CLAIMS

1. A composition comprising at least one thioguanidine complex according to Formula (I):

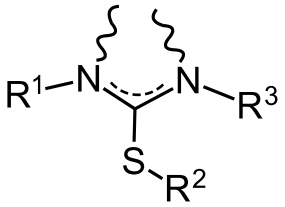
$$MQ_aX_{4-a} \quad (I)$$

where:

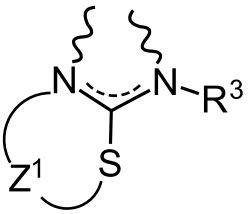
M is a metal center chosen from Ti, Zr, or Hf;

a is 1 or 2;

each group Q of the at least one thioguanidine complex is a bidentate thioguanidine ligand bound to the metal center, the thioguanidine ligand having Formula (Ia) or Formula (Ib):



(Ia)



(Ib)

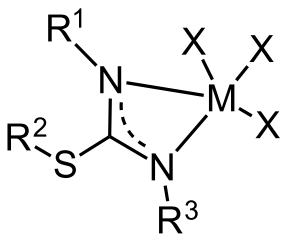
each group R^1, R^2, and R^3 in the at least one thioguanidine complex is independently chosen from alkyl groups or aryl groups;

each group Z^1 in the at least one thioguanidine complex is independently chosen from alkylene groups;

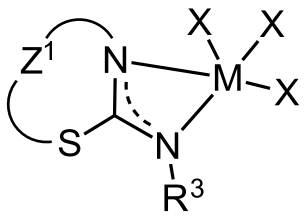
if a = 2, groups R^3 of the two groups Q are optionally linked to each other through at least one covalent bond; and

each X is covalently bonded or coordinated to the metal center and is independently chosen from alkyl groups, halides, or amides.

2. The composition of claim 1, wherein a is 1, and the at least one thioguanidine complex has Formula (IIa) or Formula (IIb):



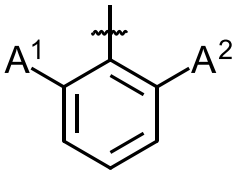
(IIa)



(IIb)

where M, R^1, R^2, R^3, Z^1, and X are as defined in Formula (I).

3. The composition of claim 2, wherein R^1 of Formula (IIa) and R^3 of Formulas (IIa) and (IIb) are independently chosen from groups according to the formula

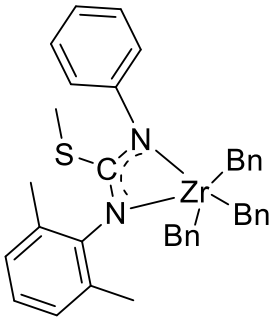


,

where A^1 and A^2 are independently hydrogen or a (C_1–C_{10}) alkyl group.

4. The composition of claim 3, wherein A^1 and A^2 are independently hydrogen or methyl.

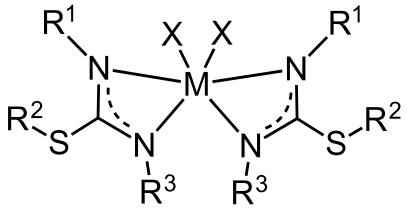
5. The composition of claim 2, wherein the at least one thioguanidine complex comprises compound C1:



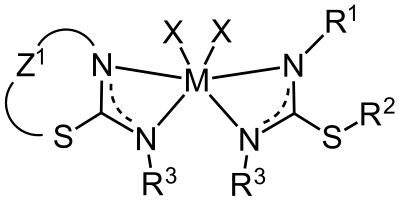
(C1)

where each Bn is benzyl (-CH_2-C_6H_5).

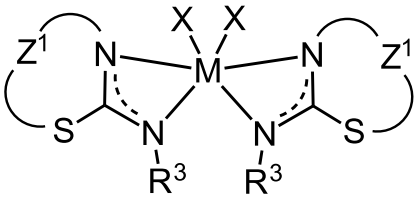
6. The composition of claim 1, wherein a is 2 and the at least one thioguanidine complex has Formula (IIIa), Formula (IIIb), or Formula (IIIc):



(IIIa)



(IIIb)



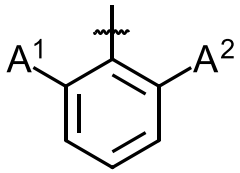
(IIIc)

where M, R^1, R^2, R^3, Z^1, and X are as defined in Formula (I).

