CLAIMS

1. A method for making a product comprising:

treating a reduced recalcitrance lignocellulosic or cellulosic material with one or more enzymes and/or organisms to produce an alpha, beta, gamma and/or delta hydroxy-carboxylic acid, and

converting the alpha, beta, gamma and/or delta hydroxy-carboxylic acid to the product.

2. The method of claim 1, wherein a feedstock is pretreated with at least one of irradiation, sonication, oxidation, pyrolysis and steam explosion to produce the reduced recalcitrance lignocellulosic or cellulosic material.

3. The method of claim 2, wherein irradiation is performed with an electron beam.

4. The method of claim 1, wherein converting is selected from the group consisting of polymerization, isomerization, esterification, oxidation, reduction, disproportionation and combinations thereof.

5. The method of any one of the above claims wherein converting the hydroxy-carboxylic acid to the product comprises converting lactic acid to esters.

6. The method of any one of the above claim wherein treating is performed initially with one of more enzymes to release one or more sugars (such as glucose, xylose, sucrose, maltose, lactose, mannose, galactose, arabinose, fructose, dimers of these such as cellobiose, heterodimers of these such as sucrose, oligomers of these, and mixtures of these) from the lignocellulosic or cellulosic material followed by adding one or more organisms to produce the hydroxy-carboxylic acid.

7. The method of any one of claims 1-6, wherein producing the hydroxy-carboxylic acid comprises treating is performed initially to release one or more sugars from the lignocellulosic or cellulosic material followed by fermenting one of the sugars with the one or more of the organisms.

8. The method of claim 6 or 7, further comprising purifying the one or more sugars (e.g., utilizing one or more of electrodialysis, distillation, centrifugation, filtration, cation exchange chromatography).

9. The method of any one of the above claims wherein the hydroxy-carboxylic acid is selected from the group consisting of glycolic acid, lactic acid, malic acid, citric acid and tartaric acid.

10. The method of claim 9, wherein the hydroxy-carboxylic acid is lactic acid.

11. The method of claim 10, wherein converting comprises polymerizing the lactic acid to a polymer (e.g., polymerizing in a melt such as without an added solvent).

12. The method of claim 11, wherein a polymerizing method is selected from the group consisting of direct condensation of the lactic acid, azeotropic dehydrative condensation of the lactic acid, and dimerizing the lactic acid to lactide followed by ring opening polymerization of the lactide.

13. The method of claim 12, wherein the polymerization method is direct condensation and includes utilizing coupling agents and/or chain extenders to increase the molecular weight of the polymer.

14. The method of claim 13, wherein the coupling agents and/or chain extenders are selected from the group consisting of triphosgene, carbonyl diimidazole, dicyclohexylcarbodiimide, diisocyanate, acid chlorides, acid anhydrides, epoxides, thiirane, oxazoline, orthoester, and mixtures of these.

15. The method of claim 12 wherein the polymerization method is azeotropic condensation.

16. The method of any one of claims 11-14, wherein catalysts and/or promoters are utilized which are selected from the group consisting of Lewis acids, Bronsted acids, H_3PO_4, H_2SO_4, methane sulfonic acid, p-toluene sulfonic acid, polymerically supported sulfonic acids, metals, Mg, Al, Ti, Zn, Sn, metal oxides, TiO_2, ZnO, GeO_2, ZrO_2, SnO, SnO_2, Sb_2O_3, metal halides, $ZnCl_2$, $SnCl_2$, $SnCl_4$, $Mn(AcO)_2$, $Fe_2(LA)_3$, $Co(AcO)_2$, $Ni(AcO)_2$, $Cu(OA)_2$, $Zn(LA)_2$, $Y(OA)_3$, $Al(i\text{-}PrO)_3$, $Ti(BuO)_4$, $TiO(acac)_2$, $(Bu)_2SnO$, $Sn(octoate)_2$, solvates of any of these and mixtures of these.

17. The method of claims 15 or 16, further comprising conducting at least a portion of the polymerization at a temperature between about 100 and about 200 °C, such as between about 110 and about 170 °C or between about 120 and about 160 ° C.

