

UNITED STATES PATENT APPLICATION

OF

BISWAROOP MAJUMDAR

AND

MICHAEL GROSS

FOR

METHOD FOR REDUCING THE RELEASE FORCE OF COMPATIBILIZED
POLYPHENYLENE ETHER-POLYAMIDE RESIN BLENDS

CROSS-REFERENCE TO RELATED APPLICATIONS

Not applicable.

FEDERALLY SPONSORED RESEARCH

Not applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a method for reducing the release force of articles made from an impact modified composition of a compatibilized polyphenylene ether-polyamide resin blend.

The invention also relates to the compositions and articles formed out of the compositions made by the method of the invention.

2. Brief Description of the Related Art

Poly(phenylene ether) resins (referred to hereafter as "PPE") are commercially attractive materials because of their unique combination of physical, chemical, and electrical properties. Furthermore, the combination of these resins with polyamide resins into compatibilized blends results in additional overall properties such as chemical resistance, high strength, and high flow. Examples of such compatibilized blends can be found in U.S.



Patents 4,315,086 (Ueno, et al); 4,659,760 (van der Meer); and 4,732,938 (Grant, et al). The properties of these blends can be further enhanced by the addition of various additives such as impact modifiers, flame retardants, light stabilizers, processing stabilizers, heat stabilizers, antioxidants and fillers.

5 The physical properties of PPE/polyamide blends make them attractive for a variety of end-use articles in the automotive market, especially for under hood and various exterior components. Many of these components are subjected to a variety of abuses such as impacts and as such require outstanding impact resistance and ductility. Moreover, many of these same
10 articles are preferentially produced using conversion techniques such as injection molding. Some of the desirable applications, for example, connectors have very thin wall sections and therefore require resins that require very little release pressure to eject the part from the tool in order to avoid distortion of the part. The same resins must also have outstanding
15 ductility, flow, and surface appearance. Conventional PPE/polyamide blends have an inadequate balance of properties to widely penetrate many potential markets.

It is therefore apparent that a need continues to exist for PPE/polyamide compositions that have reduced release force yet retain the
20 other attractive physical properties.

SUMMARY OF THE INVENTION

The needs discussed above have been generally satisfied by the discovery of an improved method for reducing the release force of articles formed from a compatibilized PPE/polyamide composition, wherein the method comprises:

- 25 (a) melt-mixing in a first step:
 (b) from about 5% to about 50% by weight polyphenylene ether resin;

This Sheet Has Been Replaced

-3-



- (c) from about 0.8% to about 1.2% by weight of citric acid or a hydrate of citric acid;
- (d) from about 1% to about 15% by weight of at least one elastomeric block copolymer, wherein the elastomeric block copolymer is a di-block copolymer, tri-block copolymer, or a mixture of a di-block copolymer and tri-block copolymer, wherein the copolymer comprises a polyarylene block and a saturated or unsaturated rubber block,
- (e) from about 1% to about 15% by weight of a functionalized elastomeric olefin; and
- (f) optionally, up to about 92% by weight of a polyamide resin, and
- (g) further melt mixing in a second step, from 0% to about 92% of a polyamide resin;
- wherein the total weight of the polyamide resin is from about 35% to about 92% by weight based on the total weight of the composition.

In a first preferred embodiment of the present invention, the PPE level is between about 10% and about 49% by weight, the citric acid level is between about 0.8% and about 1.0% by weight, the elastomeric block copolymer is present from about 1% to about 8% by weight, wherein elastomeric block copolymer contains a polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer, a polystyrene-poly(ethylene-propylene) diblock copolymer, or a mixture of a polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer and a polystyrene-poly(ethylene-propylene) diblock copolymer, the functionalized elastomeric olefin level is between about 1% and about 8% by weight, and the polyamide is present at a level between about 35% and about 85% by weight.

In a second preferred embodiment of the present invention, between about 10% and 15% of the polyamide resin is added with the PPE, the citric

acid, the elastomeric block copolymer component, and the functionalized elastomeric olefin, with the remainder of the polyamide resin added in a second step; wherein all weight percentages are based on the total weight of the composition.

