copolymer containing master batch does not phase-separate. Phase separation can occur when the olefin-maleic anhydride copolymer is chemically incompatible with the carrier resin. If phase separation occurs in a master batch there is a risk that the incorporation of the additive will not be uniform in the polymer formulation. A third challenge is to avoid very high viscosity and consequently very high torque during compounding with polyamides which can result from the rapid reactivity of the olefin-maleic anhydride copolymers with the polyamide. This viscosity increase does not occur during most of the conventional polymer or plastics compounding described in the first paragraph. Most of the typical carrier resins used for preparing master batches suffer from one or more problems and are not suitable for producing a master batch of an olefin-maleic anhydride copolymer.

Described herein is a master batch composition comprising an olefin-maleic anhydride copolymer and one or more additional additives in a matrix of a carrier resin. Also described herein are uses of the master batches to enhance the processing and properties of polymer formulations comprising polyamides or Polyamides compounded with the master batch. Some desired characteristics of a master batch include: the master batch improves the uniformity of the incorporation of the additives in the final composition, the master batch reduces the torque of the final polymer composition during processing, the carrier resin used to form the master batch does not react with the additives, the additives do not phase separate from the carrier resin, the carrier resin does not phase separate with the polymer being formulated, the carrier resin remains thermally stable at the processing temperatures and under the processing conditions typically used for processing Polyamides and polyamides, and the presence of the carrier resin in the polymer formulation should not adversely affect the performance of the formulated polymer.

In one aspect, there is provided a master batch composition ~~for use in preparing a polyamide formulation from a polyamide~~, comprising an olefin-maleic anhydride copolymer and one or more carrier resins selected from the group consisting of ethylene-n-butyl acrylate copolymer, an ethylene-ethyl acrylate copolymer, and an ethylene-methyl acrylate copolymer, or a combination thereof, wherein the concentration of olefin-maleic anhydride copolymer in the master batch is from about 5% to about 50%, or from about 10% to about 40%, or from about 10% to about 35%, or from about 10% to about 30%, or from about 15% to about 25%.

The olefin-maleic anhydride copolymer used in forming the master batch compositions described herein is not a grafted copolymer with one or two maleic anhydride groups per molecular chain, but a true copolymer with multiple maleic anhydride groups on the main chain of the polymer. In one embodiment, the olefin-maleic anhydride copolymer is an alternating copolymer of the olefin and maleic anhydride. In another embodiment, the molar ratio of the olefin and maleic anhydride monomers is 1:1. In one illustrative example, the ethylene-maleic anhydride copolymer is one of the 1:1 alternating copolymers sold under the ZeMac® trademark.

(compounds and/or polymer components added to the compounding process) may be in the form of pellets, flakes, chips, powders and/or liquids. The master batch product is usually formed into a pellet form, to be used in other plastic-forming processes such as extrusion, thermoforming, blow molding, and/or injection molding. Use of twin-screw extruders or continuous mixers is preferred where the extruder is equipped with feeders equipped to handle low bulk density powder because they give better mixing at lower melt temperatures. Most of these have screws and barrels made up of segments for mixing, conveying, venting, and additive feeding. When the carrier resin is more flexible it may be advantageous to use other plastics compounding equipment such as single-screw extruders, oscillating screw extrusion, continuous mixers, Banbury mixers, and planetary extruders for compounding as well. Processing parameters such as the temperature of each segments or zones, feed rates, residence time and screw speed can be modified by the person skilled in the art for each application.

In another aspect, there is provided a process for preparing the master batch composition as defined above, the process comprising the step of mixing an olefin-maleic anhydride copolymer with a carrier resin selected from the group consisting of ethylene-n-butyl acrylate copolymer, an ethylene-ethyl acrylate copolymer, and an ethylene-methyl acrylate copolymer, or a combination thereof, wherein the concentration of olefin-maleic anhydride copolymer in the master batch is from about 5% to about 50%, or from about 10% to about 40%, or from about 10% to about 35%, or from about 10% to about 30%, or from about 15% to about 25%.

In another aspect, there is provided a process for preparing a polyamide formulation, the process comprising ~~the step of reaction~~ compounding a polyamide with the master batch composition as defined above.

Described herein are polymer formulations comprising polyamides compounded with one or more of the olefin-maleic anhydride copolymers master batches described. Described herein are methods for compounding polyamide or polyamide-like materials with the olefin-maleic anhydride copolymer master batches described. In one embodiment, the method of producing polymer formulations of polyamides by reacting the polyamide with an olefin-maleic anhydride polymer master batch as described herein results in increases in the polyamide's molecular weight and/or favorable structural changes resulting in improved properties and performance characteristics such as increased tensile strength, stretch performance, impact strength, flex modulus, and heat deflection temperature.

In another aspect, there is provided a polyamide formulation comprising a recycled polyamide or a virgin polyamide compounded with the master batch composition as defined above.

