CARBON BASED POWDER SOLUTIONS FOR **LUBRICANTS AND GREASES**

TIMREX®
Graphite

IMERYS

ADVANCED KNOWLEDGE AND EXPERTISE – FOR HIGH QUALITY, HIGH PERFORMING SOLUTIONS

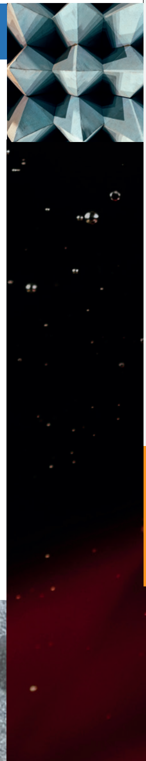
INNOVATIVE LEADERSHIP

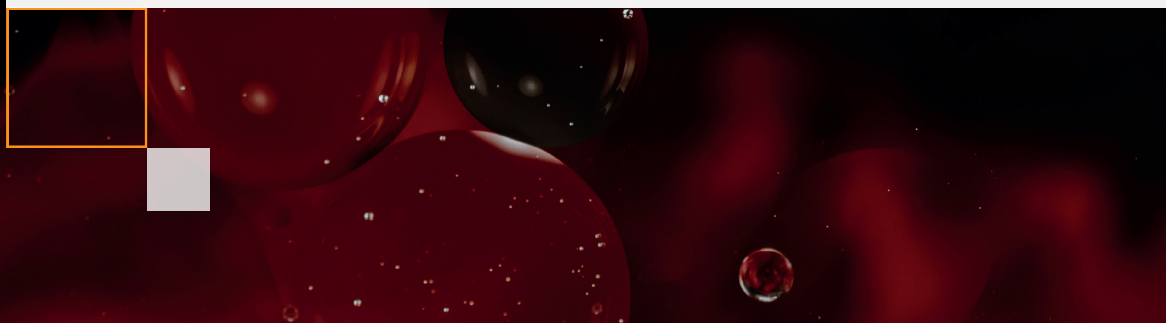
Innovative leadership and competence make Imerys Graphite & Carbon the right partner for the development and optimization of solutions for lubricants and greases.

High purity graphite powder with the right crystallite structure is an excellent solid lubricant.

Our portfolio includes a wide range of primary synthetic and natural graphite powders well suited to meet the specific requirements of the lubricants and grease markets.

Imerys Graphite & Carbon has been serving the lubricant and grease markets for decades. Our team of experts works closely with our customers to understand their particular requirements and find the optimal solution for their needs.

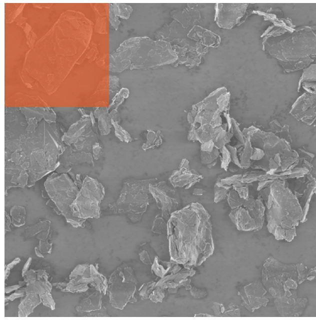




IMERYS GRAPHITE & CARBON SOLUTIONS

PRIMARY SYNTHETIC AND NATURAL GRAPHITE POWDERS

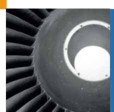
Imerys Graphite & Carbon offers a broad range of primary synthetic and natural graphite powders for the lubricant and grease market with the highest quality and consistency of the key parameters: purity and crystallite structure. The diverse range of particle size and crystalline structure included in our portfolio ensures we can work with our customers to optimize their solid lubricant system.

