to 10 carbon atoms, and

(C) from 10 to 25 wt.% of one or more copolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising 3 to 10 carbon atoms, and also

(D) a modifying system comprising (D1) from 0.04 to 0.64 wt.% of organic peroxide, (D2) from 0.04 to 0.64 wt.% of co-agent, which is represented by a vinyl monomer with three or more acrylate functional groups, and

(E) from 0.05 to 1.0 wt.% of nucleating agent and optionally other additives.

Thereby, the crystalline isotactic polypropylene (A) is a mixture of polypropylenes (A') and (A") differing in the values of melt flow indices. In accordance with the present invention, two crystalline isotactic polypropylenes (A') and (A") with melt flow indices ($MFI_{230/2.16}$) of (A') from 2.0 to 4.0 g/10 min, preferably from 2.5 to 3.5 g/10 min, and that of (A") from 20 to 40 g/10 min, preferably from 25 to 35 g/10 min are used.

The weight ratio of isotactic polypropylenes (A') and (A") according to the invention is from 0.1 to 9, preferably from 0.25 to 4, most preferably from 0.73 to 3.5; so that the content of (A') + (A") would be equal to the content of (A), i.e. the total amount of A = (A') + (A") based on the total weight of the composition would be from 53.8 to 79.8 wt.%, preferably from 58.2 to 79.7 wt.%, most preferably from 63.7 to 79.6 wt.%.

As elastomer (B) a copolymer of ethylene with α-olefin comprising 4 to 10 carbon atoms is used, preferably the one obtained using metallocene catalytic systems. Preferably, a copolymer of ethylene with octene-1 is used. The said elastomer is characterized by density from 0.855 to 0.890 g/cm^3, preferably from 0.857 to 0.885 g/cm^3, and also a melt flow index ($MFI_{190/2.16}$) from 1 to 30 g/10 min.

The content of the elastomer (B) based on 100 wt.% of the composition is from 10 to 20 wt.%, preferably from 10 to 17 wt.%, most preferably from 10 to 15 wt.%.

The component (C) in the claimed composition comprises one or several homopolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising from 3 to 10 carbon atoms. The density of the said homo- or copolymer of ethylene is from 0.910 to 0.965 g/cm^3, preferably from 0.915 to 0.960 g/cm^3, $MFI_{190/216}$ value is from 0.1 to 10 g/10 min, preferably from 0.3 to 8 g/10 min. Therefore, any basic grades of industrial polyethylene compliant with the aforesaid requirements selected from low density polyethylene (LDPE), linear low density polyethylene (LLDPE), linear medium density polyethylene (LMDPE) and high density polyethylene(HDPE) may be used as the component (C).

In the present invention a polyethylene obtained according to the mechanism of radical-chain initiation of ethylene polymerization at high pressure (up to 2000 atm and more) in tubular- or autoclave-type reactors is used as LDPE. The LDPE comprised in the claimed composition is characterized by melt flow index ($MFI_{190°C/2.16kg}$) from 0.1 to 10 g/10 min, preferably from 0.2 to 10 g/10 min, more preferably from 0.3 to 5 g/10 min and has a density from 0.910 to 0.935 g/cm^3, preferably from 0.910 to 0.930 g/cm^3, more preferably from 0.915 to 0.925 g/cm^3.

The polyethylene obtained by a method of anionic and coordination copolymerization of ethylene with α-olefins comprising 4 to 10 carbon atoms at low pressure using Ziegler-Natta catalysts or using metallocene catalytic systems according to standard industrial technologies is used as LLDPE and LMDPE according to the present invention. The LLDPE comprised in the claimed composition is characterized by melt flow index ($MFI_{190°C/2.16kg}$) from 0.1 to 10 g/10 min, preferably from 0.3 to 10 g/10 min, more preferably from 0.5 to 5 g/10 min and has a density from 0.910 to 0.927 g/cm^3, preferably from 0.915 to 0.925 g/cm^3. The melt flow index ($MFI_{190°C/2.16kg}$) of LMDPE is from 0.1 to 10 g/10 min, preferably from 0.3 to 10 g/10 min, more preferably from 0.5 to 5 g/10 min and has a density from 0.930 to 0.940 g/cm^3, preferably from 0.930 to 0.935 g/cm^3.

Copolymers of ethylene with α-olefin comprising 4 to 10 carbon atoms, for example with α-olefin selected from the group comprising butene-1, hexene-1, octene-1 and other α-olefins are used as LLDPE and LMDPE according to the present invention. The most preferable is the polymer of ethylene with octene-1. The content of the α-olefin comonomer in LLDPE and LMDPE is from 2.5 to 8 wt.%, preferably from 3 to 6 wt.%, most preferably from 3.5 to 5 wt.%.

Polyethylene obtained by a method of anionic and coordination copolymerization of ethylene with higher α-olefins comprising 4 to 10 carbon atoms at low pressure using Ziegler-Natta catalysts, or using metallocene catalytic systems according to standard industrial technologies in used as HDPE in the present invention. The HDPE comprised in the claimed composition is characterized by values melt flow index ($MFI_{190°C/5kg}$) from 0.1 to 5 g/10 min, preferably from 0.3 to 5 g/10 min, more preferably from 0.5 to 5 g/10 min and has a density from 0.945 to 0.965 g/cm^3, preferably from 0.950 to 0.960 g/cm^3.

The content of the component (C) in the composition is from 10 to 25 wt.%, preferably from 10 to 23 wt.%, most preferably from 10 to 20 wt.% based on total weight of the composition.

In order to achieve the best technical result, the amounts of the components (B) and (C) are varied in the claimed ranges, so that:

1) the concentration of the elastomer (B) in the claimed composition is at least 10 wt.%, and

2) the density of the mixture of elastomer (B) and homopolymer of ethylene and/or its random thermoplastic copolymer with α-olefin comprising 4 to 10 carbon atoms (C) is close or equal to the density of isotactic polypropylene (A), i.e. so that the density of (B + C) is at least 0.995, preferably at least 0.997 of the density of the polypropylene (A) and at most 1.007, preferably at most 1.005 of the density of the polypropylene (A).

In order to provide an optimal balance of properties, the claimed composition necessarily comprises a modifying system (D) comprising, based on the total weight of the composition, from 0.04 to 0.64 wt.% of organic peroxide (D1), from 0.04 to 0.64 wt.% of co-agent (D2), which is a vinyl monomer with three or more acrylate functional groups. The use of the said modifying system, in the inventors' opinion, would provide, in particular, for improved distribution of the phase of elastomer (B) and homopolymer of ethylene and/or random thermoplastic homopolymer of ethylene (C) in the matrix of isotactic polypropylene (A) due to chemical interaction of all three polymer components.

The organic peroxide (D1) is selected from tert-butyl hydroperoxide, cumyl hydroperoxide, diisopropyl benzoyl hydroperoxide, di-tert-butyl peroxide, tert-butylcumyl peroxide, dicumyl peroxide, 1,3-1,4-bis(tert-butylperoxyisopropyl)benzene, acetyl peroxide, benzoyl peroxide, isobutyryl peroxide, bis-3,5,5-trimethylhexanoyl peroxide, methyl ethyl ketone peroxide and other peroxides.

