CASE STUDY

Enhance your products' abrasion resistance with LUBMER™

Summary

Product type: Abrasion Resistance Agents
Application: Plastics, Polymer Additives
Key benefits: Improved abrasion resistance | Less friction coefficient | Retention of mechanical properties of resins

The Challenge

Polymer composites are increasingly being used to replace metal parts in engineering applications. High friction and abrasion wear are commonly encountered problems in the use of moving machine elements made from plastics. Polytetrafluoroethylene (PTFE) is widely used as an additive for reducing the friction coefficient and decreasing abrasion loss. A critical ingredient in the production of PTFE is Perfluorooctanoic acid (PFOA). Recent studies have linked PFOA exposure to serious health issues including cancer, high cholesterol, and hypertension. The UN's Stockholm Convention on persistent organic pollutants has, in 2019, agreed to a global ban on PFOA and related compounds. The EU, being a party to the UN convention, must implement this decision through its regulations. The regulation of PFOA is causing formulators to look for a suitable PTFE alternative. The alternative must be safer, offer better sliding properties, and reduce abrasion wear while retaining the strength and other essential physical properties of the material.

The Solution

Ultra-high-molecular-weight polyethylene (UHMW-PE) is a thermoplastic polyethylene with a molecular mass in the range 2 to 6 million amu. It is a very tough material, with the highest impact strength of any thermoplastic presently made. UHMW-PE has a low coefficient of friction, high abrasion resistance, and extremely high chemical resistance. LUBMER™ UHMW-PE, developed by Mitsui Chemicals using its proprietary polymerization technology, can be used as a substitute for PTFE

in engineering plastics. It is suitable for use as an additive with Polyamide (PA6), Polyacetal (POM), Polybutylene Terephthalate (PBT), Polycarbonate (PC), Polyphenylene Sulfide (PPS) and Acrylonitrile butadiene styrene (ABS) among other materials. When used as a tribology modifier, LUBMER™ offers the following benefits:

- Improves abrasion resistance to increase part durability
- Decreases the coefficient of friction leading to noiseless operation
- Retains the essential mechanical properties of the matrix resin

LUBMER™ LY1040 can be used as an additive in a variety of other materials including POM, PBT, ABS, PC and PPS. Figures 1 and 2 below show the decrease in the coefficient of friction and abrasion loss by addition of 5% and 10% LY1040 to various materials.

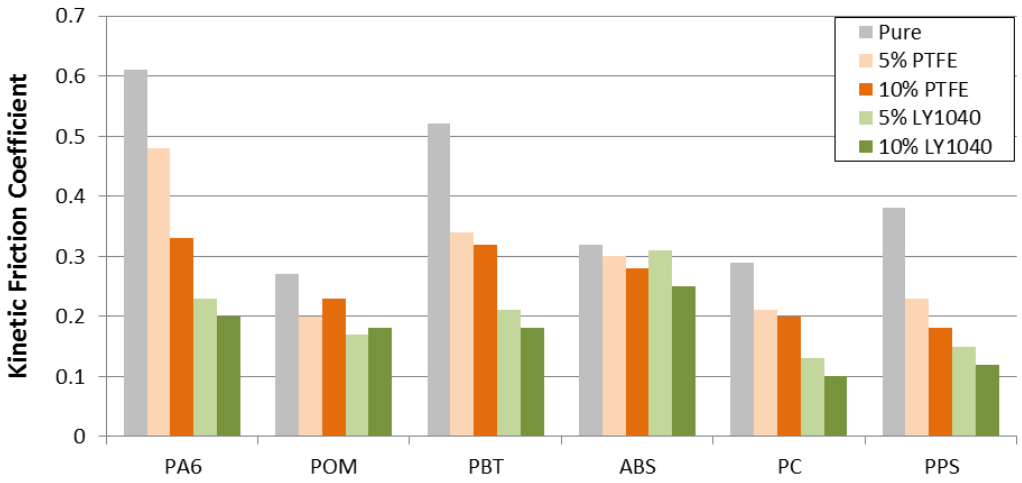


Figure 1: Comparison of the kinetic friction coefficient, in a ring test, of several pure materials with materials containing LUBMER™ LY1040 and PTFE additives.