5 In a third preferred embodiment of the present invention, the functionalized elastomeric olefin is derived from ethylene and at least one C_{3-8} 1-olefin.

 In a fourth preferred embodiment of the present invention, the functionalized elastomeric olefin is derived from an ethylene-propylene resin
10 or ethylene-propylene-diene resin.

 In a fifth preferred embodiment of the present invention, the functionalized elastomeric olefin is an ethylene-propylene resin functionalized with maleic anhydride or ethylene-propylene-diene resin functionalized with maleic anhydride.

15 In a sixth preferred embodiment of the present invention, the PPE level is between about 10% and about 30% by weight, the citric acid level is between about 0.8% and about 1.0% by weight, the elastomeric block copolymer component is present from about 1% to about 8% by weight, wherein elastomeric block copolymer component contains a mixture of a
20 polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer and polystyrene-poly(ethylene-propylene) diblock copolymer, the functionalized elastomeric olefin is an ethylene-propylene resin or ethylene-propylene-diene resin functionalized with maleic anhydride the functionalized elastomeric olefin is present at a level between about 1% and about 8% by weight, and the
25 polyamide is present at a level between about 35% and about 85% by weight.

 In a seventh preferred embodiment of the present invention, the ejector force is at least 50% less than the same composition not containing the functionalized elastomeric olefin.

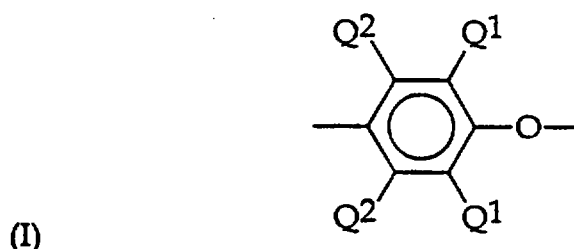
The description which follows provides further details regarding this invention.

DESCRIPTION OF THE DRAWINGS

Not applicable.

DETAILED DESCRIPTION OF THE INVENTION

PPE, per se, are known polymers comprising a plurality of
5 structural units of the formula (I):



wherein for each structural unit, each Q¹ is independently halogen,
10 primary or secondary lower alkyl (e.g., alkyl containing up to 7 carbon atoms), phenyl, haloalkyl, aminoalkyl, hydrocarbonoxy, or halohydrocarbonoxy wherein at least two carbon atoms separate the halogen and oxygen atoms; and each Q² is independently hydrogen, halogen, primary or secondary lower alkyl, phenyl, haloalkyl,
15 hydrocarbonoxy or halohydrocarbonoxy as defined for Q¹. Preferably, each Q¹ is alkyl or phenyl, especially C₁₋₄ alkyl, and each Q² is hydrogen.

Both homopolymer and copolymer PPE are included. The preferred homopolymers are those containing 2,6-dimethyl-1,4-phenylene ether units. Suitable copolymers include random copolymers containing,
20 for example, such units in combination with 2,3,6-trimethyl-1,4-phenylene

ether units. Also included are PPE containing moieties prepared by grafting vinyl monomers or polymers such as polystyrenes, as well as coupled PPE in which coupling agents such as low molecular weight polycarbonates, quinones, heterocycles and formals undergo reaction in
5 known manner with the hydroxy groups of two PPE chains to produce a higher molecular weight polymer, provided a substantial proportion of free OH groups remains.

The PPE generally has a number average molecular weight within the range of about 3,000-40,000 and a weight average molecular weight
10 within the range of about 20,000-80,000, as determined by gel permeation chromatography. Its intrinsic viscosity is most often in the range of about 0.15-0.6 dl./g., as measured in chloroform at 25°C.

The PPE are typically prepared by the oxidative coupling of at least one monohydroxyaromatic compound such as 2,6-xyleneol or 2,3,6-
15 trimethylphenol. Catalyst systems are generally employed for such coupling; they typically contain at least one heavy metal compound such as a copper, manganese or cobalt compound, usually in combination with various other materials.

