Films, Preimpregnated Tapes and Composites Made from Polyimide "Salt-Like" Solutions

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High quality films, preimpregnated tape (prepregs) and composites have been fabricated from polyimide precursor "salt-like" solutions. These "salt-like" solutions have a low viscosity (5,000 to 10,000 cp) and a high solids content (50-65% by weight) and can be coated onto reinforcing fiber to produce prepregs with excellent tack and drape at 12-15% residual solvent (~4-6% water from thermal imidization reaction). The processing of these types of prepregs significantly overcomes solvent removal problems and allows excellent fiber wet out. In addition, the physical characteristics of the polyimide precursor "salt-like" solutions permits processing into high-performance materials through the use of standard prepregging and composite fabrication equipment. The resultant composites are of high quality.

17 Claims, 6 Drawing Sheets
FIG. 1

Polyimide acid → Heat → Polyimide

Diamine + Dianhydride → Solvent (Polar Aprotic Materials)

Water By-Product
FIG. 2

Dianhydride + Alcohol → Polyimide precursor solution

Polyimide diluent solution + Solvent + Water, Solvent & Alcohol → By-Product
FIG. 5

Pressure (PSI)

Temperature (°F)

0.5 Hrs. @ 716° F
1.5 Hrs. @ 437° F
1 Hrs. @ 250° F

VACUUM 30° Hg
VACUUM 20° Hg
VACUUM 0° Hg

Time (Hrs.)
POLYIMIDES ARE CRITICAL CONSOLIDATION IN FULL VACUUM, 30" Hg. THE PROCESS IS GAINED BY HOLDING THE MATERIAL AT AN INTERMEDIATE DRYING PERIOD. THIS RESIDUAL SOLVENT MUST THEN BE REMOVED DURING蒴决WATER. FREQUENTLY, THE RESULTANT PREPEGS REQUIRE RESIDUAL SOLVENT CONTENTS. IN GENERAL, THE PROCESSING OF COMPOSITES FROM PREPEGS. COMPOSITES MANUFACTURED FROM THESE MATERIALS ARE VITAL IN ANY APPLICATION WHICH REQUIRES ELEVATED TEMPERATURE USE WITH WEIGHT CONSTRAINTS.

Another object of the present invention is to provide novel polyimide “salt-like” solutions with physical characteristics that permit processing into high-performance materials through the use of standard prepregging and composite fabrication equipment. The utilization of these novel polyimide “salt-like” solutions permits the employment of significantly less solvent and results in higher quality prepregged tape.

SUMMARY OF THE INVENTION

According to the present invention the foregoing and additional objects are obtained by fabricating films and prepregged tapes from “salt-like” solutions of high temperature polyimides. The prepregged tapes can then be used to make composites. The polyimide “salt-like” solutions are formed from the reaction of a dianhydride dissolved in a mixture of solvent and alcohol at room temperature. This solution is treated at 60°C for 3 hours in order to convert the dianhydride into a diester-diacid. Phthalic acid (PA) and a diamine are added to the diester-diacid solution and the mixture is stirred for 2 hours to yield a homogenous polyimide precursor “salt-like” solution. Likewise, similar polyimide “salt-like” resins can be formed from tetraacids and diamines mixed in different solvents and alcohols.

These “salt-like” solutions have a low viscosity (5,000 to 9,700 cp) and a high solids content (50-65% by weight) and can be coated onto reinforcing fiber to produce high quality prepeg with excellent tack and drape at 12-15% residual solvent (-4-6% water from thermal imidization reaction). Composites from these prepegs are of high quality and require significantly less solvent removal. Typically, low drying temperatures and only partial vacuum are required.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, including its objects and attendant benefits, reference should be made to the Description of the Preferred Embodiments, which is set forth in detail below. This Detailed Description should be read together with the accompanying drawings, wherein:

