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(54) Title: POST-CONSUMER RECYCLATE CONTAINING RESINS FOR GENERAL PURPOSE BLOW MOLDING

(57) Abstract: In some embodiments, a method of making a pelletized polymeric resin includes blending a first polymer component with a second polymer component to form a polymeric resin. The first polymer component is a high density polyethylene base resin. The second polymer component is a post-consumer resin (PCR), wherein at least a portion of the PCR is sourced from recycled intermediate bulk containers, drums, pipes, and combinations thereof. The method further includes extruding the polymeric resin to form polymeric resin extrudate. The method further includes pelletizing the polymeric resin extrudate to form a pelletized polymeric resin. In some embodiments, a method of making a pelletized polymeric resin comprises blending a first polymer component with a second polymer component to form a polymeric resin. The method further includes extruding the polymeric resin to form polymeric resin extrudate. The method further includes pelletizing the polymeric resin extrudate to form a pelletized polymeric resin.

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POST-CONSUMER RECYCLATE CONTAINING RESINS FOR GENERAL PURPOSE BLOW MOLDING

FIELD OF THE INVENTION

[0001] The present disclosure relates to polymeric resin compositions and articles manufactured therefrom.

BACKGROUND OF THE INVENTION

[0002] Implementing post-consumer waste products into commercial products and materials is desirable to multiple manufacturing sectors as a cost-effective and readily available feedstock. Additionally, such implementations are desirable to governmental officials and agencies, as incorporating post-consumer waste products into such manufacturing sectors provides benefits to environmental policies and regulations.

[0003] However, incorporating such waste materials and post-consumer resins (PCR) into pre-existent manufacturing methods and processes is not without drawbacks. In particular, incorporating recycled plastic products into such processes presents challenges, which can be difficult to overcome, such as reductions/changes in mechanical, physical, and rheological properties both during processing and of the final product. Typically, such deleterious consequences become magnified as the PCR content is increased.

[0004] Thus, there is a need to develop new polymeric resins capable of withstanding high levels of PCR incorporation while also maintaining the physical, mechanical, and rheological properties required for consumer and commercial use.

SUMMARY OF THE INVENTION

[0005] The present disclosure relates to polymeric resin compositions and articles manufactured therefrom.

[0006] In some embodiments, a method of making a pelletized polymeric resin includes blending a first polymer component with a second polymer component to form a polymeric resin. The first polymer component is a high density polyethylene (HDPE) base resin. The second polymer component is a post-consumer resin (PCR), wherein at least a portion of the PCR is sourced from recycled intermediate bulk containers, drums, pipes, and combinations thereof. The method further includes extruding the polymeric resin to form polymeric resin extrudate. The method further includes pelletizing the polymeric resin extrudate to form a pelletized polymeric resin.

[0007] In some embodiments, a method of making a pellitized polymeric resin comprises blending a first polymer component with a second polymer component to form a polymeric resin. The first polymer component is a high density polyethylene (HDPE) base resin comprising greater than 50 wt% of the polymeric resin. The second polymer component is a post-consumer resin (PCR)

comprising a first recycled polymer resin sourced from recycled intermediate bulk containers and a second recycled polymer resin sourced from recycled small blow molded containers. The method further includes extruding the polymeric resin to form polymeric resin extrudate. The method further includes pelletizing the polymeric resin extrudate to form a pelletized polymeric resin.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Resins of the current disclosure include one or more polymeric components, where at least one component includes a polymer having at least one ethylene monomeric unit. Notably, polymeric components of the present disclosure include copolymer compositions, namely polymers derived from two or more structurally distinct monomers. In one or more embodiments, at least one of the polymeric components includes a post-consumer resin (PCR). In some embodiments, a resin is a polymeric resin, wherein a polymeric resin includes a blend of two or more polymer components. More specifically, resins of the present disclosure can include a polymeric resin comprising two or more polymeric components, wherein the two or more polymeric components independently include a copolymer composition and at least one of the polymeric components is a PCR. Resins of the present disclosure are useful as manufacturing materials, as a result of their chemical and environments stress crack growth resistance (ESCR). Resins disclosed herein, offer alternative materials, for use in the manufacture of outdoor recreational equipment, incorporating recycled post-consumer waste plastic.

