Starting Formulation

SF 8002

Flame Retardant Prepreg Laminating Compound for High Temperature and Thin Laminating Applications

EPON™ Resin SU-8 and 1163

Introduction
A combination of EPON Resin SU-8 high functionality epoxy resin and EPON Resin 1163 brominated epoxy resin are used in this formulation for finished laminates.

Suggested Uses
- Printed circuit boards qualifying under the NEMA G-11 and FR-5 specifications
- Thin laminates for multilayer circuitry qualifying under NEMA FR-4-UT and MIL-P-55617A, Type GF specifications
- Chopped glass molding compounds

Features
- Dry prepreg with up to 4 months or greater shelf life
- Rapid gelation in press
- High strength retention at 175 °C
- Good retention of peel strength and dimensional stability after exposure to hot solder, degreasing solvents, copper etching solutions, and plating solutions
- Thin laminates are non-burning when tested in accordance with ASTM D568

Formula

<table>
<thead>
<tr>
<th>Material</th>
<th>Supplier</th>
<th>Pounds</th>
<th>Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPON Resin SU-8</td>
<td>Hexion</td>
<td>65.0</td>
<td>6.57</td>
</tr>
<tr>
<td>EPON Resin 1163</td>
<td>Hexion</td>
<td>35.0</td>
<td>2.32</td>
</tr>
<tr>
<td>Acetone</td>
<td>Shell Chemical Company</td>
<td>40.0</td>
<td>6.06</td>
</tr>
<tr>
<td>Dicyandiamide</td>
<td>SKW Corporation</td>
<td>4.0</td>
<td>0.35</td>
</tr>
<tr>
<td>2-Methoxyethanol</td>
<td>Union Carbide Corporation</td>
<td>40.0</td>
<td>4.98</td>
</tr>
<tr>
<td>1-Methylimidazole</td>
<td>BASF-Wyandotte Corporation</td>
<td>0.2</td>
<td>0.023</td>
</tr>
<tr>
<td>Total Formulation</td>
<td></td>
<td>184.2</td>
<td>20.30</td>
</tr>
</tbody>
</table>

Mixing Instructions
Dissolve the EPON Resin SU-8 and EPON Resin 1163 in acetone. This step requires a closed tank equipped with a heating jacket or coils, an agitator, and a water-cooled condenser. Solutions of these resins in acetone or other desired solvent line-ups can be supplied upon request. To eliminate the crystallization of brominated epoxy resin solutions during long term storage, a solution blend of EPON Resin SU-8 and the brominated epoxy resin, EPON Resin 1163, is suggested.

Dissolve the dicyandiamide into the 2-methoxyethanol using agitation at a temperature of 50 °C or higher. When all the dicyandiamide has been dissolved, add this warm solution to the resin solution at normal room temperature under moderate speed agitation. Continue the agitation while adding the 1-methylimidazole accelerator, and blend to a homogeneous, clear solution.

It is important to completely dissolve the dicyandiamide in the glycol ether solvent prior to adding it to the resin solution. Dicyandiamide is only sparingly soluble in acetone, and any undissolved particles will serve as “seeds” or nuclei for crystallization of the dissolved dicyandiamide during storage of the varnish.
Dicyandiamide during storage of the varnish.

Typical Formulation

**Table 1 / Properties of Laminating Solution**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity at 25 °C</td>
<td>cP</td>
<td>90</td>
</tr>
<tr>
<td>Density</td>
<td>lbs/gal</td>
<td>9.07</td>
</tr>
<tr>
<td>Pot life at 25 °C</td>
<td>wks</td>
<td>4-6</td>
</tr>
<tr>
<td>Gel time, stroke cure at 160 °C</td>
<td>sec.</td>
<td>117</td>
</tr>
</tbody>
</table>

**Prepreg Procedures**

Parameters affecting the resin pick-up and degree of "B" stage in commercial impregnation/drying tower operation are:

- Viscosity, solids content, solvent volatility, accelerator concentration, and age of the varnish
- Clearances and fabric tension on squeeze rolls and/or doctor bars
- Residence time of impregnation fabric in the drying tower
- Air temperature and air velocity in the drying tower

Impregnation of the lightweight glass used in thin laminates is easily accomplished with this system using conventional wetting and squeeze-off assemblies. Use of higher solvent levels in this compound might be necessary to provide the wetting characteristics needed when using lightweight cloth.

