

Celcon® Acetal Copolymer

Grades M90 and LW90

Construction Toy Connectors and Gears

Typical Related Applications Requiring Lubricity, Wear Resistance, Tensile Strength, Flexural Strength and Stiffness, Creep Resistance, and Dimensional Accuracy:

- Gears
- Conveyor links
- Doll arm and leg joints
- Toy car wheel bearings

Requirements

The Rodon Group's Connector Toy Company needed a material to use for its K'Nex® brand construction toys. K'Nex toys consists of 22 different types of precision molded connectors and rods which are snapped together to build moving models of objects such as cars, trucks, four wheel drive vehicles, cranes and windmills. These models can grow quite large, may be left assembled for years, and often have motorized moving parts. For example, a nine foot motorized crane has been built and left assembled. K'Nex toys also need to be durable for their use in educational settings to demonstrate engineering concepts. Students at Drexel University use K'Nex toys in an annual bridge building contest where the bridge that holds the most sand wins.

The connectors can't be made from just any ordinary material, but one with special properties to hold up under a variety of situations. For safety reasons, The Rodon Group wanted to use a plastic for the connectors that could snap-fit with the rods instead of providing metal screws for model assembly, which are potentially more likely to cause injury to children using the toy.



The wear resistance and dimensional accuracy of Celcon® acetal copolymer make it the ideal material for the snap-fit connectors in K'Nex brand toys.

Material Evaluation

The Rodon Group considered several plastics including polyethylene, polystyrene, ABS, and Celcon® acetal copolymer. Because the connector pieces are attached to the rods by snap-fits, the plastic used for the connectors must have a good combination of lubricity, flexural modulus, creep resistance, tensile strength, and dimensional accuracy. High lubricity lowers the force needed to snap the parts together and allows for a "smooth snap-fit"; high tensile strength and flexural modulus give the material the strength and stiffness it needs to bear loads, while creep resistance gives it the ability to maintain its holding power; and dimensional accuracy is needed to mold the snap-fit joints to the critical sizes.

The material must also have excellent wear resistance to withstand repeated assembly and disassembly without significant erosion which would diminish the connectors' ability to stay connected to the rods. When elaborate models are left assembled for long periods of time, creep resistance becomes a concern. The toy parts must be creep resistant so they withstand continuous stress for extended periods of time without significant deformation.

Results

The Rodon group chose Celcon acetal for the connectors of its K'Nex toys because it has the combination of properties that the toys require. Celcon acetal has a higher tensile strength than polyethylene, polystyrene, and ABS. The connectors made from Celcon acetal resist wear from repeated snap-fit assembly. Because Celcon M90 has a flexural modulus of 375,000 psi, the models can be assembled through snap-fits and the connectors are stiff enough to hold the rods in place. The lubricity of Celcon acetal copolymer allows the parts to be assembled without much friction or wear.

In order for the snap-fit joint to work properly, Celcon acetal must consistently obtain the proper dimensions in molding. Under proper molding conditions, Celcon acetal copolymer can hold a tolerance of ± 0.002 inch/inch on the first inch of part dimensions and ± 0.001 inch/inch on subsequent dimensions.

Celcon acetal resists creep, the deformation which is caused by long-term loading situations. After 1000 hours with greater than three times the load, Celcon acetal exhibits a creep modulus similar to ABS. This ability to withstand deformation under load assures continuous performance in snap-fits.

Some sets of K'Nex toys include plastic gears which are used with motors to turn moving components. Rodon Group chose Celcon LW90, a wear resistant acetal copolymer, for these gears. Before selecting Celcon LW90 resin, they tested nylon gears which lasted about a week in continuous use before showing significant wear. Gears made from low wear Celcon acetal lasted over a year in continuous use, or 52 times longer.

If you are interested in obtaining a sample of Celcon resins or would like to know how its wear resistance can help you increase your product quality or product life, please call Product Information Services at 1-800-833-4882 and mention "Application Sheet 94-06".

Property	Celcon® acetal M90 [LW90]	Polyethylene	ABS (High impact)	Polystyrene (High impact)
Coefficient of friction against steel	0.15 [0.10]	n/a	0.3	0.28
Flexural stress @ 5% deformation (psi)	13,000 [12,300]	n/a	n/a	n/a
Flexural modulus (ksi)	375 [370]	145-225	179-375	160-390
Tensile strength at yield (psi)	8800 [8500]	1650	2600-5900	2100-6000
Flexural creep modulus (ksi) 1000 hours of loading	220 [n/a] (5000 psi initial loading)	22 (1250 psi initial loading)	250 (1500 psi initial loading)	n/a
Taber abrasion (mg/1000 cycles) 1000g load, CS-17F wheel	6 [n/a]	n/a	n/a	n/a

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