[0009] In at least one embodiment, a polymeric resin for use in the production of blow molded products includes a blend of a first polymeric component and a second polymeric component. In some embodiments, the first polymeric component is a high density polyethylene (HDPE) base resin. In some embodiments, the polymeric resin further includes a post-consumer resin (PCR), which can be readily and/or commercially sourced. Such materials and products produced from the polymeric resin exhibit sufficient physical properties, mechanical properties, chemical resistant properties, impact strength, hardness, and environmental stress crack resistance (ESCR) suitable for commercial products and uses.

HDPE Base Resin

[0010] In some embodiments, the HDPE base resin has a density (as determined by ASTM1505) of about 0.940 g/cm^3 to about 0.975 g/cm^3, such as about 0.940 g/cm^3 to about 0.960 g/cm^3, such as about 0.940 g/cm^3 to about 0.955 g/cm^3, such as about 0.953 g/cm^3.

[0011] In some embodiments, the HDPE base resin has a high load melt index (HLMI) (as determined by ASTM D-1238, 190°C with a 21.6 kg load) of about 2 g/10 min to about 10 g/10 min, such as about 4 g/10 min to about 8 g/10 min, such as about 5.5 g/10 min to about 7.5 g/10 min.

[0012] In some embodiments, the HDPE base resin includes a weight average molecular weight (Mw), as determined by gel permeation chromatography (GPC), of about 180,000 g/mol to about 400,000 g/mol, such as about 215,000 g/mol to about 375,000 g/mol, such as about 275,000 g/mol to about 375,000 g/mol.

[0013] In some embodiments, the HDPE base resin has an ESCR (as determined by ISO 16770; 3.5 MPa, 2% Arkopal N100, 80 °C) of about 10 hrs to about 125 hrs, such as about 15 hrs to about 100 hrs, such as about 25 hrs to about 75 hrs, such as about 35 hrs to about 65 hrs.

[0014] In some embodiments, the HDPE base resin can include any suitable commercially available resin, such as Hostalen ACP 5231 D, Hostalen ACP 5331 A, Lupolen 4261 AG Q 469, Hyperzone HY 4008, Hyperzone HY55430, and combinations thereof. In at least one embodiment, the HDPE base resin is sourced from LyondellBasell Industries N.V.

Post-consumer Resin

[0015] In some embodiments, the HDPE base resin is blended with a PCR to form a polymeric resin. The PCR can be sourced from any appropriate plastic waste streams, such as polyethylene PCR sourced from recycled intermediate bulk containers (IBC), drums, and/or pipes. In additional or alternative embodiments, the PCR can further be sourced from suitable resins used in small blow molding applications. Without being bound by theory, blending the HDPE base resin with the PCR allows an operator to tune the rheological properties of the polymeric resin, so as to produce a resin suitable for use in general purpose large flow molding applications. Examples of such applications can include, but are not limited to, outdoor recreational equipment (*e.g.*, kayaks and playground equipment).

[0016] In some embodiments, the PCR has a density (as determined by ASTM1505) of about 0.910 g/cm^3 to about 0.970 g/cm^3, such as about 0.920 g/cm^3 to about 0.955 g/cm^3, such as about 0.935 g/cm^3 to about 0.945 g/cm^3, such as about 0.941 g/cm^3. In at least one embodiment, the PCR has a melt index (as determined by ASTM D-1238, 190°C with a 2.16 kg load) of about 0.3 g/10 min to about 10 g/10 min, such as about 0.3 g/10 min to about 10 g/10 min, such as about 0.3 g/10 min to about 5 g/10 min such as about 0.3 g/10 min to about 2 g/10 min.

[0017] In some embodiments, the PCR has a high load melt index (as determined by ASTM D-1238, 190°C with a 21.6 kg load) of about 10 g/10 min to about 60 g/10 min, such as about 10 g/10 min to about 50 g/10 min, such as about 10 g/10 min to about 40 g/10 min.