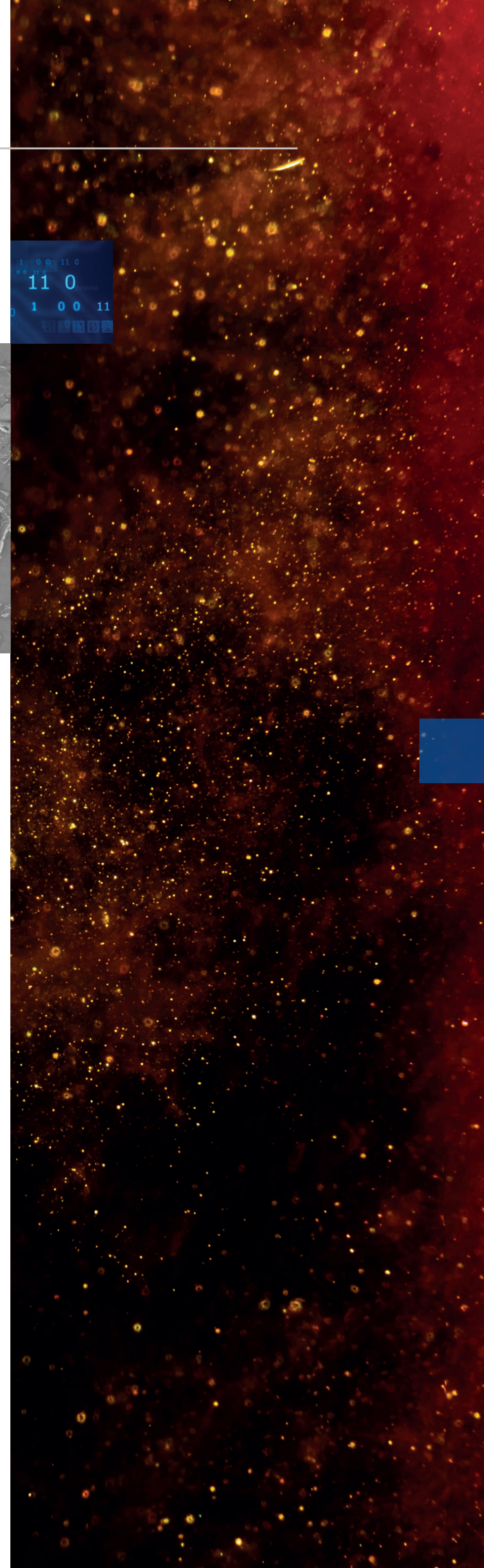


SEM image of TIMREX® KS 15

RECOMMENDED SOLUTIONS

BENEFITS	REQUIREMENTS	RECOMMENDED
Improved wear	High purity High crystalline structure	Primary Synthetic Graphites: TIMREX® KS series TIMREX® C-LUB
Cost effective	Synergy when Primary Synthetic Graphite is blended with Molybdenum Disulfide (MoS_2)	Primary Synthetic Graphites: TIMREX® KS series





OUR PORTFOLIO

PRIMARY SYNTHETIC GRAPHITE BASED POWDERS

	GUARANTEED VALUES			TYPICAL VALUES			
	ASH (%)	MOISTURE (%)	PARTICLE SIZE d90 (µm)	ASH (%)	MOISTURE (%)	PARTICLE SIZE d90 (µm)	SCOTT DENSITY (g/cm³)
KS4	< 0.2	< 0.5	< 6.8	0.07	0.1	4.3	0.07
KS6	< 0.1	< 0.5	5.5 – 6.8	0.06	0.1	6.1	0.07
KS10			9.2 – 13.2	0.06	0.1	11.7	0.09
KS15			12.3 – 18.1	0.05	0.1	15.0	0.10
KS25			18.5 – 29.5	0.05	0.1	24.2	0.14
KS44			40.0 – 51.5	0.06	0.1	44.8	0.19
C-LUB 302	< 0.5	< 0.5	5.1 – 7.1	0.2	0.1	6.1	0.07
C-LUB 304			7.2 – 11.2	0.2	0.1	9.9	0.09
C-LUB 306			12.0 – 18.0	0.2	0.1	15.4	0.10
C-LUB 310			41.9 – 51.9	0.2	0.1	49.5	0.19

NATURAL GRAPHITE BASED POWDERS

	GUARANTEED VALUES			TYPICAL VALUES			
	ASH (%)	MOISTURE (%)	PARTICLE SIZE d90 (µm)	ASH (%)	MOISTURE (%)	PARTICLE SIZE d90 (µm)	SCOTT DENSITY (g/cm³)
PP10	< 5	< 0.5	8.0 – 12.0	4.2	0.1	9.8	0.05
PP25			15.3 – 22.3	4.2	0.1	18.8	0.08
PP44			31.5 – 52.5	4.4	0.1	40.4	0.11

KEY PARAMETERS
INFLUENCING LUBRICATION

INFLUENCE OF GRAPHITE PURITY AND STRUCTURE ON WEAR

In order to understand which graphite properties have the greatest influence on reducing wear in oil and grease formulations, tests were carried out on the ASTM D-1367 standard test apparatus to determine the relative abrasiveness of various graphite powders in oil.