Preferably, organic peroxides are used as individual components, because peroxide concentrates on inorganic and polymer carriers may decrease transparency of the obtained composition.

The content of the organic peroxide based on total weight of the composition is from 0.04 to 0.64 wt.%, preferably from 0.08 to 0.48 wt.%, most preferably from 0.1 to 0.40 wt.%.

The co-agent (D2) is a vinyl monomer with three or more acrylate functional groups. Pentaerythritol tetraacrylate, sorbitol hexaacrylate, xylitol pentaacrylate, glycerol triacrylate, trimethylolpropane triacrylate, preferably, trimethylolpropane triacrylate (TMPTA) are used as such monomers. Mono- and bifunctional esters, amides and other derivatives of acrylic monomers do not allow to achieve the desired technical result, as well as polyfunctional monomers of other nature, for example such as triallyl isocyanurate (TAIC), 1,3,5-trivinylcyclohexane and the like.

The content of the D2 co-agent based on total weight of the composition is from 0.04 to 0.64 wt.%, preferably from 0.08 to 0.48 wt.%, most preferably from 0.1 to 0.40 wt.%.

In order to provide greater transparency, apart from the polymer components (A, B and C) and modifying system (D) the claimed composition comprises (E) a nucleating agent in an amount from 0.05 to 1.0 wt.%, preferably from 0.1 to 0.8 wt.%, most preferably from 0.2 to 0.5 wt.% and also other optional additives. In accordance with the present invention, the nucleating agent of organic origin is used. It is also possible to use mixtures of nucleating agents.

The most preferable nucleating agents are derivatives of dibenzylidene sorbitol that are also known as “brighteners”. In particular, the nucleating agent is selected from 3,4-dimethyldibenzylidene sorbitol, bis(4-propylbenzylidene)propyl sorbitol and similar compounds.

The composition of the present invention may also comprise optional additives other than nucleating agents, such as e.g. antioxidants, heat stabilizers, stabilizers and also mixtures thereof. The content of such additives in the composition is preferably from 0 to 0.3 wt.%.

Examples of suitable antioxidants are 2,6-di-tert-butyl-p-cresol, tetrakis[methylene-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate]methane and also 3,5-di-tert-butyl-4-hydroxy-phenylpropionic acid pentaerythritol ester of Irganox 1010 trademark.

Examples of suitable heat stabilizers and light stabilizers comprise tri(phenyl-2,4-di-tert-butyl)phosphite known under Irgafos 168 trademark and/or analogous heat stabilizers of other trademarks and also light stabilizers like sterically hindered amines and mixture systems of stabilizers known under such trademarks as Irganox B225, Irganox B215.

The composition according to the invention is obtained by mixing all components using known techniques for mixing thermoplastic materials, e.g. extrusion or mixing in mixers of various designs. Closed mixers with blades or rotors, single screw extruders, extruders with two screws rotating in the same or opposite directions are used.

In accordance with the present inventions the composition is obtained by mixing the components and subsequently compounding the obtained mixture in the melt using equipment known from the art, e.g. mixing equipment (Banbury mixers, Brabender mixer), single screw, double screw extruders and other similar mixers. Preferably, mixing is carried out in a mixing equipment and further compounding of the obtained mixture is carried out in an extruder.

Thereby, a technological process of mixing polymers and additives in order to obtain a composition with homogenously mixed components is meant as compounding in the present invention.

The present inventors have unexpectedly found that mixing of all components in a single stage adversely affects the performance of the modifying system and nucleating agent (brightener), which does not lead to achievement of the required level of transparency of the obtained compositions. Therefore, use of the modifying system and nucleating agent in one stage is undesirable; therefore, the composition according to the present invention is obtained by a two-stage method comprising a stage of providing a modified concentrate composition as described below.

Stage I. Providing a concentrate composition

Mixing elastomer (B) based on copolymer of ethylene with α-olefin comprising 4 to 10 carbon atoms and (C) one or several homopolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising 3 to 10 carbon atoms with (A') a crystalline isotactic polypropylene, is carried out.

Thereby, the mixing of said components (A' + B + C) is carried out in the presence of the modifying system (D) comprising (D1) an organic peroxide in an amount from 0.1 to 0.8 wt.% and (D2) a co-agent in an amount from 0.1 to 0.8 wt.%, as which a vinyl monomer with three or more acrylate functional groups is used.

Mixing of components is carried out in a mixing equipment for a period of time from 1 to 20 minutes, preferably from 2 to 10 minutes, at a temperature from 10 to 50°C, preferably from 20 to 40°C. Further, the obtained mixture is compounded in a melt, preferably in an extruder, at a temperature from 190 to 240 °C, preferably from 220 to 230°C. Thereby, the number of screw rotations is about 250 min^{-1}.

Stage II. Providing a polypropylene-based composition

Mixing of the concentrate composition obtained at stage I in an amount from 40 to 80 wt.%, preferably from 50 to 70 wt.% with (A”) a crystalline isotactic polypropylene and (E) a nucleating agent and optionally other additives, is performed.

Mixing of the components is carried out in a mixing equipment for a period of time from 1 to 20 minutes, preferably from 2 to 10 minutes, at a temperature from 10 to 50°C, preferably from 20 to 40°C. Further, the obtained mixture is compounded in a melt, preferably in an extruder, at a temperature from 190 to 240°C, preferably from 220 to 230°C. The number of screw rotations is equal to about 250 min^{-1}.

Thereby, the use of preferably polypropylene A’ in the first stage and A” in the second stage that differ in the values of melt flow indices as isotactic crystalline polypropylene is preferable.

As A’ a polypropylene with a melt flow index from 2.0 to 4.0 g/10 min, preferably from 2.5 to 3.5 g/10 min is used. As A” a polypropylene is used with a melt flow index from 20 to 40 g/10 min, preferably from 25 to 35 g/10 min.

(A’) and (A”) are used at their weight ratio equal to from 0.1 to 9, preferably from 0.25 to 4, most preferably from 0.73 to 3.5; so that the total content of (A’) + (A”) is equal to the content of (A), i.e. the total amount of A = (A’) + (A”) based on the total weight of the composition is from 53.8 to 79.8 wt.%, preferably from 58.2 to 79.7 wt.%, most preferably from 63.7 to 79.6 wt.%.

Without wishing to be bound by any theory, the authors of the present invention believe that the use of the polypropylenes differing in the melt flow indices provides the formation of an interphase layer of certain morphology during modification of the dispersion heterophase mixture of (A) and (B) components. The modified products comprising polypropylene-co-agent-elastomer thus formed are necessarily characterized by a high level of molecular mass characteristics in order to provide stability, uniformity and high density of the entangled polymer chains network of the macrochains in the dispersion system of polypropylene (A') and elastomer (B) at the first stage of obtaining the composition. At using the more easily flowable polypropylene grades at the first stage it is impossible to provide the required balance of impact resistance, flowability and hardness of the obtained composition. Thereby, in order to provide the required level of flowability at the second stage of obtaining the composition the polypropylene (A") with higher melt flow index (MFI) is used.