Polyethylene Homopolymer and Polyethylene Copolymer Post-consumer Resin

[0018] In one or more embodiments, the PCR is selected from an ultra-high molecular weight polyethylene (UHMWPE), ultra-low molecular weight polyethylene (ULMWPE), high molecular weight polyethylene (HMWPE), high density polyethylene (HDPE), medium density polyethylene (MDPE), linear low density polyethylene (LLDPE), low density polyethylene (LDPE), very-low

density polyethylene (VLDPE), and combinations thereof. In some embodiments, the PCR is a copolymer of polyethylene of any one or more selected from the group previously described.

[0019] In at least one embodiment, the PCR is HDPE homopolymer and/or a copolymer thereof. In some embodiments, the HDPE PCR homopolymer includes a weight average molecular weight (Mw), as determined by GPC, of about 180,000 g/mol to about 400,000 g/mol, such as about 200,000 g/mol to about 360,000 g/mol, such as about 225,000 g/mol to about 350,000 g/mol.

[0020] In some embodiments, the HDPE PCR homopolymer has a density of about 0.925 g/cm^3 to about 0.965 g/cm^3, such as about 0.935 g/cm^3 to about 0.955 g/cm^3, such as about 0.945 g/cm^3 to about 0.955 g/cm^3. In at least one embodiment, the HDPE PCR homopolymer has a melt index (as determined by ASTM D-1238, 190°C with a 2.16 kg load) of about 1 g/10 min to about 60 g/10 min, such as about 10 g/10 min to about 50 g/10 min, such as about 20 g/10 min to about 40 g/10 min such as about 25 g/10 min to about 35 g/10 min.

[0021] In some embodiments, the PCR is a HDPE PCR copolymer comprising any one or more comonomers selected from propylene, 1-butene, 1-hexene, 1-octene, 4-methyl-1-pentene, and any combination thereof. In some embodiments, the HDPE copolymer PCR includes about 90.1 mol % to about 99.9 mol % of ethylene units, such as about 91 mol % to 99 mol %, such as about 92 mol % to 98 mol %, such as about 93 mol % to 97 mol %, such as about 94 mol % to 96 mol %. In at least one embodiment, the HDPE copolymer or homopolymer PCR is sourced from post-consumer waste products, such as products formed from HDPE copolymer resins typically used for small blow molding applications.

[0022] In some embodiments, the HDPE copolymer PCR includes a backbone architecture of at least one of a random copolymer, a block copolymer, an alternating copolymer, or a gradient copolymer. In one or more embodiments, the HDPE copolymer PCR is a random copolymer. In one or more embodiments, the HDPE copolymer PCR includes a molar ratio of ethylene units to any one or more comonomer units of about 60:40 to about 99:1, such as about 70:30 to about 90:10, such as about 75:25 to about 85:15.

[0023] In some embodiments, the HDPE copolymer PCR includes a weight average molecular weight (Mw), as determined by GPC, of about 200,000 g/mol to about 400,000 g/mol, such as about 225,000 g/mol to about 375,000 g/mol, such as about 250,000 g/mol to about 375,000 g/mol.

[0024] In some embodiments, the HDPE copolymer PCR has an ESCR (as determined by ASTM D1693; 100% Igepal®, Cond B) of about 10 hrs to about 50 hrs, such as about 20 hrs to about 40 hrs, such as about 25 hrs to about 35 hrs.

[0025] In at least one embodiment, the PCR includes at least one of HDPE homopolymer PCR sourced from one or more intermediate bulk containers and/or HDPE copolymer PCR sourced from resins used in small blow molding applications. In some embodiments, the PCR includes

both HDPE PCR and HDPE copolymer PCR at a weight ratio of about 50:50 to about 99:1, such as 60:40 to about 90:10, such as 70:30 to about 80:20, such as 75:25 to about 85:15.

