SUMMARY

This need for methods and systems for promoting adhesion and bonding of composite and metal structures is satisfied. As discussed in the below detailed description, embodiments of the methods and systems may provide significant advantages over existing methods, systems, and devices.

In one aspect, there is provided a method of promoting adhesion on a composite surface, the method comprising: providing a composite structure having at least one composite surface to be bonded; preparing the at least one composite surface; providing a chemical derivatization compound containing active molecular functional groups that promote adhesion and detect adhesion mechanisms, wherein the chemical derivatization compound is selected from the group consisting of tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether; depositing the chemical derivatization compound on the prepared composite surface and activating the molecular functional groups through chemical derivatization reaction mechanisms to form a molecular functional group-adhesive promoter derivatized layer on the prepared composite surface as a bonding agent, the chemical derivatization reaction mechanisms creating reactive molecular functional groups on the prepared composite surface, and the chemical derivatization reaction mechanisms selected from the group consisting of bromination, silination, and thionation; applying an adhesive layer to the derivatized layer; and, heat curing the adhesive layer to result in a bond with another structure made of a composite, a metal, or a combination thereof.

In another aspect, there is provided a method for structural bonding of structures comprising: providing a first structure made of a composite material and a second structure made of a composite material, a metal, or a combination thereof; preparing a surface to be bonded on each of the first and second structures to form a first prepared surface and a second prepared surface; providing a chemical derivatization compound containing active molecular functional groups that promote adhesion and detect adhesion mechanisms, wherein the chemical derivatization compound is selected from the group consisting of tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether; depositing the chemical derivatization compound on each of the first and second prepared surfaces and activating the molecular functional groups through chemical derivatization reaction mechanisms to form a first molecular functional group-adhesive promoter derivatized layer on the first prepared composite surface as a first bonding agent and a second molecular functional group-adhesive promoter derivatized layer on the second prepared composite surface as a second bonding agent, the chemical derivatization reaction mechanisms creating reactive molecular functional groups on the first and second prepared surfaces, and the chemical derivatization reaction mechanisms selected from the

group consisting of bromination, silination, and thionation; applying an adhesive layer to at least one of the derivatized layers of the first and second molecular functional group-adhesive promoter derivatized layers; joining the first and second structures together with the adhesive layer and the first and second molecular functional group-adhesive promoter derivatized layers therebetween; and, heat curing the adhesive layer to the joined first and second structures to form a structural bond between the first and second structures.

In yet another aspect, there is provided a method for structural bonding of polymeric composite structures of an aircraft, the method comprising: providing a first polymeric composite aircraft structure and a second polymeric composite aircraft structure; preparing a surface to be bonded on each of the first and second polymeric composite aircraft structures to form a first prepared surface and a second prepared surface; providing a chemical derivatization compound containing active molecular functional groups that promote adhesion and detect adhesion mechanisms, wherein the chemical derivatization compound is selected from the group consisting of tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether; depositing the chemical derivatization compound on each of the first and second prepared surfaces and activating the molecular functional groups through chemical derivatization reaction mechanisms to form a first molecular functional group-adhesive promoter derivatized layer on the first prepared composite surface as a first bonding agent and a second molecular functional group-adhesive promoter derivatized layer on the second prepared composite surface as a second bonding agent, the chemical derivatization reaction mechanisms creating reactive molecular functional groups on the first and second prepared surfaces, and the chemical derivatization reaction mechanisms selected from the group consisting of bromination, silination, and thionation; applying an adhesive layer to at least one of the first and second molecular functional group-adhesive promoter derivatized layers; joining the first and second polymeric composite aircraft structures together with the adhesive layer and the first and second molecular functional group-adhesive promoter derivatized layers therebetween; and, heat curing the adhesive to the joined first and second polymeric composite aircraft structures to form an aircraft structural bond between the first and second polymeric composite aircraft structures.

In an embodiment of the disclosure, there is provided a method of promoting adhesion on a composite surface. The method comprises providing a composite structure having at least one composite surface to be bonded. The method further comprises preparing the at least one composite surface, wherein the composite surface may be prepared with one or more surface preparation treatments selected from the group comprising solvent wiping, abrading, grit blasting, sanding, sandblasting, chemical cleaning, and chemical etching.. The method further comprises providing a chemical derivatization compound containing active functional groups that promote adhesion. The method further comprises depositing the chemical derivatization compound on the prepared composite surface to form a functional group-adhesive promoter derivatized layer, wherein the chemical derivatization compound is may be deposited via chemical vapor deposition or vacuum deposition.. The method further comprises applying an adhesive layer to the derivatized layer. The method further comprises heat curing the adhesive layer to result in a bond with another structure made of a composite, a metal, or a combination thereof. The method further comprises a method wherein the resulting bond may be selected from the group comprising a structural bond and a repair bond or wherein the composite structure and the other

CLAIMS

What is claimed is:

1. A method (150) of promoting adhesion on a composite surface, the method comprising:

providing (152) a composite structure (32) having at least one composite surface (34) to be bonded;

preparing (154) the at least one composite surface (34);

providing (156) a chemical derivatization compound containing active functional groups that promote adhesion;

depositing (158) the chemical derivatization compound on the prepared composite surface (34) to form a functional group-adhesive promoter derivatized layer (40);

applying (160) an adhesive layer (46) to the derivatized layer (40); and,

heat curing (162) the adhesive layer (46) to result in a bond with another structure made of a composite, a metal, or a combination thereof.

