FRP Raw Materials

Introduction

In this chapter FRP raw materials are discussed with particular emphasis on their use in pultrusion processing. A discussion of the background chemistry is included where applicable. For inert fillers the chemical formulas are provided, notes on where the base minerals normally are found, any relevant processing information, normal packaging, and the fillers’ contribution to the FRP product are included.

For polyester resins, thermoplastic additives, calcium carbonate, other inert fillers, catalysts, glass roving, mat reinforcements, and surfacing mats, schedules of commercially available products are included.

Unsaturated Polyester Resins

The reaction between an acid and an alcohol produces an ester and water. By using difunctional alcohols or glycols and dibasic acids, esterification reactions can take place at each reactive site to form linear polymers. Generally, mixtures of unsaturated and saturated dibasic acids are used but at least one of the acids must contain unsaturation. This esterification reaction does not affect the double bond or unsaturation in the dibasic acid. The chemistry of this reaction may be pictured as follows:
If \( G = \) Glycol  
\( M = \) Maleic (or Fumaric) Unsaturated Acid  
\( P = \) Phthalic (or Other Saturated) Acid  
\( S = \) Styrene (or Other Monomer)  
then the linear polyester may be represented as:

\[
P - G - M - G - P - G - M - G - P
\]

This polyester will not polymerize by itself, however, if another unsaturated material is included such as styrene which can react with the maleic unsaturation then a cross-linked three-dimensional polymer can result which may be represented as:

\[
P - G - M - G - P - G - M - G - P
\]

\[
\begin{array}{c}
S \\
S
\end{array}
\]

\[
P - G - M - G - P - G - M - G - P
\]

Different ingredients used in the cook bring different properties to the polyester resin. Table 4.1 contains a list of the more

<table>
<thead>
<tr>
<th>Building Blocks</th>
<th>Ingredients</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsaturated anhydrides and dibasic acids</td>
<td>a. Maleic anhydride</td>
<td>a. Lowest cost, moderately high HDT (Heat Distortion Temperature)</td>
</tr>
<tr>
<td></td>
<td>b. Fumaric acid</td>
<td>b. Highest reactivity, highest HDT, more rigidity</td>
</tr>
<tr>
<td></td>
<td>a. Orthophthalic anhy.</td>
<td>a. Lowest cost, moderately high HDT, high flexural strength, high tensile strength</td>
</tr>
<tr>
<td></td>
<td>b. Isophthalic acid</td>
<td>b. Higher tensile and flexural strengths, better chemical resistance, improved water resistance</td>
</tr>
<tr>
<td>Saturated anhydrides and dibasic acids</td>
<td>c. Adipic acid, azaleic acid, sebasic acid</td>
<td>c. Flexibility (toughness, resilience)</td>
</tr>
</tbody>
</table>