Particularly useful PPE for many purposes are those which
20 comprise molecules having at least one aminoalkyl-containing end group. The aminoalkyl radical is typically located in an ortho position to the hydroxy group. Products containing such end groups may be obtained by incorporating an appropriate primary or secondary monoamine such as di-n-butylamine or dimethylamine as one of the constituents of the
25 oxidative coupling reaction mixture. Also frequently present are 4-hydroxybiphenyl end groups, typically obtained from reaction mixtures in which a by-product diphenoquinone is present, especially in a copper-halide-secondary or tertiary amine system. A substantial proportion of the polymer molecules, typically constituting as much as about 90% by

weight of the polymer, may contain at least one of said aminoalkyl-containing and 4-hydroxybiphenyl end groups.

It will be apparent to those skilled in the art from the foregoing that the PPE contemplated for use in the present invention include all those
5 presently known, irrespective of variations in structural units or ancillary chemical features.

The polyamide resins useful in the practice of the present invention are a generic family of resins known as nylons, characterized by the presence of an amide group (-C(O)NH-). Nylon-6 and nylon-6,6 are the generally preferred
10 polyamides and are available from a variety of commercial sources. Other polyamides, however, such as nylon-4,6, nylon-12, nylon-6,10, nylon 6,9, nylon 6/6T and nylon 6,6/6T with triamine contents below about 0.5 weight percent as well as others, such as the amorphous nylons may be useful for particular PPE-polyamide applications. Mixtures of various polyamides as
15 well as various polyamide copolymers are also useful. The most preferred polyamides for the blends of the present invention are nylon-6 and nylon-6,6. Branched polyamide resins are also useful as are mixtures of branched and linear polyamide resins.

The polyamides can be obtained by a number of well-known processes
20 such as those described in U.S. Patent Nos. 2,071,250; 2,071,251; 2,130,523; 2,130,948; 2,241,322; 2,312,966; and 2,512,606. Nylon-6, for example, is a polymerization product of caprolactam. Nylon-6,6 is a condensation product of adipic acid and 1,6-diaminohexane. Likewise, nylon 4,6 is a condensation product between adipic acid and 1,4-diaminobutane. Besides adipic acid,
25 other useful diacids for the preparation of nylons include azelaic acid, sebacic acid, dodecane diacid, as well terephthalic and isophthalic acids. Other useful diamines include m-xylylene diamine, di-(4-aminophenyl)methane, di-(4-aminocyclohexyl)methane; 2,2-di-(4-aminophenyl)propane, and 2,2-di-(4-

aminocyclohexyl)propane. Copolymers of caprolactam with diacids and diamines are also useful.

In one embodiment of the invention, polyamides having viscosity number of about 90 to about 350 ml/g, preferably between about 110 and about 240
5 ml/g as measured in a 0.5 weight percent solution in 96 weight percent sulphuric acid in accordance with ISO 307 is preferred. In another preferred embodiment of the present invention, it is preferred that the amine endgroup to acid endgroup ratio (i.e., $\text{-NH}_2/\text{-CO}_2\text{H}$) be < 1.0 .

The amount of the PPE and polyamide used in the present invention can
10 vary widely depending on the properties desired. Generally, the amounts are such that the polyamide remains the continuous phase with the other components dispersed within the polyamide and/or each other. Useful amounts of polyamide range between about 35% and about 85% by weight based on the weight of the entire composition. For applications wherein a
15 lower viscosity is an important factor, higher levels of polyamide, e.g., from about 50% to about 85% by weight based on the entire weight of the composition, are typically used. Conversely, for applications wherein dimensional stability is key, lower levels of polyamide, e.g., from about 35% to about 50% by weight based on the entire weight of the composition, are
20 typically used. An exact amount of polyamide can be readily determined without under experimentation by one of ordinary skill in this art.

