Application number: E.2.10 (Transport)

Application name: Auxiliary material (mold release) for manufacturing aircraft parts

An exemption is requested for the following application of PFAS used in the aviation field.

Product: Fluororesin film for aviation field

Fluororesin used: PTFE (CAS No. 9002-84-0)

Product overview: Release film (auxiliary material for molding aircraft parts such as CFRP stringer)

Product requirements: Heat resistance, releasability, etc.

Alternative: None

As a release film, it satisfies many of the required functions such as releasability from a prepreg, and there is no alternative at present because of the quality risks associated with other polymeric materials.

Typical properties of PTFE are shown below.

Table 1.1.10 Wettability[1]

| Type of material | Contact angle of water (degrees) | Adhesion energy with water ($\times 10^{-3}$N/cm) | Critical surface tension ($\gamma_c$) ($\times 10^{-3}$N/cm) |
|---|---|---|---|
| FEP | 115 | 42.0 | 16.2 |
| PTFE | 114 | 43.1 | 18.5 |
| PFA | (Same level as those of FEP or PTFE) | | |
| Silicone resin | 90~110 | 47.8~72.7 | — |
| Paraffin | 10.5~10.6 | 52.7~53.8 | 23 |
| Polyethylene | 88 | 75.2 | 31 |
| Nylon | 77 | 97.7 | 46 |
| Phenol | 60 | 109 | — |

| Physical properties | Test method | Unit | PPS | PAR | PTFE | PSU | | PES | |
|---|---|---|---|---|---|---|---|---|---|
| Classification and features | | | GF40% cross-linking type | Natural | Natural | Natural | GF30% | Natural | GF30% |
| Mechanical properties | | | | | | | | | |
| Tensile strength | ASTM D 638 | MPa | 150 | 70 | 27~34 | 71 | 108 | 84 | 140 |
| Tensile elongation at break | ASTM D 638 | % | 1.2 | 70 | 200~400 | 50~100 | 2 | 80 | 3 |
| Bending strength | ASTM D 790 | MPa | 206 | 78 | 118[3] | 108 | 157 | 129 | 190 |
| Bending modulus of elasticity | ASTM D 790 | GPa | 13.7 | 1.9 | 0.34~0.62 | 2.6 | 7.6 | 2.5 | 8.3 |
| Izod impact strength: Notched | ASTM D 256 | J/m | 69 | 245 | 157 | 69 | 78 | 88 | 78 |
| Rockwell hardness | ASTM D 785 | R-scale | 123 | 125 | — | 120 | 134 | 120 | 134 |
| Thermal properties | | | | | | | | | |
| Load deflection temperature[1] | ASTM D 648 | | | | | | | | |
| : 0.45 MPa load | | ℃ | 260 | 175 | 55 | — | — | 203 | 216 |
| : 1.82 MPa load | | ℃ | — | — | 121 | 174 | 181 | 210 | — |
| Continuous use temperature[2] | UL746B | ℃ | 200~220 | 140~160 | 180 | 140~160 | 140~160 | 180~190 | 180~190 |
| Linear expansion coefficient | ASTM D 696 | $10^{-5}$×K$^{-1}$ | 2.9 | 6.2 | 10 | 5.6 | 1.9 | 5.6 | 2.3 |
| Combustibility | | — | V-0/5V | V-2 | V-0 | HB | V-0 | V-0 | V-0 |
| Physical properties | | | | | | | | | |
| Specific gravity | ASTM D 792 | — | 1.67 | 1.21 | 2.14~2.20 | 1.24 | 1.49 | 1.37 | 1.60 |
| Water absorption rate | ASTM D 570 | % | 0.05 | 0.26 | <0.01 | 0.3 | 0.49 | 0.43 | 0.30 |
| Mold shrinkage rate | ASTM D 955 | mm/mm | 0.0025 | 0.008 | | 0.007 | 0.002 | 0.006 | 0.002 |
| Electrical properties | | | | | | | | | |
| Volume resistivity | ASTM D 257 | Ω·mm | $1\times10^{15}$ | $2\times10^{16}$ | $>10^{17}$ | — | — | $10^{16}$ | $10^{15}$ |
| Dielectric fracture strength | ASTM D 149 | kV/mm | 17.2 | — | 30~35 | 17 | 19 | 16 | 16 |
| Dielectric constant ($10^6$ Hz) | ASTM D 150 | — | 3.8 | 3.0 | <2.1 | 3.1 | 3.7 | 3.5 | — |
| Dielectric loss tangent ($10^6$ Hz) | ASTM D 150 | — | 0.0014 | 0.01 | 0.0001 | 0.005 | 0.004 | 0.0035 | — |