FIG. 1 is a general equation showing the synthesis of polyimides;
FIG. 2 is a general equation showing the synthesis of polyimide “salt-like” resins;
FIG. 3 is a schematic diagram of a Tape Machine’s modular components;
FIG. 4 is a schematic illustration of solution prepregging using the dip tank method;
FIG. 5 shows the cure cycle for the polyimide “salt-like” prepregged tape according to the present invention; and
FIG. 6 shows the composite laminate lay-up configuration according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Films, preimpregnated tapes (prepeg) and composites are fabricated from “salt-like” solutions of high temperature polyimides. The polyimide “salt-like” solutions are formed from the reaction of a dianhydride dissolved in a mixture of solvent and alcohol at room temperature. This solution is treated at 60°C for 3 hours in order to convert the dianhydride into a diester-diacid. Phthalic acid (PA) and a diamine are added to the resulting diester-acid solution and the mixture is stirred for 2 hours to yield a homogenous polyimide precursor “salt-like” solution. Likewise, polyimide “salt-like” resins can be formed from tetraacids and diamines mixed in different solvents and alcohols. These polyimide “salt-like” solutions have a low viscosity (5,000 to 9,700 cp) and a high solids content (50–65% by weight) and are coated onto reinforcing fiber to produce high quality prepeg with excellent tack and drape at 12–15% residual solvent (4–6% water from thermal imidization reaction). Composites from these prepeg are of high quality and require significantly less solvent removal.

In one aspect, the present invention is films, preimpregnated tapes and composites fabricated from polyimide precursor “salt-like” solutions having high solids content (50–80%), low residual volatiles (12–15%), and low viscosity (5,000 to 10,000 cp) at ambient temperature.

A particularly preferred embodiment of the present invention is the fabrication of films and preimpregnated tapes using the polyimide precursor “salt-like” solution of LaRC™ IA. The LaRC™ IA “salt-like” solution is formed from the reaction of oxydiphthalic anhydride (ODPA) dissolved in a mixture of NMP and methanol at room temperature. This solution is treated at 60°C for 3 hours in order to convert the ODPA into an ODP-dimethyl ester. Phthalic acid (PA) and 3,4'-oxydianiline (3,4'-ODA) are added to the ODP-dimethyl ester solution and the mixture is stirred for 2 hours to yield a homogenous polyimide precursor “salt-like” solution.

Another particularly preferred embodiment of the present invention is films, preimpregnated tapes and composites fabricated from polyimide precursor “salt-like” solution of LaRC™ IAX. The LaRC™ IAX “salt-like” solution is formed from the reaction of oxydiphthalic anhydride (ODPA) dissolved in a mixture of NMP and methanol at room temperature. This solution is treated at 60°C for 3 hours in order to convert the ODPA into an ODP-dimethyl ester. Phthalic acid (PA) and 0.9 moles of 3,4'-oxydianiline (3,4'-ODA) and 0.1 moles of phenylene diamine (PDA) are added to the ODP-dimethyl ester solution and the mixture is stirred for 2 hours to yield a homogenous polyimide precursor “salt-like” solution.

Yet another particularly preferred embodiment of the present invention is the fabrication of films and preimpregnated tape using the polyimide precursor “salt-like” solution of PETI-5. The “salt-like” solution is formed from the reaction biphenylene dianhydride (BPDA) dissolved in a mixture of NMP and methanol at room temperature. This solution is treated at 60°C for 3 hours in order to convert the BPDA to a biphenyl-dimethyl ester. Phthalic acid (PA), 0.85 moles of 3,4'-oxydianiline (3,4'-ODA) and 0.15 moles of 1,3-bisaminophenoxybenzene (APB) are added to the ODP-dimethyl ester solution and the mixture is stirred for 2 hours to yield a homogenous copolyimide precursor “salt-like” solution.

In another aspect, the present invention is the process of fabricating preimpregnated tape and composites from polyimide precursor “salt-like” solutions.

In yet another respect, the present invention is the process of laminating preimpregnated tape fabricated using polyimide precursor “salt-like” solutions.

Having generally described the invention, a more complete understanding thereof can be obtained by reference to the following examples, which are provided herein for purposes of illustration only and do not limit the invention.

EXAMPLE 1

Biphenylene dianhydride (BPDA) (0.91 moles) was dissolved in a mixture of NMP and methanol at room temperature. This solution was treated at 60°C for 3 hours in order to convert the BPDA to a biphenyl-dimethyl ester 3,4'-oxydianiline (3,4'-ODA) (0.85 moles), 1,3-bisaminophenoxybenzene (APB) (0.15 moles) and the endcapper phenylethynyl phthalic anhydride (PEPA) (0.18 moles) were added to the BPA-dimethyl ester solution and the mixture was stirred for 12 hours to yield a homogenous, dark brown PETI-5 precursor solution. Solid contents and viscosity of the solution was 60% weight % and 3100 cp respectively.