[0026] In some embodiments, the PCR further includes one or more additional polymers selected from the group consisting of low density polyethylene (LDPE), medium density polyethylene (MDPE), polypropylene, polyester, acrylic resin, polyvinyl alcohol, polyvinyl chloride, polyvinyl acetate, polyvinyl ether, ethylene-vinyl acetate copolymers (EVA), ethylenevinyl alcohol copolymers (EVOH), ethylene-acrylic acid copolymers, any one or more nylons, and the like, and mixtures thereof. In at least one embodiment, the one or more additional polymers includes less than 15 wt% of the PCR, such as about 0.01 wt% to about 15 wt%, such as about 0.01 wt% to about 10 wt%, such as about 0.01 wt% to about 5 wt%, such as about 0.01 wt% to about 2.5 wt%, such as about 0.01 wt% to about 1 wt%.

[0027] In some embodiments, the PCR further includes one or more compatiblizers, such as grafted copolymers of maleic anhydride with HDPE, LLDPE, and/or LDPE. In at least one embodiment, the one or more compatibilizers includes less than 15 wt% of the PCR, such as about 0.01 wt% to about 15 wt%, such as about 0.01 wt% to about 10 wt%, such as about 0.01 wt% to about 5 wt%, such as about 0.01 wt% to about 2.5 wt%, such as about 0.01 wt% to about 1 wt%.

[0028] In some embodiments, the PCR further includes one or more tie layer material. A tie layer is commonly used in multi-layered film applications as an adhesive applied to prevent film delamination. A tie layer material typically includes a polyolefin base resin as the predominant component and one or more grafted polyolefins. In at least one embodiment, the one or more tie layer materials includes less than 15 wt% of the PCR, such as about 0.01 wt% to about 15 wt%, such as about 0.01 wt% to about 10 wt%, such as about 0.01 wt% to about 5 wt%, such as about 0.01 wt% to about 2.5 wt%, such as about 0.01 wt% to about 1 wt%.

[0029] In one or more embodiments, the compositional summation of the one or more additional polymers, one or more compatibilizers, and one or more tie layer materials of the PCR includes less than 15 wt% of the PCR, such as about 0.01 wt% to about 15 wt%, such as about 0.01 wt% to about 10 wt%, such as about 0.01 wt% to about 5 wt%, such as about 0.01 wt% to about 2.5 wt%, such as about 0.01 wt% to about 1 wt%.

Polymeric Resin and Components Thereof

[0030] In one or more embodiments, the polymeric resin includes about 50 wt% to about 99 wt% of HDPE base resin, such as about 75 wt% to about 95 wt%, alternatively about 20 wt% to about 80 wt%. In at least one embodiment, HDPE base resin includes at least 50 wt% of the polymeric resin.

[0031] In one or more embodiments, the polymeric resin includes about 1 wt% to about 50 wt% of PCR, such as about 5 wt% to about 25 wt%, such as about 10 wt% to about 20 wt%. In at least one embodiment, PCR includes less than 50 wt% of the polymeric resin.

[0032] In one or more embodiments, the polymeric resin includes a weight ratio of HDPE base resin to PCR of about 60:40 to about 90:10, such as about 70:30 to about 90:10, such as about 75:25 to about 90:10.

[0033] In some embodiments, the polymeric resin can further include any one or more additives. Suitable additives include, but are not limited to UV stabilizers, flame retardants, fillers, and pigments. Additives are important in establishing the long term stability of the polymeric resin as well as the resulting material's chemical and impact resistance.

[0034] In one or more embodiments, the polymeric resin further includes one or more UV stabilizers in an amount of about 1500 ppm to about 2500 ppm, such as about 1750 ppm to about 2250 ppm, such as about 2000 ppm. Suitable UV stabilizers include, but are not limited to, hindered amine light stabilizers ("HALS"). Examples of HALS include: Chimassorb 944, Chimassorb 994, Chimassorb 905, Tinuvin 770, Tinuvin 992, Tinuvin 622, Tinuvin 144, and Spinuvex A36 available from Geigy; and Cyasorb UV 3346 and Cyasorb UV 944 commercially available American Cyanamide. Particularly preferred UV stabilizers are Cytec UV 3346 and Chemasorb 944 (poly[N,N-bis(2,2,6,6-tetramethyl-4-piperidinyl)-1,6-hexanediamine-co-2,4-dichloro-6-morpholino-1,3,5-triazine).