The apparatus is a double row roller bearing turning at high speed (1750 rpm), through which a dispersion of graphite (15%) in paraffin oil (21 cSt at 38 °C) is made to circulate. Bearing wear is determined by the change in weight of the bearing during the test.

Secondary synthetic, natural amorphous and macrocrystalline graphite powders were compared to primary synthetic graphite powders **(TIMREX® KS15 and TIMREX® KS44).** The rate of wear loss (mg/h) was determined over a period of 32 hours.

The characteristics of the various graphite powders tested are shown in Table 1.

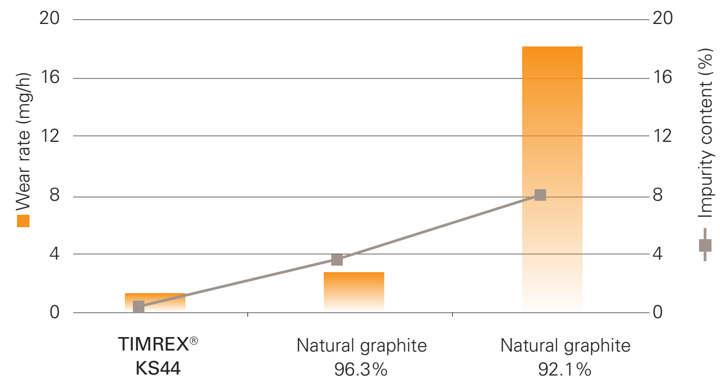
PROPERTIES OF GRAPHITE POWDERS TESTED WITH THE ASTM D-1367 STANDARD TEST APPARATUS

Table 1

	PURITY (% C)	CRYSTALLINE STRUCTURE		SURFACE AREA (m^2/g)	PARTICLE SIZE (d50, µm)
		c/2 (nm)	Lc (nm)		
Amorphous	81.2	-	13		25
Secondary Synthetic Graphite	99.8	0.3359	60	19.8	3
Secondary Synthetic Graphite	99.4	0.3358	80	22.0	13
Natural Graphite 99.5%	99.5	0.3356	> 100	9.1	2
Natural Graphite 96.3%	96.3	0.3355	> 100	12.9	13
Natural Graphite 92.1%	92.1	0.3355	> 100	8.4	17
TIMREX® KS15	> 99.9	0.3355	> 90	12.0	7.1
TIMREX® KS44	> 99.9	0.3356	> 100	9.0	15.8

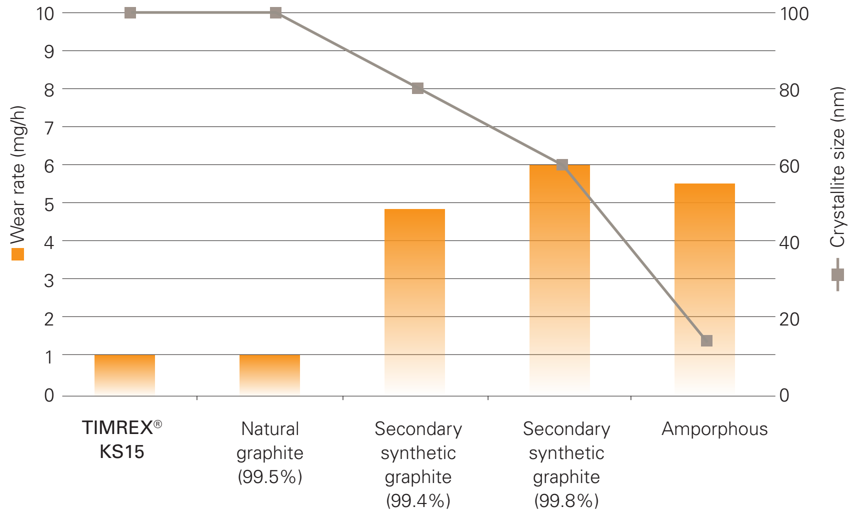
Influence of purity on the bearing wear
of high crystallinity graphite powders