In the method of the present invention, a compatibilizing agent should be employed in the preparation of the composition. The two-fold purpose for using a compatilizing agent is to improve, in general, the physical properties
25 of the PPE-polyamide resin blend, as well as to enable the use of a greater proportion of the polyamide component. When used herein, the expression "compatibilizing agent" refers to those polyfunctional compounds which interact with either the PPE, the polyamide resin, or both. This interaction may be chemical (e.g. grafting) or physical (e.g. affecting the surface

characteristics of the dispersed phases). In either instance the resulting PPE-polyamide composition appears to exhibit improved compatibility, particularly as evidenced by enhanced impact strength, mold knit line strength and/or elongation. As used herein, the expression "compatibilized polyphenylene ether-polyamide base resin" refers to those compositions which have been physically or chemically compatibilized with an agent as discussed above, as well as those compositions which are physically compatible without such agents, as taught in U.S. Pat. No. 3,379,792.

In the practice of the present invention, non-polymeric aliphatic polycarboxylic acids are used as the compatibilizing agent. Included in the group of non-polymeric aliphatic polycarboxylic acids species, also known as compatibilizers or functionalizers, are, for example, the aliphatic polycarboxylic acids, and acid esters represented by the formula (II):



wherein R is a linear or branched chain, saturated aliphatic hydrocarbon of from 2 to 20, preferably 2 to 10, carbon atoms; each R^I is selected from the group consisting of hydrogen or an alkyl, aryl, acyl, or carbonyl dioxy group of 1 to 10, preferably 1 to 6, most preferably 1 to 4, carbon atoms, with hydrogen being especially preferred; each R^{II} is independently selected from the group consisting of hydrogen or an alkyl or aryl group of from 1 to 20 carbon atoms preferably from 1 to 10 carbon atoms; each R^{III} and R^{IV} is independently selected from the group consisting essentially of hydrogen or an alkyl or aryl group of from 1 to 10, preferably from 1 to 6, most preferably 1 to 4, carbon atoms; m is equal to 1 and (n+s) is greater than or equal to 2, preferably equal to 2 or 3, and n and s are each greater than or equal to zero; and wherein (OR^I) is alpha or beta to a carbonyl group and at least two carbonyl groups are separated by 2 to 6 carbon atoms. Obviously, R^I, R^{II}, R^{III}, and R^{IV} cannot be aryl when the respective substituent has less than 6 carbon atoms.

Illustrative of suitable polycarboxylic acids are citric acid, malic acid, and agaricic acid; including the various commercial forms thereof, such as, for example, the anhydrous and hydrated acids. Illustrative acid esters useful herein include, for example, acetyl citrate and mono- and/or di- stearyl
5 citrates and the like. Suitable acid amides useful herein include, for example, N,N'-diethyl citric acid amide; N,N'-dipropyl citric acid amide; N-phenyl citric acid amide; N-dodecyl citric acid amide; N,N'-didodecyl citric acid amide and N-dodecyl malic acid amide. Derivatives of the foregoing polycarboxylic acids are also suitable for use in the practice of the present
10 invention. Examples of suitable functionalizing compounds can be found in U.S. Patent Nos. 4,315,086, 4,755,566, 4,873,286 and 5,000,897.

The amount of the above mentioned non-polymeric aliphatic polycarboxylic acids that is required to appropriately functionalize the PPE is that which is sufficient to improve the compatibility between the various
15 components in the composition and improve the surface characteristics of the composition without loss of desirable properties such as, for example, impact properties, tensile properties, surface appearance, and the like. As previously discussed, indications of improved compatibility include resistance to lamination, improved physical properties such as increased tensile and
20 impact properties and a stabilized morphology between the blend component phases under static and/or low shear conditions.