WHAT IS CLAIMED IS:

1. A master batch composition ~~for use in preparing a polyamide formulation from a polyamide~~, comprising an olefin-maleic anhydride copolymer and one or more carrier resins selected from the group consisting of ethylene-n-butyl acrylate copolymer, an ethylene-ethyl acrylate copolymer, and an ethylene-methyl acrylate copolymer, or a combination thereof, wherein the concentration of olefin-maleic anhydride copolymer in the master batch is from about 5% to about 50%, or from about 10% to about 40%, or from about 10% to about 35%, or from about 10% to about 30%, or from about 15% to about 25%.

~~2. The master batch composition of claim 1 wherein the carrier resin is selected from the group consisting of ethylene-ester copolymers; polyamides wherein amine end groups of the polyamide are capped, or the end groups of the polyamide are carboxylic acid groups and not amines; polysulfonylamides, where the end groups of the polysulfonylamides are not amines; polycarbonates, where the end groups of the polycarbonate are carboxylic acid groups; and polyesters, where the end groups of the polyester are carboxylic acid groups; or combinations thereof.~~

~~3. The master batch composition of claim 1wherein the carrier resin is an ethylene-n-butyl acrylate copolymer, an ethylene-ethyl acrylate copolymer, an ethylene-methyl acrylate copolymer, or a combination thereof.~~

42. The master batch composition of claim 1 wherein the carrier resin is an ethylene-methyl acrylate copolymer.

~~5~~3. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, further comprising one or more additives independently selected in each instance from the group consisting of anti-oxidants, nucleating agents, colorants, plasticizers, lubricants, rheology modifiers, friction modifiers, other processing aids, and heat stabilizers for polyamides.

~~6~~4. The master batch composition of claim ~~5~~ 3 wherein the one or more additives are independently selected in each instance from the group consisting of anti-oxidants and heat stabilizers for polyamides.

~~7~~5. The master batch composition of claim ~~5s~~ 3 wherein the additives are cuprous iodide, potassium iodide, N,N'-hexane-1,6-diylbis[3-(3,5-di-tert-butyl-4-hydroxyphenylpropionamide)], and tris(2,4-di-tert-butylphenyl)phosphite.

~~8~~6. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the master batch is compounded with a polyamide, wherein the polyamide is a prime polyamide or a recycled polyamide.

~~9~~7. The master batch composition of ~~any one of claims 1 to 4~~claim 6. wherein the polyamide is a prime polyamide.

~~10~~8. The master batch composition of ~~any one of claims 1 to 4~~claim 6, wherein the polyamide is a recycled polyamide-6 or polyamide-6,6.

~~11~~9. The master batch composition of ~~any one of claims 1 to 4~~claim 6, wherein the polyamide is a recycled polyamide-6.

~~12~~10. The master batch composition of ~~any one of claims 1 to 4~~claim 6, wherein the polyamide is a recycled polyamide-6,6.

~~13~~11. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the olefin-maleic anhydride copolymer is a 1:1 olefin-maleic anhydride copolymer.

~~14~~12. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the olefin-maleic anhydride copolymer is a 1:1 ethylene-maleic anhydride copolymer.

~~15~~13. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the olefin-maleic anhydride copolymer is a 1:1 alternating copolymer.

~~16~~14. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the olefin-maleic anhydride copolymer is a 1:1 alternating ethylene-maleic anhydride copolymer has a weight average molecular weight (MW_w) of 1,000 to 800,000 Daltons.

~~17~~15. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the olefin-maleic anhydride copolymer is 1:1 alternating ethylene-maleic anhydride copolymer has a weight average molecular weight (MW_w) of 50,000 to 500,000 Daltons.

~~18~~16. The master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, wherein the olefin-maleic anhydride copolymer is a 1:1 alternating ethylene-maleic anhydride copolymer has a weight average molecular weight (MW_w) of 60,000 Daltons.

~~19. The master batch composition of any one of claims 1 to 4 wherein the concentration of olefin-maleic anhydride copolymer in the master batch is from about 5% to about 50%, or from about 10% to about 40%, or from about 10% to about 35%, or from about 10% to about 30%, or from about 15% to about 25%.~~

~~20~~17. A process for preparing the master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2, the process comprising the step of mixing an olefin-maleic anhydride copolymer with a carrier resin selected from the group consisting of ethylene-n-butyl acrylate copolymer, an ethylene-ethyl acrylate copolymer, and an ethylene-methyl acrylate copolymer, or a combination thereof, wherein the concentration of olefin-maleic anhydride copolymer in the master batch is from about 5% to about 50%, or from about 10% to about 40%, or from about 10% to about 35%, or from about 10% to about 30%, or from about 15% to about 25%.

~~21. The process of claim 20 wherein the carrier resin is selected from the group consisting of ethylene-ester copolymers; polyamides wherein amine end groups of the polyamide are capped, or the end groups of the polyamide are carboxylic acid groups; polysulfonylamides, where the end groups of the polysulfonylamides are not amines; polycarbonates, where the end groups of the polycarbonate are carboxylic acid groups; and polyesters, where the end groups of the polyester are carboxylic acid groups; or combinations thereof.~~

~~22. The process of claim 20 wherein the carrier resin is an ethylene-n-butyl acrylate copolymer, an ethylene-ethyl acrylate copolymer, an ethylene-methyl acrylate copolymer, or a combination thereof.~~

~~23~~18. The process of claim ~~20~~ 17, wherein the carrier resin is an ethylene-methyl acrylate copolymer.