The precursor solution was coated on a glass plate using an automatic film applicator. After drying at 50°F and 80°F for an hour, respectively, the films were thermally cured at 100, 225, and 350°F. for one hour, respectively. The resulting film was removed from the glass plate to yield a transparent film with a thickness of 14 mil.

Tensile strength, elongation and tensile modulus of the resulting film was 13.7 kg/mm², 5.5% and 400 kg/mm².

EXAMPLE 2

LaRC™ PETI-5 was placed in the resin dip tank of the LaRC Multipurpose Prepeg Machine (FIGS. 3 and 4). The solution had a solids content of 65% resin by weight in NMP with a Brookfield viscosity of 3000 cp at 20°C. The hotplates were set at 300°F while the oven was set at 260°F. The hotplates were set at 300°F while the oven was set at 260°F. The metering bar gap was set at 0.015 inches and the line speed was set to 1.8 ft/min. The comb was adjusted to attain a fiber weight of 145 g/m. Seventy ends of 12 k sized Hercules IM7 carbon fiber were utilized. A prepeg, tape with FAW of 145 g/m², 35 wt % dry resin content, and a wet volatile percent of 15 was produced. The 8.5 inch wide prepeg tape was of high quality with excellent wet out, tack and drape.

EXAMPLE 3

LaRC™ 8515 “salt-like” solution was placed in the resin dip tank of the LaRC Multipurpose Prepeg Machine (FIGS.
5

3 and 4). The solution had a solids content of 65% resin by weight in NMP with a Brookfield viscosity of 9660 cp at 18°C. The hotplates were set at 300°F while the oven was set at 280°F. The metering bar gap was set at 0.016 inches and the line speed was set to 2.5 ft/min. The comb was adjusted to attain a fiber aerial weight of 145 g/m². Seventy ends of 12 k sized Hercules IM7 carbon fiber were utilized. A prepreg tape with FAW of 148 g/m², 35.7 wt % dry resin content, and a wet volatile percent of 15.0 was produced. The 8.5 inch wide prepreg tape was of high quality with excellent wet out, tack, and drape. A total of 350 linear feet of material was produced.

EXAMPLE 4

LaRC™-IA “salt-like” solution was placed in the resin dip tank of the LaRC Multipurpose Prepeg Machine (FIGS. 3 and 4). The solution had a solids content of 65% resin by weight in NMP with a Brookfield viscosity of 6780 cp at 23°C. The hotplates were set at 300°F while the oven was set at 260°F. Nip stations 2, 3, and 4 were utilized with only contact pressure and were set at 200°F. The metering bar gap was set at 0.016 inches and the line speed was set to 1.9 ft/min. The comb was adjusted to attend a fiber aerial weight of 145 g/m². Seventy ends of 12 k sized Hercules IM7 carbon fiber were utilized. A prepreg tape with FAW of 150 g/m², 37.5 wt % dry resin content, and a wet volatile percent of 13.8 was produced. The 8.5 inch wide prepreg tape was of high quality with excellent wet out, tack, and drape. A total of 350 linear feet of material was produced.

EXAMPLE 5

LaRC™-IA “salt-like” solution was placed in the resin dip tank of the LaRC Multipurpose Prepeg Machine (FIGS. 3 and 4). The solution had a solids content of 65% resin by weight in NMP with a Brookfield viscosity of 4955 cp at 22°C. The hotplates were set at 300°F while the oven was set at 280°F. Nip stations 2, 3, and 4 were utilized with only contact pressure and were set at 200°F. The metering bar gap was set at 0.016 inches and the line speed was set to 1.8 ft/min. The comb was adjusted to attend a fiber aerial weight of 145 g/m². Seventy ends of 12 k sized Hercules IM7 carbon fiber were utilized. A prepreg tape with FAW of 150 g/m², 34.0 wt % dry resin content, and a wet volatile percent of 13.2 was produced. The 8.5 inch wide prepreg tape was of high quality with excellent wet out, tack, and drape. A total of 350 linear feet of material was produced.