[0035] In one or more embodiments, the polymeric resin further includes one or more flame retardants. Flame retardants include, for example, halogen-containing compounds, antimony oxides, or phosphorus compounds. Suitable flame retardants include, but are not limited to aluminum trihydrate, antimony oxide (Sb_2O_3), and decabromobiphenyl oxide ("decabrome").

[0036] In one or more embodiments, the polymeric resin includes 0.01 wt% to about 5 wt% of one or more additives, such as about 0.01 wt% to about 2.5 wt%, such as about 0.01 wt% to about 1 wt%. In one or more embodiments, the polymeric resin includes about 1% or less of additives (such as flame retardant).

[0037] In one or more embodiments, the one or more components of the polymeric resin can be blended via any one or more suitable methods known to one of ordinary skill in the art. Such blending methods can include, solution processing, thermal processing, and/or mechanical processing. In some embodiments, melt screw extrusion is implemented to form the polymeric resin extrudate, which can then be further processed via pelletization to form a pelletized polymeric resin. Melt blending is one suitable method for preparing the final polymer blend of the present disclosure, although any suitable polymer blending techniques available to those of ordinary skill in the art may be used. Techniques for melt blending of a polymer with additives of all types are

known to those of ordinary skill the art and can typically be used with the present disclosure. In one type of melt blending operation useful with the present disclosure, the individual components of the blend are combined in a mechanical extruder or mixer, and then heated to a temperature sufficient to form a polymer melt.

[0038] The mechanical mixer can be a continuous or batch mixer. Examples of suitable continuous mixers include single screw extruders, intermeshing co-rotating twin screw extruders such as Werner & Pfleiderer ZSK™ extruders, counter-rotating twin screw extruders such as those manufactured by Leistritz™, and reciprocating single screw kneaders such as Buss™ co-kneaders. Examples of suitable batch mixers are lateral 2-roll mixers such as Banbury™ or Boling™ mixers. The temperature of the melt, residence time of the melt within the mixer, and the mechanical design of the mixer are several well-known variables that control the amount of shear to be applied to the composition during mixing, and can be readily selected by one of ordinary skill in the art based on the disclosure of the disclosure herein.

[0039] The polymeric resins disclosed herein may be pelletized via strand pelleting or commercial underwater pelletization. Pellets of the polymeric resin may then be easily processed into shaped articles by injection molding, profile extrusion, blow molding, and other forming processes to give products which have well balanced properties suitable for commercial applications.

[0040] In at least one embodiment, pellets of the polymeric resin are formed in a continuous process. As such, components of the polymeric resin are fed into a continuous mixer, a single screw or twin screw extruder via volumetric or gravimetric feeders. The extruder is heated to a temperature sufficient to melt the polymers, for example between 165 °C and 190 °C. The components are fed into an extruder and mixed/blended together in a molten state. The extruder speed may be from about 1 to about 100 revolutions per minute (rpm), more typically from about 10 to about 50 rpm. The gas from the extruder may be evacuated by a vacuum pump. The polymeric resin extrudate is typically cooled (*e.g.*, in a water bath or underwater pelletizer) and pelletized to form pellets of the polymeric resin.

[0041] In at least one embodiment, pellets of the polymeric resin are formed in a batch process. As such, components of the polymeric resin are added to a mixing device, such as a Banbury mixer, and heated to a temperature sufficient to melt the polymer, such as about 100 °C to about 155 °C. The mixing speed is typically about 35 to about 75 rpm. The output from the mixer was cooled and pelletized to form pellets of the polymeric resin.

[0042] In one or more embodiments, the polymeric resin, or pellets thereof, is useful for making articles by injection molding, blow molding, rotomolding, and compression molding. In at least one embodiment, the polymeric resin can be implemented into an extrusion blow molding process to manufacture jerry cans comprising recycled PCR material.

