Aromatic Thermosetting CoPolyester

AV™ Thermoset Foam

Presented by Frederick Deans, Director Emeritus SPE Automotive & Composite Divisions
On behalf of ATSP Innovations, Inc., Houston, TX
ATSP Innovations, Inc

Founded in 2010 at University of Illinois Research Park; Currently located in Houston, TX

30+ years of research, 5 foundational issued patents, with 1 patents pending

Performance validated and utilized by major federal technology agencies

ATSP Staff combines inventors from initial polymer era and new generation materials and product developers and industrialists
What is ATSP? Aromatic Thermosetting CoPolyester is an uncatalyzed, condensation-cure oligomer containing both amorphous and crystalline segments that can be cross-linked (like a thermoset) and also can be reprocessed like a thermoplastic.

Tailorable properties based on Crosslinkable oligomer architecture enables processability, performance, and cost structure unmatched by traditional high temperature materials.
ATSP’s Resins Unique Mix of Properties

- Designed for **high temperatures** (up to 350 °C in air, with Tg of up to 310°C)
- **Liquid crystalline** character results in lower residual stresses at interfaces – producing stronger bonds and tougher composites
- **Flammability resistance** superior to aramids, epoxies, phenolics and other high temperature polymers (limited oxygen index: 40%)
- Strong **adhesion** to metal surfaces
- **Tribological** performance combining low friction and low wear

**ATSP Innovations**

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ATSP POLYMER Products

ATSP Thermosetting Co-Polyesters are cross-linkable and capable of recyclable under heat. The Co-polyesters provide alloy improvements when compounded with various thermoplastics thus creating new and improved properties that exhibit properties of each polymer.

- **SELF-BOND™**: Powder coatable, reboundable structural adhesives capable of high shear and bond strength to metals.
- **NOWE™**: Wear resistant bearings for extreme conditions. Alloy capable with a variety of thermoplastics.
- **ESTHERM™**: High temperature stable advanced polyester powder capable of thin protective coatings for heat and corrosion protection.
**ATSP AV Foam**: Using ATSP’s by product of polymerization and cross-linking a light weight, open cell foam can be produced. Various foam product variations can be produced.

- Density Range: 0.007 to 0.025 lbs/in^3 (Can be filled with additives)
- Can be block formed (for shaping) or shape molded
- Can be laminated to composite “skins” to form high performance sandwich panels
- Conductive fillers can achieve EMI performance
- Natural color, low density, shown below
- Low thermal conductivity
Mechanical Properties: AV Foam’s Elastic and Compressive properties vary with desired density values

- Elastic Modulus: 323 MPa (high density) to 315 MPa (low density)
- Compressive Strength: 17 MPa (High density) to 10 MPa (low density)
Fire Performance: AV Foam is naturally flame retarded

- ATSP Limiting Oxygen Index (LOI, the minimum concentration of oxygen that will support combustion of a polymer): 40%, and 85% as ATSP/C composite
- Among the highest neat LOI for non-halogenated unfilled polymers

<table>
<thead>
<tr>
<th>Polymer</th>
<th>LOI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene</td>
<td>17.4</td>
</tr>
<tr>
<td>Polybutadiene</td>
<td>18.3</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>18.3</td>
</tr>
<tr>
<td>Cellulose</td>
<td>19.9</td>
</tr>
<tr>
<td>Polyethylene terephthalate (PET)</td>
<td>20.6</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>21.5</td>
</tr>
<tr>
<td>Polycarbonate</td>
<td>29.4</td>
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<tr>
<td>Polyetheretherketone (PEEK)</td>
<td>24</td>
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<tr>
<td>Nomex</td>
<td>29.8</td>
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<tr>
<td>Kynol</td>
<td>35.5</td>
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<tr>
<td>ATSP</td>
<td>40</td>
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<tr>
<td>Benzimidazole</td>
<td>41.5</td>
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<tr>
<td>Polyvinylidene fluoride</td>
<td>43.7</td>
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<tr>
<td>Polyvinyl chloride</td>
<td>47</td>
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<tr>
<td>Polyvinylidene chloride</td>
<td>60</td>
</tr>
<tr>
<td>Polytetrafluoroethylene (PTFE)</td>
<td>95</td>
</tr>
</tbody>
</table>

Unfilled 5wt% mass loss point -
537°C \((\text{N}_2)\) - 527°C \((\text{air})\)

https://www.youtube.com/watch?v=V-Mx78VxPLM
EV Battery Cell “Dividers” – The performance properties of ATSP AV Foam – High temperature (+300°C), FR behavior, high compressive strength, low mass, make it an ideal EV Battery separator. In other EV applications AV Foam’s EMI behavior is an added benefit.
ATSP AV Foam Applications

High Strength Composite Laminates – The ability to laminate AV Foam to both thermoplastic and thermoset composite “skins” will produce light weight, high impact, structure applications for automotive, aerospace, construction, and industrial applications. The AV Foam laminate structures are being characterized and evaluated for use in the development of blades for axial- and cross-flow marine and riverine turbines.
ATSP AV Foam – Next Steps

Overcoming traditional polymer issues such as fire retardancy, low melt temperature, and structural strength/stiffness, ATSP AV Foam has opened new application development opportunities in many market segments.

For further information and support, contact ATSP Innovations at 832-344-3635 or Allied Composite Technologies, authorized commercial representative, at 248-760-7717