EXAMPLE 6

LaRC™-8515 “salt-like” prepreg was processes into various different composite laminates by the process illustrated in FIG. 5. One ply of Kapton™ film and one ply of 0.0025” Teflon bleeder/breather cloth was placed on either side of several plies of LaRC™-85 15 “salt-like” prepreg (see FIG. 6). The material was then placed in a closed mold and processed in a hydraulic vacuum press. The LaRC™-8515 “salt-like” prepreg was heated to 250°F under isobaric conditions and held for one hour. During the one hour hold, the residual solvent within the material was removed. After 30 minutes at 250°F, 20° Hg of vacuum was applied. Once the 250°F hold was completed, the material was ramped to 437°F, where an additional 10° Hg was added to allow full vacuum to be present. During the one and half hour hold at 437°F, the material becomes fully imidized. After the hold at 437°F, the LaRC™-8515 polyimide was heated to the final cure temperature of 716°F. At the final cure temperature, 100 psi was applied to the laminate and the material was held at this temperature and pressure for 30 minutes. During this hold, the LaRC™-8515 polyimide becomes amorphous and reaches minimum viscosity which allows for proper consolidation. Once the hold has been completed, the material is cooled to ambient under fill vacuum and 100 psi pressure. At ambient temperature, the mold was removed from the hydraulic vacuum press and the laminate was released from the mold. Upon visual and ultrasonic examination, the laminate was determined to be of excellent quality. The properties for LaRC™-8515/IM-7 “salt-like” composites is given in Table 1 and 2.

<table>
<thead>
<tr>
<th>Mechanical Tests</th>
<th>Test Temperature *°C</th>
<th>Failure Load (Kg)</th>
<th>Failure Stress (MPa)</th>
<th>Modulus (Gpa)</th>
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<tbody>
<tr>
<td>SBS RT 10</td>
<td>352.7 ± 12.2</td>
<td>117.8 ± 3.8</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>177 10</td>
<td>135.6 ± 45.4</td>
<td>5 ± 3.0</td>
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<td></td>
</tr>
<tr>
<td>0° RT 6</td>
<td>79.9 ± 4.4</td>
<td>172.5 ± 8.4</td>
<td>146.9 ± 3.4</td>
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<tr>
<td>Flexural 177 5</td>
<td>57.6 ± 2.5</td>
<td>1299.0 ± 101.4</td>
<td>137.2 ± 7.4</td>
<td></td>
</tr>
<tr>
<td>90° RT 5</td>
<td>26.4 ± 1.9</td>
<td>117.9 ± 6.1</td>
<td>4.62 ± 0.28</td>
<td></td>
</tr>
<tr>
<td>30 Flexural 177 5</td>
<td>14.2 ± 3.3</td>
<td>58.6 ± 13.1</td>
<td>4.34 ± 0.28</td>
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<tr>
<th>Mechanical Properties For LaRC™-8515/IM-7 Composites</th>
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<td>Mechanical Test</td>
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<tr>
<td>------------------</td>
</tr>
<tr>
<td>SBS RT 177</td>
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<tr>
<td>0° Flexural RT</td>
</tr>
<tr>
<td>90° Flexural RT</td>
</tr>
<tr>
<td>177</td>
</tr>
<tr>
<td>60.67 ± 5.89</td>
</tr>
</tbody>
</table>

| EXAMPLE 7 |

LaRC™-IA “salt-like” prepreg was processed into various different composite laminates by the process illustrated in FIG. 3. One ply of Kapton™ film and one ply of 0.0025” Teflon bleeder/breather cloth was placed on either side of several plies of LaRC™-8515 “salt-like” prepreg (see FIG. 4). The material was then placed in a closed mold and processed in a hydraulic vacuum press. The LaRC™-IA “salt-like” prepreg was heated to 250°F under isobaric conditions and held for one hour. During the one hour hold, the residual solvent within the material was removed. After 30 minutes at 250°F, 20° Hg of vacuum was applied. Once the 250°F hold was completed, the material was ramped to 437°F, where an additional 10° Hg was added to allow fill vacuum to be present. During the one and half hour hold at 437°F, the material becomes fully imidized. After the hold at 437°F, the LaRC™-IA polyimide was heated to the final cure temperature of 716°F. At the final cure temperature, 100 psi was applied to the laminate and the material was held at this temperature and pressure for 30 minutes. During this hold, the LaRC™-IA polyimide becomes amorphous
and reaches minimum viscosity which allows for proper consolidation. Once the hold has been completed, the material is cooled to ambient under full vacuum and 100 psi pressure. At ambient temperature, the mold was removed from the hydraulic vacuum press and the laminate was released from the mold. Upon visual and ultrasonic examination, the laminate was determined to be of excellent quality.