Fig. 1



Influence of the graphite crystallinity
structure on bearing wear

Fig. 2



TEST RESULTS

The test results demonstrate that the parameters with the greatest impact on wear are purity and crystallite size. Figure 1 shows the wear rate as a function of impurity content for one primary synthetic graphite and for two natural graphites with different purity levels. Higher impurity content results in higher wear.

TEST RESULTS

Figure 2 illustrates the bearing wear rate as a function of crystallite size for several high purity graphite powders and one amorphous graphite containing 20% impurities. Bearing wear clearly decreases with increasing crystallite size.

When graphites with similar purity and crystallinity, such as TIMREX® KS15 and TIMREX® KS44, were compared, there was no significant difference in wear observed, suggesting that the effect of particle size is negligible under these test conditions.

SYNERGY BETWEEN GRAPHITE POWDERS AND MoS_2

OPTIMIZE PERFORMANCE/PRICE RATIO OF SOLID LUBRICANTS

High purity graphite powder with the right crystalline structure is an excellent solid lubricant for applications below 300°C. Depending on the operating conditions, powder blends of TIMREX® primary synthetic graphite powder and MoS_2 can have equivalent results or synergistic results with regards to friction and wear. Due to the high cost of MoS_2, such powder blends are a cost effective solution for solid lubricant systems.

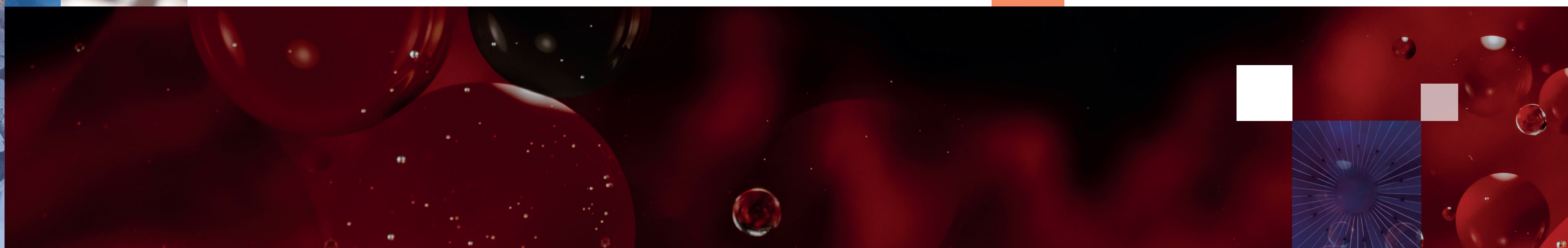
To understand the synergistic benefits of graphite powder blends with MoS_2, primary synthetic graphite (TIMREX® KS15) and MoS_2 powders were evaluated both separately, and in blends of different proportions.

The characteristics of the solid lubricants used in the tests are shown in Table 2.

CHARACTERISTICS OF SOLID LUBRICANT POWDERS

Table 2

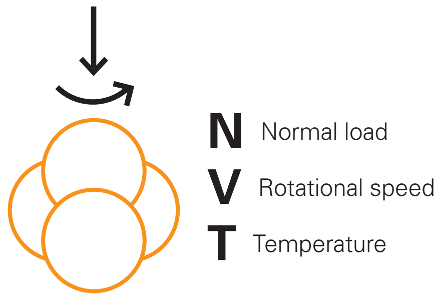
	IMPURITY LEVEL (%)	CRYSTALLINE STRUCTURE c/2 (nm)	Lc (nm)	XYLENE DENSITY (g/cm³)	SPECIFIC SURFACE AREA (m²/g)	PARTICLE SIZE DISTRIBUTION
TIMREX® KS15	< 0.1	0.3355	> 90	2.25	12.0	d50 = 7.1µm
MoS_2	< 1.5	–	–	4.3	5.0	d50 < 9µm