[0043] In embodiments wherein the polymeric resin includes a blend of the HDPE base resin and PCR, the polymeric resin exhibits intermediate physical and mechanical properties in comparison the input materials. That is to say that such resulting physical and mechanical properties are tailorable via altering the feed of the polymeric components and/or additives.

[0044] In some embodiments, the polymeric resin has a density (as determined by ASTM D1505) of about of about 0.940 g/cm^3 to about 0.975 g/cm^3, such as about 0.940 g/cm^3 to about 0.960 g/cm^3, such as about 0.940 g/cm^3 to about 0.955 g/cm^3, such as about 0.948 g/cm^3

[0045] In some embodiments, the polymeric resin has a melt index (as determined by ASTM D-1238, 190°C with a 2.16 kg load) of about 0.05 g/10 min to about 1 g/10 min, such as about 0.05 g/10 min to about 0.5 g/10 min, such as about 0.05 g/10 min to about 0.1 g/10 min.

[0046] In some embodiments, the polymeric resin has a high load melt index (as determined by ASTM D-1238, 190°C with a 21.6 kg load) of about 2 g/10 min to about 20 g/10 min, such as about 5 g/10 min to about 15 g/10 min, such as about 8.5 g/10 min to about 12.5 g/10 min, such as about 10 g/10 min.

[0047] In some embodiments, the polymeric resin has an ESCR (as determined by ASTM D1693; 100% Igepal®, Cond B) of greater than 1000 hrs.

[0048] In at least one embodiment, the polymeric resin includes physical and mechanical properties comparable to that of other commercially resins of similar composition, such as, but not limited to, Marlex® HXM 50100 Polyethylene as sourced from Chevron Phillips Chemical.

[0049] It should be noted that an object of the present disclosure is that the polymeric resin be implemented into extrusion blow molded articles, such as playground equipment, outdoor recreational equipment (*e.g.*, kayaks), and the like, in an effort to produce usable materials and products from post-consumer waste products. Furthermore, it is an object of the present disclosure to provide hollow plastic articles whose structure has one or more layers which have PCR content, and also to provide a process for their production. Such products can be produced via blow molding or co-extrusion blow molding processes.

[0050] In at least one embodiment, hollow plastic articles can be produced via a process comprising: (1) molding a blow molded article in a blow molding and/or co-extrusion blow molding machine, whereby the blow molding cavity formed by the two mold contours is shaped in such a way that said cavity essentially matches the outer contour of the plastic hollow article to be fabricated and, in addition, it has a circumferential indentation and/or protuberance, preferably located in the middle relative to the nip-off edge, (2) separation of the indentation and/or protuberance, which yields at least two sheets, (3) optionally, prior to joining the sheets together to form a hollow article, installation of the built-in components on the inside of the sheets, and (4) joining the sheets together to form a hollow article, optionally by means of welding and/or gluing.

[0051] The principle of the process for the production of plastic hollow articles consists first of the conventional fabrication of a blow molded article in a regular blow molding or co-extrusion blow molding machine. The cavity formed by the two mold contours is shaped in such a way that said cavity essentially matches the outer contour of the plastic hollow article or plastic tank to be manufactured. In one or more embodiments, the above-mentioned blow molding cavity or the blowing mold used for the process additionally has a circumferential indentation and/or protuberance, preferably located in the middle relative to the nip-off edge. "Circumferential", as defined herein, means that the indentation and/or protuberance preferably extends around the entire blow molded article or plastic hollow article. Therefore, the modified configuration of the contact areas of the mold, which is new in comparison to the commonly employed blowing molds, allows the creation of a hollow plastic article that has an indentation and/or protuberance (a groove or bead) extending around the container.

[0052] In the second step of the process, the described indentation and/or protuberance is separated, preferably in the perpendicular direction with respect to the above-mentioned indentation and/or protuberance. Two half shells or sheets are obtained by this separation procedure, that is to say, for instance, by cutting, grinding or punching out the indentation and/or protuberance that encircles the hollow plastic article. In some embodiments, the half shells obtained are glued and/or welded together to form a hollow article.