The compounds described above are used as components (A), (B), (C), (D), (E) at producing the composition. Thereby, the content of the said components during producing the composition is varied in such a way, so the obtained composition complies with the claimed quantitative content; namely, comprises:

(A) from 53.8 to 79.8 wt.% of crystalline isotactic homopolypropylene,

(B) from 10 to 20 wt.% of an elastomer based on copolymer of ethylene with α-olefins comprising 4 to 10 carbon atoms, and

(C) from 10 to 25 wt.% of one or more copolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising 3 to 10 carbon atoms, and also

(D) a modifying system comprising (D1) from 0.04 to 0.64 wt.% of an organic peroxide, (D2) from 0.04 to 0.64 wt.% of a co-agent, as which a vinyl monomer with three or more acrylate functional groups is used, and

(E) from 0.05 to 1.0 wt.% of a nucleating agent and optionally additional additives.

As it has been already recited above, in order to achieve the best technical result, the ratios of the components (B) and (C) are varied in such a way, so that the density of the mixture of elastomer (B) and homopolymer (C) of ethylene and/or its thermoplastic copolymer with α-olefin comprising 4 to 10 carbon atoms , is close or equal to the density of isotactic polypropylene (A), i.e. it is required that the density of (B + C) is at least 0.995, preferably at least 0.997 of the density of the polypropylene (A) and at most 1.007, preferably at most 1.005 of the density of the polypropylene (A). Thereby, the concentration of the elastomer (B) in the composition should be at least 10 wt.%.

The compositions of the present invention are preferably used as a material for manufacturing injection-molded articles, preferably, articles obtained by injection molding. It is even more preferable to use the compositions of the present invention for making thin-walled containers and packaging articles such as plastic cups, household items and food packaging.

The present invention also concerns articles made of the composition according to the invention; preferably, such articles are produced by injection molding.

The invention would be further explained by examples which have been outlined for illustrating the invention and are not meant to restrict the scope thereof.

Examples

Test methods

The determination of the melt flow index (MFI) at the temperature of 230°C and load of 2.16 kg is carried out according to ASTM D 1238-04C.

The samples for mechanical tests are prepared by injection molding according to ASTM D 4101. The modes for injection molding on the injection molding machine Engel Victory 200/50 are as follows:

- injection volume: 31 cm^3;
- transition point: 3.5 cm^3;
- temperature of the zones: 230-230-225-220°C;
- mold temperature: 35 °C;
- dosage rate: 0.06 m/s;
- injection rate: 100 cm^3/s;
- injection pressure: 800 bar;
- velocity pressure: 50 bar;
- backup pressure: 400 bar;
- dwelling time: 20 s;
- cooling time: 30 s.

The determination of the Izod notched impact resistance at a temperature of 23°C and -10°C is carried out according to ASTM D 256 (testing type A).

The determination of haze and transparency for the 1 and 2 mm thick samples is carried out according to ASTM D1003.

The determination of the tensile stress at yield and elongation at yield is carried out according to ASTM D 638.

The determination of the flexural modulus is carried out according to ASTM D

790, testing type: three point bending, testing rate is 1.3 mm/min.

Components used in the examples.

The examples of the suitable polypropylenes (A’) comprise commercially available products known under the following trademarks: PPH 030 GP made by OOO “Tomskneftekhim”, OOO “Tobol'sk-Polymer”, OOO “Poliom”, NPO “Neftekhimija”, Balen 01030 made by OAO “Ufaorgsintez”, PP 1500J made by OOO “Nizhnekamskneftekhim” etc. Examples of the suitable polypropylenes (A”) are the products known under the following trademarks: PPH 270 GP made by OOO “Tomskneftekhim”, OOO “Tobol'sk-Polymer”, OOO “Poliom”, NPO “Neftehimija”, Balen 01270 made by OAO “Ufaorgsintez”, PP 1300R made by OOO “Nizhnekamskneftekhim” and the like. In particular, the following are used as crystalline isotactic homopolypropylene (A):

PPH030GP made by OOO “Tomskneftekhim”, ($MFI_{230°C/2.16}$ = 3 g/10 min),

PPH350FF made by OOO “Tomskneftekhim”, ($MFI_{230°C/2.16}$ = 25 g/10 min),

PPH270GP made by OOO “Tomskneftekhim”, ($MFI_{230°C/2.16}$ = 27 g/10 min).

Examples of suitable elastomers (B) are commercially available products known under such trademarks as, for example, Engage 8452, Engage 8842, Engage 8137, Exact 8210. In particular, the following are used as the elastomer (B) in the present invention:

Engage 8452, 8842, 8137 – a copolymer of ethylene and octene made by Dow Chemical,

Exact 8210 - a copolymer of ethylene and octene made by ExxonMobil,

EPDM R563 – a triple copolymer of ethylene, propylene and diene.

Any known trademarks of LDPE may be used as LDPE.

Examples of suitable thermoplastic copolymers of ethylene with α-olefins (component (C) comprise low density polyethylenes (LDPE), for example such as PE 15303-003, PE 15803-020, PE 10803-020,PE 11503-070, PE 16803-070, Novex 20P730, LDPE 19N430, CA 8200, MA 8200, or mixtures thereof, linear low density polyethylenes (LLDPE), for example such as XP 9400, XP 9200, XP 9100, 3306WC4, PE 5118Q, UF414C4, 3840, SABIC LLDPE 318B, SABIC LLDPE 6318 BE, SABIC LLDPE R500035, or mixtures thereof, or linear medium density polyethylenes (LMDPE) such as e.g. DOWLEX 5066, Lumicene M3410 EP, or mixtures thereof, and also high density polyethylenes (HDPE), e.g. PE 6948C, PND-276-73, PND 273-83, SABIC HDPE B5205, SABIC HDPE B5429, SABIC HDPE F04660, PND PE30T-49, or mixture thereof.

In particular, for the present invention it is preferable to use the following compounds as the thermoplastic copolymers of ethylene with α-olefins (C):

Daelim XP 9200, 9400 – metallocene linear low density polyethylene,
LDPE 15303-003 - low density polyethylene made by OOO “Tomskneftekhim”,
HDPE 276-73 – high density polyethylene made by OOO “Kazanorgsintez”.

Examples of suitable peroxides are products known under the following trademarks: Trigonox 301, Luperox DCP, Luperox DI, Luperox DTA, Luperox F, Luperox 101, Luperox 801. In particular, it is preferable to use as organic peroxide (D1) the Trigonox 301, a cyclic peroxide made by AkzoNobel. Trimethylolpropane triacrylate (TMPTA), 1,4-butanediol dimethacrylate (BDDMA), triallyl isocyanurate (TAIC) are used as co-agents (D2).

Examples of the nucleating agents suitable for use in the compositions of the present invention comprise products known under the trademarks Millad 3988, Millad 8000, in particular, a brightener Millad 8000 made by Milliken is used as the nucleating agent (E).

Example 1 (comparative).

