CLAIMS

1. A method of making acrylic acid, acrylic acid derivatives, or mixtures thereof comprising contacting the following compositions under conditions including a water partial pressure and a temperature:
   a) hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof;
   b) water vapor; and
   c) a dehydration catalyst consisting essentially of one or more amorphous phosphate salts; wherein said one or more amorphous phosphate salts consist essentially of:
   i) one or more monovalent cations selected from the group consisting of K^+, Rb^+, Cs^+, and mixtures thereof, and
   ii) one or more phosphate anions selected from the group represented by empirical formula (I):

$$\left[H_{2(1-x)}PO_{(4-x)}\right]^- \qquad \text{(I)};$$

wherein x is any real number equal to or greater than 0 and equal to or less than 1; wherein said one or more amorphous phosphate salts in said dehydration catalyst are neutrally charged; and

whereby said acrylic acid, acrylic acid derivatives, or mixtures thereof is produced as a result of said water vapor and said hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof being contacted with said dehydration catalyst.

2. The method of claim 1, wherein said hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof are in the gas phase, at least partially, during said contacting step with said dehydration catalyst.

3. The method of claim 1 wherein the water partial pressure during said contacting step in said gas mixture is equal to or greater than about 0.8 bar.

4. The method of claim 1 wherein the water partial pressure during said contacting step in said gas mixture is equal to or greater than about 4 bar.

5. The method of claim 1 wherein said contacting step is performed at a temperature equal to or greater than about 250 °C.

6. The method of claim 1, wherein at least one of said one or more amorphous phosphate salts consists of two or more different monovalent cations selected from the group consisting of K^+, Rb^+, and Cs.

7. The method of claim 1, wherein said dehydration catalyst consists essentially of one or more amorphous phosphate salts represented by empirical formula (Ia):

$$M^I H_{2(1-x)} PO_{(4-x)} \qquad \text{(Ia)};$$

wherein M^I is a monovalent cation; wherein x is any real number equal to or greater than 0 and equal to or less than 1.

8. The method of claim 7, wherein said one or more amorphous phosphate salts are selected from the group consisting of $KH_{2(1-x)}PO_{(4-x)}$, $RbH_{2(1-x)}PO_{(4-x)}$, $CsH_{2(1-x)}PO_{(4-x)}$, any of their hydrated forms, and mixtures thereof; wherein x is any real number equal to or greater than 0 and equal to or less than 1.

9. The method of claim 7, wherein said one or more amorphous phosphate salts is $KH_{2(1-x)}PO_{(4-x)}$; wherein x is any real number equal to or greater than 0 and equal to or less than 1.

10. The method of claim 1, wherein said dehydration catalyst consists essentially of one or more amorphous phosphate salts represented by empirical formula (Ib):

$$M_w^I N_{(1-w)}^I H_{2(1-x)} PO_{(4-x)} \qquad \text{(Ib)};$$

wherein M^I and N^I are essentially two different monovalent cations; wherein x is any real number equal to or greater than 0 and equal to or less than 1; wherein w is any real number greater than 0 and less than 1.

11. The method of claim 10, wherein said one or more amorphous phosphate salts are selected from the group consisting of $K_wRb_{(1-w)}H_{2(1-x)}PO_{(4-x)}$, $K_wCs_{(1-w)}H_{2(1-x)}PO_{(4-x)}$, $Rb_wCs_{(1-w)}H_{2(1-x)}PO_{(4-x)}$, any of their hydrated forms, and mixtures thereof; wherein x is any real number equal to or greater than 0 and equal to or less than 1; wherein w is any real number greater than 0 and less than 1.

12. The method of claim 1, wherein said dehydration catalyst further consists of silicon oxide (SiO_2) and wherein said silicon oxide is substantially chemically inert to said one or more amorphous phosphate salts.

13. The method of claim 12, wherein the weight ratio between the total amount of said one or more amorphous phosphate salts and the total amount of said silicon oxide in said dehydration catalyst is between about 1:10 and about 4:1.

