CLAIMS

What is claimed is:

1. A method of making acrylic acid, acrylic acid derivatives, or mixtures thereof comprising contacting a stream comprising lactic acid, lactic acid derivatives, or mixtures thereof with a catalyst comprising:

the phosphate anions described by formulae (Ic) and (IIc):

$$[H_{(1-\beta)}P_{(1+\beta)}O_{(4+3\beta)}]^{2(1+\beta)-} \quad \text{(Ic)},$$

$$[H_{(2-2\gamma)}PO_{(4-\gamma)}]_{(1+(n-1)\gamma)}^{(1+(n-1)\gamma)-} \quad \text{(IIc)},$$

and

at least two different cations,
wherein the catalyst is neutrally charged, wherein β and γ are greater or equal to 0 and less or equal to 1, wherein n is at least 2, wherein the molar ratio of said phosphate anions in said catalyst is between about 0.1 and about 10, wherein said at least two different cations comprise at least one monovalent cation and at least one polyvalent cation, and wherein said polyvalent cation is selected from the group consisting of the cations of the metals Be, Mg, Ca, Sr, Ba, Sc, Y, Ti, Zr, V, Nb, Cr, Mo, Mn, Ga, Si, Ge, B, Al, In, Tl, Sb, Sn, Bi, Pb, La, Ce, Er, Ac, Th, and mixtures thereof, wherein said stream further comprises:

a. diluent consisting of water; and
b. inert gas selected from the group consisting of nitrogen, helium, argon, carbon dioxide, carbon monoxide, and mixtures thereof:

and further, wherein the water partial pressure in said stream is about 50 psi (3.5 bar) or more.

2. The method of claim 1, wherein the water partial pressure in said stream is between about 10 psi (0.7 bar) and about 500 psi (34.5 bar).

3. The method of claim 1, wherein the water partial pressure in said stream is about 186 psi (12.8 bar).

4. A process for converting lactic acid, lactic acid derivatives, or mixtures thereof to acrylic acid, acrylic acid derivatives. or mixtures thereof comprising the following steps:

a. providing an aqueous solution comprising lactic acid, lactic acid derivatives, or mixtures thereof, wherein said lactic acid is in monomeric form in said aqueous solution;
b. combining said aqueous solution with an inert gas to form an aqueous solution/gas blend;
c. evaporating said aqueous solution/gas blend to produce a gaseous mixture; and

d. dehydrating said gaseous mixture by contacting said gaseous mixture with a dehydration catalyst under a water partial pressure of about 10 psi (0.7 bar) or more, producing said acrylic acid, acrylic acid derivatives, or mixtures thereof.

5. The process of claim 4, wherein said evaporating step is performed in a reactor, wherein said reactor has a material surface comprising materials with less than 0.1 wt % of Group 8-11 transition metals.

6. The process of claim 4, wherein said dehydrating step is performed in a reactor, wherein said reactor has a material surface comprising materials with less than 0.1 wt % of Group 8-11 transition metals.

7. A process for converting lactic acid to acrylic acid comprising the following steps:

a. diluting an about 88% lactic acid aqueous solution with water to form an about 20 wt % lactic acid aqueous solution;
b. heating said about 20 wt % lactic acid aqueous solution at a temperature between about 95° C. to about 100° C. to remove oligomers of said lactic acid, producing a monomeric lactic acid aqueous solution comprising at least 95 wt % of said lactic acid in monomeric form based on the total amount of lactic acid;
c. combining said monomeric lactic acid aqueous solution with nitrogen to form an aqueous solution/gas blend;
d. evaporating said aqueous solution/gas blend in a reactor with inside surface of borosilicate glass at a GHSV of about 6,000 h^{-1} to about 7,200 h^{-1} at a temperature between about 300° C. to about 375° C. to produce a gaseous mixture comprising about 2.5 mol % lactic acid and about 50 mol % water;
e. dehydrating said gaseous mixture in a reactor with inside surface of borosilicate glass at a GHSV of about 3,600 h^{-1} at a temperature between about 350° C. to about 425° C. by contacting said mixture with a dehydration catalyst under a pressure of about 360 psig (24.8 barg), producing said acrylic acid; and
f. cooling said acrylic acid to give an acrylic acid solution at a GHSV between about 360 h^{-1} to about 36,000 h^{-1}.