18. The method of any one of claims 15 through 17, wherein at least a portion of the polymerization is performed under vacuum (e.g., between about 0.1 mm Hg to 300 mm Hg).

19. The method of claim 12, wherein the polymerization method includes dimerizing the lactic acid to lactide followed by ring opening polymerization of the lactide.

20. The method of claim 19, wherein the dimerization includes heating the lactic acid to between 100 and 200 °C under a vacuum of about 0.1 to about 100 mmHg.

21. The method of claims 19 or 20, wherein the dimerization includes a catalyst selected from the group consisting of Sn octoate, Li carbonate, Zn diacetate dehydrate, Ti tetraisopropoxide, potassium carbonate, tin powder and mixtures of these.

22. The method of any one of claims 19 through 21, wherein a ring opening polymerization catalyst is utilized which is selected from the group of Bronsted acids, HBr, HCl, triflic acid, Lewis acids, $ZnCl_2$, $AlCl_3$, anions, potassium benzoate, potassium phenoxide, potassium t-butoxide, and zinc stearate, metals, Tin, zinc, aluminum, antimony, bismuth, lanthanide and other heavy metals, Tin (II) oxide and tin (II) octoate (e.g., 2-ethylhexanoate), tetraphenyl tin, tin (II) and (IV) halogenides, tin (II) acetylacetonoate, distannoxanes (e.g., hexabutyldistannoxane, $R_3SnOSnR_3$ where R groups are alkyl or aryl groups), $Al(OiPr)_3$, other functionalized aluminium alkoxides (e.g., aluminum ethoxide, aluminium methoxide), ethyl zinc, lead (II) oxide, antimony octoate, bismuth octoate, rare earth catalysts, yttrium tris(methyllactate), yttrium tris(2-N-N-dimethylamino ethoxide), samarium tris(2-N-N-dimethylamino ethoxide), yttrium tris(trimethylsilylmethyl), lanthanum tris(2,2,6,6-tetramethylheptanedionate), lanthanum tris(acetylacetonate), yttrium octoate, yttrium tris(acetylacetonate), yttrium tris(2,2,6,6-tetramethylheptanedionate), combinations of these (e.g., ethyl zinc/aluminum isopropoxide) and mixtures of these

23. The method of any one of claims 11 through 22, wherein converting further includes blending the polymer with a second polymer.

24. The method of claim 23, wherein the second polymer is selected from the group consisting of polyglycols, polyvinyl acetate, polyolefins, styrenic resins, polyacetals, poly(meth)acrylates, polycarbonate, polybutylene succinate, elastomers, polyurethanes, natural rubber, polybutadiene, neoprene, silicone, and combinations of these.

25. The method of any one of claims 11 through 24, wherein a co-monomer is co-polymerized with the lactic acid.

26. The method of claim 25, wherein the co-monomer is selected from the group consisting of elastomeric units, lactones, glycolic acid, carbonates, morpholinediones, epoxides, 1,4- benzodioxepin-2,5-(3H)-dione glycosalicylide, 1,4- benzodioxepin-2,5-(3H, 3-methyl)-dione lactosalicylide, dibenzo-1,5 dioxacin-6-12-dione disalicylide, morpholine-2,5-dione, 1,4-dioxane-2,5-dione glycolide, oxepane-2-one ε-caprolactone, 1,3-dioxane-2-one trimethylene carconate, 2,2-dimethyltrimethylene carbonate, 1,5-dioxepane-2-one, 1,4-dioxane-2-one p-dioxanone, gamma-butyrolactone, beta-butyrolactone, beta-me-delta-valerolactone, 1,4-dioxane-2,3-dione ethylene oxalate, 3-[benzyloxycarbonyl methyl]-1,4-dioxane-2,5-dione, ethylene oxide, propylene oxide, 5,5'(oxepane-2-one), 2,4,7,9-tetraoxa-spiro[5,5]undecane-3,8-dione Spiro-bid-dimethylene caronate and mixtures of these.

