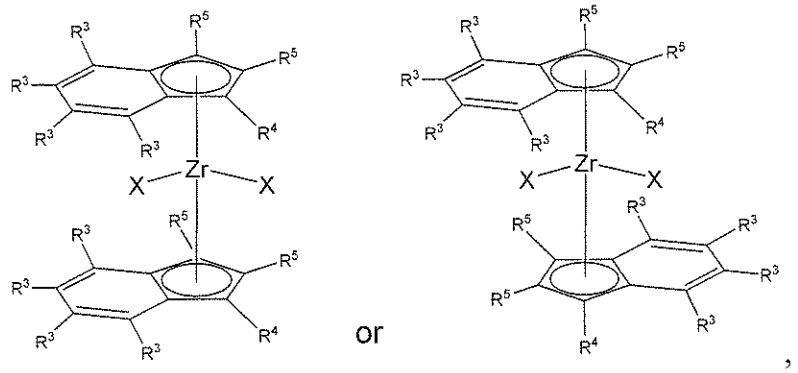
[0009] In this formula, each R^1 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; each R^2 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; a and c are ≥ 3; a+b = c+d = 5; at least one R^1 and at least one R^2 is a hydrocarbyl or substituted hydrocarbyl group; adjacent groups R^1 and R^2 groups may be coupled to form a ring; and each X is independently a leaving group selected from a labile hydrocarbyl, substituted hydrocarbyl, or heteroatom group, or a divalent radical that links to an R^1 or R^2 group. The second catalyst compound includes at least one of the following formulas:



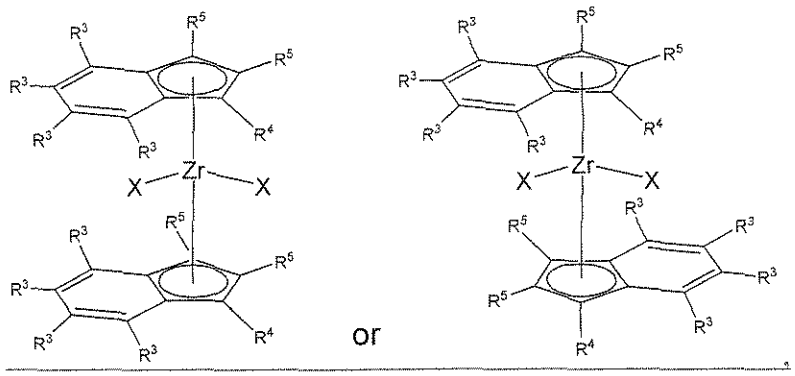
In these formulas, each R^3 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; R^4 is a hydrocarbyl group, a substituted hydrocarbyl group, or a heteoatom group; each R^5 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; wherein R^3, R^4, and R^5 may be the same or different; wherein R^3, R^4, or R^5 groups may be joined with R^3 , R^4, or R^5 groups on an opposing cyclopentadienyl structure to form one or more bridges if the number of atoms connecting the two cyclopentadienyl rings is ≥ 3; and each X is independently a leaving group selected from a labile hydrocarbyl, substituted hydrocarbyl, or heteroatom group.

[0009a] In one aspect, there is provided a method of polymerizing olefins to produce a polyolefin polymer with a multimodal composition distribution, comprising contacting ethylene and a comonomer with a catalyst system, wherein the catalyst system comprises a first catalyst compound and a second catalyst compound that are co-supported to form a commonly supported catalyst system, wherein the first catalyst compound comprises the following formula:

$$(C_5H_aR^1_b)(C_5H_cR^2_d)HfX_2$$

wherein each R^1 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; each R^2 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; a and c are ≥ 3; a+b = c+d = 5; at least one R^1 and at least one R^2

is a hydrocarbyl or substituted hydrocarbyl group; adjacent groups R^1 and R^2 groups may be coupled to form a ring; and each X is independently a leaving group selected from a labile hydrocarbyl, substituted hydrocarbyl, or heteroatom group, or a divalent radical that links to an R^1 or R^2 group; and the second catalyst compound comprises at least one of the following formulas:



wherein each R^3 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; R^4 is a hydrocarbyl group, a substituted hydrocarbyl group, or a heteoatom group; each R^5 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; wherein R^3, R^4, and R^5 may be the same or different; and each X is independently a leaving group selected from a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to an R^3, R^4, or R^5 group.

[0010] Another embodiment provides a catalyst composition including a first catalyst compound and a second catalyst compound that are co-supported forming a commonly supported catalyst system. The first catalyst compound includes a compound with the following formula:

$$(C_5H_aR^1{}_b)(C_5H_cR^2{}_d)HfX_2.$$

In this formula, each R^1 is independently H, a hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; each R^2 is independently a H, hydrocarbyl group, a substituted hydrocarbyl group, or a heteroatom group; a and c are ≥ 3; a+b = c+d = 5; at least one R^1 and at least one R^2 is a hydrocarbyl or substituted hydrocarbyl group; adjacent groups R^1 and R^2 groups