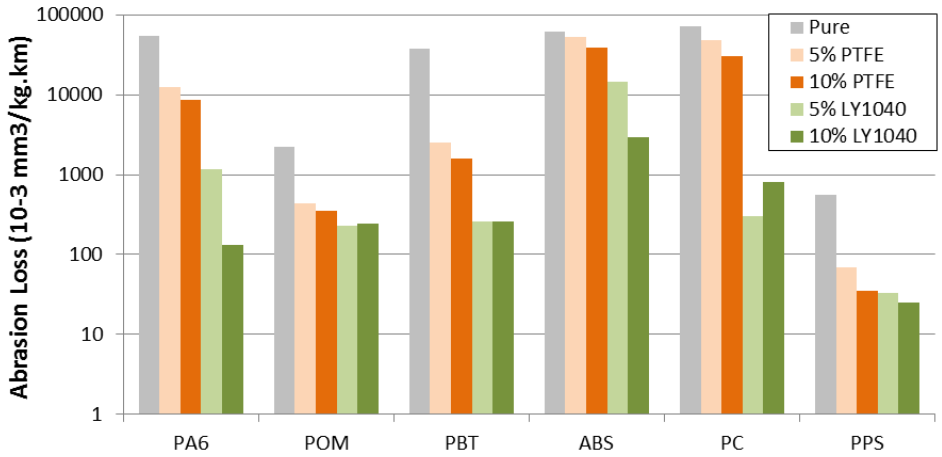
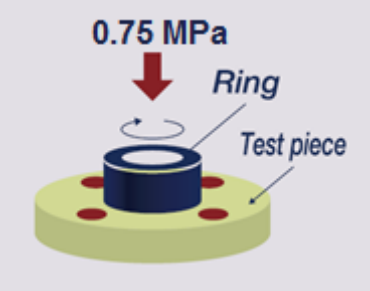


Figure 2: Comparison of abrasion loss, in a ring test, from several pure materials with materials containing LUBMER™ LY1040 and PTFE additives.

LUBMER™ is useful as a friction-reducing additive in a broad range of applications including automotive, electronics, building materials and parts for household appliances. It helps achieve

noiseless operation in various devices containing moving plastic parts. Some specific examples include bearings for film development processors, motor bearings for vending machines, chain/belt for food machinery, curtain rail rings, furniture rails/rollers, aqueduct valve parts and gears inside small handheld gadgets. LUBMER™ is a light material with less than half the density of PTFE. It is ideal for producing lighter parts with increased durability.

Performance of LUBMER™ as a Polyamide (PA6) Modifier



Tests were conducted to compare the friction coefficient and abrasion loss of PA6 with various friction reducing additives including LUBMER™ LY1040, PTFE and Molybdenum disulfide. PA6 pellets and LUBMER™ LY1040 pellets were compounded in a twin extruder at a cylinder temperature of 240'C. The plastic was injection molded into test pieces which were used to measure the friction coefficient and abrasion loss with S45C steel as the counter material.

Figure 3 shows that LUBMER™ LY1040 is more efficient in reducing the coefficient of friction of PA6 than PTFE and Molybdenum disulfide. Addition of just 5% of LUBMER™ to PA6 reduces the coefficient of friction to a value well below that achieved by using 10% PTFE. Addition of 10% LY1040 further reduces the friction coefficient to one-third of the value of pure PA6.

