CLAIMS

What is claimed is:

1. A method of curing a coating composition comprising a radical polymerizable compound and an organoborane-amine complex having an organoborane initiator, an amine blocking agent, and water, said method comprising the steps of:

A. combining the organoborane-amine complex, the radical polymerizable compound, and water to form the coating composition;

B. introducing carbon dioxide into the coating composition or into a composition including at least one of the organoborane-amine complex, the radical polymerizable compound, and water prior to forming the coating composition, wherein the carbon dioxide is present in the coating composition in a molar ratio of at least 500:1 with the amine blocking agent of the organoborane-amine complex to thereby form in situ carbonic acid in a predetermined amount based upon temperature of the coating composition and/or pressure of an atmosphere surrounding the coating composition;

C. decomplexing the organoborane-amine complex with the carbonic acid thereby separating the organoborane initiator and the amine blocking agent; and

D. polymerizing the radical polymerizable compound using the organoborane initiator in the presence of oxygen.

2. A method as set forth in claim 1 wherein the predetermined amount of carbonic acid is further defined as a molar ratio of at least 1:1 of carbonic acid to the amine blocking agent of the organoborane-amine complex.

3. A method as set forth in claim 2 wherein the carbonic acid is formed at atmospheric pressure of about 1 atm and a temperature of from about -78°C to about 30°C.

4. A method as set forth in claim 1 wherein the in situ carbonic acid is formed in the predetermined amount within a period of less than or equal to 60 minutes.

5. A method as set forth in any preceding claim wherein the step of introducing carbon dioxide is further defined as exposing the coating composition to a controlled gaseous atmosphere containing carbon dioxide present in a concentration greater than concentration of carbon dioxide in ambient atmospheric air.

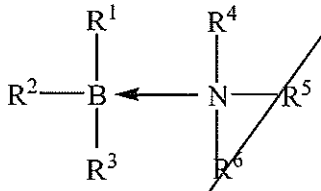
6. A method as set forth in any of claims 1-4 wherein the step of introducing carbon dioxide is further defined as introducing supercritical carbon dioxide into the coating composition or into the composition including at least one of the organoborane-amine complex, the radical polymerizable compound, and the water prior to forming the coating composition.

7. A method as set forth in any of claims 1-4 wherein the step of introducing carbon dioxide is further defined as introducing solid carbon dioxide into the coating composition or into the composition including at least one of the organoborane-amine complex, the radical polymerizable compound, and the water prior to forming the coating composition.

8. A method as set forth in any of claims 1-4 wherein the step of introducing the carbon dioxide is further defined as spraying the carbon dioxide from a nozzle of an impingement spray gun.

9. A method as set forth in any preceding claim further comprising the step of limiting an amount of oxygen present in the coating composition.

10. A method as set forth in any preceding claim wherein the organoborane-amine complex has the following formula:



wherein each of R^1, R^2, R^3, R^4, R^5, and R^6 is independently selected from the group of a hydrogen atom, an alkyl group, an alkoxy group, an arylalkyl group, an alkylene group, halogenated homologs thereof, and combinations thereof.

11. A method as set forth in any preceding claim wherein the radical polymerizable compound is selected from the group of unsaturated acrylic ester resins, functional acrylic ester monomers, and combinations thereof.

12. A method as set forth in any preceding claim wherein the radical polymerizable compound is present in an amount of from 90 to 97 percent by weight based on the total weight of the coating composition and the organoborane-amine complex is present in an amount of from 2 to 5 percent by weight based on the total weight of the coating composition.

13. A method as set forth in any preceding claim wherein the step of decomplexing the organoborane complex occurs in the absence of external heating of the reactive composition.

14. A method as set forth in any preceding claim wherein step A) further comprises applying the coating composition onto an automobile component.

15. An automobile component including a cured coating formed thereon according to the method as set forth in claim 14.

Claims

1. A method of curing a coating composition comprising a radical polymerizable compound and an organoborane-amine complex having an organoborane initiator, an amine blocking agent, and water, said method comprising the steps of:

   A. combining the organoborane-amine complex, the radical polymerizable compound, and water to form the coating composition;
   B. introducing carbon dioxide into the coating composition or into a composition including at least one of the organoborane-amine complex, the radical polymerizable compound, and water prior to forming the coating composition, wherein the carbon dioxide is present in the coating composition in a molar ratio of at least 500:1 with the amine blocking agent of the organoborane-amine complex to thereby form in situ carbonic acid in a molar ratio of at least 1:1 of carbonic acid to the amine blocking agent of the organoborane-amine complex;
   C. decomplexing the organoborane-amine complex with the carbonic acid thereby separating the organoborane initiator and the amine blocking agent; and
   D. polymerizing the radical polymerizable compound using the organoborane initiator in the presence of oxygen.

2. A method as set forth In claim 1 wherein the carbonic acid is formed at atmospheric pressure of about 1013,25 hPa (1 atm) and a temperature of from -78°C to 30°C.

3. A method as set forth in claim 1 wherein the in situ carbonic acid is formed within a period of less than or equal to 60 minutes.

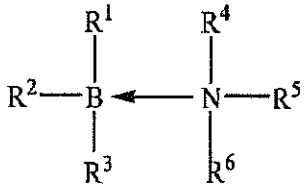
4. A method as set forth in any preceding claim wherein the step of introducing carbon dioxide comprises exposing the coating composition to a controlled gaseous atmosphere containing carbon dioxide present in a concentration greater than concentration of carbon dioxide in ambient atmospheric air.

5. A method as set forth in any of claims 1 to 3 wherein the step of introducing carbon dioxide comprises introducing supercritical carbon dioxide into the coating composition or into the composition including at least one of the organoborane-amine complex, the radical polymerizable compound, and the water prior to forming the coating composition.

6. A method as set forth in any of claims 1 to 3 wherein the step of introducing carbon dioxide comprises introducing solid carbon dioxide into the coating composition or into the composition including at least one of the organoborane-amine complex, the radical polymerizable compound, and the water prior to forming the coating composition.

7. A method as set forth in any of claims 1 to 3 wherein the step of introducing the carbon dioxide comprises spraying the carbon dioxide from a nozzle of an impingement spray gun.

8. A method as set forth in any preceding claim wherein the organoborane-amine complex has the following formula:



wherein each of R^1, R^2, R^3, R^4, R^5, and R^6 is independently selected from the group consisting of a hydrogen atom, an alkyl group, an alkoxy group, an arylalkyl group, an alkylene group, halogenated homologs thereof, and combinations thereof.

9. A method as set forth in any preceding claim wherein the radical polymerizable compound is selected from the group of unsaturated acrylic ester resins, functional acrylic ester monomers, and combinations thereof.

10. A method as set forth in any preceding claim wherein the radical polymerizable compound Is present in an amount of from 90 to 97 percent by weight based on the total weight of the coating composition and the organoborane-amine complex is present in an amount of from 2 to 5 percent by weight based on the total weight of the coating composition.

11. A method as set forth in any preceding claim wherein the step of decomplexing the organoborane complex occurs in the absence of external heating of the reactive composition.

12. A method as set forth in any preceding claim wherein step A) further comprises applying the coating composition onto an automobile component.

13. An automobile component comprising a cured coating thereon formed according to the method as set forth in claim 12.