Optimum conditions for prepreg production must be established for each manufacturing line, since industrial equipment varies considerably with respect to air velocity, the ratio of air exhausted to air recirculated, fabric tension, and varnish squeeze-off devices. Air temperatures as high as 175 °C are commonly used in commercial drying towers to process epoxy/dicy prepregs at high production speeds.

The usable life of this prepreg should be approximately three months when stored at normal room temperature or below, and in a low humidity environment.

**Prepreg Properties**

**Table 2 / Prepreg Properties**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-stage schedule, 125°C in a forced air oven</td>
<td>min.</td>
<td>10</td>
</tr>
<tr>
<td>Resin pick-up</td>
<td>%</td>
<td>38-42</td>
</tr>
<tr>
<td>Percent flow, cured at 175°C and 150 psi</td>
<td>%</td>
<td>12</td>
</tr>
</tbody>
</table>

1 Style 181 glass prepregs were prepared from laminating solutions aged at room temperature for periods ranging from 2 hours to 3 weeks.

**Cure Properties**

**Table 3 / Press Cure Conditions and Laminate Properties**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact period</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Platen temperature</td>
<td>°C</td>
<td>175</td>
</tr>
<tr>
<td>Pressure</td>
<td>psi</td>
<td>150</td>
</tr>
<tr>
<td>Time in press</td>
<td>min.</td>
<td>40</td>
</tr>
</tbody>
</table>

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Table 4 / Properties of Formulation No. 8002 Glass Laminate vs. NEMA G-5 Requirements

<table>
<thead>
<tr>
<th>Laminate property</th>
<th>Conditioning</th>
<th>NEMA G-5 requirements</th>
<th>Test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin content, weight percent</td>
<td>—</td>
<td>—</td>
<td>24</td>
</tr>
<tr>
<td>Thickness, inches</td>
<td>—</td>
<td>—</td>
<td>0.098</td>
</tr>
<tr>
<td>Flexural strength, psi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lengthwise</td>
<td>23 °C, 50% RH</td>
<td>6 x 10⁴ min.</td>
<td>9.1 x 10⁴</td>
</tr>
<tr>
<td>Crosswise</td>
<td>23 °C, 50% RH</td>
<td>5 x 10⁴ min.</td>
<td>7.7 x 10⁴</td>
</tr>
<tr>
<td>Flexural strength, %</td>
<td>58,000 psi</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Lengthwise</td>
<td>1 hour at 150 °C</td>
<td>50 min</td>
<td>64</td>
</tr>
<tr>
<td>IZOD impact, ft•lb/inch notch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lengthwise</td>
<td>48 hours at 50 °C</td>
<td>7.0 min.</td>
<td>15.8</td>
</tr>
<tr>
<td>Crosswise</td>
<td>48 hours at 50 °C</td>
<td>5.5 min.</td>
<td>13.6</td>
</tr>
<tr>
<td>Peel strength, lb/inch width</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 oz. copper</td>
<td>1 hour at 150 °C</td>
<td>3.0 min.</td>
<td>6.5</td>
</tr>
<tr>
<td>1 oz. copper</td>
<td>20 sec. solder dip</td>
<td>8.0 min.</td>
<td>8.5</td>
</tr>
<tr>
<td>Water absorption, %</td>
<td>24 hours at 23 °C</td>
<td>0.20 max.</td>
<td>0.06</td>
</tr>
<tr>
<td>Volume resistivity, μm²/cm²</td>
<td>96 hours at 35 °C, 90% RH</td>
<td>10⁶ min.</td>
<td>9 x 10⁶</td>
</tr>
<tr>
<td>Surface resistivity</td>
<td>96 hours at 35 °C, 90% RH</td>
<td>10⁴ min.</td>
<td>9 x 10⁷</td>
</tr>
<tr>
<td>Dielectric constant, %</td>
<td>23 °C, 50% RH</td>
<td>5.2 max.</td>
<td>5.1</td>
</tr>
<tr>
<td>at 1 megacycle</td>
<td>24 hours at 23 °C, in water</td>
<td>5.4 max.</td>
<td>5.3</td>
</tr>
<tr>
<td>Dissipation factor, %</td>
<td>23 °C, 50% RH</td>
<td>0.025 max.</td>
<td>0.015</td>
</tr>
<tr>
<td>at 1 megacycle</td>
<td>24 hours at 23 °C, in water</td>
<td>0.035 max.</td>
<td>0.017</td>
</tr>
<tr>
<td>Dielectric breakdown (KV),</td>
<td>23 °C, 50% RH</td>
<td>45 min.</td>
<td>&gt; 56</td>
</tr>
<tr>
<td>parallel to laminations</td>
<td>48 hours at 50 °C</td>
<td>40 min.</td>
<td>&gt; 56</td>
</tr>
<tr>
<td>Flammability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burning time, seconds</td>
<td>—</td>
<td>15 max.</td>
<td>3</td>
</tr>
<tr>
<td>Burning length, inches</td>
<td>—</td>
<td>1 max.</td>
<td>Nil</td>
</tr>
</tbody>
</table>