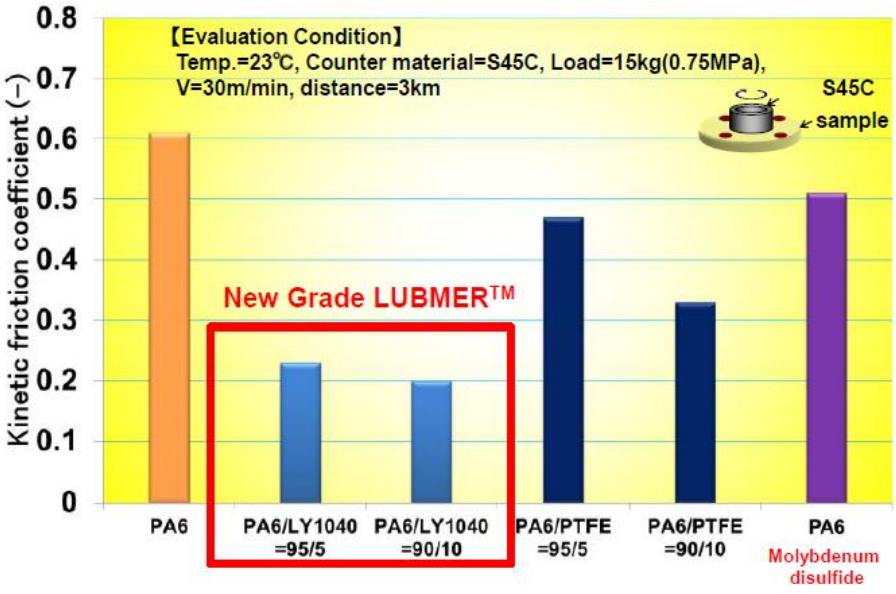


Figure 3: Comparison of the kinetic friction coefficient of PA6 with various additives. The samples with LUBMER™ LY1040 additive show the lowest friction coefficients.

LUBMER™ also performs better than PTFE in improving abrasion resistance of PA6. Figure 4 displays the results of an abrasion ring test in which pure PA6, PA6 modified with 5% and 10% LUBMER™, and PA6 modified with PTFE and molybdenum disulfide were tested.

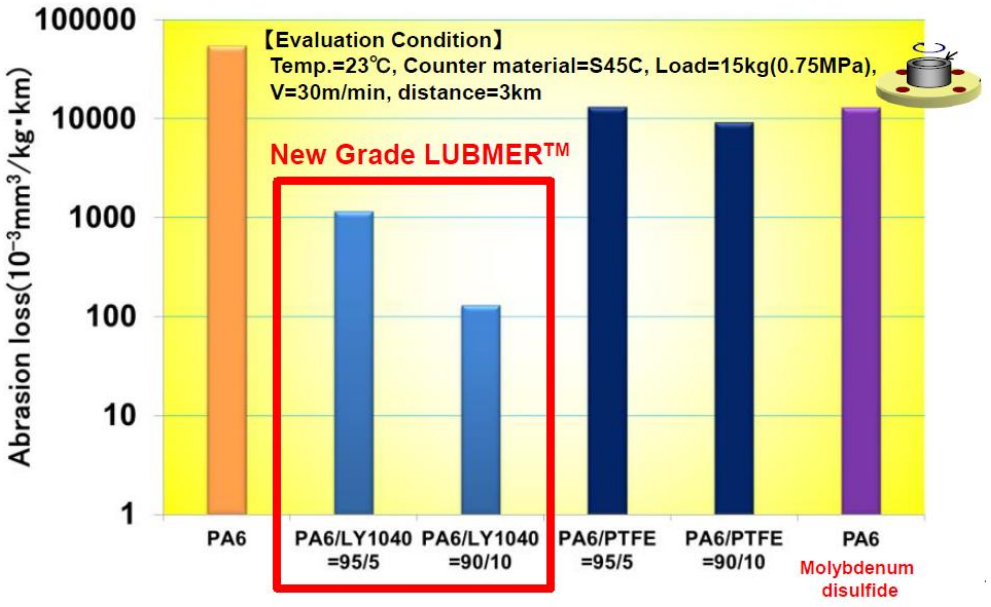
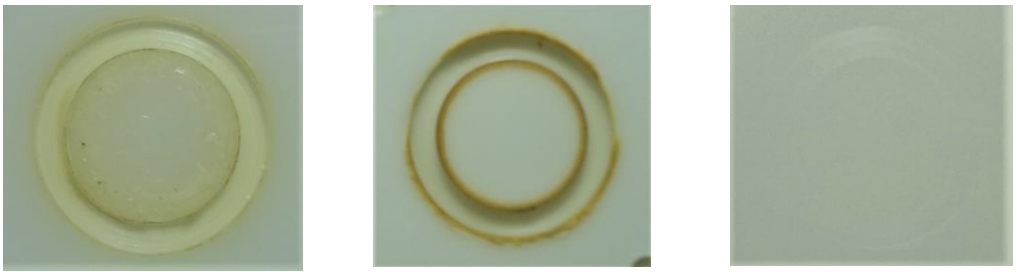


Figure 4: Comparison of abrasion loss of PA6 with various additives. The samples with LUBMER™ LY1040 additive show the lowest abrasion loss.