TEST METHOD

Dry blending of the two solids, which are similar in particle size distribution, was executed using a Brabender mixer/kneader apparatus for a duration of 30 minutes in ambient temperature and atmosphere. The solids and solid blends for this test were suspended in mineral oil. The suspensions were prepared in a propeller stirrer at low speed (100 rpm) and in ambient temperature. Tests were carried out with the aid of a Shell-4-Ball tester.

Figure 3 shows the principal characteristics of the apparatus as well as the working conditions which prevailed during the testing. For each of the test runs, a given load was applied N (daN) for one minute. A wear cup appears on the metal surfaces in contact with each of the three steel balls. The wear rate is determined by the average diameter d (mm) of that wear mark for the three steel balls combined.



SHELL-4-BALL TEST MACHINE – PRINCIPAL CHARACTERISTICS

Fig. 3

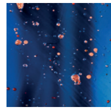
APPLIED LOAD N (daN)	MAXIMUM HERTZIAN PRESSURE (daN/mm²)	AVERAGE HERTZIAN PRESSURE (daN/mm²)	ROTATIONAL SPEED V (cm/min)	INITIAL TEMP. T (°C)
60-175	271 $N^{1/3}$	7.94 $N^{2/3}$	1450	18-20

1 daN = 10 N
Steel balls: diameter 12.7mm, hardness HRC 64
Material: steel 105 Cr 2

The solids for this test were suspended in mineral oil

Oil: neutral mineral oil no. 350 (220mm²/s, 20°C)