7. The composition of claim 6, wherein each R^1 is independently chosen from phenyl or a (C_1–C_{10}) alkyl group.

8. The composition of claim 6, wherein each R^1 is independently chosen from phenyl or *n*-butyl.

9. The composition of claim 6, wherein each R^3 is independently chosen from groups according to the formula

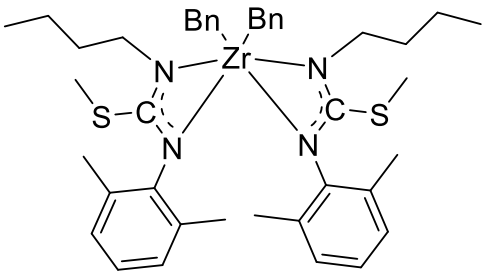


,

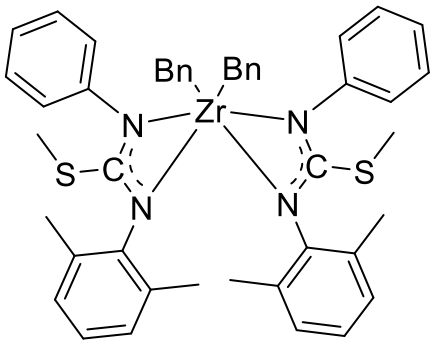
where A^1 and A^2 are independently a (C_1–C_{10}) alkyl group.

10. The composition of claim 9, wherein both A^1 and A^2 are methyl.

11. The composition of claim 6, wherein the at least one thioguanidine complex is chosen from compounds C2 or C3 or combinations thereof:



(C2)



(C3)

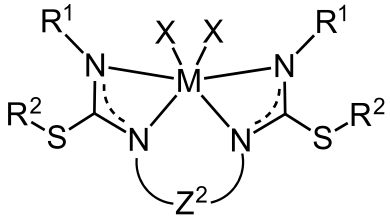
where each Bn in compounds C2 and C3 is benzyl (-CH_2-C_6H_5).

12. The composition of claim 1, wherein:

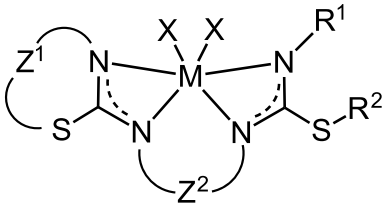
a is 2;

R^3 of the two groups Q are linked to each other as a bridging group Z^2; and

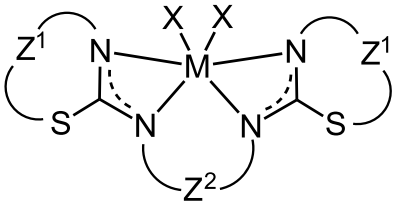
the at least one thioguanidine complex has Formula (IVa), Formula (IVb), or Formula (IVc):



(IVa)



(IVb)



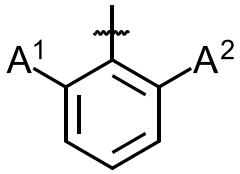
(IVc)

where M, R^1, R^2, Z^1, and X are as defined in Formula (I) and Z^2 is an alkylene group.

13. The composition of claim 12, wherein Z^2 is $-(CH_2)_n-$, where n is from 4 to 10.

14. The composition of claim 12, wherein Z^2 is $-(CH_2)_n-$, where n is 4 or 5.

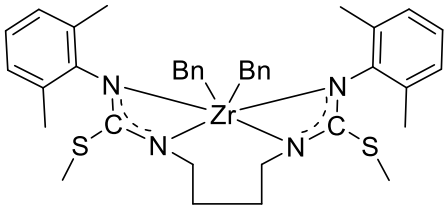
15. The composition of claim 12, wherein each R^1 is independently chosen from groups having the formula:



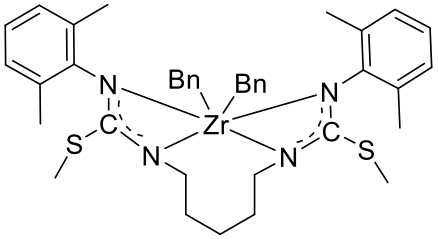
where A^1 and A^2 are independently a (C_1–C_{10}) alkyl group.

