CELLULAR POLYMERIC MATERIAL

PRIORITY CLAIM

[0001] This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application Serial No. 61/779,951, filed March 13, 2013, which is expressly incorporated by reference herein.

BACKGROUND

[0002] The present disclosure relates to polymeric materials that can be formed to produce a container, in particular polymeric materials that insulate. More particularly, the present disclosure relates to morphology and crystalline structure of cellular polymeric material that can be transformed into usable articles, such as insulated containers.

SUMMARY

[0003] In one aspect of the present disclosure, there is provided a process for producing an insulative cellular polypropylene-based material comprising:

extruding a formulation through extruder die lips at a die exit angle of 20^{o} to about 60^{o} to produce the insulative cellular polypropylene-based material,

wherein the formulation comprises

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer,

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, and mixtures thereof,

iii) at least one nucleating agent, and

iv) at least one slip agent.

[0003A] In another aspect of the present disclosure, there is provided a process for producing an insulative cellular polypropylene-based material comprising:

~~extruding a formulation through extruder die lips to produce the insulative cellular polypropylene-based material,~~

~~wherein the formulation comprises~~providing a formulation comprising

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer,

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, and mixtures thereof,

iii) at least one nucleating agent, and

iv) at least one slip agent, and

~~wherein cell dimensional attributes are according to $y = Ax^K$, wherein either x or y is cell density of the insulative cellular polypropylene-based material and the non-cell density variable is cell length, cell width, or cell wall thickness of the insulative cellular polypropylene-based material~~extruding the formulation through an extruder die lip at a die exit angle of about 20 ^{o} to about 60^{o} to form a sheet of the material without surface indentations of greater than 5 microns when the sheet of the material is curved to form a round article.

[0003B] In a further aspect of the present disclosure, there is provided an insulative cellular polypropylene-based material comprising:

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer, and

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, and mixtures thereof,

wherein the material ~~is wrinkle-resistant or crease resistant~~ has been extruded through an extruder die lip at a die exit angle of about 20^{o} to about 60^{o} so that surface indentations of greater than 5 microns are not present when a sheet of the material is curved to form a round article.

[0003C] Yet a further aspect of the present disclosure provides a process for producing an insulative cellular polypropylene-based material comprising:

~~extruding a formulation through an extruder nozzle including an inner die lip at an inner die lip angle of about 45^{o} to about 60^{o} and an outer die lip at an angle of about 35^{o} degrees to about 55^{o} to produce the insulative cellular polypropylene-based material,~~

~~wherein the formulation comprises~~providing a formulation comprising

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer,

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, ~~and~~ mixtures thereof,

iii) at least one nucleating agent, and

iv) at least one slip agent, and

. extruding the formulation through an extruder nozzle including an inner die lip at an inner die lip angle of about 45° to about 60° and an outer die lip at an angle of about 35° to about 55° to produce the insulative cellular polypropylene-based material without surface indentations of greater than 5 microns when the sheet of the material is curved to form a round article.

[0003D] Also disclosed herein is an insulated container in accordance with the present disclosure, which may be a drink cup or a food-storage cup (*e.g.*), is manufactured from a sheet extrudate or tubular extrudate produced in an extrusion process. In illustrative embodiments, the extrudate is a cellular polymeric material.

[0004] In illustrative embodiments, an insulative container in accordance with the present disclosure is manufactured from a tubular extrudate produced in an extrusion process. In illustrative embodiments, the extrudate is an insulative cellular polypropylene-based material configured to provide resistance to creasing and/or wrinkling during cup convolution or shaping.

[0005] In illustrative embodiments, the cell morphology of an extruded sheet of insulative cellular polypropylene-based material in accordance with the present disclosure is a function of the extrusion angle, which has an effect on the quality of an article, such as an insulative container, formed therewith. In particular, cell morphology is affected by the angle at which a polypropylene-based material in accordance with the present disclosure exits an enclosed die volume through extruder die lips, and is related to a reduction in, if not an elimination of, deep creases and/or wrinkles inside the formed article.