Stage I. A mixture is prepared in a blade mixer according to the formulation of the concentrate composition (K-1) shown in Table 1. Such a ratio of elastomer component (B) and polyethylene thermoplast (C) is selected that the density of the mixture (B + C) is equal to 0.900 g/cm^3. Then the polymer components A + (B + C), organic peroxide (D1) and co-agent (D2) are mixed for 2 to 10 minutes at room temperature. The obtained mixture is then processed in the LTE-20-44 double screw extruder at a maximum temperature in cylinder zone of 230°C and number of screw rotations equal to 250 min^{-1}. The granulate obtained at the line of this extruder is further used in stage II of the composition preparation.

Stage II. A mixture is prepared in a blade mixer according to the formulation shown in Table 2 and mixing is carried out for 2 to 10 minutes at a temperature of 20 to 50°C. For a more uniform distribution of additives (nucleating agent and other possible additives) in the composition mass, mineral oil in an amount of up to 0.2 wt.% may be optionally applied to the granules. The obtained mixture of components is processed in the LTE-20-44 double screw extruder at a maximum temperature in cylinder zone of 210°C and number of screw rotations equal to 250 min^{-1}. The second stage granulate obtained at the line of the LTE-20-44 extruder is further used in a dry form for determination of the $MFI_{230/2.16}$ values and for preparing samples by injection molding method for subsequent mechanical, optical, and physical tests.

The results of all tests of the obtained compositions are shown in Table 2.

Example 2.

The example is carried out according to the Example 1 except that 60.0% of the modified concentrate K-1 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 155 J/m and 42 J/m respectively. The haze of the 2 mm-thick sample is 74.1%.

Example 3.

The example is carried out according to the Example 1 except that 70.0% of the modified concentrate K-1 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 486H J/m (H - hinge break) and 48 J/m respectively. The haze of the 2 mm-thick sample is 75.4%.

Example 4.

The example is carried out according to the Example 1 except that 80.0% of the modified concentrate K-1 is dosed at stage II. The results of all tests are outlined in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23 °C and -20 °C equal to 517H J/m and 52 J/m respectively. The haze of the 2 mm sample is 79.4%.

Example 5 (comparative).

The example is carried out according to the Example 1 except that 85.0% of the modified concentrate K-1 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 528H J/m and 56 J/m respectively. The haze of the 2 mm-thick sample is 85.3%.

Example 6 (comparative).

The example is carried out according to the Example 1 except that the modified K-2 concentrate formulation (Table 1) is used at stage I, and 80.0% of the modified concentrate K-2 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 143 J/m and 40 J/m respectively. The haze of the 2 mm sample is 80.0%.

Example 7.

The example is carried out according to the Example 1 except that the modified K-3 concentrate formulation (Table 1) is used at stage I, and 80.0% of the modified concentrate K-3 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 157 J/m and 41 J/m respectively. The haze of the 2 mm-thick sample is 74.3%.

Example 8.

The example is carried out according to the Example 1 except that the modified K-4 concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-4 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 208 J/m and 43 J/m respectively. The haze of the 2 mm-thick sample is 65.1%.

Example 9.

The example is carried out according to the Example 1 except that the modified K-5 concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-5 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 157 J/m and 43 J/m respectively. The haze of the 2 mm-thick sample is 79.5%.

Example 10.

The example is carried out according to the Example 1 except that the modified K-6 concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-6 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 355H J/m and 45 J/m respectively. The haze of the 2 mm-thick sample is

75.1%.

Example 11.

The example is carried out according to the Example 1 except that the modified K-7 concentrate formulation (see Table 1) is used at stage I, and 40.0% of the modified concentrate K-7 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 162 J/m and 42 J/m respectively. The haze of the 2 mm-thick sample is 60.1%.

Example 12.

The example is carried out according to the Example 1 except that the modified K-8 concentrate formulation (see Table 1) is used at stage I, and 60.0% of the modified concentrate K-8 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23 °C and -20 °C equal to 151 J/m and 41 J/m respectively. The haze of the 2 mm sample is 71.4%.

Example 13.

The example is carried out according to the Example 1 except that the modified K-9 concentrate formulation (see Table 1) is used at stage I, and 60.0% of the modified concentrate K-9 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 178 J/m and 44 J/m respectively. The haze of the 2 mm-thick sample is 75.6%.

Example 14 (comparative).

The example is carried out according to the Example 1 except that the modified K-10 (comp.) concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-10 (comp.) is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 175 J/m and 42 J/m respectively. The haze of the 2 mm-thick sample is 85.0%.

Example 15 (comparative).

The example is carried out according to the Example 1 except that the modified K-11 (comp.) concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-11 (comp.) is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 79 J/m and 33 J/m respectively. The haze of the 2 mm-thick sample is 64.1%.

Example 16.

The example is carried out according to the Example 1 except that the modified K-12 concentrate formulation (Table 1) is used at stage I, and 50.0% of the modified concentrate K-12 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 168 J/m and 43 J/m respectively. The haze of the 2 mm-thick sample is 75.3%.

Example 17.

The example is carried out according to the Example 1 except that the modified K-13 concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-13 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 259 J/m and 48 J/m respectively. The haze of the 2 mm-thick sample is 77.9%.

Example 18 (comparative).

The example is carried out according to the Example 1 except that the modified K-14 (comp.) concentrate formulation (Table 1) is used at stage I, and 70.0% of the modified concentrate K-14 (comp.) is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 77 J/m and 35 J/m respectively. The haze of the 2 mm-thick sample is 95.1%.

Example 19 (comparative).

The example is carried out according to the Example 1 except that the modified K-15 (comp.) concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-15 (comp.) is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 116 J/m and 35 J/m relatively. The haze of the 2 mm-thick sample is 70.1%.

Example 20 (comparative).

The example is carried out according to the Example 1 except that the modified K-16 (comp.) concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-16 (comp.) is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 111 J/m and 32 J/m respectively. The haze of the 2 mm-thick sample is 72.4%.

Example 21 (comparative).

The example is carried out according to the Example 1 except that the modified K-17 (comp.) concentrate formulation (Table 1), wherein the ratio of elastomer (B) (Engage 8452) to component C (LLDPE Daelim XP9200) is altered so that the total density of the B + C mixture is the value of 0.891 g/cm^3, is used at stage I, and 50.0% of the modified concentrate K-17 (comp.) is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 198 J/m and 48 J/m respectively. The haze of the 2 mm-thick sample is 87.6%.

Example 22 (comparative).

The example is carried out according to the Example 1 except that the non-modified K-18 (comp.) concentrate formulation (Table 1) is used at stage I, and 60.0% of the non-modified concentrate K-18 (comp.) is dosed at stage II. The results of all tests are outlined in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 75 J/m and 29 J/m respectively. The haze of the 2 mm-thick sample is 70.2%.

Example 23 (comparative).

The example is carried out according to the Example 1 except that the modified K-13 concentrate formulation (Table 1) is used at stage I, and 60.0% of the modified concentrate K-13 is dosed at stage II without the use of nucleating agent. The results of all tests are outlined in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 215 J/m and 47 J/m respectively. The haze of the 2 mm-thick sample is 89.1%.

Example 24 (comparative).

