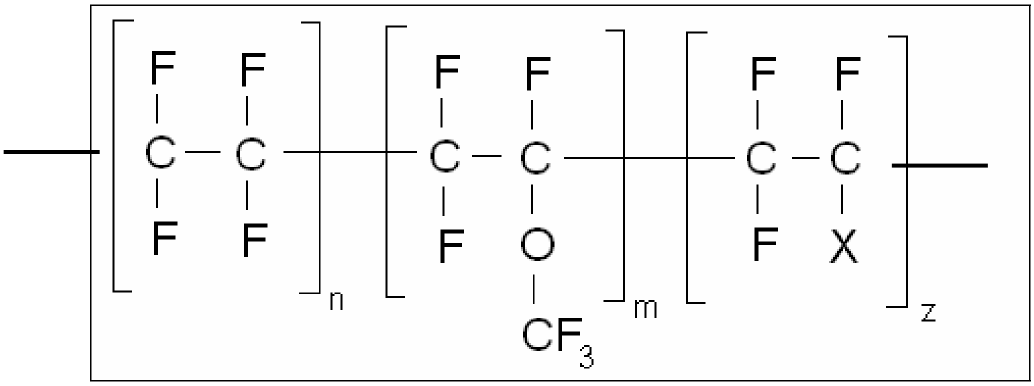
Nano-technology performance edge for Perfluoroelastomers

Perfluoroelastomers are a solid sealing performer in the most aggressive of chemical, petrochemical and pharmaceutical processes. Long considered the flexible rubber alternative to its more rigid PTFE equivalent, recent developments in perfluoroelastomer chemistry have cast new light on the elastomer's capabilities, reports Darryl Turland, materials technologist at Perlast Ltd.

During many chemical processes, elastomer seals are exposed to a cocktail of solvents and high temperatures. Most polymers will degrade very quickly when exposed to these conditions. For such aggressive environments the elastomer of choice is a perfluorinated rubber or FFKM. Perfluoroelastomers have very high levels of fluorine and feature a fully-fluorinated polymer backbone. This dramatically increases their chemical and temperature resistance. They are resistant to organic solvents, many aggressive chemicals, oils, and fluids. In addition, they also exhibit toughness and flexibility at low temperature, non-adhesiveness and very low friction properties.



Typical Structure of a Perfluoroelastomer

However, perfluoroelastomers chemical and temperature resistance come at a price, most notably poor mechanical properties compared to other elastomers.

Elastomers consist of an organic polymer and inorganic reinforcing filler systems. Although the polymer back-bone may be similar, thus determining many of the physical properties; there can be significant differences to the cross linking and filler systems. These are responsible for many of the differences in physical properties observed by engineers who often mistakenly believe that all perfluoroelastomers are the same.

For instance, the Perlast range of perfluoroelastomers are fully-fluorinated terpolymers made up from tetrafluoroethylene (TFE), perfluoromethylvinylether (PMVE) and a cure-site monomer, placing them at the high end of FFKM performance. Perlast is a third generation perfluoroelastomer using a patented Pseudo Living Polymerization technology designed to extend high temperature performance and improve chemical resistance over existing perfluoroelastomer materials.

Recent work by Perlast polymer technologists has shown that these inert elastomers can be used to tackle a wider range of chemical processes than had been previously realised. By making changes to the filler system it is possible to optimise the physical properties of a particular grade of perfluoroelastomer.

The reinforcement effect of a filler is complex and dependent upon its structure, particle size and chemical make-up of the particles themselves. Black seals commonly contain the filler 'carbon black' which has a very irregular surface, making the reinforcement particularly effective. Some synthetic silicas, on the other hand, are perfectly spherical, offering very little in terms of reinforcement. Fillers can be classed as reinforcing or non-reinforcing, depending upon whether they arrest crack propagation to a greater extent than they raise stresses, or vice versa. In order to achieve specific physical properties from a material the correct combination of reinforcing and non-reinforcing fillers must be selected.

Nano-fillers – raising the physical performance standard

Perlast's research has shown that nano-scale filler systems greatly increase the surface area to volume ratio of the filler system, significantly increasing the extent to which a single, or group of physical properties can be modified. This has led to the development of a new type of perfluoroelastomer specifically for low pressure applications.

Nano-filler technology has been used to optimise perfluoroelastomer characteristics for low pressure, chemically aggressive environments, such as those seen in bio-analytical equipment and some pharmaceutical processes.

When operating in chemically aggressive, low pressure environments the preferred filler systems enhance tensile strength and elongation at break, but offer the low modulus needed to achieve good sealing and prevent accelerated chemical attack. By utilising a spherical perfluoropolymer filler system of 30-35 nanometre diameter the perfluoroelastomer tensile strength and elongation at break are increased, while still maintaining a low modulus. The perfluoropolymer fillers are highly inert, preventing chemical attack of the fillers. By offering a low modulus of 3.5MPa the perfluoroelastomer offers high sealing efficiency at low pressures and minimises stresses within the polymer. By minimising stresses the perfluoroelastomer offers far higher resistance to stress induced chemical attack than conventional perfluoroelastomers, proving time and again that it maintains excellent chemical resistance under actual process conditions.

With the need to process increasingly aggressive and potent compounds, chemical engineers and equipment suppliers can now consider using nano-scale fillers to 'fine tune' the physical properties and chemical resistance of the perfluoroelastomer seal. Greater seal customisation in turn can reduce seal maintenance, allow greater operational flexibility and ultimately increase plant productivity.

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