14. The method of claim 12, wherein said silicon oxide is selected from the group consisting of amorphous silica, quartz, tridymite, cristobalite, moganite, coesite, and mixtures thereof.

15. The method of claim 14, wherein said one or more amorphous phosphate salts are selected from the group consisting of $KH_{2(1-x)}PO_{(4-x)}$, $RbH_{2(1-x)}PO_{(4-x)}$, $CsH_{2(1-x)}PO_{(4-x)}$, any of their hydrated forms, and mixtures thereof; wherein x is any real number equal to or greater than 0 and equal to or less than 1; and wherein said silicon oxide is selected from the group consisting of amorphous silica, quartz, and mixtures thereof.

16. The method of claim 15, wherein said one or more amorphous phosphate salts is $KH_{2(1-x)}PO_{(4-x)}$; wherein x is any real number equal to or greater than 0 and equal to or less than 1; and wherein said silicon oxide is amorphous silica.

17. The method of claim 1, wherein said dehydration catalyst further consists of one or more oxysalts comprising:

one or more polyvalent cations, and

one or more oxyanions selected from the group represented by molecular formulae (II) and (III):

$$\left[H_{(a-2b)}S_cO_{(4c-b)}\right]^{(2c-a)-} \quad \text{(II)}$$

$$\left[Ta_{2d}O_{(5d+e)}\right]^{2e-} \quad \text{(III);}$$

wherein a and b are positive integers or zero; wherein c, d, and e are positive integers; wherein (a-2b) is equal to or greater than zero; wherein (2c-a) is greater than zero; wherein said one or more oxysalts are neutrally charged; and wherein said one or more oxysalts are substantially chemically inert to said one or more amorphous phosphate salts.

18. The method of claim 17, wherein the weight ratio between the total amount of said one or more amorphous phosphate salts and the total amount of said one or more oxysalts in said dehydration catalyst is between about 1:10 and about 4:1.

19. The method of claim 17, wherein said one or more oxyanions are selected from the group represented by molecular formulae (IIa) to (IId), (IIIa) to (IIIg), and mixtures thereof:

$[SO_4]^{2-}$ (IIa)

$[S_2O_7]^{2-}$ (IIb)

$[HSO_4]^{1-}$ (IIc)

$[SO_4]^{2-} \cdot [HSO_4]^{-}$ (IId)

$[Ta_2O_6]^{2-}$ (IIIa)

$[Ta_2O_7]^{4-}$ (IIIb)

$[Ta_2O_9]^{8-}$ (IIIc)

$[Ta_2O_{10}]^{10-}$ (IIId)

$[Ta_2O_{11}]^{12-}$ (IIIe)

$[Ta_4O_{11}]^{2-}$ (IIIf)

$[Ta_4O_{15}]^{10-}$ (IIIg).

20. The method of claim 17, wherein said one or more oxyanions are selected from the group represented by molecular formulae (IIa), (IIIa), and mixtures thereof:

$[SO_4]^{2-}$ (IIa)

$[Ta_2O_6]^{2-}$ (IIIa).

21. The method of claim 17, wherein said one or more oxysalts are selected from the group consisting of $CaSO_4$, $SrSO_4$, $BaSO_4$, $SrK_2(SO_4)_2$, $SrRb_2(SO_4)_2$, $Ca_2K_2(SO_4)_3$, $Ca_2Rb_2(SO_4)_3$, $Ca_2Cs_2(SO_4)_3$, $CaTa_4O_{11}$, $SrTa_4O_{11}$, $BaTa_4O_{11}$, $MgTa_2O_6$, $CaTa_2O_6$, $SrTa_2O_6$, $BaTa_2O_6$, $Mg_2Ta_2O_7$, $Ca_2Ta_2O_7$, $Sr_2Ta_2O_7$, $SrK_2Ta_2O_7$, $Ba_2Ta_2O_7$, $Ba_3Ta_2O_8$, $Mg_4Ta_2O_9$, $Ca_4Ta_2O_9$, $Sr_4Ta_2O_9$, $Ba_4Ta_2O_9$, $Ca_5Ta_2O_{10}$, $Ca_2KTa_3O_{10}$, $Ca_2RbTa_3O_{10}$, $Ca_2CsTa_3O_{10}$, $Sr_2KTa_3O_{10}$, $Sr_2RbTa_3O_{10}$, $Sr_2CsTa_3O_{10}$, $Mg_5Ta_4O_{15}$, $Sr_5Ta_4O_{15}$, $Ba_5Ta_4O_{15}$, $Sr_2KTa_5O_{15}$, $Ba_2KTa_5O_{15}$, $Sr_6Ta_2O_{11}$, $Ba_6Ta_2O_{11}$, any of their hydrated forms, and mixtures thereof.