It is thought that reactions can occur between some of the components of the composition, for example, between the PPE and the non-polymeric aliphatic polycarboxylic acids, the non-polymeric aliphatic polycarboxylic
25 acids and the polyamide resin, or between the PPE, non-polymeric aliphatic polycarboxylic acid, and the polyamide resin. These reactions are thought to lead to various copolymers between the components of the blend. In this manner, as the non-polymeric aliphatic polycarboxylic acid is added to a PPE/polyamide composition, the average particle size of the dispersed PPE

phase decreases presumably due to the formation of the copolymer structures. It is believed that a reduction in the number of PPE particles, in the formed articles, having an average particle diameter of about 10 microns or greater is responsible for the improvement in the overall surface appearance. There appears to be a minimum threshold level of non-polymeric aliphatic polycarboxylic acid that is required to achieve the desired compatibility between the PPE and the polyamide as indicated by enhanced physical properties yet which results in sufficient numbers of relatively larger PPE particles that lead to surface imperfections. An increase in the level of non-polymeric aliphatic polycarboxylic acid above the minimum has a positive effect on enhancing the compatibility but unexpectedly has been discovered to have a significant effect on improving the surface characteristics of the blend.

In the practice of the present invention, an effective amount of the above mentioned non-polymeric aliphatic polycarboxylic acids, based on the total weight of the composition, is from about 0.6% to about 1.2% by weight, preferably from about 0.7% to about 1.0% by weight. Amounts less than about 0.6% by weight result sufficient numbers of PPE particles having an average diameter greater than about 10 microns such that an article formed from a sheet of the compatibilized PPE/ polyamide composition has unacceptable surface appearance with respect to pits and grits. Amounts in excess of about 1.2% by weight afford increased flow characteristics but at the expense of low temperature impact strength and the color of the composition darkens considerably.

The method according to the invention incorporates in the composition one or more of the so called elastomeric block copolymers, for example, A-B-A triblock copolymers and A-B diblock copolymers. The A-B and A-B-A type block copolymer rubber additives which may be used are thermoplastic rubbers comprised of one or two alkenyl aromatic blocks which are typically

styrene blocks and a rubber block, e.g., a butadiene block which may be partially or totally hydrogenated. Mixtures of these triblock copolymers and diblock copolymers are especially preferred in the present compositions.

Suitable A-B and A-B-A type block copolymers are disclosed in, for
5 example, U.S. Patent Nos. 3,078,254, 3,402,159, 3,297,793, 3,265,765, and
3,594,452 and U.K. Patent 1,264,741. Examples of typical species of A-B and
A-B-A block copolymers include polystyrene-polybutadiene (SBR),
polystyrene-poly(ethylene-propylene), polystyrene-polyisoprene, poly(α -
methylstyrene)-polybutadiene, polystyrene-polybutadiene-polystyrene (SBR),
10 polystyrene-poly(ethylene-butylene)-polystyrene, polystyrene-polyisoprene-
polystyrene and poly(α -methylstyrene)-polybutadiene-poly(α -
methylstyrene), as well as the selectively hydrogenated versions thereof.
Mixtures of the aforementioned block copolymers are also useful. Such A-B
and A-B-A block copolymers are available commercially from a number of
15 sources, including Phillips Petroleum under the trademark SOLPRENE, Shell
Chemical Co., under the trademark KRATON, Dexco under the tradename
VECTOR, and Kuraray under the trademark SEPTON.

In the method of the present invention, the functionalized elastomeric
polyolefin is an elastomeric polyolefin containing at least one moiety of the
20 group consisting of anhydride, epoxy, oxazoline, and orthoester. The
essential structural units of the elastomeric polyolefin are derived from
ethylene and at least one C_{3-8} 1-olefin, such as, propylene, 1-butene, 1-hexene,
and 1-octene. The proportions of ethylene and at least one C_{3-8} 1-olefin are
not critical provided that they together constitute the major portion of the
25 polymer.

In a preferred embodiment, the functionalized elastomeric polyolefin is
a functionalized ethylene-propylene rubber or a functionalized ethylene-
propylene-diene elastomer. The diene portion is at least one non-conjugated
diene, such as ethylidene norbornene, 1,4-hexadiene, or dicyclopentadiene.

These elastomeric polyolefins are known in the art as EPR and EPDM elastomers.