2. The method of claim 1, wherein the composite structure (32) is made of a polymeric composite material selected from the group comprising bismaleimides (BMI), epoxies, and polyimides.

3. The method of claim 1, wherein the composite structure (32) comprises bismaleimide (BMI), and the chemical derivatization compound activates carbon-carbon double bond functional groups on the composite surface of the bismaleimide.

4. The method of claim 1, wherein the chemical derivatization compound is selected from the group consisting of fluorinated compounds, tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether.

5. The method of claim 1, wherein the prepared composite surface (34) is exposed to a vapor phase chemical derivatization compound containing selected functional groups, wherein selection of the functional groups is based on a resin formulation of the composite structure (32).

6. A method (200) for structural bonding of structures comprising:

providing (202) a first structure (32) made of a composite material and a second structure made of a composite material (36), a metal (52), or a combination thereof;

preparing (204) a surface to be bonded on each of the first and second structures to form a first prepared surface and a second prepared surface;

providing (206) a chemical derivatization compound containing active functional groups that promote adhesion;

depositing (208) the chemical derivatization compound on each of the first and second prepared surfaces to form a first (40a) functional group-adhesive promoter

derivatized layer and a second (40b) functional group-adhesive promoter derivatized layer;

applying (210) an adhesive layer (46) to at least one of the derivatized layers of the first (40a) and second (40b) functional group-adhesive promoter derivatized layers;

joining (212) the first and second structures together with the adhesive layer (46) and the first (40a) and second (40b) functional group-adhesive promoter derivitized layers therebetween; and,

heat curing (214) the adhesive layer (46) to the joined first and second structures to form a structural bond (48) between the first and second structures.

7. The method of claim 6, wherein the composite material is selected from the group comprising bismaleimides (BMI), epoxies, and polyimides.

8. The method of claim 6, wherein the chemical derivatization compound is selected from the group consisting of fluorinated compounds, tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether.

9. The method of claim 1 or claim 6, wherein the first and second structures are aircraft structures.

10. A method (300) for structural bonding of polymeric composite structures of an aircraft (10), the method comprising:

providing (302) a first polymeric composite aircraft structure (172) and a second polymeric composite aircraft structure (176);

preparing (304) a surface to be bonded on each of the first (172) and second (176) polymeric composite aircraft structures to form a first prepared surface (174) and a second prepared surface (178);

providing (306) a chemical derivatization compound containing active functional groups that promote adhesion;

depositing (308) the chemical derivatization compound on each of the first (174) and second (178) prepared surfaces to form a first functional group-adhesive promoter derivitized layer (40a) and a second functional group-adhesive promoter derivitized layer (40b);

applying (310) an adhesive layer (46) to at least one of the first (40a) and second (40b) functional group-adhesive promoter derivitized layers;

joining (312) the first (172) and second (176) polymeric composite aircraft structures together with the adhesive layer (46) and the first (40a) and second (40b) functional group-adhesive promoter derivitized layers therebetween; and,

heat curing (314) the adhesive (46) to the joined first (172) and second (176) polymeric composite aircraft structures to form a structural bond (180) between the first and second polymeric composite aircraft structures.

11. The method of claim 10, wherein the first (172) and second (176) polymeric composite structures are made of a material selected from the group comprising bismaleimides (BMI), epoxies, and polyimides.

12. The method of claim 10, wherein the chemical derivatization compound is selected from the group consisting of fluorinated compounds, tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether.

13. A bonded structure formed by the method of claim 1, 6, or 10.

CLAIMS

What is claimed is:

1. A method of promoting adhesion on a composite surface, the method comprising:

providing a composite structure having at least one composite surface to be bonded;

preparing the at least one composite surface;

providing a chemical derivatization compound containing active molecular functional groups that promote adhesion and detect adhesion mechanisms, wherein the chemical derivatization compound is selected from the group consisting of tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether;

depositing the chemical derivatization compound on the prepared composite surface and activating the molecular functional groups through chemical derivatization reaction mechanisms to form a molecular functional group-adhesive promoter derivatized layer on the prepared composite surface as a bonding agent, the chemical derivatization reaction mechanisms creating reactive molecular functional groups on the prepared composite surface, and the chemical derivatization reaction mechanisms selected from the group consisting of bromination, silination, and thionation;

applying an adhesive layer to the derivatized layer; and,

heat curing the adhesive layer to result in a bond with another structure made of a composite, a metal, or a combination thereof.