The polypropylene (PP) composition with the content of the components analogous to Example 2 is prepared in one stage without preliminary making of the modified concentrate. For this purpose a mixture is prepared in a blade mixer according to the formulation outlined in Table 2, and mixing is carried out for 2 to 10 minutes at a temperature of 20 to 50°C. The obtained mixture of components is processed in the LTE-20-44 double screw extruder at maximum temperature in cylinder zones of 230°C and a number of screw rotations of 250 min^{-1}. The second stage granulate obtained on the line of the LTE-20-44 extruder is further used in dry form for determination of the $MFI_{230/2.16}$ values and for making samples by injection molding method for subsequent mechanical,optical, and physical tests (names of tests are shown in Table 2). The molding modes in the injection molding machine are analogous to the Example 1. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 158 J/m and 42 J/m respectively. The haze of the 2 mm-thick sample is 89.7%.

Example 25.

The example is carried out according to the Example 1 except that the modified K-7 concentrate formulation (Table 1) is used at stage I, and 80.0% of the modified concentrate K-7 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 162 J/m and 42 J/m respectively. The haze of the 2 mm-thick sample is 60.1%.

Example 26.

The example is carried out according to the Example 1 except that the modified K-7-1 concentrate formulation (Table 1) is used at stage I, and 40.0% of the modified concentrate K-7-1 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 159 J/m and 42 J/m respectively. The haze of the 2 mm-thick sample is 65.0%.

Example 27.

The example is carried out according to the Example 1 except that the modified K-19 concentrate formulation (Table 1) is used at stage I, and 80.0% of the modified concentrate K-19 is dosed at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 505H J/m and 50 J/m respectively. The haze of the 2 mm-thick sample is

79.7%.

Example 28.

The example is carried out according to the Example 11 except that 0.05% of the nucleating agent is used at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 157 J/m and 41 J/m respectively. The haze of the 2 mm-thick sample is 71.4%.

Example 29.

The example is carried out according to the Example 11 except that 1.0% of the nucleating agent is used at stage II. The results of all tests are shown in Table 2. The obtained composition is characterized by Izod notched impact resistance at +23°C and -20°C equal to 168 J/m and 43 J/m respectively. The haze of the 2 mm-thick sample is 64.5%.

Table 1. Formulation of the concentrate compositions obtained at stage I of the **composition preparation**

No.	**Contents, wt.%**		**K-1**	**K-2**	**K-3**	**K-4**	**K-5**	**K-6**	**K-7**	**K-7-1**	**K-8**	**K-9**
1	Component (A)*	PPH030GP	59.2	59.2	59.2	59.2	59.2	54.3	49.3	49.8	59.5	58.8
2	Component (B)	Engage 8452	16.74	-	-	-	16.74	18.84	-		16.74	16.74
3		Engage 8842	-	11.80	-	-	-	-	-		-	-
4		Engage 8137	-	-	13.33	-	-	-	-		-	-
5		Exact 8210	-	-	-	20.0	-	-	25.0	25.0	-	-
6	Component (C)	Daelim XP 9200	23.26	28.20	26.67	20.0	-	26.16	25.0	25.0	23.26	23.26
7		HDPE 153	-	-	-	-	23.26	-	-	-	-	-
8	Component (D1)	Trigonox 301	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.1	0.4	0.4
9	Component (D2)	TMPTA	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.8

Table 1 (continued).

No.	Contents, wt.%		K-10 (comp.)	K-11 (comp.)	K-12	K-13	K-14 (comp)	K-15 (comp)	K-16 (comp)	K-17 (comp)	K-18 (comp)	K-19
1	Component (A)*	PPH030GP	58.6	49.60	49.35	58.9	59.4	58.9	58.9	59.2	-	58.4
2		PPH350FF									60.0	
3	Component (B)	Engage 8452	16.74	20.93	20.93	23.33	-	16.74	16.74	25.0	16.74	16.74
4		EPDM R563		-	-	-	15.0	-	-	-	-	
5	Component (C)	Daelim XP 9200	23.26	29.07	-	10.01	25.0	23.26	23.26	15.0	23.26	23.26
6		Daelim XP 9400		-	29.07	-	-	-	-	-	-	
7		LDPE 276-73		-	-	6.66	-	-	-	-	-	
8	Component (D1)	Trigonox 301	0.4	0.4	0.25	0.4	0.4	0.4	0.4	0.4	-	0.8
9	Component (D2)	TMPTA	1.0	-	0.4	0.7	0.2	-	-	0.4	-	0.8
10		BDDMA	-	-	-	-	-	0.7	-	-	-	
11		TAIC	-	-	-	-	-	-	0.7	-	-	

* isotactic homopolypropylene added at stage I of the preparation

Table 2. Contents and properties of the obtained compositions (based on mixtures from Stage I).

No.	**Contents, wt.%**		**Example 1 (comp)**	**Example 2**	**Example 3**	**Example 4**	**Example 5 (comp)**	**Example 6 (comp)**	**Example 7**	**Example 8**
1	Component (A)**	PPH270GP	49.7	39.7	29.7	19.7	14.7	19.7	19.7	19.7
2	Concentrate compositions (K), obtained at Stage I	K-1	50.0	60.0	70.0	80.0	85			
3		K-2						80.0		
4		K-3							80.0	
5		K-4								60,0
6	Nucleating agent	Millad 8000	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
7	Contents of component (B) in the composition, % wt.		8.37	10.05	11.73	13.39	14.23	9.44	10.66	12.0
Properties of the obtained composition										
1	$MFI_{230/2.16}$, g/10 min		27.8	25.4	23.6	21.1	18.6	18.9	24.6	27.8
2	TSY, MPa		24.1	23.6	22.2	21.5	20.4	23.2	21.3	25.4
3	EY, %		9	10	11	12	12	11	11	10
4	FM, MPa		1120	1060	980	910	840	960	940	1110
5	Izod notched +23°C, J/m		114	155	486H	517H	528H	143	157	208
6	Izod notched -20°C, J/m		35	42	48	52	56	40	41	43
7	Haze 1mm/2mm, %*		45.3/ 70.5	47.3/ 74.1	48.6/ 75.4	50.1/ 79.4	58.9/ 85.3	56.3/ 80.0	44.2/ 74.3	33.5/ 65.1
8	Transparency 1mm/2mm, %		87.4/ 49.6	85.2/ 48.4	82.3/ 45.6	79.3/ 41.2	73.2/ 39.4	71.2/ 40.3	85.1/ 46.8	88.9/ 67.2

TSY - Tensile Stress at Yield

EY - Elongation at Yield

FM - Flexural Modulus

Table 2 (continued)

