[0067] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_{12}V_{4.8}Sr_{0.5}W_{2.4}Cu_{2.2}O_x$$

[0068] where x is the quantity of oxygen bonded to the other elements and depends on their oxidation state. This catalyst is disclosed in U.S. Pat. No. 6,310,240 B1 as being useful in the conversion of acrolein to acrylic acid. This patent is incorporated herein by reference.

[0069] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_aW_bV_cA_dB_eO_x$$

[0070] wherein A is Fe, Cu, Bi, Cr, Sn, Sb, Ni, Co, Mn, Ce or Tl; B is an alkali or alkaline earth metal; and a, b, c, d, e and x respectively indicate the atomic ratio for Mo, W, V, A, B and O. When a is 10, b is 1.5 to 4, c is 1 to 5, d is 1 to 4, e is 0 to 2, and x is determined according to oxidation states of the other elements. This catalyst is disclosed in U.S. Pat. No. 6,384,275 B2 as being useful for the conversion of acrolein to acrylic acid. This patent is incorporated herein by reference.

[0071] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_{12}V_aX^1{}_bX^2{}_cX^3{}_dX^4{}_eX^5{}_fX^6{}_gO_n$$

[0072] where X^1 is W, Nb, Ta, Cr and/or Ce; X^2 is Cu, Ni, Co, Fe, Mn and/or Zn; X^3 is Sb and/or Bi; X^4 is one or more alkali metals; X^5 is one or more alkaline earth metals; X^6 is Si, Al, Ti and/or Zr; a is from 1 to 6; b is from 0.2 to 4; c is from 0.5 to 18; d is from 0 to 40; e is from 0 to 2; f is from 0 to 4; g is from 0 to 40 and n is a number which is determined by the valency and frequency of the elements other than oxygen. This catalyst is disclosed in U.S. Pat. No. 6,403,829 B2 as being useful for the conversion of acrolein to acrylic acid. This patent is incorporated herein by reference.

[0073] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_aV_bW_cCu_dX_eO_g$$

[0074] wherein X is at least one element selected from the group consisting of Mg, Ca, Sr and Ba, and a, b, c, d, e, and g are atomic ratios respectively of Mo, V, W, Cu, X and O such that when a is 12, b is in the range of 2 to 14, c in the range of 0 to 12, d in the range of 0 to 6 excluding 0 (0.1 to 6, for example), e is in the range of 0 to 3, and g is a numeral to be determined by the oxidized states of the elements. This catalyst is disclosed in U.S. Pat. No. 6,429,332 B1 as being useful for the conversion of acrolein to acrylic acid. This patent is incorporated herein by reference.

[0075] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_aW_bBi_cFe_dA_eB_fC_gD_hE_iO_x$$

[0076] wherein: A is Ni or Co; B is Na, K, Rb, Cs or Tl; C is an alkaline earth metal; D is P, Te, Sb, Sn, Ce, Pb, Nb, Mn, As, B or Zn; and E is Si, Al, Ti or Zr. When a is 12, b is from 0 to 10, c is from 0 to 10, d is from 0 to 10, e is from 2 to 15, f is from 0 to 10, g is from 0 to 10, h is from 0 to 4, I is from 0 to 30, and x is determined by the degree of oxidation of each of the elements. This catalyst is disclosed in U.S. Pat. No. 6,383,973 B1 as being useful for the conversion of propylene, isobutylene, t-butanol or methyl-t-butyl ether to (meth)acrolein or (meth)acrylic acid. This patent is incorporated herein by reference.

[0077] The catalyst may comprise an oxidation catalyst represented by the formula

$$Mo_aP_bA_cB_aC_eD_fO_x$$

[0078] wherein A is at least one element selected from the group consisting of As, Sb, Ge, Bi, Zr, Ce and Se; B is at least one element selected from the group consisting of Cu, Fe, Cr, Ni, Mn, Co, Sn, Ag, Zn, Pd, Rh and Te; C is at least one element selected from the group consisting of V, W and Nb; D is at least one element selected from the group consisting of alkali metals, alkaline earth metals and Tl, and a, b, c, d, e, f, and x are atomic ratios respectively of Mo, P, A, B, C, D, and O such that when a is 12, b is a numeral in the range of 0.5 to 4, and in one embodiment 0.5 to 3; c is in the range of 0 to 5, and in one embodiment 0.01 to 3; d in the range of 0 to 3, and in one embodiment 0.01 to 2; e is in the range or 0 to 4, and in one embodiment 0.01 to 3; f is in the range or 0.01 to 4, and in one embodiment 0.01 to 3, and x is a numeral to be determined by the oxidized states of the elements. This catalyst is disclosed in U.S. Pat. No. 5,618,974 as being useful for the conversion of methacrolein, isobutyl aldehyde, or isobutyric acid to methacrylic acid. This patent is incorporated herein by reference.

[0079] The catalyst may comprise an oxidation catalyst containing Mo, V, Nb and Pd, or Mo, La, V and Pd. Specific examples include

$$MoV_{0.396}Nb_{0.128}Pd_{0.000384}$$

[0080] and

$$MoV_{0.628}Pd_{0.000288}La_{0.00001,}$$

[0081] These catalysts are disclosed in U.S. Pat. No. 6,274,764 B1, which is incorporated herein by reference.

[0082] U.S. Pat. No. 6,143,921, which is incorporated herein by reference, discloses three oxidation catalysts, any one of which may be used with the inventive process. The first catalyst is represented by the formula $Mo_aV_bNb_cPd_d$, wherein: a is 1 to 5; b is 0 to 0.5; c is 0.01 to 0.5; and d is 0 to 0.2. The numerical values of a, b, c and d represent the relative gram-atom ratios of the elements Mo, V, Nb and Pd, respectively, in the catalyst. The elements are present in combination with the oxygen in the form of various oxides. The second catalyst has a composition comprising the elements Mo, V, Pd, Nb, La, and X where X is Al, Ga, Si or Ge in the form of oxides in the ratio $Mo_aV_bLa_cPd_dNb_eX_f$ wherein: a is 1; b is 0.01 to 0.9; c is >0 to 0.2; d is >0 to 0.2; e is >0 to 0.2; and f is >0 to 0.3. The third catalyst is formed from a calcined composition represented by the formula $Mo_aV_bNb_cX_d$, wherein X is at least one promoter element selected from the group consisting of: P, B, Hf, Te and As; a is about 1 to 5; b is 1; c is about 0.01 to 0.5; and d is about 0 to 0.1.

[0083] The catalyst may be an oxidation catalyst which comprises in combination with oxygen the elements molybdenum, vanadium, niobium and gold according to the formula:

$$Mo_aW_bAu_cV_dNb_eY_f$$

[0084] wherein: Y is one or more elements selected frm the group consisting of Cr, Mn, Ta, Ti, B, Al, Ga, In, Pt, Zn, Cd, Bi, Ce, Co, Rh, Ir, Cu, Ag, Fe, Ru, Os, K, Rb, Cs, Mg,