Ultra-High Performance Material for Wire and Cable Applications

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Semi-crystalline thermoplastics marked by excellent chemical resistance, high temperature performance and high mechanical strength.

The need for increased powers is significantly growing as the future of technology including that of electric vehicles is striving towards greater voltages. **Arkema**, a material supplier of high performance polymers, has released a new ultrahigh performance material, Kepstan® PEKK that meets these exact needs. PEKK, or Poly-ether-ketone-ketone, is a member of the Poly-aryl-ether-ketone (PAEK) family. It was originally developed by **Dupont** as a high performance thermoplastic for the Apollo program in the 1960s. PEKK's original success in aerospace and defense applications has since evolved into other markets including transportation, chemical processing, defense, oil and gas, semiconductor and electrical.

What are PAEKs?

Kepstan PEKK is a member of the PAEK family, which consists of semi-crystalline thermoplastics marked by excellent chemical resistance, high-temperature performance and high mechanical strength. In the family of PAEK polymers, the "backbone" of the monomers are ether groups and ketone groups. The PAEK family is designated by excellent thermo-mechanical properties, chemical resistance, resistance to thermos-oxidation, fire resistance and tribological properties.

PEKK has a ketone/ether ratio of 2:1, giving it incredibly high strength, modulus and thermal properties of the material. This enables PEKK to be used in applications with high continuous use temperature, up to 260°C, requirements compared to PEEK. This distinguishes PEKK as a "PEEK plus" materials similar to PEK and PEKEKK while remaining lower cost, providing more processing options and allowing for wider processing windows. Compared to PEEK, PEKK offers a higher glass transition temperature ranging from 17°C to 22°C or greater, 10% higher tensile strength, 20% higher compression strength, 2.5 times improved barrier properties to gases such as CO_2 or H_2S, improved tribological properties including lower and controlled coefficient of friction at high temperatures and higher polarity. Unlike other polymers in the same family, PEKK can be injection molded and extruded as well as powder coated, thermoformed and even 3D printed.

PEKK is a high-strength polymer (120 to 140 MPa tensile strength) with phenomenal chemical resistance including greater than 90% retention in mechanical properties even after a week of soaking in aggressive agents such as phosphoric or hydrochloric acid, toluene or acetone. PEKK also benefits from excellent wear and friction properties and a low dielectric constant. In addition to this, PEKK's ability to be alloyed for even greater performance (improved dielectric properties, better flexibility) will allow for excellent value in the wire and cable market.

The Electric Vehicle Market

The market for electric motors has a wide range of applications. On the simpler side, electric motors are part of everyday life including home appliances and small electronic devices like fans, vacuum cleaners, hair dryers, washing machines, refrigerators, freezers, computers and even electric can openers. But these electric motors also operate on larger scales including industrial applications. Larger scale industrial uses include power drills and saws and even electric forklifts. Yet they are not the only ones seeking a newer generation in electric motors. The automotive industry is having a stronger presence in electric vehicles, which requires higher temperature, higher power materials for innovation in the market. PEKK is a proven material that allows for significantly higher temperature applications and better electrical insulation properties allowing for more efficient and higher power motors.

Magnet Wire

PEKK has a wide array of applications and increasingly plays a role in electric vehicles due to its low dielectric constant (2.9). As electric vehicles increase their capacities to higher power and voltages, increased Partial Discharge Induction Voltages (PDIV) are required to prevent cross-talk among electrical components. By maintaining this lower dielectric constant at elevated temperatures, PEKK has the ability to outperform other PAEK materials. This opens up an immense benefit for PEKK to act as insulation for magnet wire.

Compared to classical thermoset enamels, PEKK thermoplastic as an EV magnet wire insulation offers not only a lower dielectric constant, but also lower process costs for extrusion. Compared to PEEK, PEKK offers higher polarity and thus better adhesion onto metal. Compared to PEEK, PEKK also offers higher polarity, due to its backbone of two ketones in the backbone, allowing for excellent adhesion to metal including the ability to coat copper or aluminum wire with PEKK without the use of a primer.

In addition to these properties, PEKK is known for its high melting point and extremely high thermal properties including continuous use temperatures of up to 260°C. It also has excellent flame resistance with *UL94* V0 ratings. PEKK does not have any halogenated groups allowing it to exhibit excellent flame, smoke and toxicity (FST) ratings.

Electronics

Additionally, this excellent performance in insulation (low dielectric constant even at elevated temps, also makes PEKK an excellent candidate for stock shape applications in the electronics and semiconductors markets including RFI/EMI

Kepstan® PEKK Insulated Wires.
(see Axon at www.axon-cable.com)

connectors, wafer/electronic carriers or trays and semiconductor test sockets. PEKK's ease of processing, strong mechanical and tribological performance and excellent high temperature properties allows for easy adoption into these applications. PEKK has even demonstrated excellent performance in terms of low outgassing, allowing for applications in outer space to be considered. PEKK is available as neat grades or filled with glass or carbon fiber to achieve desired mechanical or anti-static performance. For those interested in exploring new flexible manufacturing methodologies, PEKK has been used commercially for both FFF and SLS 3D printing.

Busbars

Finally, PEKK is being considered as a material for coating a next generation of busbar applications. As safety requirements are being tightened, the higher melting point of PEKK allows coated parts to withstand the harsh conditions encountered during motor vehicle accidents. This enhances passenger safety by preventing electrical breakdown with ability to withstand extremely high temperatures for short periods of time. PEKK can be applied to busbars through various processing methods including powder coating, extrusion or overmolding, extrusion with easy adhesion to metal again providing great value.

The ability to color PEKK (demonstrated in bright orange) also brings significant value to the busbar application.

Compatibility & Versatility

The value of PEKK does not only lie within its neat properties. Due to its increased polarity, PEKK achieves better compatibility with other polymers, providing a toolbox to enhance its performance. Several new polymer alloys are under development, which increase the versatility of PEKK.

The first alloy introduces a more economical solution with increased 15°C to 20°C glass transition temperature. It also allows for greater adhesion to copper and reduced tensile modulus (3.8 to 3.4-3.6 GPa).A second alloy option offers higher performance properties. This includes a very low dielectric constant and offers 25% to 33% more flexibility to the material (as low as 2.6 GPa). *www.arkema.com* WCTI

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Company Profile:

Arkema *is a leader in specialty materials. Building on its unique set of expertise in materials science, Arkema designs materials to address the ever-growing demand for innovative and sustainable materials, driven by the challenges of new energies, new technologies, the depletion of resources, mobility and increasing urbanization. Arkema is structured into three coherent and complementary segments dedicated to specialty materials (Adhesive Solutions, Advanced Materials, and Coating Solutions).* ***www.arkema.com***