CLAIMS

1. A method comprising:

(a) producing a piece of partially-delignified cellulose-based material by subjecting a piece of naturally-occurring cellulose-based material to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of naturally-occurring cellulose-based material, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material;

(b) drying the piece of partially-delignified cellulose-based material so as to remove moisture therefrom, such that lumina of at least some of the cellulose-based longitudinal cells collapse and such that the dried piece has a moisture content less than or equal to 15 wt%;

(c) performing a fluid-shock treatment to the dried piece of partially-delignified cellulose-based material to yield a rehydrated piece of partially-delignified cellulose-based material, the fluid-shock treatment comprising exposing the dried piece to moisture, the rehydrated piece having a moisture content of at least 35 wt%; and

(d) forming the rehydrated piece of partially-delignified cellulose-based material from a substantially flat planar configuration into a non-planar three-dimensional configuration,

wherein the lumina of first cellulose-based longitudinal cells in the rehydrated piece of partially-delignified cellulose-based material that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the rehydrated piece of partially-delignified cellulose-based material that have a cross-sectional size greater than the first size are at least partially open.

2. The method of claim 1, wherein a thickness of the piece of naturally-occurring cellulose-based materialin a direction perpendicular to the extension direction is 10 mm or less.

3. The method of claim 1, wherein the moisture content of the rehydrated piece during (d) is at least 50 wt%.

4. A method comprising:

(a) producing a piece of partially-delignified cellulose-based material by subjecting a piece of naturally-occurring cellulose-based material to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of naturally-occurring cellulose-based material, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material;

(b) partially drying the piece of partially-delignified cellulose-based material so as to remove some moisture therefrom, the partially-dried piece of partially-delignified cellulose-based material having a moisture content of at least 35%; and

(c) forming the partially-dried piece of partially-delignified cellulose-based material from a substantially flat planar configuration into a non-planar three-dimensional configuration,

wherein lumina of first cellulose-based longitudinal cells in the partially-dried piece of partially-delignified cellulose-based material that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the partially-dried piece of partially-delignified cellulose-based material that have a cross-sectional size greater than the first size are at least partially open.

5. The method of any one of claims 1-4, wherein a thickness of the piece of naturally-occurring cellulose-based material in a direction perpendicular to the extension direction is between 0.1 mm and 10 mm, inclusive.

6. The method of either of claim 1 or claim 4, wherein the forming into the non-planar three-dimensional configuration comprises folding the piece, bending the piece, or any combination thereof.

7. The method of either of claim 1 or claim 4, further comprising, after the forming into the non-planar three-dimensional configuration:

(e) drying the piece to remove moisture therefrom so as to set a shape of the piece and form a rigid monolithic piece of partially-delignified cellulose-based material in the non-planar three-dimensional configuration,

wherein the rigid monolithic piece has a moisture content less than or equal to 15 wt%.

8. The method of claim 7, further comprising:

forming a protective layer or coating over the rigid monolithic piece, the protective layer or coating being constructed to prevent rehydration of the rigid monolithic piece.

9. The method of claim 1, wherein the exposing to moisture of (c) comprises immersing partially or fully within a fluid, exposing to fluid vapor in a humidified environment, or any combination thereof.

10. The method of claim 4, wherein the moisture content of the partially-dried piece during (c) is at least 50 wt%.

11. The method of either of claim 1 or claim 4, wherein the naturally-occurring cellulose-based material is a hardwood, softwood, bamboo, grass, or reed.

12. The method of either claim 1 or claim 4, wherein the naturally-occurring cellulose-based material comprises a hardwood, the first cellulose-based longitudinal cells comprise fibers or tracheids of the hardwood, and the second cellulose-based longitudinal cells comprise vessels of the hardwood; or

the naturally-occurring cellulose-based material comprises a softwood, and the first and second cellulose-based longitudinal cells comprise tracheids.

13. The method of either claim 1 or claim 4, wherein for each lumen of the second cellulose-based longitudinal cells, a cross-sectional size thereof after the drying of (b) is less than a cross-sectional size thereof in the naturally-occurring cellulose-based material prior to (a).

14. The method of either claim 1 or claim 4, wherein:

the subjecting to one or more chemical treatments of (a) is such that a lignin content in the naturally-occurring cellulose-based material is reduced by between 0.1% and 99%, inclusive, to produce the piece of partially-delignified cellulose-based material;

the subjecting to one or more chemical treatments of (a) is such that a hemicellulose content in the naturally-occurring cellulose-based material is reduced by between 0.1% and 99%, inclusive, to produce the piece of partially-delignified cellulose-based material; or

any combination of the above.

15. The method of either claim 1 or claim 4, wherein:

the naturally-occurring cellulose-based material is a hardwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 10 wt%;

the naturally-occurring cellulose-based material is a softwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 12.5 wt%; or

the naturally-occurring cellulose-based material is a bamboo, and an amount of lignin in the piece of partially-delignified bamboo after (a) is at least 13 wt%.

16. A moldable structure comprising:

a monolithic piece of partially-delignified, naturally-occurring cellulose-based material having a moisture content of at least 35 wt%,

wherein the monolithic piece has a microstructure where lumina of first cellulose-based longitudinal cells of the naturally-occurring cellulose-based material, which have a cross-sectional size less than a first size, are substantially collapsed and lumina of second cellulose-based longitudinal cells of the naturally-occurring cellulose-based material, which have a cross-sectional size greater than the first size, are at least partially open, and

the cellulose-based longitudinal cells extend along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material.

17. The structure of claim 16, wherein the moisture content is at least 50 wt%.

18. The structure of claim 16, wherein the naturally-occurring cellulose-based material is a fibrous plant, and wherein the fibrous plant is a hardwood, softwood, bamboo, grass, or reed.

19. The moldable structure of claim 16, wherein for each lumen of the second cellulose-based longitudinal cells, a cross-sectional size thereof in the monolithic piece is less than a cross-sectional size thereof in the naturally-occurring cellulose-based material prior to the partial delignification.

20. A molded structure comprising:

the moldable structure of claim 16 formed into a non-planar three-dimensional configuration and subsequently dried to remove moisture therefrom, so as to have a moisture content less than or equal to 15 wt%.