16. The composition of claim 15, wherein both A^1 and A^2 are methyl.

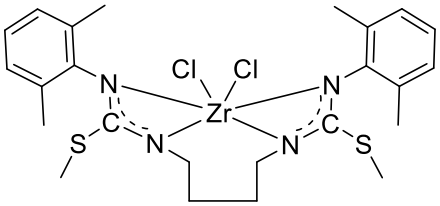
17. The composition of claim 12, wherein the at least one thioguanidine complex is chosen from compounds C4, C5, C6, or C7, or combinations thereof:



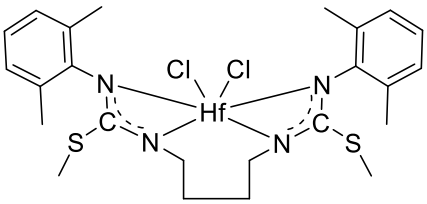
(C4)



(C5)



(C6)



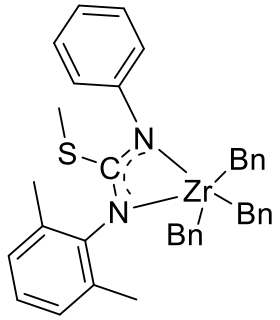
(C7)

where each Bn in compounds C4 and C5 is benzyl (-CH_2-C_6H_5).

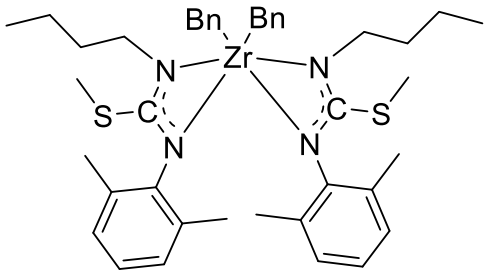
18. A polymerization method comprising:

reacting ethylene and an α-olefin comonomer in the presence of a catalytic amount of the composition of claim 1 to form an ethylene-co-alkylene copolymer, wherein the α-olefin comonomer comprises at least one C_3-C_{12} α-olefin.

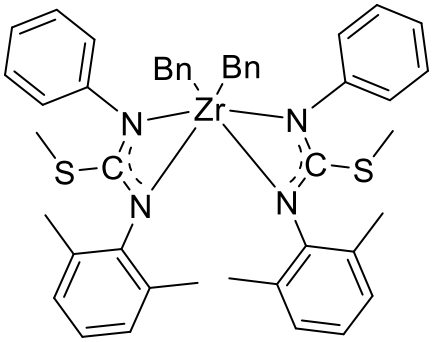
19. The polymerization method of claim 18, wherein the composition comprises at least one thioguanidine complex chosen from compounds C1, C2, C3, C4, C5, C6, C7, or combinations thereof:



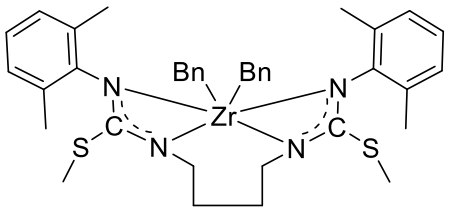
(C1)



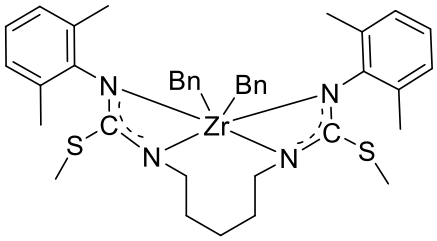
(C2)



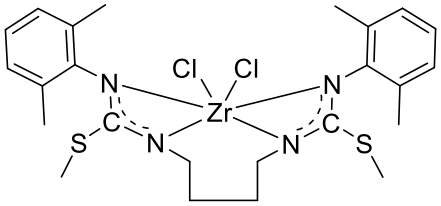
(C3)



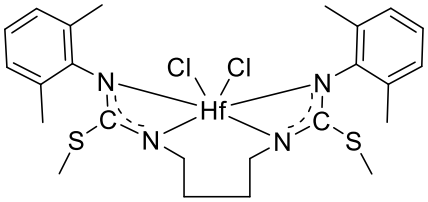
(C4)



(C5)



(C6)



(C7)

where each Bn in compounds C1, C2, C3, C4, and C5 is benzyl ($-CH_2-C_6H_5$).

20. The polymerization method of claim 19, wherein the α-olefin comonomer is 1-octene.