[0006] In illustrative embodiments, the cell morphology of an extruded sheet of insulative cellular polypropylene-based material in accordance with the present disclosure is a function of formulation and process conditions, which conditions have an effect on the quality of

CLAIMS

1. A process for producing an insulative cellular polypropylene-based material comprising

extruding a formulation through extruder die lips at a die exit angle of ~~0°~~ 20° to about 60° to produce the insulative cellular polypropylene-based material,

wherein the formulation comprises

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer,

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, and mixtures thereof,

iii) at least one nucleating agent, and

iv) at least one slip agent.

~~2. The process of claim 1, wherein the die exit angle is 0° to about 10°.~~

~~3. The process of claim 1, wherein the die exit angle is about 10° to about 20°.~~

~~4~~2. The process of claim 1, wherein the die exit angle is about 20° to about 30°.

~~5~~3. The process of claim 1, wherein the die exit angle is about 30° to about 40°.

~~6~~4. The process of claim 1, wherein the die exit angle is about 44°.

~~7~~5. The process of claim 1, wherein the die exit angle is about 40° to about 50°.

~~8~~6. The process of claim 1, wherein the die exit angle is about 50° to about 60°.

~~9~~7. A process for producing an insulative cellular polypropylene-based material comprising

~~extruding a formulation through extruder die lips to produce the insulative cellular polypropylene-based material,~~

~~wherein the formulation comprises~~providing a formulation comprising

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer,

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, and mixtures thereof,

iii) at least one nucleating agent, and

iv) at least one slip agent, and

~~wherein cell dimensional attributes are according to $y = Ax^K$, wherein either x or y is cell density of the insulative cellular polypropylene-based material and the non-cell density variable is cell length, cell width, or cell wall thickness of the insulative cellular polypropylene-based material.~~extruding the formulation through an extruder die lip at a die exit angle of about 20^o to about 60^o to form a sheet of the material without surface indentations of greater than 5 microns when the sheet of the material is curved to form a round article.

~~10. The process of claim 9, wherein power law constant A ranges from 9×10^8 to 1.3×10^9, power law constant K ranges from -2.4 to -2.8, and x and y represent cell length and cell density, respectively.~~

~~11. The process of claim 9, wherein power law constant A ranges from 2×10^8 to 4.3×10^8, power law constant K ranges from -3.1 to -3.5, and x and y represent cell width and cell density, respectively.~~

~~12. The process of claim 9, wherein power law constant A ranges from 4×10^5 to 5×10^5, power law constant K ranges from -2.8 to -3.2, and x and y represent cell wall thickness and cell density, respectively.~~

~~13~~8. An insulative cellular polypropylene-based material comprising

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer, and

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, and mixtures thereof,

wherein the material ~~is wrinkle-resistant or crease resistant~~has been extruded through an extruder die lip at a die exit angle of about 20^o to about 60^o so that surface indentations of greater than 5 microns are not present when a sheet of the material is curved to form a round article.

~~14~~9. The insulative cellular polypropylene-based material of claim ~~13~~8, further comprising at least one nucleating agent.

~~15~~10. The insulative cellular polypropylene-based material of claim ~~13~~8, further comprising at least one slip agent.

~~16~~11. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell aspect ratio in the machine direction of less than about 2.75.

~~17~~12. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell aspect ratio in the machine direction of less than about 2.5.

~~18~~13. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell aspect ratio in the cross direction of less than about 2.75.

~~19~~14. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell aspect ratio in the cross direction of less than about 2.5.

~~20~~15. The insulative cellular polypropylene-based material of claim ~~19~~ 14 having a cell aspect ratio in the machine direction of less than about 3.5.

~~21~~16. The insulative cellular polypropylene-based material of claim ~~20~~ 15 having a cell aspect ratio in the machine direction of less than about 3.25.

~~22~~17. The insulative cellular polypropylene-based material of claim ~~21~~ 16 having a cell aspect ratio in the machine direction of less than about 3.0.