Addition of just 5% LUBMER™ LY1040 to PA6, shows abrasion loss that is lower by a factor of 10, when compared to abrasion loss from PA6 with 10% PTFE. The improvement in durability is so remarkable that it is clearly visible from a visual inspection of the test pieces. Figure 5 visually compares the abrasion loss from test pieces made from PA6, PA6 modified with 10% PTFE and PA6 modified with 10% LUBMER™ LY1040. The PA6 piece with 10% LUBMER™ shows very little abrasion loss over the course of the experiment.



PA6 | **PA6/PTFE 90:10** | **PA6/LUBMER 90:10**

Figure 5: Images showing abrasion loss form test pieces made from pure PA6, PA6 modified with 10% PTFE and PA6 modified with 10% LUBMER™ LY1040

In a worm gear abrasion test, a gear made from pure PA6 fails after about 15,000 revolutions due to high abrasion against an S45C worm. An identical gear modified with LY1040 continues to perform even after 100,000 revolutions and at a temperature exceeding 100°C.

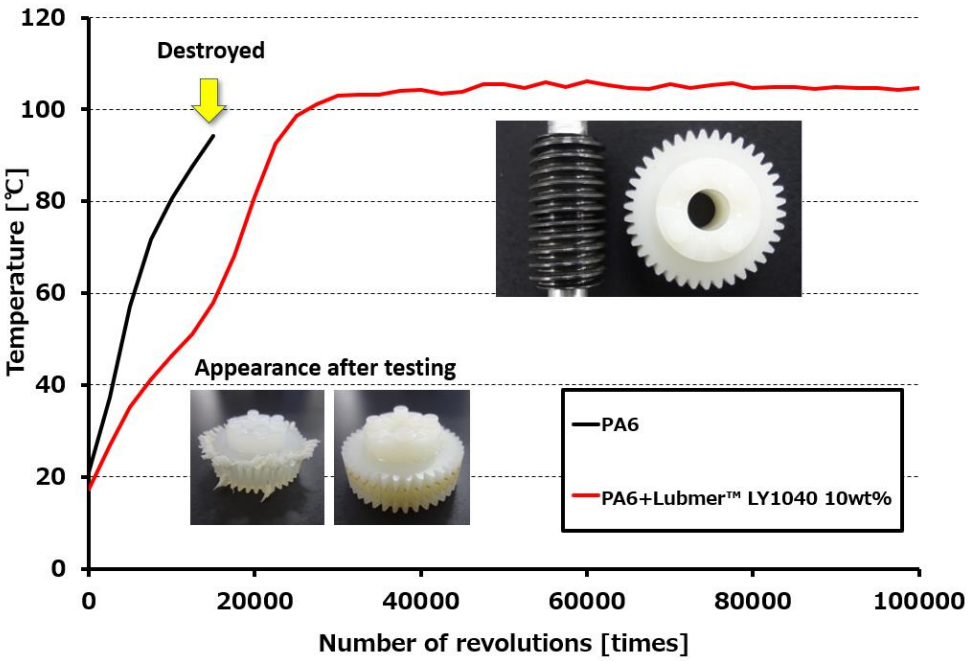


Figure 6: A gear made from pure PA6 is destroyed after 15,000 revolutions whereas a PA6 gear modified with LY1040 continues to perform after 100,000 revolutions.

Addition of LY1040 to PA6 not only reduces the coefficient of friction and abrasion loss but also leads to reduction in noise during operation. Figure 7 shows that a single gear modified with LY1040 reduces the average level of gear noise from 60.5 dB for pure PA6 to 57.1 dB for PA6 modified with LY1040. The noise level is lower than that for PA6 modified with PTFE.