### TABLE 3

<table>
<thead>
<tr>
<th>Mechanical Test</th>
<th>Test Temperature, °C</th>
<th>No. Spec. at each Temperature</th>
<th>Failure Load (Kg)</th>
<th>Failure Stress (MPa)</th>
<th>Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBS RT</td>
<td>10</td>
<td>380.2 ± 16.3</td>
<td>125.1 ± 5.4</td>
<td>N/A</td>
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<tr>
<td></td>
<td>177</td>
<td>1261 ± 3.2</td>
<td>41.4 ± 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0° RT</td>
<td>5</td>
<td>73.4 ± 3.4</td>
<td>1589.9 ± 84.8</td>
<td>137.2 ± 9.7</td>
<td></td>
</tr>
<tr>
<td>Flexural</td>
<td>177</td>
<td>47.1 ± 3.5</td>
<td>1065.9 ± 79.3</td>
<td>131.0 ± 6.9</td>
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<tr>
<td>90° RT</td>
<td>5</td>
<td>37.74 ± 3.5</td>
<td>133.1 ± 17.2</td>
<td>4.27 ± 0.34</td>
<td></td>
</tr>
<tr>
<td>Flexural</td>
<td>177</td>
<td>19.01 ± 1.59</td>
<td>73.1 ± 5.5</td>
<td>3.44 ± 0.29</td>
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</tbody>
</table>

### TABLE 4

<table>
<thead>
<tr>
<th>Mechanical Test</th>
<th>Test Temperature, °C</th>
<th>Failure Stress (Ksi)</th>
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<tr>
<td>SBS RT</td>
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<tr>
<td>0° Flexural</td>
<td>1347.8</td>
<td></td>
</tr>
<tr>
<td>90° Flexural</td>
<td>181.2</td>
<td></td>
</tr>
<tr>
<td>177</td>
<td>131.6</td>
<td></td>
</tr>
</tbody>
</table>

### EXAMPLE 8

LaRC™-IAX "salt-like" prepreg was processes into various different composite laminates by the process illustrated in FIG. 3. One ply of Kapton™ film and one ply of 0.0025" Teflon bleeder/breather cloth was placed on either side of several plies of LaRC™-8515 "salt-like" prepreg (see FIG. 4). The material was then placed in a closed mold and processed in a hydraulic vacuum press. The LaRC™-IAX "salt-like" prepreg was heated to 250° F. under isobaric conditions and held for one hour. During the one hour hold, the residual solvent within the material was removed. After 30 minutes at 250° F., 20° Hg of vacuum was applied. Once the 250° F. hold was completed, the material was rapped to 437° F. where an additional 10° Hg was added to allow full vacuum to be present. During the one and half hour hold at 437° F., the material becomes fully imidized. After the hold at 437° F., the LaRC™-IAX polyimide was heated to the final cure temperature of 716° F. At the final cure temperature, 100 psi was applied to the laminate and the material was held at this temperature and pressure for 30 minutes. During this hold, the LaRC™-IAX polyimide becomes amorphous and reduces minimum viscosity which allows for proper consolidation. Once the hold has been completed, the material is cooled to ambient under full vacuum and 100 psi pressure. At ambient temperature, the mold was removed from the hydraulic vacuum press and the laminate was released from the mold. Upon visual and ultrasonic examination, the laminate was determined to be of excellent quality.

### TABLE 5

<table>
<thead>
<tr>
<th>Mechanical Test</th>
<th>Test Temperature, °C</th>
<th>Failure Load (Kg)</th>
<th>Failure Stress (MPa)</th>
<th>Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBS RT</td>
<td>10</td>
<td>313.9 ± 14.1</td>
<td>112.8 ± 3.6</td>
<td>N/A</td>
</tr>
<tr>
<td>0° RT</td>
<td>6</td>
<td>67.3 ± 2.9</td>
<td>1525.1 ± 145.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Flexural</td>
<td>177</td>
<td>45.8 ± 1.5</td>
<td>964.6 ± 93.1</td>
<td>135.1 ± 9.7</td>
</tr>
<tr>
<td>90° RT</td>
<td>5</td>
<td>31.71 ± 2.5</td>
<td>121.34 ± 4.34</td>
<td>1.5</td>
</tr>
</tbody>
</table>