As previously discussed, the functionalized elastomeric polyolefin is an elastomeric polyolefin containing at least one moiety of the group consisting of anhydride, epoxy, oxazoline, and orthoester. The functionalized elastomeric polyolefins are well-known in the art as are methods for their preparation. Examples of the methods can be found in U.S. Patent Nos. 3,882,194, 3,928,497, 4,147,740, 4,590,241, 4,996,263, 5,124,410, and 5,393, 833, among others.

10 In an especially preferred embodiment of the invention, the functionalized elastomeric polyolefin is an elastomeric polyolefin containing anhydride moieties. Preferably, the functionalized elastomeric polyolefin is an EPR or EPDM that has been allowed to react with maleic anhydride. The resultant elastomers are commonly referred to EPR-graft-maleic anhydride and EPDM-graft-maleic anhydride. The level of maleic anhydride is 15 generally in the range of between about 0.05% and 3% by weight based on the weight of the elastomer.

A useful amount of the elastomeric block copolymers is between about 1% and about 15% by weight, preferably between about 1% and about 8% by 20 weight, wherein the weight percentages are based on the entire weight of the composition. In an especially preferred embodiment, the impact modifier comprises a mixture of a polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer and polystyrene-poly(ethylene-propylene) diblock copolymer. The amount of the functionalized elastomeric olefin level is 25 preferably between about 1% and about 8% by weight.

Compositions of the present invention can also include effective amounts of at least one additive selected from the group consisting of anti-oxidants, flame retardants, drip retardants, dyes, pigments, colorants, stabilizers, small particle mineral such as clay, mica, and talc, antistatic

agents, plasticizers, lubricants, and mixtures thereof. These additives are known in the art, as are their effective levels and methods of incorporation. Effective amounts of the additives vary widely, but they are usually present in an amount up to about 50% or more by weight, based on the weight of the entire composition. Especially preferred additives include hindered phenols, thio compounds and amides derived from various fatty acids. The preferred amounts of these additives generally ranges up to about 2% total combined weight based on the total weight of the composition.

The preparation of the compositions of the present invention is normally achieved by merely blending the ingredients under conditions for the formation of an intimate blend. Such conditions often include mixing in single or twin screw type extruders or similar mixing devices which can apply a shear to the components.

All of the ingredients may be added initially to the processing system, or else certain additives may be precompounded with one or more of the primary components, preferably the PPE, elastomeric block copolymers, the functionalized elastomeric olefin, and/or the polyamide. It appears that certain properties, such as impact strength and elongation, are sometimes enhanced by initially precompounding the PPE, elastomeric block copolymers, and the functionalized elastomeric olefin, optionally with any other ingredients, prior to compounding with the polyamide resin, however, these improvements are done at the expense of increasing the viscosity of the compatibilized composition. In the present invention, it is preferable that at least 5% by weight, preferably at least 8% by weight, and most preferably, at least 10% by weight polyamide be added with the PPE and non-polymeric carboxylic acid. The remaining portion of the polyamide is fed through a port downstream. In this manner, the viscosity of the compatibilized composition is reduced without significant reduction in other key physical properties. While separate extruders may be used in the processing, these compositions



are preferably prepared by using a single extruder having multiple feed ports along its length to accommodate the addition of the various components. It is often advantageous to apply a vacuum to the melt through at least one or more vent ports in the extruder to remove volatile impurities in the composition. Those of ordinary skill in the art will be able to adjust blending times and temperatures, as well as component addition, without undue additional experimentation.

It should be clear that compositions and articles made from the compositions made by the method of this disclosure are within the scope of the invention.

All patents cited are incorporated herein by reference.

The invention will be further illustrated by the following examples.

EXPERIMENTAL

In the examples the following materials have been used:

PPE: a poly(2,6-dimethyl-1,4-phenylene ether) with an intrinsic viscosity of 45 ml/g as measured in toluene at 25°C. and a concentration of 0.6 gram per 100 ml;

PA-6,6: a polyamide-6,6 with a viscosity of 54-62 ml/g according to ASTM D789 in a solution of 8.4% by weight of nylon in 90% Formic Acid and an amine endgroup number of 42 $\mu\text{eq./g.}$;

CAH: citric acid monohydrate;

SEBS: polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer;

SEP: polystyrene-poly(ethylene-propylene) diblock copolymer;

EPR-g-MAH: ethylene-propylene rubber grafted with about 0.7% by weight maleic anhydride.