¹ Twelve-ply 181 style. 1-550 finish glass.
### Glass Laminate 1 vs. MIL-P-55617A, Type GE and NEMA G-10-UT Requirements

<table>
<thead>
<tr>
<th>Laminate property</th>
<th>Conditioning</th>
<th>Specification requirements</th>
<th>Test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin content, weight percent</td>
<td>—</td>
<td>—</td>
<td>57</td>
</tr>
<tr>
<td>Thickness, inches</td>
<td>—</td>
<td>0.031 max.</td>
<td>0.003</td>
</tr>
<tr>
<td>Visual effect of solder dip</td>
<td>20 seconds at 200 °C</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td>Peel strength, lb/inch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 25 °C</td>
<td>20 second solder dip</td>
<td>6 min.</td>
<td>8.1</td>
</tr>
<tr>
<td>at 25 °C</td>
<td>5 temperature cycles</td>
<td>6 min.</td>
<td>8.4</td>
</tr>
<tr>
<td>at 25 °C</td>
<td>1 hr. at 125 °C</td>
<td>7 min.</td>
<td>9.0</td>
</tr>
<tr>
<td>at 25 °C</td>
<td>Exposure to plating solution</td>
<td>5 min.</td>
<td>76</td>
</tr>
<tr>
<td>at 125 °C</td>
<td>None</td>
<td>5 min.</td>
<td>6.1</td>
</tr>
<tr>
<td>Volume resistivity, ohm·cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 25 °C</td>
<td>96 hours at 35 °C, 90% RH</td>
<td>$10^{12}$ min.</td>
<td>$11 \times 10^{13}$</td>
</tr>
<tr>
<td>at 125 °C</td>
<td>24 hours at 125 °C</td>
<td>109 min.</td>
<td>$2.5 \times 10^{10}$</td>
</tr>
<tr>
<td>Surface resistivity, ohm·cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 25 °C</td>
<td>96 hours at 35 °C, 90% RH</td>
<td>$10^{10}$ min.</td>
<td>$2.8 \times 1.1 \times 10^{12}$</td>
</tr>
<tr>
<td>at 125 °C</td>
<td>24 hours at 125 °C</td>
<td>$10^{9}$ min.</td>
<td>$1.8 \times 10^{11}$</td>
</tr>
<tr>
<td>Dimensional stability, inches/inch</td>
<td>Etching</td>
<td>0.0005 max.</td>
<td>0.00010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 minutes at 170 °C</td>
<td>0.0005 max.</td>
<td>&lt; 0.000005</td>
</tr>
<tr>
<td></td>
<td>5 temperature cycles</td>
<td>0.0003 max.</td>
<td>0.00029</td>
</tr>
<tr>
<td>Dielectric strength, volt/ml</td>
<td>48 hr. water immersion at 50 °C</td>
<td>750 min.</td>
<td>990</td>
</tr>
<tr>
<td>Dielectric constant, at 1 megacycle</td>
<td>None</td>
<td>5.4 max.</td>
<td>3.6</td>
</tr>
<tr>
<td>Dissipation factor, at 1 megacycle</td>
<td>None</td>
<td>0.035 max.</td>
<td>0.01</td>
</tr>
<tr>
<td>Flammability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burn time</td>
<td>None</td>
<td>15 max.</td>
<td>Non-burning</td>
</tr>
<tr>
<td>Burn length</td>
<td>None</td>
<td>12 max.</td>
<td>Non-burning</td>
</tr>
</tbody>
</table>

1. Two-ply laminates prepared from Style 106, GB-399 Finish Glass.
2. One ounce per square tool copper with “TC” treatment.
3. Cycle conditions: 30 minutes at 125 °C, 15 minutes at 25 °C, 30 minutes at -65 °C, and 15 minutes at 25 °C.
4. Exposed to hot trichloroethylene vapor, hot aqueous sodium hydroxide/sodium carbonate, hot aqueous sulfuric acid/boric acid and solutions.
Storage

Recommendations regarding storage conditions can be obtained by visiting our web site at www.hexion.com

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