CLAIMS

1. A method of processing hydroxy-carboxylic acids~~making a polymer or copolymer~~, the method comprising:

providing hydroxy-carboxylic acid produced by fermentation of biomass derived sugars;

producing a poly hydroxy-carboxylic acid from the hydroxy-carboxylic acid;

transferring the poly hydroxy-carboxylic acid to a surface of a thin film evaporator;

evaporating water as it is formed during condensation of a hydroxy-carboxylic acid polymer as it traverses a surface of a thin film evaporator.

2. The method of claim 1, where the thin film evaporator comprises a thin film polymerization/devolatilization device.

3. The method of claim 2, where an extruder is fluid communication with the thin film polymerization/devolatilization device and the effluent of the extruder is the poly hydroxy-carboxylic acid polymer or effluent of the extruder is recycled to the thin film evaporator.

4. The method of claim 3, where the extruder is a twin screw extruder.

5. The method of any one of the above claims wherein the hydroxy-carboxylic acid is selected~~hydroxycarboxylic oligomer is derived~~ from the monomer group consisting of glycolic acid, D-lactic acid and/or L-lactic acid, D-malic acid, L-malic acid, citric acid, L-tartaric acid and D-tartaric acid and mixtures thereof.

6. The method of claim 5, wherein the hydroxy-carboxylic acid is D-lactic acid and/or L-lactic acid.

7. The method of any one of claims 1-6, where at least a part of the thin film evaporator operates at a temperature of 100 to 260°C.

8. The method of any one of claims 1-7, where at least a part of the thin film evaporator operates at a pressure of 0.0133 Pa [0.0001 torr] ~~0.0001 torr~~ or lower.

9. The method of any one of the claims 2- 8, where prior to transferring the poly hydroxy-carboxylic acid to a thin film polymerization/devolatilization device or during operation of the thin film polymerization/ devolatilization device a catalyst deactivator and/or stabilizer agent is added, thereby forming deactivated catalyst and/or stabilized catalyst.

10. The method of any one of ~~the~~ claims 2- 8, where cyclic dimers derived from hydroxy-carboxylic acid is less than 5 weight percent based on the total mass of the hydroxy-carboxylic monomers, oligomers and polymers.

11. The method of any one of claims 2-10, where an aliphatic or aromatic dicarboxylic acid and an aliphatic or aromatic diol is added just prior to transferring the poly hydroxy-carboxylic acid to the thin film polymerization/devolatilization device.

12. The method of claim 11, where the mole ratio of the aliphatic or aromatic dicarboxylic acid to the aliphatic or aromatic diol is 0.95:1 to 1.05:1.

13. The method of claim 11 or 12, where the mole ratio of the sum of the aliphatic or aromatic dicarboxylic acid and the aliphatic or aromatic diol to the hydroxy-carboxylic acid monomer of the poly hydroxy-carboxylic acid is 0.1 or less.

14. The method of claim 11 or 12, where the mole ratio of the sum of the aliphatic or aromatic dicarboxylic acid and the aliphatic or aromatic diol to the hydroxy-carboxylic acid monomer of the poly hydroxy-carboxylic acid 0.05 or less.

15. The method of any one of the claims 1-14, where a polymerization catalyst is added to the poly hydroxy-carboxylic acid and the polymerization catalyst is selected from the group consisting of protonic acids, H_3PO_4, H_2SO_4, methane sulfonic acid, p-toluene sulfonic acid, polymerically supported sulfonic acid, 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(II)octoate, Li carbonate, Zn diacetate dehydrate, Ti tetraisopropoxide, potassium carbonate, tin powder, solvates of any of these and mixtures of any of these.

16. The method of any one of claims 2-8, where at least a part of the thin film polymerization/ devolatilization device operates at a pressure of less than about 0.133Pa [0.001 torr]~~0.001 torr~~.

17. The method of any one of claims 2-8, where at least a part of the thin film polymerization/ devolatilization device operates at a pressure of less than about 1.33Pa [0.01 torr]~~0.01 torr~~.

18. The method of any one of claims 2-8, where at least a part of the thin film polymerization/ devolatilization device operates at a pressure of less than about 13.3Pa [0.1 torr]~~0.1 torr~~.

19. The method of any one of claims 2-8, where at least a part of the thin film polymerization/ devolatilization device operates at a pressure of less than about 133Pa [1 torr]~~1 torr~~.