22. The method of claim 21, wherein said one or more oxysalts are selected from the group consisting of $CaSO_4$, $CaTa_2O_6$, $SrSO_4$, $SrTa_2O_6$, $BaSO_4$, $BaTa_2O_6$, any of their hydrated forms, and mixtures thereof.

23. The method of claim 17, wherein said one or more amorphous phosphate salts are selected from the group consisting of $KH_{2(1-x)}PO_{(4-x)}$, $RbH_{2(1-x)}PO_{(4-x)}$, $CsH_{2(1-x)}PO_{(4-x)}$, any of their hydrated forms, and mixtures thereof; wherein x is any real number equal to or greater than 0 and equal to or less than 1; and wherein said one or more non-phosphate compounds are selected from the group consisting of $CaSO_4$, $CaTa_2O_6$, $SrSO_4$, $SrTa_2O_6$, $BaSO_4$, $BaTa_2O_6$, any of their hydrated forms, and mixtures thereof.

24. The method of claim 23, wherein said one or more amorphous phosphate salts is $KH_{2(1-x)}PO_{(4-x)}$; wherein x is any real number equal to or greater than 0 and equal to or less than 1; and wherein said one or more non-phosphate compounds is $BaSO_4$.

25. The method of Claim 1, wherein said hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof are lactic acid, lactic acid derivatives, or mixtures thereof.

26. The method of Claim 2, wherein said hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof and water vapor are a gas mixture.

27. The method of Claim 26, wherein said gas mixture further comprises an essentially chemically inert gas selected from the group consisting of nitrogen, helium, argon, carbon dioxide, carbon monoxide, air, water vapor, and mixtures thereof.

28. The method of Claim 3, wherein said temperature is between about 300°C and about 450°C.

29. The method of Claim 1, wherein said contacting step with said dehydration catalyst is performed under a total pressure of at least 1 bar.

30. The method of Claim 29, wherein said total pressure is between about 4 bar and about 35 bar.

31. A method of making acrylic acid, acrylic acid derivatives, or mixtures thereof comprising contacting the following compositions under conditions including a water partial pressure and a temperature:

a gas mixture comprising:

a) hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof; and

b) water vapor; with

a dehydration catalyst precursor mixture consisting essentially of one or more precursor phosphate salts; wherein said one or more precursor phosphate salts consist essentially of:

i) one or more monovalent cations, and

ii) one or more phosphate anions selected from the group represented by molecular formulae (IV) and (V):

$$\left[H_2P_yO_{(3y+1)}\right]^{y-} \qquad \text{(IV)}$$

$$\left[PO_3\right]_z^{z-} \qquad \text{(V)};$$

wherein y is any integer number equal to or greater than 1; wherein z is any integer number equal to or greater than 3; wherein said one or more precursor phosphate salts are neutrally charged; wherein the water partial pressure during said contacting step in said gas mixture is

equal to or greater than the water partial pressure at the triple point of said one or more precursor phosphate salts; and whereby said acrylic acid, acrylic acid derivatives, or mixtures thereof is produced as a result of said water vapor and said hydroxypropionic acid, hydroxypropionic acid derivatives, or mixtures thereof being contacted with said dehydration catalyst precursor mixture.