No.	**Contents, wt.%**		**Example 9**	**Example 10**	**Example 11**	**Example 12**	**Example 13**	**Example 14 (comp)**	**Example 15 (comp)**	**Example 16**
1	Component (A)**	PPH270 GP	39.7	39.7	59.7	39.7	39.7	39.7	39.7	49.7
2	Concentrate compositions (K), obtained at Stage I	K-5	60.0							
3		K-6		60.0						
4		K-7			40.0					
5		K-8				60.0				
6		K-9					60.0			
7		K-10 (comp)						60.0		
8		K-11 (comp)							60.0	
9		K-12								50.0
10	Nucleating agent	Millad 8000	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
11	Contents of component (B) in the composition, % wt.		10.05	11.30	10.0	10.05	10.05	10.05	10.05	10.47
Properties of the obtained composition										
1	$MFI_{230/2.16}$, g/10 min		22.3	24.2	27.6	26.7	22.3	19.5	22.7	21.8
2	TSY, MPa		21.5	23.1	26.2	22.9	24.4	25.2	21.3	23.4
3	EY, %		10	11	9	10	11	11	9	10
4	FM, MPa		1080	1010	1250	990	1050	1060	840	1040
5	Izod notched +23°C, J/m		157	355H	162	151	178	175	79	168
6	Izod notched -20°C, J/m		43	45	42	41	44	42	33	43
7	Haze 1mm/2mm, %*		58.4/ 79.5	46.3/ 75.1	30.4/ 60.1	42.3/ 71.4	49.9/ 75.6	59.3/ 85.0	39.2/ 64.1	51.5/ 75.3

8	Transparency 1mm/2mm, %	70.4/ 43.6	86.2/ 47.3	95.3/ 75.9	89.3/ 61.2	83.2/ 49.6	80.2/ 41.3	94.1/ 69.3	80.9/ 47.2

Table 2 (continued)

No.	**Contents, wt.%**		Example 17	Example 18 (comp.)	Example 19 (comp.)	Example 20 (comp.)	Example 21 (comp.)	Example 22 (comp.)	Example 23 (comp.)	Example 24 (comp.)
1	Component (A)	PPH270GP	39.7	29.7	39.7	39.7	49.7	39.7	-	-
2		PPH350FF							40.0	-
3		PPH030GP								75.04
4	Component (B)	Engage 8452								10.05
5		Daelim XP9200								13.96
5	Concentrate compositions (K), obtained at Stage I	K-13	60.0						60.0	
6		K-14(comp)		70.0						
7		K-15(comp)			60.0					
8		K-16(comp)				60.0				
9		K-17(comp)					50.0			
10		K-18 (comp)						60.0		
11	Nucleating agent	Millad 8000	0.3	0.3	0.3	0.3	0.3	0.3	-	0.3
12	Component (D1)	Trigonox 301								0.25
13	Component (D2)	ТМПТА								0.4
14	Contents of component (B) in the composition, % wt.		13.98	10.5	10.05	10.05	12.5	10.05	10.05	10.05
Properties of the obtained composition										
1	$MFI_{230/2.16}$, g/10 min		21.5	22.1	28.1	29.7	23.3	25.5	21.7	20.0
2	TSY, MPa		25.7	23.6	20.2	19.2	22.1	19.7	23.4	25.8
3	EY, %		10	10	9	9	10	5	10	10
4	FM, MPa		1120	910	810	880	930	960	990	1080

5	Izod notched +23°C, J/m	259	77	116	111	198	75	215	158
6	Izod notched -20°C, J/m	48	35	35	32	48	29	47	42
7	Haze 1mm/2mm, %*	56.1/ 77.9	80.3/ 95.1	43.2/ 70.1	44.1/ 72.4	72.9/ 87.6	39.3/ 70.2	71.7/ 89.1	69.8/ 89.7
8	Transparency 1mm/2mm, %	72.2/ 44.2	18.2/ 6.7	85.3/ 49.9	81.3/ 41.2	33.2/ 19.6	81.5/ 61.3	56.1/ 29.3	71.1/ 31.2

* isotactic homopolypropylene (A'), added at Stage I of the preparation; ** isotactic homopolypropylene (A"), added at Stage II of the preparation

H – hinge break: incomplete destruction of the sample wherein parts of the sample are held together by only thin peripheral layer in a form of a hinge, having low residual hardness, **TSY** – tensile strength at yield, **EY** – elongation at yield, **notched** – test of impact resistance with notch, **MFI** – melt flow index

Table 2 (continued)

No.	**Contents, wt.%**		**Example 25**	**Example 26**	**Example 27**	**Example 28**	**Example 29**
1	Component (A)**	PPH270GP	19.7	59.7	19,7	59.95	59.0
2	Concentrate compositions (K), obtained at Stage I	K-7	80.0			40,0	40,0
3		K-7-1		40,0			
4		K-19			80,0		
10	Nucleating agent	Millad 8000	0.3	0.3	0,3	0.05	1,0
11	Contents of component (B) in the composition, wt.%		20,0	10,0	13,39	10,0	10,0
Properties of the obtained composition							
1	$MFI_{230/2.16}$, g/10 min		21.2	20.2	20.0	20.7	20.1
2	TSY, MPa		22.4	24.1	22.0	23.5	24.9
3	EY, %		11	11	12	11	11
4	FM, MPa		940	1200	970	1150	1250
5	Izod notched +23°C, J/m		450H	159H	505H	157	168

6	Izod notched -20°C, J/m	50	42	50	41	43
7	Haze 1mm/2mm, %*	48.4/75.5	31.3/65.0	51.3/79.7	42.3/71.4	31.0/64.5
8	Transparency 1mm/2mm, %	80.6/44.2	92.2/73.2	77.5/40.3	90.3/71.0	93.0/74.6

As it is seen from the presented experimental data, the polypropylene-based composition obtained in accordance with the method of the present invention has an improved balance of properties compared to prototypes and analogues and has the following parameters (in accordance with the Examples 2-4, 7-13, 16-17, Table 2):

- Izod notched impact resistance at +23°C – from 151 J/m to 517 J/m; at -20°C – from 41 J/m to 52 J/m;

- Flexural modulus – from 910 MPa to 1250 MPa;

- $MFI_{230/2.16}$ - from 21.1 g/10 min to 27.8 g/10 min;

- Haze of 2 mm cast samples – from 60.1% to 79.5%.

The compositions wherein the contents of components and their ratios are outside the claimed ranges, demonstrate a significant deterioration of strength, mechanical and optical properties, which is confirmed by experimental data according to Examples 1, 5, 6 and 22.

Moreover, an infeasibility of the technical result has been shown at making the composition in the absence of modifying system, in particular, organic peroxide (D1) and co-agent (D2) (see Example 22, Table 2). Thereby, the content of the co-agent D2 in the modifying system is an important condition because its absence affects impact and strength characteristics of the composition, and its content above the claimed range affects the optical properties (see Example 15 and Example 14, correspondingly). It has been also shown that the use of the co-agent of another nature, in particular, BDDMA instead of TMPTA (Example 19, Table 2) or TAIC instead of TMPTA (Example 20, Table 2) leads to significant decrease in impact and strength properties of the composition, which indicates a necessity to use the vinyl monomer with three or more acrylate functional groups as co-agent.

The obtained experimental data indicate that the best technical result is achievable at using nucleating agent in the composition, whereas in its absence optical properties of the composition decrease (Example 23, Table 2). Thereby, it is essential to implement the method of making the composition in 2 stages as it is described in the present invention. Otherwise, at simple mixing of all of the components in one stage the obtained compositions would be characterized by insufficient balance of mechanical and optical properties (see Example 24, Table 2).