The ingredients were compounded in the weight ratios as indicated in the following table in a twin-screw extruder with temperature settings over the length of the extruder between about 280 and about 310° C. The screw speed was 300 rpm, the throughput 10 kilograms per hour. All ingredients with



exception of the polyamide were fed at the throat of the extruder; the polyamide was split-fed partially into the throat of the extruder with the remainder fed downstream about halfway the length of the extruder. The strands coming from the extruder were pelletized in a laboratory equipment and dried for about 3 hours at about 110°C. The dried pellets were injection molded into standard ASTM test specimens for measurement of physical properties. The ejector force was measured in psi as the amount of force required for the ejector pins to push a molded specimen out of the injection molding tool. A lower level of force is preferred.

Sample:	1	2	3	4
PPE	20	20	20	20
CAH	0.85	0.85	0.85	0.85
SEBS	4.75	0	0	2
SEP	3.75	3	0	2
EPR-g- MAH	0	5	8	4
PA-6,6 ¹	13	13	13	13
PA-6,6 ²	55.7	55.7	55.7	55.7
Properties				
HDT ³	191	199	199	195
NI ⁴	3.3	2.7	2.4	4.1
Dyn. ⁵ (73°F)	32.3	28	28.8	28.0
Dyn. (-20°F)	4.5	22.2	14.1	14.0
TS ⁶	8.99	8.42	9.1	8.98
TE ⁷	47	23	37	40
FM ⁸	346	334	339	336
FY ⁹	1386	1283	1338	1335
Ejector force	1512	736	637	636

¹ denotes amount of PA-6,6 added with the PPE; ² denotes amount of PA-6,6 added downstream; ³ HDT is reported in °C and was measured at a load of 66 psi as measured according to ASTM D648; ⁴ NI stands for notched Izod impact reported in ft-lbs/in and tested according to D256; ⁵ Dyn. stands for Dynatup impact strength (energy to fracture falling dart test) reported in ft-lbs and measured according to D3763; ⁶ TS stands for tensile strength at yield reported in Kpsi and measured according to ASTM D638; ⁷ TE stands for



tensile elongation at break reported in percent and measured according to ASTM D638; ⁸ FM stands for flexural modulus and is reported in Kpsi and measured according to ASTM D790; ⁹ FY stands for flexural yield and is reported in Kpsi and measured according to ASTM D790. All compositions contain the following additives: 0.3 weight percent Seenox 412S, 0.3 weight percent Irganox 1010, and 0.3 weight percent KI; wherein all weight are based upon the total weight of the composition.

As can be seen from the properties of the compositions presented in the table, the compositions containing the functionalized elastomeric olefin have significantly lower ejector forces than does sample 1 that contains only an elastomeric block copolymer. A composition containing only the
5 functionalized elastomeric olefin is illustrated by Sample 3. Compositions 2 and 4, containing both the functionalized elastomeric olefin and an elastomeric block copolymer unexpectedly exhibited less the 50% of the ejector force of sample 1 containing only the elastomeric block copolymer. As demonstrated by the above data, use of the combination of the elastomeric
10 block copolymer and the functionalized elastomeric olefin unexpectedly resulted in superior notched Izod impact strength as compared to sample 3 while maintaining the very low ejector force. Moreover, compositions containing only the functionalized elastomeric olefin, e.g., sample 3, unexpectedly demonstrated an inferior surface appearance as compared to
15 composition containing both the functionalized elastomeric olefin and as elastomeric block copolymer.