20. The method of any one of claims 1-19, further comprising branching or cross linking the poly hydroxy-carboxylic acid.

21. The method of claim 20, wherein a branching or cross linking agent is utilized to cross link the poly hydroxy-carboxylic acid 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.

22. The method of any one of claims 1-19, wherein the poly hydroxycarboxylic acid is blended with a second polymer either when the poly hydroxycarboxylic acid is transferred to the thin film polymerization/devolatilization device or after the thin film polymerization/devolatilization device.

23. The method of claim 22, wherein the second polymer is selected from the group consisting of polyglycols, polyvinyl acetate, polyolefins, styrenic resins, polyacetals, poly(meth)acrylates, polycarbonate, polybutylene succinate, polyesters, polyurethanes, natural rubber, polybutadiene, neoprene, silicone, other poly hydroxy carboxylic acids, and combinations of these.

24. The method of any one of claims 1-23, comprising combining the poly hydroxy-carboxylic acid with fillers.

25. The method of claim 24, 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.

26. The method of any one of claims 1-25, further comprising combining the poly hydroxyl-carboxylic acid with a dye or pigment.

27. The method of claim 26, wherein the dye is selected from the group consisting of blue3, blue 356, brown 1, orange 29, violet 26, violet 93, yellow 42, yellow 54, yellow 82 and combinations of these.

28. The method of any one of claims 1-27, further comprising combining the poly hydroxy-carboxylic acid with a fragrance.

29. The method of claim 28, wherein the fragrance is selected from the group consisting of wood, evergreen, redwood, peppermint, cherry, strawberry, peach, lime, spearmint, cinnamon, anise, basil, bergamot, black pepper, camphor, chamomile, citronella, eucalyptus, pine, fir, geranium, ginger, grapefruit, jasmine, juniper berry, lavender, lemon, mandarin, marjoram, musk, myrrh, orange, patchouli, rose, rosemary, sage, sandalwood, tea tree, thyme, wintergreen, ylang ylang, vanilla, new car or mixtures of these fragrances.

30. The method of claims 28 or 29, wherein the fragrances are combined with the poly hydroxy-carboxylic acid in an amount between about 0.005 % by weight and about 20 % by weight (e.g., between about 0.1 % and about 5 wt. %, between about 0.25 wt.% and about 2.5 %).

31. The method of any one of claims 1-31, wherein converting further includes blending the poly hydroxy-carboxylic acid with a plasticizer.

32. The method of claim 31, wherein plasticizer is selected from the group consisting of triacetin, tributyl citrate, polyethylene glycol, acetic ester of monoglyceride, diethyl bishydroxymethyl malonate and mixtures of these.

33. The method of claim 9, where the stabilizer~~stabilizing~~ agent is selected from the group consisting of anhydrides, phosphites, polycarboxylic acids, polyamines, silica, functionalized silica, alumina, aluminosilicates, clays, functionalized clays and mixtures of these.

34. The method of claim 33, where the polycarboxylic acid is a poly methacrylic acid.

35. The method of claim 11 and claims 33 and 34, comprising removing the deactivated/stabilized catalyst prior to, during or after the thin film polymerization/ devolatilization device~~:~~ by a filtration device.

36. The method of claim 11 and claims 33 - 35, comprising removing the deactivated/stabilized catalyst by a filtration device.

37. The method of claim 36, where the filtration device is in fluid communication with the thin film polymerization/ devolatilization device.

~~38. The method of any one of claims 2-8, where at least a part of the thin film polymerization/ devolatilization device operates at a pressure of from about 0.0001 to about 100 torr.~~

~~39. The method of any one of claims 2-8, where at least a part of the thin film polymerization/ devolatilization device operates at a pressure of from about 0.001 to about 50 torr.~~

~~40~~38. The method of any one of claims 2-8, wherein the hydroxy-carboxylic ~~oligomer is derived~~acid is selected from the monomer group consisting of glycolic acid, D-lactic acid and/or L-lactic acid, beta-hydroxy beta-methylbutyric acid, 4-hydroxy-4-methylpentanoic acid, hydroxybutyric acid, 2-hydroxybutyric acid, beta-hydroxybutyric acid, gamma-hydroxybutyric acid 3-hydroxyisobutyric acid, 3-hydroxypentanoic acid, 3-hydroxypropionic acid alpha, beta, gamma or delta-hydroxyvaleric acid and mixtures thereof.