WHAT IS CLAIMED IS:

1. A polypropylene-based composition for preparation of injection molded articles, comprising the following components, based on the total weight of the composition:

(A) from 53.8 to 79.8 wt.% of crystalline isotactic polypropylene,

(B) from 10 to 20 wt.% of elastomer based on copolymer of ethylene with α-olefin comprising 4 to 10 carbon atoms, and

(C) from 10 to 25 wt.% of one or several homopolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising 3 to 10 carbon atoms; and also

(D) a modifying system comprising from 0.04 to 0.64 wt.% of organic peroxide (D1) and from 0.04 to 0.64 wt.% of co-agent (D2), that is a vinyl monomer with three or more acrylate functional groups, and

(E) from 0.05 to 1.0 wt.% of nucleating agent.

2. The composition of claim 1 wherein the content of (A) crystalline isotactic polypropylene is from 58.2 to 79.7 wt.%, based on the total weight of the composition.

3. The composition of claim 2 wherein the content of (A) crystalline isotactic polypropylene is from 63.7 to 79.6 wt.%, based on the total weight of the composition.

4. The composition of claim 1 wherein the content of the said elastomer (B) is from 10 to 17 wt.%, based on the total weight of the composition.

5. The composition of claim 4 wherein the content of the said elastomer (B) is from 10 to 15 wt.%, based on the total weight of the composition.

6. The composition of claim 1 wherein the content of the component (C) is from 10 to 23 wt.%, based on the total weight of the composition.

7. The composition of claim 6 wherein the content of the component (C) is from 10 to 20 wt.%, based on the total weight of the composition.

8. The composition of claim 1 wherein the content of the organic peroxide (D1) is from 0.08 to 0.48 wt.%, based on the total weight of the composition.

9. The composition of claim 8 wherein the content of the organic peroxide (D1) is from 0.1 to 0.4 wt.%, based on the total weight of the composition.

10. The composition of claim 1 wherein the content of the co-agent (D2) is from 0.08 to 0.48 wt.%, based on the total weight of the composition.

11. The composition of claim 10 wherein the content of the co-agent (D2) is from 0.1 to 0.4 wt.%, based on the total weight of the composition.

12. The composition of claim 1 wherein the content of the nucleating agent (E) is from 0.1 to 0.8 wt.%, based on the total weight of the composition.

13. The composition of claim 12 wherein the content of the nucleating agent (E) is from 0.2 to 0.5 wt.%, based on the total weight of the composition.

14. The composition of claim 1 wherein the composition further comprises optional additives in an amount from 0 to 0.3 wt.%, based on the total weight of the composition.

15. The composition of claim 1 wherein the crystalline isotactic polypropylene (A) is a mixture of polypropylenes (A') and (A") differing in melt flow index values.

16. The composition of claim 15 wherein the values of melt flow index of the polypropylenes A' and A" are from 2.0 to 4.0 g/10 min and from 20 to 40 g/10 min respectively.

17. The composition of claim 14 wherein the values of melt flow index of the polypropylenes A' and A" are from 2.5 to 3.5 g/10 min and from 25 to 35 g/10 min respectively.

18. The composition of claim 1 wherein a copolymer of ethylene with octene-1 is used as the elastomer (B).

19. The composition of claim 18 wherein the said elastomer (B) based on the copolymer of ethylene with α-olefin is characterized by the density from 0.855 to 0.890 g/cm^3.

20. The composition of claim 18 wherein the said elastomer (B) is characterized by the density from 0.857 to 0.885 g/cm^3.

21. The composition of claim 19 wherein the said elastomer (B) is characterized by the melt flow index ($MFI_{190/2.16}$) from 1 to 30 g/10 min.

22. The composition of claim 1 wherein the said component (C) is selected from polymers selected from the group of low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), linear medium density polyethylene (LMDPE) and high density polyethylene (HDPE).

23. The composition of claim 1 wherein the said component (C) is characterized by the density from 0.910 to 0.965 g/cm^3.

24. The composition of claim 21 wherein the said component (C) is characterized by the density from 0.915 to 0.960 g/cm^3.

25. The composition of claim 1 wherein the said component (C) is characterized by the melt flow index (MFI$_{190/2.16}$) from 0.1 to 10 g/10 min.

26. The composition of claim 23 wherein melt flow index (MFI$_{190/2.16}$) of the component (C) is from 0.3 to 8 g/10 min.

27. The composition of claim 1 wherein the elastomer (B) and homopolymer and/or copolymer (C) are used in such weight ratio to each other, that the density of the mixture (B + C) is similar or equal to the density of isotactic polypropylene (A).

28. The composition of claim 27 wherein the density of the mixture of elastomer (B) and homopolymer and/or copolymer (C) is at least 0.995, preferably at least 0.997 of the density of the isotactic polypropylene (A) and at most 1.007, preferably at most 1.005 of the density of the isotactic polypropylene (A).

29. The composition of claim 27 wherein the elastomer (B) and homopolymer and/or copolymer (C) are used in such weight ratio to each other, that the concentration of elastomer (B) in the composition is at least 10 wt.% based on the total weight of the composition.

30. The composition of claim 1 wherein the organic peroxide (D1) is selected from the group comprising tert-butyl hydroperoxide, cumyl hydroperoxide, diisopropyl benzoyl hydroperoxide, di-tert-butyl peroxide, tert-butylcumyl peroxide, dicumyl peroxide, 1,3-1,4-bis(tert-butylperoxyisopropyl)benzene, acetyl peroxide, benzoyl peroxide, isobutyryl peroxide, bis-3,5,5-trimethylhexanoyl peroxide, methyl ethyl ketone peroxide.

31. The composition of claim 1 wherein trimethylolpropane triacrylate is used as a vinyl monomer of the co-agent (D2).

32. The composition of claim 1 wherein a nucleating agent of organic origin or a mixture of such nucleating agents are used as nucleating agent (E).

33. The composition of claim 32 wherein "brighteners" are used as nucleating agent of organic origin.

34. The composition of claim 32 wherein derivatives of dibenzylidene sorbitol, such as 3,4-dimethyldibenzylidene sorbitol, bis(4-propylbenzylidene)propyl sorbitol or mixture thereof are used as nucleating agent.

35. The composition of claim 14 wherein optional additives other than nucleating agent particularly comprise antioxidants, heat stabilizers, stabilizers and also mixtures thereof.

36. A method for preparing a polypropylene-based composition comprising the stages of:

I) Providing a concentrate composition by mixing (B) an elastomer based on copolymer of ethylene with α-olefin comprising 4 to 10 carbon atoms and (C) one or several homopolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising 3 to 10 carbon atoms with (A') a crystalline isotactic polypropylene with MFI from 2.0 to 4.0 g/10 min, in a presence of a modifying system (D) comprising (D1) an organic peroxide taken and (D2) a co-agent, as which a vinyl monomer with three or more acrylate functional groups is used, and subsequent compounding of the obtained mixture in a melt; and

II) Mixing of the concentrate composition obtained at stage (I) taken in an amount from 40 to 80 wt.% with (A") a crystalline isotactic polypropylene having MFI value from 20 to 40 g/10 min and (E) a nucleating agent with subsequent compounding of the said mixture in a melt.