27. The method of any one of claims 11 through 26, comprising combining the polymer with fillers.

28. The method of claim 27, wherein the filler is selected from the group consisting of silicates, layered silicates, polymer and organically modified layered silicate, synthetic mica, carbon, carbon fibers, glass fibers, boric acid, talc, montmorillonite, clay, starch, corn starch, wheat starch, cellulose fibers, paper, rayon, non-woven fibers, wood flours, whiskers of potassium titanate, whiskers of aluminum borate, 4,4'-thiodiphenol, glycerol and mixtures of these.

29. The method of claim 27 or 28, wherein combining further includes extrusion and/or compression molding.

30. The method of any one of claims 11 through 29, further comprising branching or cross linking the polymer.

31. The method of claim 30, wherein a cross linking agent is utilized to cross link the polymer and the cross-linking agent selected from the group consisting of 5,5'-bis(oxepane-2-one)(bis- ε -caprolactone)), spiro-bis-dimethylene carbonate, peroxides, dicumyl peroxide, benzoyl peroxide, unsaturated alcohols, hydroxyethyl methacrylate, 2-butene-1,4-diol, unsaturated anhydrides, maleic anhydride, saturated epoxides, glycidyl methacrylate, irradiation and combinations of these.

32. The method of any one of claims 11 through 31, further comprising processing the polymer by a method selected from injection molding, blow molding and thermoforming.

33. The method of any one of claims 11 through 32, further comprising combining the polymer with a dye or pigment.

34. The method of any one of claims 11 through 33, wherein converting further includes blending the polymer with a plasticizer.

35. The method of claim 34, wherein plasticizer is selected from the group consisting of triacetin, tributyl citrate, polyethylene glycol, acetic acid ester of a monoglycerides, diethyl bishydroxymethyl malonate and mixtures of these.

36. The method of any one of claims 11 through 35, further comprising grafting a molecule to the polymer.

37. The method of claim 36, wherein the molecule is selected from a monomer or a polymer.

38. The method of claim 36 or 37, further including treating the polymer with a peroxide, heating above about 120 °C, irradiation and combinations thereof.

39. The method of any one of claims 11 through 38, further comprising shaping, molding, carving, extruding and/or assembling the polymer into the product.

40. The method of any one of claims 11 through 39, wherein the product is selected from the group consisting of personal care items, tissues, towels, diapers, green packaging, compostable pots, consumer electronics, laptop casings, mobile phone casings, appliances, food packaging, disposable packaging, food containers, drink bottles, garbage bags, waste compostable bags, mulch films, controlled release matrices, controlled release containers, containers for fertilizers, containers for pesticides,

containers for herbicides, containers for nutrients, containers for pharmaceuticals, containers for flavoring agents, containers for foods, shopping bags, general purpose film, high heat film, heat seal layer, surface coating, disposable tableware, plates, cups, forks, knives, spoons, sporks, bowls, automotive parts, panels, fabrics, under hood covers, carpet fibers, clothing fibers, fibers for garments, fibers for sportswear, fibers for footwear, surgical sutures, implants, scaffolding and drug delivery systems.

41. A product comprising:

one or more converted alpha, beta, gamma and delta hydroxy-carboxylic acids, wherein

the alpha, beta, gamma and delta hydroxy-carboxylic acid(s) is produced by the fermentation of sugars derived from the acidic or enzymatic saccharification of an irradiated lignocellulosic or cellulosic material.

42. The product of claim 41, wherein the alpha, beta, gamma and delta hydroxy-carboxylic acid is selected from the group consisting of glycolic acid, lactic acid, malic acid, citric acid and tartaric acid.

43. The product of claim 41 or 42, wherein the product is a polymer including one or more of the converted hydroxy-carboxylic acids in the polymer backbone.

44. The product of any one of claim 43, further comprising a non-hydroxy carboxyl acid in the polymer backbone.

45. The product of any one of claims 41 through 44, wherein the polymer is cross-linked.

46. The product of any one of claims 41 through 45, wherein the polymer is a graft co-polymer.

47. A system for polymerization comprising;

a reaction vessel, a screw extruder and a condenser;

a recirculating fluid flow path from an outlet of the reaction vessel to an inlet of the screw extruder and from an outlet of the screw extruder to an inlet to the reaction vessel, and

a fluid flow path from a second outlet of the reaction vessel to an inlet of the condenser.