[0053] In at least one embodiment, it is provided that the hollow plastic articles manufactured by means of the process according to this disclosure are preferably employed as playground and outdoor recreational equipment (*e.g.*, kayaks), automotive dunnage, truck bedliners, and the like.

[0054] Overall, the polymeric resin of the present disclosure includes a composition suitable for use in general purpose large blow molding applications, such as outdoor recreational materials and equipment, while also incorporating recycled PCR content. The polymeric resin disclosed herein exhibits suitable physical and mechanical properties for implementation into already existent blow molding, co-extrusion blow molding, and/or rotomolding processes to produce articles with high ESCR and recycled PCR.

[0055] The phrases, unless otherwise specified, "consists essentially of" and "consisting essentially of" do not exclude the presence of other steps, elements, or materials, whether or not, specifically mentioned in this specification, so long as such steps, elements, or materials, do not affect the basic and novel characteristics of the present disclosure, additionally, they do not exclude impurities and variances normally associated with the elements and materials used.

[0056] For the sake of brevity, only certain ranges are explicitly disclosed herein. However, ranges from any lower limit may be combined with any upper limit to recite a range not explicitly recited, as well as, ranges from any lower limit may be combined with any other lower limit to

recite a range not explicitly recited, in the same way, ranges from any upper limit may be combined with any other upper limit to recite a range not explicitly recited. Additionally, within a range includes every point or individual value between its end points even though not explicitly recited. Thus, every point or individual value may serve as its own lower or upper limit combined with any other point or individual value or any other lower or upper limit, to recite a range not explicitly recited.

[0057] All documents described herein are incorporated by reference herein, including any priority documents and or testing procedures to the extent they are not inconsistent with this text. As is apparent from the foregoing general description and the specific embodiments, while forms of the present disclosure have been illustrated and described, various modifications can be made without departing from the spirit and scope of the present disclosure. Accordingly, it is not intended that the present disclosure be limited thereby. Likewise, the term "comprising" is considered synonymous with the term "including" for purposes of United States law. Likewise whenever a composition, an element or a group of elements is preceded with the transitional phrase "comprising," it is understood that we also contemplate the same composition or group of elements with transitional phrases "consisting essentially of," "consisting of," "selected from the group of consisting of," or "is" preceding the recitation of the composition, element, or elements and vice versa.

[0058] While the present disclosure has been described with respect to a number of embodiments and examples, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope and spirit of the present disclosure.

CLAIMS

1. A method of making a pelletized polymeric resin, comprising:

blending a first polymer component with a second polymer component to form a polymeric resin, wherein:

the first polymer component is a high density polyethylene (HDPE) base resin, and

the second polymer component is a post-consumer resin (PCR), wherein at least a portion of the PCR is sourced from recycled intermediate bulk containers, drums, pipes, and combinations thereof;

extruding the polymeric resin to form polymeric resin extrudate; and

pelletizing the polymeric resin extrudate to form a pelletized polymeric resin.

2. The method of claim 1, wherein the HDPE base resin has a density (as determined by ASTM1505) of about 0.940 g/cm^3 to about 0.955 g/cm^3.

3. The method of claim 1, wherein the HDPE base resin has a high load melt index (as determined by ASTM D-1238, 190°C with a 21.6 kg load) of about 2 g/10 min to about 10 g/10 min.

4. The method of claim 1, wherein the PCR has a density (as determined by ASTM1505) of about 0.910 g/cm^3 to about 0.970 g/cm^3.

5. The method of claim 1, wherein the PCR has a melt index (as determined by ASTM D-1238, 190°C with a 2.16 kg load) of about 0.3 g/10 min to about 10 g/10 min.

6. The method of claim 1, wherein the PCR has a high load melt index (as determined by ASTM D-1238, 190°C with a 21.6 kg load) of about 10 g/10 min to about 40 g/10 min.