~~23.~~18 The insulative cellular polypropylene-based material of claim ~~22~~ 17 having a cell aspect ratio in the machine direction of less than about 2.75.

~~24~~19. The insulative cellular polypropylene-based material of claim ~~23~~ 18 having a cell aspect ratio in the machine direction of less than about 2.5.

~~25~~20. The insulative cellular polypropylene-based material of claim ~~18~~ 13 having a cell aspect ratio in the machine direction of less than about 3.5.

~~26~~21. The insulative cellular polypropylene-based material of claim ~~25~~ 20 having a cell aspect ratio in the machine direction of less than about 3.25.

~~27~~22. The insulative cellular polypropylene-based material of claim ~~26~~ 21 having a cell aspect ratio in the machine direction of less than about 3.0.

~~28~~23. The insulative cellular polypropylene-based material of claim ~~27~~ 22 having a cell aspect ratio in the machine direction of less than about 2.75.

~~29~~24. The insulative cellular polypropylene-based material of claim ~~28~~ 23 having a cell aspect ratio in the machine direction of less than about 2.5.

~~30~~25. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell aspect ratio in the cross direction of about 2.75 to about 3.75 and a cell density of about 800,000 cells/in^3.

~~31~~26. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 200,000 cells/in^3 to about 700,000 cells/in^3 and a cell aspect ratio in the machine direction of about 2.75 to about 3.5.

~~32~~27. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 200,000 cells/in^3 to about 900,000 cells/in^3 and a cell aspect ratio in the cross direction of about 2.75 to about 4.0.

~~33~~28. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 700,000 cells/in^3 to about 2,000,000 cells/in^3 and a cell aspect ratio in the machine direction of about 2.75 to about 4.5, wherein the material is micro-creasing or macro-creasing.

~~34~~29. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 900,000 cells/in^3 to about 2,000,000 cells/in^3 and a cell aspect ratio in the cross direction of about 2.75 to about 4.5, wherein the material is micro-creasing or macro-creasing.

~~35~~30. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell aspect ratio in the machine direction greater than 3.5.

~~36.~~31 The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 800,000 cells/in^3.

~~37~~32. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 200,000 cells/in^3 to about 700,000 cells/in^3.

~~38~~33. The insulative cellular polypropylene-based material of claim ~~13~~ 8 having a cell density of about 200,000 cells/in^3 to about 900,000 cells/in^3.

~~39~~34. A process for producing an insulative cellular polypropylene-based material comprising

~~extruding a formulation through an extruder nozzle including an inner die lip at an inner die lip angle of about 45° to about 60° and an outer die lip at an angle of about 35° degrees to about 55° to produce the insulative cellular polypropylene-based material,~~

~~wherein the formulation comprises~~providing a formulation comprising

i) a first polymer material comprising at least one high melt strength polypropylene homopolymer,

ii) a second polymer material comprising at least one polymer selected from the group consisting of crystalline polypropylene homopolymer, impact polypropylene copolymer, ~~and~~ mixtures thereof,

iii) at least one nucleating agent, and

iv) at least one slip agent, and

extruding the formulation through an extruder nozzle including an inner die lip at an inner die lip angle of about 45° to about 60° and an outer die lip at an angle of about 35° to about 55° to produce the insulative cellular polypropylene-based material without surface

indentations of greater than 5 microns when the sheet of the material is curved to form a round article.

~~40~~35. The process of claim ~~39~~34, wherein the inner die lip angle is about 48^{o} to about 57^{o}.

~~41~~36. The process of claim ~~40~~35, wherein the inner die lip angle is about 49^{o}.

~~42~~37. The process of claim ~~41~~36, wherein the outer die lip angle is about 40^{o} to about 49^{o}.

~~43~~38. The process of claim ~~42~~37, wherein the outer die lip angle is about 41^{o}.

~~44~~39. The process of claim ~~39~~34, wherein the outer die lip angle is about 40^{o} to about 49^{o}.

~~45~~40. The process of claim ~~44~~39, wherein the outer die lip angle is about 41^{o}.