48. The system of claim 47, further comprising a vacuum pump in fluid connection with the second fluid flow path for producing a vacuum in the second fluid flow path.

49. The system of claim 47 or 48, further comprising a control valve that in a first position provides a non-disrupted flow in the recirculating fluid flow path and in a second position provides a second fluid flow path.

50. The system of claim 49, wherein when the second fluid flow path is from the outlet of the reaction vessel to an inlet of a pelletizer.

51. The system of claim 50, wherein the second fluid flow path is from the outlet of the reaction vessel to the inlet of the extruder and from the outlet of the extruder to the inlet of a pelletizer.

52. The method of any one of the above claims wherein the hydroxy-carboxylic acid is selected from the group consisting of glycolic acid, lactic acid (e.g., D, L or mixtures of D and L), malic acid, citric acid, tartaric acid, carmine, cyclobutyrol, 3-dehydroquinic acid, diethyl tartrate, 2,3-dihydroxy-3-methylpentanoic acid, 3,4-dihydroxymandelic acid, glyceric acid, homocitric acid, homoisocitric acid, beta-hydroxy beta-methylbutyric acid, 4-hydroxy-4-methylpentanoic acid, hydroxybutyric acid, 2-hydroxybutyric acid, beta-hydroxybutyric acid, gamma-hydroxybutyric acid, alpha-hydroxyglutaric acid, 5-hydroxyindoleacetic acid, 3-hydroxyisobutyric acid, 3-hydroxypentanoic acid, 3-hydroxypropionic acid, hydroxypyruvic acid, gluconic acid, glucuronic acid, alpha, beta, gamma or delta-hydroxyvaleric acid; isocitric acid, isopropylmalic acid, kynurenic acid, mandelic acid, mevalonic acid, monatin, myriocin, pamoic acid, pantoic acid, prephenic acid, shikimic acid, tartronic acid, threonic acid, tropic acid, vanillylmandelic acid, xanthurenic acid and mixtures of these.

53. A method comprising inoculating a raw sugar mixture produced by saccharifying a reduced recalcitrance lignocellulosic material to produce a hydroxy-carboxylic acid.

54. The method of claim 53, where the hydroxy-carboxylic acid is selected from the group glycolic acid, D-lactic acid, L-lactic acid, D-malic acid, L-malic, citric acid and D-tartaric acid, L-tartaric acid, and meso-tartaric acid.

55. The method of claim 53, where the reduced recalcitrance lignocellulosic material was processed by irradiating the lignocellulosic material with an electron beam.

56. The method of claim 53, where the electron beam has a total beam power of 100 to 1500 kW.

57. The method of claim 55 or 56, after irradiation, before saccharification the reduced recalcitrance lignocellulosic material is heat treated at a temperature of 95 to 160 °C.

58. A method comprising inoculating a sugar mixture, such as a raw sugar mixture produced by saccharifying a reduced recalcitrance lignocellulosic material to produce a hydroxy-carboxylic acid, wherein the mixture is inoculated with an organism selected from the group consisting of Lactobacillus casei, Lactobacillus rhamnosus, Lactobacillus delbrueckii subspecies delbrueckii, Lactobacillus plantarum, Lactobacillus coryniformis subspecies torquens, Lactobacillus pentosus, Lactobacillus brevis, Pediococcus pentosaceus, Rhizopus oryzae, Enterococcus faecalis, Lactobacillus helveticus, Lactobacillus bulgaricus, Lactobacillus casei, lactobacillus amylophilus and mixtures thereof.

59. The method of claim 58, where the organism is selected from the group consisting of *Lactobacillus rhamnosus, Lactobacillus coryniformis subspecies torquens, Lactobacillus pentosus, Lactobacillus brevis*, and mixtures thereof.

60. The method of claim 59, where the hydroxy-carboxylic acid is selected from the group glycolic acid, D-lactic acid, L-lactic acid, D-malic acid, L-malic, citric acid and D-tartaric acid, L-tartaric acid, and meso-tartaric acid.