Soild content: 5% by weight

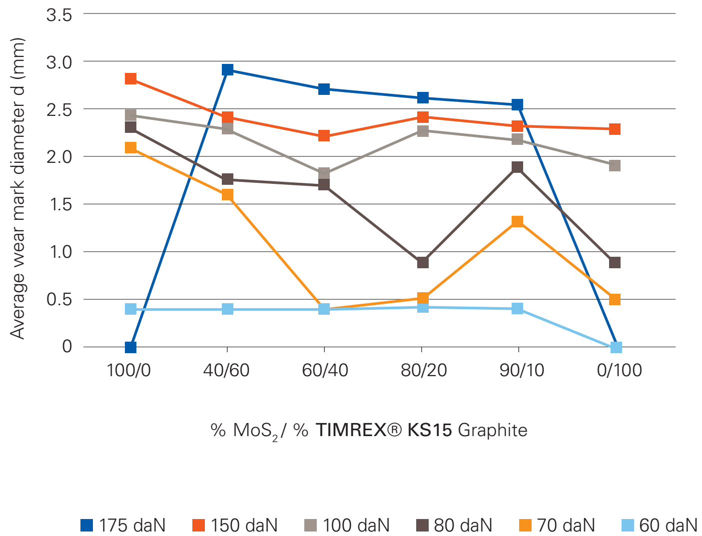


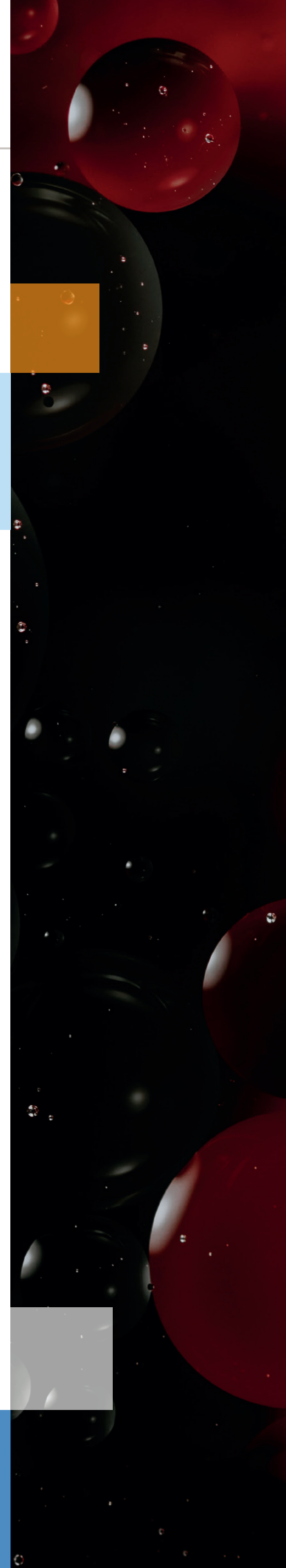
TEST RESULTS

Figure 4 illustrates the role of the blending ratio. Results are plotted as a function of the proportion of graphite or MoS_2 powder contained in the blend with the various points connected as isobars.

Wear function of blending ratios
and various loads (solids in oil)

Fig. 4





CONCLUSIONS

Based on the test results, the following suggestions can be made depending on the load requirements for the lubrication application.

NORMAL LOAD 60 daN

At this load level the oil itself provides sufficient lubrication as neither the presence of a solid nor the blending proportion seem to have an effect on the wear.

NORMAL LOAD 70-80 daN

As the load increases by up to 33%, the presence of solid lubricants in the oil improves the lubrication.

There is a general decrease in wear both for MoS_2 on its own and the blends with 40%, and even more so with 20% graphite. The blend with only 10% graphite caused an abrupt increase in wear to a level similar to that as 100% graphite.

NORMAL LOAD 100-150 daN

The effectiveness of the solid lubricants in terms of reduced wear is still considerable at a load of 100-150 daN when using blend of 20% or 40% graphite.

However, to a somewhat lesser degree than was the case for the same blends at loads of 70 and 80 daN.

At 100-150 daN the difference in wear for MoS_2 and for graphite tested on their own is smaller than at lower loads.

NORMAL LOAD 175 daN

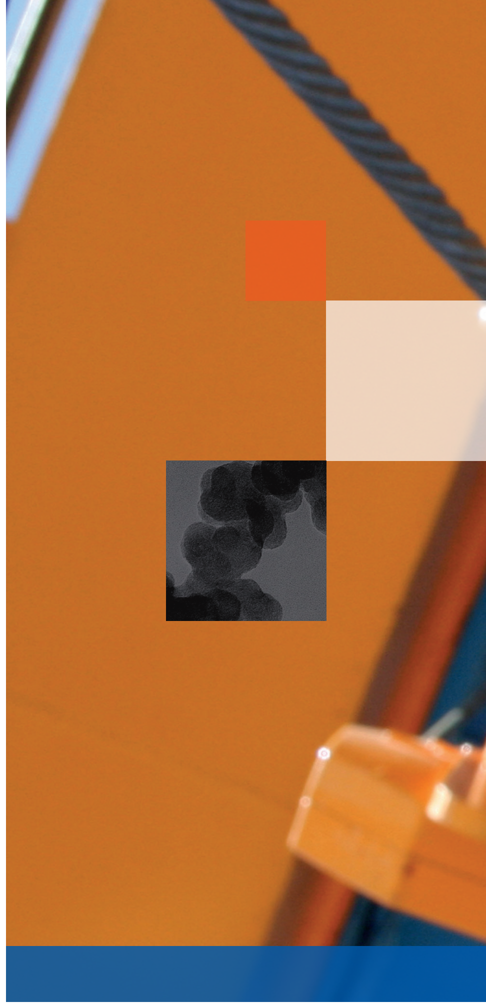
With a normal load of 175 daN, a synergistic effect occurs with regard to the limit of effectiveness of the lubricant film, which is extended by the various blends as compared to either of the two solids on their own.

The lowest wear rate was achieved with those graphite/MoS_2 blends containing 10 and 20% graphite.

RECOMMENDATION

Graphite powder can be an excellent solid lubricant if high purity and crystalline structure are optimized.

By selecting TIMREX® primary synthetic graphite powders and exploiting the synergistic effect between MoS_2 and graphite, performance/price ratio of lubricants can be considerably increased.



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