

WHAT IS CLAIMED IS:

1. A method for synthesizing a nucleic acid,
comprising:
 providing an initiator having an unprotected
5 nucleoside base and a 3' hydroxyl group at a 3'
terminus thereof;
 providing a nucleic acid polymerase having at
least a conservative catalytic polymerase domain
of a family-B DNA polymerase;
10 providing a nucleotide monomer; and
 exposing the initiator to the nucleotide
monomer in the presence of the nucleic acid
polymerase and at least one type of metal
cofactors which are divalent cations, and in the
15 absence of a template, such that the nucleotide
monomer is incorporated to the initiator, wherein
 the initiator is in a single-stranded form;
and
 the family-B DNA polymerase is a *Thermococcus*
20 DNA polymerase or a *Pyrococcus* DNA polymerase.
2. The method of Claim 1, wherein the initiator has
a sequence selected from a non-self complementary
sequence and a non-self complementarity forming
sequence.
- 25 3. The method of Claim 1, wherein the initiator is
linked to a solid support and has a 5' end linked
to the solid support.

4. The method of Claim 3, wherein the solid support is selected from the group consisting of a microarray, a bead, a column, an optical fiber, a wibe, nitrocellulose, nylon, glass, quartz, a
5 diazotized membrane, a silicone, polyformaldehyde, cellulose, cellulose acetate, paper, a ceramic, a metal, a metalloid, a semiconductor material, a magnetic particle, a plastic, a gel-forming material, a gel, a nanostructured surface, a
10 nanotube, and a nanoparticle.
5. The method of Claim 1, wherein the initiator is exposed to the nucleotide monomer at a temperature ranging from 10°C to 90°C.
6. The method of Claim 1, wherein the initiator is
15 exposed to the nucleotide monomer at a pH of not less than 8.0.
7. The method of Claim 1, wherein the metal cofactor is selected from the group consisting of Mg^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} , Mn^{2+} , Co^{2+} , Fe^{2+} , Ni^{2+} , Cu^{2+} , Zn^{2+} and
20 combinations thereof.
8. The method of Claim 1, wherein the nucleic acid polymerase further has a 3' to 5' exonuclease domain.
9. The method of Claim 1, wherein the family-B DNA
25 polymerase is selected from the group consisting of a family-B DNA polymerase of *Thermococcus kodakaraensis* (KOD1), a family-B DNA polymerase

of *Pyrococcus furiosus* (Pfu), a family-B DNA polymerase of *Thermococcus* sp. (9°N), a family-B DNA polymerase of *Thermococcus gorgonarius* (Tgo), and a family-B DNA polymerase of *Thermococcus*
5 *litoralis* (Vent).

10. The method of Claim 8, wherein the 3' to 5' exonuclease domain of the family-B DNA polymerase is modified in a manner selected from the group consisting of inactivation, attenuation, and
10 deletion.

11. The method of Claim 1, wherein the initiator has at least five nucleotide monomers.

12. The method of Claim 1, wherein the nucleotide monomer has a phosphate group selected from the
15 group consisting of a monophosphate, a diphosphate, a triphosphate, a tetraphosphate, a pentaphosphate, and a hexaphosphate.

13. The method of Claim 1, wherein the nucleotide monomer has a removable blocking moiety selected
20 from the group consisting of a 3'-O-blocking moiety, a base blocking moiety, and a combination thereof.

14. A kit for synthesizing a nucleic acid, comprising:
an initiator having an unprotected nucleoside base
25 and a 3' hydroxyl group at a 3' terminus thereof;
a nucleic acid polymerase having at least a conservative catalytic polymerase domain of a

family-B DNA polymerase; and a nucleotide monomer; wherein the initiator is in a single-stranded form, and the family-B DNA polymerase is a *Thermococcus* DNA polymerase or a *Pyrococcus* DNA polymerase.

5 15. The kit of Claim 14, wherein the initiator has a sequence selected from a non-self complementary sequence and a non-self complementarity forming sequence.

10 16. The kit of Claim 14, wherein the nucleic acid polymerase further has a 3' to 5' exonuclease domain.

15 17. The kit of Claim 14, wherein the family-B DNA polymerase is selected from the group consisting of a family-B DNA polymerase of *Thermococcus kodakaraensis* KOD1, a family-B DNA polymerase of *Pyrococcus furiosus* (Pfu), a family-B DNA polymerase of *Thermococcus* sp. (9°N), a family-B DNA polymerase of *Thermococcus gorgonarius* (Tgo), and a family-B DNA polymerase of *Thermococcus*
20 *litoralis* (Vent).

25 18. The kit of Claim 16, wherein the 3' to 5' exonuclease domain of the family-B DNA polymerase is modified in a manner selected from the group consisting of inactivation, attenuation, and deletion.

19. The kit of Claim 14, wherein the nucleotide monomer has a removable blocking moiety selected

from the group consisting of a 3'-O-blocking moiety, a base blocking moiety, and a combination thereof.