~~24~~19. The process of claim ~~20~~ 17, further comprising the step of adding one or more additives independently selected in each instance from the group consisting of anti-oxidants, nucleating agents, colorants, plasticizers, lubricants, rheology modifiers, friction modifiers, other processing aids, and heat stabilizers for polyamides.

~~25~~20. The process of claim ~~24~~ 19, wherein one or more of the additives is independently selected in each instance from the group consisting of anti-oxidants and heat stabilizers for polyamides.

~~26~~21. The process of claim ~~24~~ 19, wherein the additives are cuprous iodide, potassium iodide, N, N'-hexane-1,6-diylbis[3-(3,5-di-tert-butyl-4-hydroxyphenylpropionamide)], and tris(2,4-di-tert-butylphenyl)phosphite.

~~27~~22. The process of claim ~~20~~ 17, further comprising adding the master batch to a ~~wherein the~~ polyamide, wherein the polyamide is a prime polyamide or a recycled polyamide.

~~28~~23. The process of claim ~~20~~ 22, wherein the polyamide is a prime polyamide.

~~29~~24. The process of claim ~~20~~ 22, wherein the polyamide is a recycled polyamide-6 or polyamide-6,6.

~~30~~25. The process claim ~~20~~ 17, wherein the olefin-maleic anhydride copolymer is a 1:1 olefin-maleic anhydride copolymer.

~~31~~26. The process of claim ~~20~~ 17, wherein the olefin-maleic anhydride copolymer is a 1:1 ethylene-maleic anhydride copolymer.

~~32~~27. The process of a claim ~~20~~ 17, wherein the olefin-maleic anhydride copolymer is a 1:1 alternating copolymer.

~~33~~28. The process of claim ~~32~~ 27, wherein the 1:1 alternating ethylene-maleic anhydride copolymer has a weight average molecular weight (MW_w) of 1,000 to 800,000 Daltons.

~~34~~29. The process of claim ~~32~~ 27, wherein the 1:1 alternating ethylene-maleic anhydride copolymer has a weight average molecular weight (MW_w) of 50,000 to 500,000 Daltons.

~~35~~30. The process of claim ~~32~~ 27, wherein the 1:1 alternating ethylene-maleic anhydride copolymer has a weight average molecular weight (MW_w) of 60,000 Daltons.

~~36~~31. A polyamide formulation comprising a recycled polyamide or a virgin polyamide compounded with the master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2.

~~37~~32. The polyamide formulation of claim ~~36~~ 31, wherein the polyamide is a virgin polyamide.

~~38~~33. The polyamide formulation of claim ~~36~~ 31, wherein the polyamide is a recycled polyamide-6 or polyamide-6,6.

~~39~~34. The polyamide formulation of claim ~~36~~ 31, wherein the polyamide is a recycled polyamide-6.

~~40~~35. The polyamide formulation of claim ~~36~~ 31, wherein the polyamide is a recycled polyamide-6,6.

~~41~~36. The polyamide formulation of claim ~~36~~ 31, wherein the average molecule weight of the compounded polyamide is increased.

~~42~~37. The polyamide formulation of a claim ~~36~~ 31, wherein the polyamide formulation has increased tensile strength, improved stretch performance, increased impact strength, increased flex modulus, increased heat deflection temperature, or a combination thereof compared to the recycled polyamide

~~43~~38. The polyamide formulation of claim ~~36~~ 31, wherein each of the tensile strength, tensile elongation, flexural strength and flexural modulus of the polyamide formulation increases.

~~44~~39. A process for preparing a polyamide formulation, the process comprising ~~the step of reaction~~ compounding a polyamide with the master batch composition of ~~any one of claims 1 to 4~~claim 1 or 2.

~~45~~40. The process of claim ~~44~~ 39, wherein the polyamide is a virgin polyamide or a recycled polyamide.

~~46~~41. The process of claim ~~44~~ 39, wherein the polyamide is virgin polyamide.

~~47~~42. The process of claim ~~44~~ 39, wherein the polyamide is a recycled polyamide.

~~48~~43. The process of claim ~~44~~ 39, wherein the temperature of the compounding step is from about 230° C to about 280° C.

~~49~~44. The process of claim ~~44~~ 39, wherein the compounding step in performed in a twin-screw extruder, a single-screw extruder, an oscillating screw extruder, a continuous mixer , a Banbury mixer, or a planetary extruder.

~~50~~45. The process of claim ~~44~~ 39, wherein the concentration of the master batch composition in the polyamide formulation is from about 0.5% to about 10%, or about 1%, or about 2%, or about 3% or about 4% or about 5%.