2. The method of claim 1, wherein the composite structure is made of a polymeric composite material selected from the group comprising bismaleimides (BMI), epoxies, and polyimides.

3. The method of claim 1, wherein the composite structure comprises bismaleimide (BMI), and the chemical derivatization compound activates carbon-carbon double bond molecular functional groups on the composite surface of the bismaleimide.

4. The method of claim 1, wherein the composite surface is prepared with one or more surface preparation treatments selected from the group comprising solvent wiping, abrading, grit blasting, sanding, sandblasting, chemical cleaning, and chemical etching.

5. The method of claim 1, wherein the chemical derivatization compound is deposited via chemical vapor deposition or vacuum deposition.

6. The method of claim 1, wherein the prepared composite surface is exposed to a vapor phase chemical derivatization compound containing selected molecular functional groups, wherein selection of the molecular functional groups is based on a resin formulation of the composite structure.

7. The method of claim 1, wherein the resulting bond is selected from the group comprising a structural bond and a repair bond.

8. The method of claim 1, wherein the composite structure and the other structure made of the composite, the metal, or the combination thereof, are aircraft structures.

9. A method for structural bonding of structures comprising:

providing a first structure made of a composite material and a second structure made of a composite material, a metal, or a combination thereof;

preparing a surface to be bonded on each of the first and second structures to form a first prepared surface and a second prepared surface;

providing a chemical derivatization compound containing active molecular functional groups that promote adhesion and detect adhesion mechanisms, wherein the chemical derivatization compound is selected from the group consisting of tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether;

depositing the chemical derivatization compound on each of the first and second prepared surfaces and activating the molecular functional groups through chemical derivatization reaction mechanisms to form a first molecular functional group-adhesive promoter derivatized layer on the first prepared composite surface as a first bonding agent and a second molecular functional group-adhesive promoter derivatized layer on the second prepared composite surface as a second bonding agent, the chemical derivatization reaction mechanisms creating reactive molecular functional groups on the first and second prepared surfaces, and the chemical derivatization reaction mechanisms selected from the group consisting of bromination, silination, and thionation;

applying an adhesive layer to at least one of the derivatized layers of the first and second molecular functional group-adhesive promoter derivatized layers;

joining the first and second structures together with the adhesive layer and the first and second molecular functional group-adhesive promoter derivatized layers therebetween; and,

heat curing the adhesive layer to the joined first and second structures to form a structural bond between the first and second structures.

10. The method of claim 9, wherein the composite material is selected from the group comprising bismaleimides (BMI), epoxies, and polyimides.

11. The method of claim 9, wherein the surface to be bonded is prepared with one or more surface preparation treatments selected from the group comprising solvent wiping, abrading, grit blasting, sanding, sandblasting, chemical cleaning, and chemical etching.

12. The method of claim 9, wherein the chemical derivatization compound is deposited via chemical vapor deposition or vacuum deposition.

13. The method of claim 9, wherein the first and second structures are aircraft structures.

14. A method for structural bonding of polymeric composite structures of an aircraft, the method comprising:

providing a first polymeric composite aircraft structure and a second polymeric composite aircraft structure;

preparing a surface to be bonded on each of the first and second polymeric composite aircraft structures to form a first prepared surface and a second prepared surface;

providing a chemical derivatization compound containing active molecular functional groups that promote adhesion and detect adhesion mechanisms, wherein the chemical derivatization compound is selected from the group consisting of tetrafluoroaceticanhydride (TFAA), pentafluorophenol, allyl pentafluorobenzene, tridecafluorononyl maleimide, and glycidyloctafluoropentyl ether;

depositing the chemical derivatization compound on each of the first and second prepared surfaces and activating the molecular functional groups through chemical derivatization reaction mechanisms to form a first molecular functional group-adhesive promoter derivatized layer on the first prepared composite surface as a first bonding agent and a second molecular functional group-adhesive promoter derivatized layer on the second prepared composite surface as a second bonding agent, the chemical derivatization reaction mechanisms creating reactive molecular functional groups on the first and second prepared surfaces, and the chemical derivatization reaction mechanisms selected from the group consisting of bromination, silination, and thionation;

applying an adhesive layer to at least one of the first and second molecular functional group-adhesive promoter derivatized layers;

joining the first and second polymeric composite aircraft structures together with the adhesive layer and the first and second molecular functional group-adhesive promoter derivatized layers therebetween; and,

heat curing the adhesive to the joined first and second polymeric composite aircraft structures to form an aircraft structural bond between the first and second polymeric composite aircraft structures.

15. The method of claim 14, wherein the first and second polymeric composite structures are made of a material selected from the group comprising bismaleimides (BMI), epoxies, and polyimides.

16. The method of claim 14, wherein the surface to be bonded is prepared with one or more surface preparation treatments selected from the group comprising solvent wiping, abrading, grit blasting, sanding, sandblasting, chemical cleaning, and chemical etching.