| Physical properties | Test method | Unit | LCP | | | PEEK | | PEI | PAI | TPI |
|---|---|---|---|---|---|---|---|---|---|---|
| Classification and features | | | GF30% type I | GF30% type II | GF30% type III | Natural | GF30% high flow | Natural | Natural | Amorphous, natural |
| Mechanical properties | | | | | | | | | | |
| Tensile strength | ASTM D 638 | MPa | 137 | 211 | 113 | 97 | 236 | 105 | 191 | 92 |
| Tensile elongation at break | ASTM D 638 | % | 1.7 | 2.2 | 3.8 | 80 | 5 | 60 | 15 | 90 |
| Bending strength | ASTM D 790 | MPa | 157 | 250 | 176 | 142 | 330 | 145 | 240 | 137 |
| Bending modulus of elasticity | ASTM D 790 | GPa | 13.3 | 14.7 | 12.6 | 3.7 | 21.1 | 3.3 | 5.0 | 2.9 |
| Izod impact strength: Notched | ASTM D 256 | J/m | 108 | 137 | 118 | 88 | — | 49 | 147 | 88 |
| Rockwell hardness | ASTM D 785 | R-scale | 77 | 84(M) | 69 | 126 | 124 | 109(M) | 86(E) | 129 |
| Thermal properties | | | | | | | | | | |
| Load deflection temperature[1] | ASTM-D-648 | | | | | | | | | |
| : 1.82 MPa load | | ℃ | 346 | 240 | 180 | 152 | 300 | 200 | 278 | 238 |
| : 0.45 MPa load | | ℃ | — | — | — | — | — | 210 | — | — |
| Continuous use temperature[2] | UL746B | ℃ | 240~280 | ~220 | — | 240 | 240 | 170~180 | 200~220 | — |
| Linear expansion coefficient | ASTM D 696 | $10^{-5}$×K$^{-1}$ | 1.2 | — | — | 4.6 | — | 5.6 | 3.1 | 5.5 |
| Combustibility | | — | V-0 | V-0 | V-0 | V-0 | V-0 | V-0/5V | V-0 | V-0 |
| Physical properties | | | | | | | | | | |
| Specific gravity | ASTM D 792 | — | 1.60 | 1.62 | 1.60 | 1.30 | 1.44 | 1.27 | 1.42 | 1.33 |
| Water absorption rate | ASTM D 570 | % | <0.1 | 0.05 | 0.02 | 0.14 | — | 0.25 | 0.33 | 0.34 |
| Mold shrinkage rate | ASTM D 955 | mm/mm | — | — | 0.0023[4] | — | 0.006 | 0.006 | — | 0.008 |
| Electrical properties | | | | | | | | | | |
| Volume resistivity | ASTM D 257 | Ω·mm | $1\times10^{15}$ | $3\times10^{15}$ | $5\times10^{15}$ | $10^{16}$ | — | $10^{16}$ | $2\times10^{16}$ | — |
| Dielectric fracture strength | ASTM D 149 | kV/mm | 25 | 43 | — | 19 | — | 30 | 24 | — |
| Dielectric constant ($10^6$ Hz) | ASTM D 150 | — | 3.6 | 3.8 | 2.7 | 3.3 | — | 3.15 | 3.9 | 3.1 |
| Dielectric loss tangent ($10^6$ Hz) | ASTM D 150 | — | 0.034 | 0.017 | 0.030 | 0.003 | — | 0.0013 | 0.031 | 0.0034 |

Notes (1) Previous "thermal deformation temperature"
(2) There are three items: mechanical strength (with or without impact); and electrical properties.
(3) Compressive strength
(4) Average value of MD and TD. Actual value: MD/TD=0.0013/0.0033

Remarks Abbreviations and names of the resins are as follows.
PPS: polyphenylene sulfide, PAR: polyarylate, PTFE: polytetrafluoroethylene, PSU: polysulfone, PES: polyethersulfone, LCP: liquid crystal polymer, PEEK: polyether ether ketone, PEI: polyetherimide, PAI: polyamideimide, TPI: thermoplastic polyimide, GF: glass fiber

Cited literature
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3) Industrial Material, November, 1976, Nikkan Kogyo Shimbun, Ltd.
4) Takaharu Ikeda, Valqua Review, Vol. 35, No. 1
5) "Plastic Processing Technology Handbook" edited by The Society of Polymer Science, Japan, Nikkan Kogyo Shimbun, 1995
6) Daikin Industries, Ltd., Technical Materials
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Reference material: VALQUA Handbook Technical Section

Socio-economic impacts/concerns:

In the aviation field, weight reduction has been in progress and the application of CFRP is expanding year by year.

In cases where it became impossible to use a fluororesin film used in CFRP processing, socio-economic impacts on the aviation field would be significant.

Based on the above, we propose a permanent exemption.