37. The method for preparing a composition of claim 36, wherein the amounts of the component used are varied in such a way, so the composition obtained in accordance with the claimed method comprises:

(A' + A") = (A) from 53.8 to 79.8 wt.% of crystalline isotactic polypropylene,

(B) from 10 to 20 wt.% of elastomer based on copolymer of ethylene with α-olefin comprising 4 to 10 carbon atoms, and

(C) from 10 to 25 wt.% of one or several homopolymers of ethylene and/or random thermoplastic copolymers of ethylene with α-olefins comprising 3 to 10 carbon atoms; and also

(D) a modifying system comprising from 0.04 to 0.64 wt.% of organic peroxide (D1) and from 0.04 to 0.64 wt.% of co-agent (D2), that is a vinyl monomer with three or more acrylate functional groups, and

(E) from 0.05 to 1.0 wt.% of nucleating agent and optionally additional additives.

38. The method for preparing a composition of claim 36, wherein the

components (A') and (A") are used at their weight ratio equal to from 0.1 to 9, preferably from 0.25 to 4, most preferably from 0.75 to 3.5.

39. The method for preparing a composition of claim 36, wherein the component (A') is a crystalline isotactic polypropylene characterized by the melt flow index from 2.5 to 3.5 g/10 min.

40. The method for making a composition of claim 36, wherein the component (A") is a crystalline isotactic polypropylene characterized by the melt flow index from 25 to 35 g/10 min.

41. The method for preparing a composition of claim 36, wherein a copolymer of ethylene with octene-1 is used as elastomer (B).

42. The method for preparing a composition of claim 36, wherein the elastomer (B) is characterized by the density from 0.855 to 0.890 g/cm^3.

43. The method for preparing a composition of claim 42, wherein the elastomer (B) is characterized by the density from 0.857 to 0.885 g/cm^3.

44. The method for preparing a composition of claim 36, wherein the elastomer (B) is characterized by the melt flow index ($MFI_{190/2.16}$) from 1 to 30 g/10 min.

45. The method for preparing a composition of claim 36, wherein any polymers from the group of LDPE, LLDPE, LMDPE and HDPE are used as component (C).

46. The method for preparing a composition of claim 36, wherein the component (C) is characterized by the density from 0.910 to 0.965 g/cm^3.

47. The method for preparing a composition of claim 46, wherein the said component (C) is characterized by the density from 0.915 to 0.960 g/cm^3.

48. The method for preparing a composition of claim 36, wherein the said component (C) is characterized by the melt flow index ($MFI_{190/2.16}$) from 0.1 to 10 g/10 min.

49. The method for preparing a composition of claim 48, wherein the said component (C) is characterized by the melt flow index ($MFI_{190/2.16}$) from 0.3 to 8 g/10 min.

50. The method for preparing a composition of claim 36, wherein the elastomer (B) and homopolymers of ethylene and/or random thermoplastic copolymers of ethylene (C) are used in such weight ratio to each other, that the density of the mixture (B + C) would be similar or equal to the density of isotactic polypropylene (A).

51. The method for preparing a composition of claim 50, wherein the density of the mixture of elastomer (B) and homopolymer and/or copolymer(C) is at least 0.995, preferably at least 0.997 of the density of the isotactic polypropylene (A) and at most 1.007, preferably at most 1.005 of the density of the isotactic polypropylene (A).

52. The method for preparing a composition of claim 50, wherein the elastomer (B) and homopolymer and/or copolymer (C) are used in such weight ratio to each other, wherein the concentration of elastomer (B) in the composition is at least 10 wt.% based on the total weight of the composition.

53. The method for preparing a composition of claim 36, wherein a compound selected from a group comprising tert-butyl hydroperoxide, cumyl hydroperoxide, diisopropyl benzoyl hydroperoxide, di-tert-butyl peroxide, tert-butylcumyl peroxide, dicumyl peroxide, 1,3-1,4-bis(tert-butylperoxyisopropyl)benzene, acetyl peroxide, benzoyl peroxide, isobutyryl peroxide, bis-3,5,5-trimethylhexanoyl peroxide, methyl ethyl ketone peroxide is used as the organic peroxide (D1).

54. The method for preparing a composition of claim 36, wherein trimethylolpropane triacrylate is used as a vinyl monomer with three or more acrylate functional groups of the co-agent (D2).

55. The method for preparing a composition of claim 36, wherein a nucleating agent of organic origin or a mixture of such nucleating agents are used as nucleating agent (E).

56. The method for preparing a composition of claim 55, wherein “brighteners” are used as nucleating agents of organic origin.

57. The method for preparing a composition of claim 55, wherein derivatives of dibenzylidene sorbitol, such as 4-dimethyldibenzylidene sorbitol, bis(4-propylbenzylidene)propyl sorbitol or mixture thereof, are used as nucleating agent.

58. The method for making a composition of claim 37, wherein optional additives other than nucleating agent comprise, such as antioxidants, heat stabilizers, stabilizers and also mixtures thereof.

59. The method for making a composition of claim 36, wherein mixing of the components at stages I and II is carried out in a mixing equipment for a period of time from 1 to 20 minutes, preferably from 2 to 10 minutes.

60. The method for making a composition of claim 36, wherein mixing of the

components at stages I and II is carried out at temperature from 10 to 50°C, preferably from 20 to 40°C.

61. The method for making a composition of claim 36, wherein mixing and compounding in the melt at stages I and II are carried out using mixing equipment and extruder, respectively.

62. A polypropylene-based composition prepared by a method of claim 36.

63. Use of the polypropylene-based composition according to any one of claims 1 to 35 as a material for preparing injection molded, thin-walled articles.

64. An injection molded, thin-walled article comprising a polypropylene-based composition according to any one of claims 1 to 35.

65. The article of claim 64 manufactured by injection molding.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2018/000720

A. CLASSIFICATION OF SUBJECT MATTER

(see extra sheet)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C08F, C08L

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

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

Espacenet, PatSearch, USPTO, RUPTO, DEPATIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0004864 A1 (BEATTY et al.) 04.01.2007, [0004], [0007], [0012], [0017], [0021], [0022]	1-31, 35
Y		32-34
A		36-61
Y	US 2003/055179 A1 (OTA et al.) 20.03.2003, [0207]-[0237]	32-34
A	US 2012/289620 A (DEHEUNYNCK et al.) 15.11.212	1-61
A	US 2009/118426 A (MITANI et al.) 07.05.2009	1-61
A	US 2010/0087602 A1 (LI et al.) 08.04.2010	1-61

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier document but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” 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

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

29 July 2019 (29.07.2019)

Date of mailing of the international search report

15 August 2019 (15.08.2019)

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INTERNATIONAL SEARCH REPORT	International application No. PCT/RU 2018/000720

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 62-65
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 62-65 do not comply with the requirements of Rule 6.3(a) of the Regulations under the PCT, the definition of the matter for which protection is sought shall be in terms of the technical features of the invention.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

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