CLAIMS:

I claim:

1. A method for reducing the ejector force of articles formed from a compatibilized polyphenylene ether resin / polyamide resin composition, wherein the method comprises:
 - (a) melt-mixing in a first step, from about 5% to less than 50% by weight polyphenylene ether resin with from about 0.7% to about 1.1% by weight of a non-polymeric aliphatic polycarboxylic acid or derivative thereof and from about 5% to about 15% by weight of at least one elastomeric block copolymer, wherein the elastomeric block copolymer is a di-block copolymer, tri-block copolymer, or a mixture of a di-block copolymer and tri-block copolymer, wherein the copolymer comprises a polyarylene block and a saturated or unsaturated rubber block, and from about 1% to about 15% of a functionalized elastomeric olefin with from about 0% to about 85% by weight of a polyamide resin, and
 - (b) further melt mixing in a second step, from 0% to about 85% of a polyamide resin;wherein the total weight of the polyamide resin is from about 35% to about 85% by weight based on the total weight of the composition.
2. The method of claim 1, wherein the method is done in an extruder and wherein the first step and the second step are done sequentially in the same extruder.
3. The method of claim 1, wherein the non-polymeric aliphatic polycarboxylic acid or derivative thereof is citric acid or a hydrate of citric acid present in an amount from about 0.8% to about 1.0% by weight.

This Sheet Has Been Replaced





4. The method of claim 1, wherein the polyamide resin is a nylon-6 or a nylon-6,6 resin.
5. The method of claim 1, wherein the amount of polyphenylene ether resin is from about 10% to about 30% by weight.
6. The method of claim 1, wherein the amount of the elastomeric block copolymer is from about 1% by weight to about 8% by weight based on the weight of the entire composition.
7. The method of claim 1, wherein the amount of the functionalized elastomeric olefin is from about 1% by weight to about 8% by weight based on the weight of the entire composition.
8. The method of claim 1, wherein the elastomeric block copolymer is a polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer, a polystyrene-poly(ethylene-propylene) diblock copolymer, or a mixture of a polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer and polystyrene-poly(ethylene-propylene) diblock copolymer.
9. The method of claim 1, wherein the elastomeric block copolymer is a mixture of a polystyrene-poly(ethylene-butylene)-polystyrene triblock copolymer and polystyrene-poly(ethylene-propylene) diblock copolymer.
10. The method of claim 1, wherein the functionalized elastomeric olefin is an elastomeric polyolefin containing at least one moiety of the group consisting of anhydride, epoxy, oxazoline, and orthoester.
11. The method of claim 1, wherein the functionalized elastomeric olefin is functionalized ethylene-propylene rubber or a functionalized ethylene-propylene-diene elastomer.
12. The method of claim 1, wherein the functionalized elastomeric olefin is EPR-graft-maleic anhydride or EPDM-graft-maleic anhydride.
13. The method of claim 1, wherein the ejector force is less than 50% that of the same composition not containing the elastomeric block copolymer.





14. The method of claim 1, further comprising melt mixing in the first step, at least one additive selected from the group consisting of anti-oxidants, flame retardants, drip retardants, dyes, pigments, colorants, stabilizers, antistatic agents, plasticizers, lubricants, and mixtures thereof.
15. A composition made from the method of claim 1.
16. An article formed out of the composition of claim 15.
17. A method for reducing the ejector force of articles formed from a compatibilized polyphenylene ether resin / polyamide resin composition, wherein the method comprises:
- (a) melt-mixing in a first step, from about 10% to less than 30% by weight polyphenylene ether resin with from about 0.7% to about 1.1% by weight of a non-polymeric aliphatic polycarboxylic acid or derivative thereof and from about 1% to about 15% by weight of at least one elastomeric block copolymer, wherein the elastomeric block copolymer is a mixture of a di-block copolymer and tri-block copolymer, wherein the copolymer comprises a polyarylene block and a saturated or unsaturated rubber block, and from about 1% to about 15% of a functionalized elastomeric olefin wherein the functionalized elastomeric olefin is EPR-graft-maleic anhydride or EPDM-graft-maleic anhydride, with from about 0% to about 20% by weight of a polyamide resin and
- (b) further melt mixing in a second step, from 15% to about 85% of a polyamide resin;
- wherein the total weight of the polyamide resin is from about 35% to about 85% by weight based on the total weight of the composition.