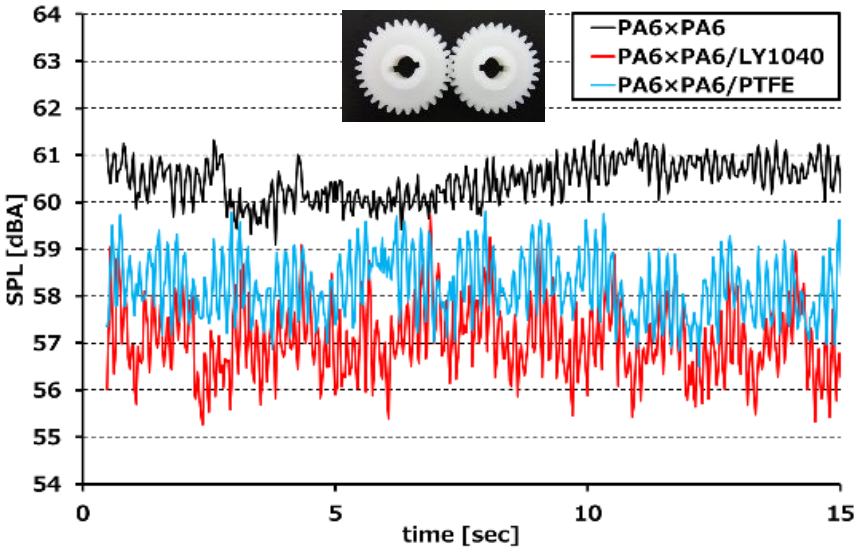


Figure 7: Addition of LY1040 to PA6 reduces the level of gear noise to a level below that achieved through the addition of PTFE

An additive used to decrease the friction coefficient and abrasion loss must retain the essential physical properties of the matrix resin. The table below compares various physical properties of pure PA6 to PA6 modified with 2%, 5% and 10% LUBMER™ LY1040.

	Method	Unit	PA6	PA6/LY1040 =98/2	PA6/LY1040 =95/5	PA6/LY1040 =90/10
MFR (230℃,2.16kgf)	MCI method	g/10min	62	53	45	30
Density	MCI method	Kg/m^3	1144	1124	1121	1120
Tensile strength at yield point	ISO527-1,2	MPa	85	80	80	70
Tensile strength at break	ISO527-1,2	MPa	50	50	50	45
Tensile elongation at break	ISO527-1,2	%	35	25	30	35
Flexural Strength	ISO178	MPa	120	110	110	100
Flexural Modulus	ISO178	MPa	2600	2600	2600	2600
Charpy impact strength (V/ notched)	ISO179	kJ/m^2	4.0	5.0	5.0	5.5
HDT (0.45MPa)	ISO75-1,2	℃	160	150	150	150
Mold shrinkage (MD/TD)	MCI method	%	1.4/1.5	1.4/1.6	1.6/1.6	1.6/1.6
Kinetic Coefficient of friction	MCI method[1)]	-	0.61	0.38	0.23	0.20
Abrasion Loss	MCI method[1)]	$10^{-3}mm^3$ /kg km	55000	6850	1170	130
Limit PV value	MCI method[2)]	MPa/m·min	10	15	>30	>30

1) Counter material S45C, Load=15kg,V=30m/min, distance=3km、2) Counter material SUS, V=12m/min, Load stay time 30min (Step up)

Figure 8: Physical properties of PA6 modified with various amounts of LUBMER™ LY1040 additive.

The data shows that addition of LUBMER™ LY1040 improves impact strength, shows no change in the flexural modulus, and leads to only a small variation in tensile strength while greatly reducing the kinetic coefficient of friction and abrasion loss.

Conclusion

LUBMER™ exhibits better sliding properties than PTFE and molybdenum disulfide, when used as an additive in low dosage. It remarkably improves the abrasion resistance of PA6 and many other materials when added in a 5-10% weight ratio. LUBMER™ is a safer, better performing substitute for PTFE. It can help manufacturers of various parts and appliances, improve durability and performance, reduce health hazards, and prepare themselves for the new regulations restricting use of PFOA and related compounds.

Learn more about LUBMER™ on our Universal Selector

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