63. A method comprising, irradiating biomass with an electron beam, saccharifying the irradiated biomass with enzymes, inoculating the saccharified biomass with an organism selected from the group consisting of *Lactobacillus rhamnosus, Lactobacillus coryniformis subspecies torquens, Lactobacillus pentosus, Lactobacillus brevis* and mixtures thereof.

64. The method of claim 63, where prior to irradiation the biomass size is reduced by cutting, grinding, shearing, pulverizing, and/or chopping.

65. The method of claim 63 or 64, after irradiation, before saccharification the biomass is heat treated at a temperature of 95 to 160 °C.

66. The method of claim 65, wherein the biomass is heat treated at a temperature of 100 to 150 °C.

67. The method of claim 65, wherein the biomass is heat treated at a temperature of 110 to 140 °C.

68. The method of claim 65, where the heat treated biomass step comprises an aqueous mixture with the biomass 10 to 90 wt. % of the entire mixture.

69. The method of claim 1 where converting comprises chemically converting.

70. The method of claim 69, wherein chemically converting is selected from the group consisting of polymerization, isomerization, esterification, oxidation, reduction, disproportionation and combinations thereof.

71. The method of claim 5 wherein converting comprises chemically converting the hydroxy-carboxylic acid to the product which further comprises converting lactic acid to esters by treating with an alcohol and an acid catalyst.

CLAIMS

1. A method for processing biomass comprising:

treating cellulosic or lignocellulosic material with an electron beam to provide a reduced recalcitrance lignocellulosic or cellulosic material;

treating the reduced recalcitrance lignocellulosic or cellulosic material with one or more enzymes to obtain a sugar solution comprising xylose and glucose;

fermenting the sugar solution with an organism that selectively ferments glucose to lactic acid, while xylose is not significantly consumed, and

converting the lactic acid to a product, wherein the product is an ester or polymer.

2. The method of claim 1 wherein converting comprises converting the lactic acid to esters.

3. The method of claim 2 wherein converting comprises chemically converting the lactic acid to esters by treating with an alcohol and an acid catalyst.

4. The method of claim 1, wherein converting comprises polymerizing the lactic acid to a polymer (e.g., polymerizing in a melt such as without an added solvent).

5. The method of claim 4, wherein polymerizing the lactic acid to a polymer comprises a polymerizing method selected from the group consisting of direct condensation of the lactic acid, azeotropic dehydrative condensation of the lactic acid, and dimerizing the lactic acid to lactide followed by ring opening polymerization of the lactide.

6. The method of claim 5, wherein the polymerization method is direct condensation and includes utilizing coupling agents and/or chain extenders to increase the molecular weight of the polymer.

7. The method of Claim 6, wherein the coupling agents and/or chain extenders are selected from the group consisting of triphosgene, carbonyl diimidazole, dicyclohexylcarbodiimide, diisocyanate, acid chlorides, acid anhydrides, epoxides, thiirane, oxazoline, orthoester, and mixtures of these.

8. The method of any one of claims 5 to 7 wherein the polymerization method is azeotropic condensation.

9. The method of any one of claims 4 to 8, further comprising utilizing catalysts and/or promoters which are selected from the group consisting of Lewis acids, Bronsted acids, H_3PO_4, H_2SO_4, methane sulfonic acid, p-toluene sulfonic acid, polymerically supported sulfonic acids, metals, Mg, Al, Ti, Zn, Sn, metal oxides, TiO_2, ZnO, GeO_2, ZrO_2, SnO, SnO_2, Sb_2O_3, metal halides, $ZnCl_2$, $SnCl_2$, $SnCl_4$, $Mn(AcO)_2$, $Fe_2(LA)_3$, $Co(AcO)_2$, $Ni(AcO)_2$, $Cu(OA)_2$, $Zn(LA)_2$, $Y(OA)_3$, $Al(i\text{-}PrO)_3$, $Ti(BuO)_4$, $TiO(acac)_2$, $(Bu)_2SnO$, $Sn(octoate)_2$, solvates of any of these and mixtures of these.

10. The method of claim 9, further comprising conducting at least a portion of the polymerization at a temperature between 100 and 200 °C.

11. The method of claim 10, wherein said conducting at least a portion of the polymerization is at a temperature of between 110 and 170 °C or between 120 and 160 ° C.