7. The method of claim 1, wherein the first portion of the PCR comprises one or more polymers selected from the group consisting of ultra-high molecular weight polyethylene (UHMWPE), ultra-low molecular weight polyethylene (ULMWPE), high molecular weight polyethylene (HMWPE), high density polyethylene (HDPE), medium density polyethylene (MDPE), linear low density polyethylene (LLDPE), low density polyethylene (LDPE), very-low density polyethylene (VLDPE), or combinations thereof.

8. The method of claim 1, wherein a second portion of the PCR is sourced from recycled resins suitable for small blow molding applications.

9. The method of claim 8, wherein the second portion of the PCR comprises a HDPE copolymer.

10. The method of claim 9, wherein the HDPE copolymer comprises a backbone architecture selected from the group consisting of a random copolymer, a block copolymer, an alternating copolymer, a gradient copolymer, and combinations thereof.

11. The method of claim 8, wherein the PCR comprises a weight ratio of the first portion relative to the second portion of about 60:40 to about 90:10.

12. A method of making a pelletized polymeric resin, comprising:

blending a first polymer component with a second polymer component to form a polymeric resin, wherein:

a first polymer component is a high density polyethylene (HDPE) base resin comprising greater than 50 wt % of the polymeric resin, and

a second polymer component is a post-consumer resin (PCR), the PCR comprising:

a first recycled polymer resin sourced from recycled intermediate bulk containers; and

a second recycled polymer resin sourced from recycled small blow molded containers;

extruding the polymeric resin to form polymeric resin extrudate; and

pelletizing the polymeric resin extrudate to form a pelletized polymeric resin.

13. The method of claim 12, wherein the polymeric resin has a high load melt index (as determined by ASTM D-1238, 190°C with a 21.6 kg load) of about 8.5 g/10 min to about 12.5 g/10 min.

14. The method of claim 12, wherein the first polymer component comprises about 50 wt% to about 90 wt% of the polymeric resin.

15. The method of claim 12, wherein the second polymer component comprises about 1 wt% to about 50 wt% of the polymeric resin.

16. The method of claim 12, wherein the first recycled polymer resin is HDPE PCR.

17. The method of claim 12, wherein the second polymer component is a HDPE copolymer PCR comprising one or more comonomers selected from the group consisting of propylene, 1-butene, 1-hexene, 1-octene, 4-methyl-1-pentene, and any combination thereof.

18. The method of claim 12, wherein the PCR further comprises one or more additional polymers selected from the group consisting of low density polyethylene (LDPE), medium density polyethylene (MDPE), polypropylene, polyester, acrylic resin, polyvinyl alcohol, polyvinyl chloride, polyvinyl acetate, polyvinyl ether, ethylene-vinyl acetate copolymers (EVA), ethylenevinyl alcohol copolymers (EVOH), ethylene-acrylic acid copolymers, any one or more nylons, and combinations thereof.

19. The method of claim 18, wherein the one or more additional polymers comprises less than 15 wt% of the PCR.

20. The method of claim 12, wherein the polymeric resin comprises a weight ratio of HDPE base resin to PCR of about 60:40 to about 90:10.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 23/84594

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. C08L 23/06, B29B 11/06, B32B 27/08 (2024.01)
ADD. B32B 27/32 (2024.01)

CPC - INV. C08L 23/06, B29B 11/06, B32B 27/08
ADD. B32B 27/32

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)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 2022/0396689 A1 (Equistar Chemicals LP) 15 December 2022 (15.12.2022) Abstract, claims, para [0003], para [0014], para [0072], para [0070], para [0039], para [0037] and entire document	1-8 -------- 9-20
Y	US 2022/0402187 A1 (Equistar Chemicals LP) 22 December 2022 (22.12.2022) Abstract, claims, para [0010], para [00116], para [0036], para [00118], para [00108] and entire document	9-20
A	US 2022/0177681 A1 (Equistar Chemicals LP) 9 June 2022 (09.06.2022) Abstract, claims, para [0009]-[0045]	1-20
A	US 2023/0114045 A1 (Borealis AG) 13 April 2023 (13.04.2023) Abstract, claims, para [0013]-[0072]	1-20

☐ 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
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"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	Date of mailing of the international search report
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