8. The process of claim 7, wherein said dehydration catalyst is a catalyst comprising:

the phosphate anions described by formulae (Ic) and (IIc):

$$[H_{(1-\beta)}P_{(1+\beta)}O_{(4+3\beta)}]^{2(1+\beta)-} \quad \text{(Ic)},$$

$$[H_{(2-2\gamma)}PO_{(4-\gamma)}]_{(1+(n-1)\gamma)}^{(1+(n-1)\gamma)-} \quad \text{(IIc), and}$$

at least two different cations,
wherein the catalyst is neutrally charged, wherein β and γ are greater or equal to 0 and less or equal to 1, wherein n is at least 2, wherein the molar ratio of said phosphate anions in said

catalyst is between about 0.1 and about 10, wherein said at least two different cations comprise at least one monovalent cation and at least one polyvalent cation, and wherein said polyvalent cation is selected from the group consisting of the cations of the metals Be, Mg, Ca, Sr, Ba, Sc, Y, Ti, Zr, V, Nb, Cr, Mo, Mn, Ga, Si, Ge, B, Al, In, Tl, Sb, Sn, Bi, Pb, La, Ce, Er, Ac, Th, and mixtures thereof.

9. A process for converting lactic acid, lactic acid derivatives, or mixtures thereof to acrylic acid, acrylic acid derivatives, or mixtures thereof comprising the following steps:
a. providing a solution comprising lactic acid, lactic acid derivatives, or mixtures thereof;
b. combining said solution with a gas to form a solution/gas blend; and
c. dehydrating said solution/gas blend by contacting said solution/gas blend with a dehydration catalyst; said dehydration catalyst comprising:
   i. the phosphate anions described by formulae (Ic) and (IIc):

$$[H_{(1-\beta)}P_{(1+\beta)}O_{(4+3\beta)}]^{2(1+\beta)-} \quad \text{(Ic)},$$

$$[H_{(2-2\gamma)}PO_{(4-\gamma)}]_{(1+(n-1)\gamma)}^{(1+(n-1)\gamma)-} \quad \text{(IIc), and}$$

   ii. at least two different cations,

wherein the catalyst is neutrally charged, wherein β and γ are greater or equal to 0 and less or equal to 1, wherein n is at least 2, wherein the molar ratio of said phosphate anions in said catalyst is between about 0.1 and about 10, wherein said at least two different cations comprise at least one monovalent cation and at least one polyvalent cation, and wherein said polyvalent cation is selected from the group consisting of the cations of the metals Be, Mg, Ca, Sr, Ba, Sc, Y, Ti, Zr, V, Nb, Cr, Mo, Mn, Ga, Si, Ge, B, Al, In, Tl, Sb, Sn, Bi, Pb, La, Ce, Er, Ac, Th, and mixtures thereof.

10. The process of claim 9, wherein said dehydration catalyst comprises:
a. at least one condensed phosphate anion selected from the group consisting of formulae (I), (II), and (III),

$$[P_nO_{3n+1}]^{(n+2)-} \quad \text{(I)},$$

$$[P_nO_{3n}]^{n-} \quad \text{(II)},$$

$$[P_{(2m+n)}O_{(5m+3n)}]^{n-} \quad \text{(III)},$$

wherein n is at least 2 and m is at least 1, and
b. at least two different cations,
wherein said catalyst is essentially neutrally charged, and further wherein the molar ratio of phosphorus to the at least two different cations is between about 0.7 and about 1.7.

11. The process of claim 10, wherein said molar ratio of phosphorus to the at least two different cations is about 1.

12. The process of claim 9, wherein said dehydration catalyst comprises:
monophosphate salts described by the formulae (Ib) and (IIb):

$M^{II}HPO_4$ (Ib)

and

$M^{I}H_2PO_4$ (IIb),

wherein M^{I} is one or more monovalent cation(s) and M^{II} is one or more divalent cations, and further, wherein the molar ratio of $M^{II}HPO_4$ to $M^{I}H_2PO_4$ is between about 0.1 and about 10.

13. The process of claim 12, wherein said molar ratio of $M^{II}HPO_4$ to $M^{I}H_2PO_4$ in said catalyst is between about 0.2 and about 5.

14. The process of claim 13, wherein said molar ratio of $M^{II}HPO_4$ to $M^{I}H_2PO_4$ in said catalyst is about 1.