12. The method of claim 10 or 11, wherein at least a portion of the polymerization is performed under vacuum.

13. The method of claim 12, wherein said vacuum is between 0.1 mm Hg to 300 mm Hg.

14. The method of any one of claims 5 to 7, wherein the polymerization method includes dimerizing the lactic acid to lactide followed by ring opening polymerization of the lactide.

15. The method of claim 14, wherein the dimerization includes heating the lactic acid to between 100 and 200 °C under a vacuum of 0.1 to 100 mmHg.

16. The method of claim 14 or 15, wherein the dimerization includes a catalyst selected from the group consisting of Sn octoate, Li carbonate, Zn diacetate dehydrate, Ti tetraisopropoxide, potassium carbonate, tin powder and mixtures of these.

17. The method of any one of claims 14 to 16, wherein a ring opening polymerization catalyst is utilized which is selected from the group of Bronsted acids, HBr, HCl, triflic acid, Lewis acids, $ZnCl_2$, $AlCl_3$, anions, potassium benzoate, potassium phenoxide, potassium t-butoxide, and zinc

stearate, metals, Tin, zinc, aluminum, antimony, bismuth, lanthanide and other heavy metals, Tin (II) oxide and tin (II) octoate, tetraphenyl tin, tin (II) and (IV) halogenides, tin (II) acetylacetonoate, distannoxanes, $Al(OiPr)_3$, other functionalized aluminium alkoxides, ethyl zinc, lead (II) oxide, antimony octoate, bismuth octoate, rare earth catalysts, yttrium tris(methyllactate), yttrium tris(2-N-N-dimethylamino ethoxide), samarium tris(2-N-N-dimethylamino ethoxide), yttrium tris(trimethylsilylmethyl), lanthanum tris(2,2,6,6-tetramethylheptanedionate), lanthanum tris(acetylacetonate), yttrium octoate, yttrium tris(acetylacetonate), yttrium tris(2,2,6,6-tetramethylheptanedionate), combinations of these (e.g., ethyl zinc/aluminum isopropoxide) and mixtures of these.

18. The method of any one of claims 4 through 17, wherein converting further includes blending the polymer with a second polymer.

19. The method of claim 18, wherein the second polymer is selected from the group consisting of polyglycols, polyvinyl acetate, polyolefins, styrenic resins, polyacetals, poly(meth)acrylates, polycarbonate, polybutylene succinate, elastomers, polyurethanes, natural rubber, polybutadiene, neoprene, silicone, and combinations of these.

20. The method of any one of claims 4 through 19, wherein a co-monomer is co-polymerized with the lactic acid.

21. The method of claim 20, wherein the co-monomer is selected from the group consisting of elastomeric units, lactones, glycolic acid, carbonates, morpholinediones, epoxides, 1,4-benzodioxepin-2,5-(3H)-dione glycosalicylide, 1,4- benzodioxepin-2,5-(3H, 3-methyl)-dione lactosalicylide, dibenzo-1,5 dioxacin-6-12-dione disalicylide, morpholine-2,5-dione, 1,4-dioxane-2,5-dione glycolide, oxepane-2-one ε-caprolactone, 1,3-dioxane-2-one trimethylene carconate, 2,2-dimethyltrimethylene carbonate, 1,5-dioxepane-2-one, 1,4-dioxane-2-one p-dioxanone, gamma-butyrolactone, beta-butyrolactone, beta-me-delta-valerolactone, 1,4-dioxane-2,3-dione ethylene oxalate, 3-[benzyloxycarbonyl methyl]-1,4-dioxane-2,5-dione, ethylene oxide, propylene oxide, 5,5'(oxepane-2-one), 2,4,7,9-tetraoxaspiro[5,5]undecane-3,8-dione Spiro-bid-dimethylene caronate and mixtures of these.

22. The method of any one of claims 4 through 21, further comprising combining the polymer with fillers.

23. The method of claim 22, wherein the filler is selected from the group consisting of silicates, layered silicates, polymer and organically modified layered silicate, synthetic mica, carbon, carbon fibers, glass fibers, boric acid, talc, montmorillonite, clay, starch, corn starch, wheat starch, cellulose fibers, paper, rayon, non-woven fibers, wood flours, whiskers of potassium titanate, whiskers of aluminum borate, 4,4'-thiodiphenol, glycerol and mixtures of these.