### TABLE 6

<table>
<thead>
<tr>
<th>Mechanical Test</th>
<th>Test Temperature, °C</th>
<th>Failure Stress (Ksi)</th>
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<tbody>
<tr>
<td>SBS RT</td>
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</tr>
<tr>
<td>0° Flexural</td>
<td>1489.2</td>
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<tr>
<td>90° Flexural</td>
<td>731.8</td>
<td></td>
</tr>
</tbody>
</table>

While the invention has been described in terms of its preferred embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

We claim:

1. A preimpregnated tape produced from aromatic polyimide precursor solutions wherein the solution has a solids content between 50 and 80%, a volatile content less than 35% and a Brooksfeld viscosity between 4,000 and 10,000 cp at ambient temperatures.

2. The preimpregnated tape of claim 1 wherein the polyimide precursor solution comprises oxydiphthalic anhydride (ODPA), phthalic acid (PA) and 3,4'-oxydianiline (3,4'-ODA).

3. A tape produced from aromatic polyimide precursor solutions wherein the solution has a solids content between 50 and 80%, a volatile content less than 35% and a Brooksfeld viscosity between 4,000 and 10,000 cp at ambient temperatures.

4. The preimpregnated tape of claim 1 wherein the polyimide precursor solution comprises oxydiphthalic anhydride (ODPA), phthalic acid (PA), 3,4'-oxydianiline (3,4'-ODA) and phenylene diamine (PDA).

5. The preimpregnated tape of claim 1 wherein the polyimide precursor solution comprises biphenylene anhydride (BP), phthalic acid (PA), 3,4'-oxydianiline (3,4'-ODA), 1,3-bisaminophenoxynenzene (APB) and phenylethynyl phthalic anhydride (PEPA).

6. A film produced from aromatic polyimide precursor solutions wherein the solution has a solids content between 50 and 80%, a volatile content less than 35% and a Brooksfeld viscosity between 4,000 and 10,000 cp at ambient temperatures.
7. The film of claim 6 wherein the polyimide precursor solution comprises oxydiphthalic anhydride (ODPA), phthalic acid (PA) and 3,4'-oxydianiline (3,4'-ODA).

8. The film of claim 6 wherein the polyimide precursor solution comprises oxydiphthalic anhydride (ODPA), phthalic acid (PA), 3,4'-oxydianiline (3,4'-ODA) and phénylene diamine (PDA).

9. The film of claim 6 wherein the polyimide precursor solution comprises biphenylene dianhydride (BPDA), phthalic acid (PA), 3,4'-oxydianiline (3,4'-ODA) and 1,3-bisaminophenoxylbenzene (APB).

10. The film of claim 6 wherein the polyimide precursor solution comprises biphenylene dianhydride (BPDA), phthalic acid (PA), 3,4'-oxydianiline (3,4'-ODA), 1,3-bisaminophenoxylbenzene (APB) and phénylethynyl phthalic anhydride (PEPA).

11. The process of fabricating preimpregnated tape from polyimide precursor solutions, wherein the solution has a solids content between 50 and 80%, a volatile content less than 35% and a Brookfield viscosity between 4,000 and 10,000 cp at ambient temperatures, comprising the steps of:
   (a) placing the polyimide precursor solution in a resin dip tank,
   (b) running collimated reinforcing fibers over a set of impregnation bars within the resin dip tank,
   (c) metering excess resin through a gap between a set of metering bars to between 0.0010-0.0025 inches,
   (d) devolatilizing the resin with a heat source,
   (e) running the preimpregnated tape over a series of 30 heated nip rollers,
   (f) taking up a final preimpregnated product on a take-up spool.

12. A process for laminating the polyimide preimpregnated tape of claim 1 comprising the steps of:
   (a) encapsulating the polyimide preimpregnated tape with a release film and a bleeder cloth,
   (b) elevating the encapsulated material to remove residual volatiles under partial vacuum of less than 30° Hg.
   (c) heating the encapsulated material to fully imidize the system,
   (d) applying full vacuum and pressure to the encapsulated material,
   (e) heating to ensure full consolidation of the encapsulated material,
   (f) and cooling to ambient conditions.

13. A composite prepared from the preimpregnated tape of claim 1.


15. A composite prepared from the preimpregnated tape of claim 3.


17. A composite prepared from the preimpregnated tape of claim 5.