24. The method of claim 22 or 23, wherein combining further includes extrusion and/or compression molding.

25. The method of any one of claims 4 through 24, further comprising branching or cross linking the polymer.

26. The method of claim 25, wherein a cross linking agent is utilized to cross link the polymer and the cross-linking agent selected from the group consisting of 5,5'-bis(oxepane-2-one)(bis- ε -caprolactone)), spiro-bis-dimethylene carbonate, peroxides, dicumyl peroxide, benzoyl peroxide, unsaturated alcohols, hydroxyethyl methacrylate, 2-butene-1,4-diol, unsaturated anhydrides, maleic anhydride, saturated epoxides, glycidyl methacrylate, irradiation and combinations of these.

27. The method of any one of claims 4 through 26, further comprising processing the polymer by a method selected from injection molding, blow molding and thermoforming.

28. The method of any one of claims 4 through 27, further comprising combining the polymer with a dye or pigment.

29. The method of any one of claims 4 through 28, wherein converting further includes blending the polymer with a plasticizer.

30. The method of claim 29, wherein the plasticizer is selected from the group consisting of triacetin, tributyl citrate, polyethylene glycol, acetic acid ester of a monoglycerides, diethyl bishydroxymethyl malonate and mixtures of these.

31. The method of any one of claims 4 through 30, further comprising grafting a molecule to the polymer.

32. The method of claim 31, wherein the molecule is selected from a monomer or a polymer.

33. The method of claim 31 or 32, further including treating the polymer with a peroxide, heating above 120 °C, irradiation and combinations thereof.

34. The method of any one of claims 4 through 33, further comprising shaping, molding, carving, extruding and/or assembling the polymer into the product.

35. The method of any one of claims 4 through 34, wherein the product is selected from the group consisting of personal care items, tissues, towels, diapers, green packaging, compostable pots, consumer electronics, laptop casings, mobile phone casings, appliances, food packaging, disposable packaging, food containers, drink bottles, garbage bags, waste compostable bags, mulch films, controlled release matrices, controlled release containers, containers for fertilizers, containers for pesticides, containers for herbicides, containers for nutrients, containers for pharmaceuticals, containers for flavoring agents, containers for foods, shopping bags, general purpose film, high heat film, heat seal layer, surface coating, disposable tableware, plates, cups, forks, knives, spoons, sporks, bowls, automotive parts, panels, fabrics, under hood covers, carpet fibers, clothing fibers, fibers for garments, fibers for sportswear, fibers for footwear, surgical sutures, implants, scaffolding and drug delivery systems.

36. The method of claim 1 wherein after irradiation, before saccharification the reduced recalcitrance lignocellulosic material is heat treated at a temperature of 95 to 160 °C.

37. The method of claim 1, wherein the electron beam has a total beam power of 100 to 1500 kW.

38. The method of claim 37, wherein after irradiation, before saccharification the reduced recalcitrance lignocellulosic material is heat treated at a temperature of 95 to 160 °C.

39. The method of any one of claims 36 to 38 wherein the organism is selected from the group consisting of Lactobacillus casei, Lactobacillus rhamnosus, Lactobacillus delbrueckii subspecies delbrueckii, Lactobacillus plantarum, Lactobacillus coryniformis subspecies torquens,

Lactobacillus pentosus, Lactobacillus brevis, Pediococcus pentosaceus, Rhizopus oryzae, Enterococcus faecalis, Lactobacillus helveticus, Lactobacillus bulgaricus, Lactobacillus casei, lactobacillus amylophilus and mixtures thereof.

40. The method of claim 39, wherein the organism is selected from the group consisting of *Lactobacillus rhamnosus, Lactobacillus coryniformis subspecies torquens, Lactobacillus pentosus, Lactobacillus brevis*, and mixtures thereof.

41. The method of claim 40, wherein the lactic acid is selected from the group D-lactic acid, and L-lactic acid.

42. The method of claim 39, wherein the organism is *Lactobacillus casei*.