



**THE FUNCTIONAL ATTRIBUTES
AND UTILIZATION OF BORATES
IN LUBRICATION TECHNOLOGY**

BORON

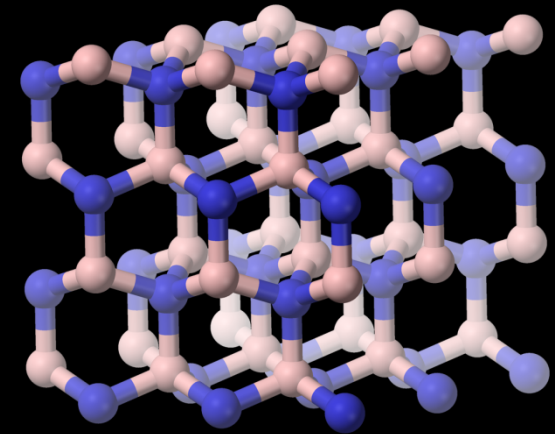
- ❖ Discovered in 1808 by Sir Humphrey Davy
- ❖ Brittle, black semi metallic substance
- ❖ Tends to form planar compounds



THE USE OF BORON IN LUBRICANT FORMULATION

BORON NITRIDE (BN)

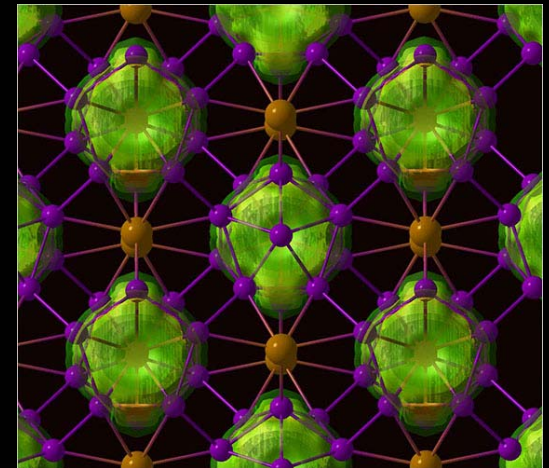
- ❖ Planar hexagonal structure
- ❖ Similar to graphite
- ❖ Works well as a solid lubricant
- ❖ Ceramic
 - Exceptional thermal stability
 - Stable in acids



THE USE OF BORON IN LUBRICANT FORMULATIONS

OIL SOLUBLE BORIC ACID ESTERS

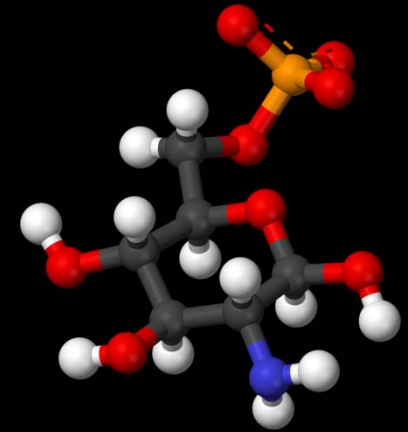
- ❖ Lubrizol Corp. 1986
- ❖ Used as an anti-wear additive in engine oil formulations
- ❖ Exhibits some rust inhibition properties
- ❖ Poor hydrolytic stability



THE USE OF BORON IN LUBRICANT FORMULATIONS

OIL SOLUABLE BORATED AMINES

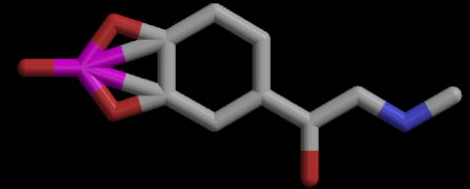
- ❖ Watts et al., Infineum, late 1990's
- ❖ Friction modifier and anti-wear additives for engine oils
- ❖ Useful in automatic transmission fluids
- ❖ High treat rates



THE USE OF BORON IN LUBRICANT FORMULATIONS

Borated amine and borate ester

- ❖ Compared to traditional phosphorus additives
- ❖ Tested for engine exhaust emissions
- ❖ Determined that tailpipe emissions are reduced using boron additives
- ❖ No reduction in catalytic converter performance



THE USE OF BORON IN LUBRICATION FORMULATIONS

BORIC ACID NANOPARTICLES

- ❖ Used to improve diesel fuel lubricity
- ❖ Problem dispersing particles
- ❖ Substantial friction reduction
- ❖ Problems related to suspension
- ❖ Does not tolerate water

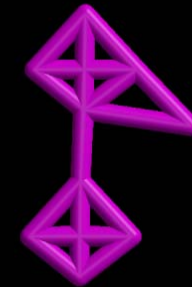


NEW TECHNOLOGY

BORATE NANOPARTICLES

COMBINES THE BEST OF EXISTING TECHNOLOGY

- ❖ Produced using unique manufacturing process
- ❖ Create planar structures on metal surfaces
- ❖ Stable suspension
- ❖ Tolerate water
- ❖ Almost half the friction reduction of boric acid 0.037



NEW TECHNOLOGY

BORATE NANOPARTICLES PERFORMANCE ESTABLISHED

- ❖ Difficulties lie in delivering nanoparticles to active site where friction is occurring
- ❖ Improved hydrolytic stability can lead to more environmentally friendly applications

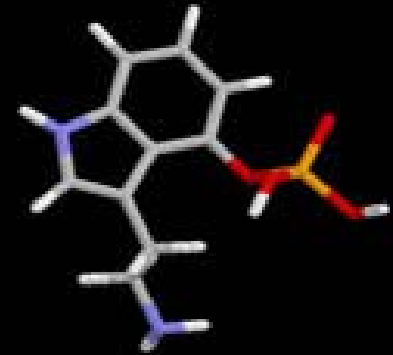
IMPROVED DELIVERY SYSTEM

- ❖ Transports nanoparticles to where they are needed
- ❖ Keeps particles in suspension

NEW TECHNOLOGY

THE DELIVERY SYSTEM IS A SPECIAL SYNTHETIC ESTER MATRIX

- ❖ Made from natural, renewable ingredients
- ❖ Highly surface active
- ❖ Forms a strong lubricating film
 - Film is self healing
- ❖ Superior anti-wear performance
- ❖ Will not agglomerate like boric acid
- ❖ Tolerant of water
 - Soluble in oil and other hydrocarbons



NEW TECHNOLOGY

DELIVERY MUST BE ABLE TO COVER ALL METAL CONTACTS



- ❖ Additive must be able to exist and perform in high friction contact areas
 - Nanoborate blended into the ester matrix which has a polar adhesive interaction with the metal surface
 - A chelation bond to the metal develops
 - Unlike anti-wear additives in oil which take up to 20 minutes to perform, nanoborate takes no time.

NEW TECHNOLOGY

COMBINATION OF BORATE NANOPARTICLES AND ESTER CARRIER

- ❖ Gives improved stability and performance
- ❖ Offers the opportunity to formulate water-based lubricants
 - Replace oil as carrier with water
 - Ester/nanoparticulate borate combined with emulsifier forms emulsion lubricant when blended into water

PERFORMANCE

FOUR BALL WEAR

- ❖ 0.35 mm scar vs. 0.80mm base oil

FOUR BALL LOAD

- ❖ Standard lithium-complex grease held a load of 700 kg



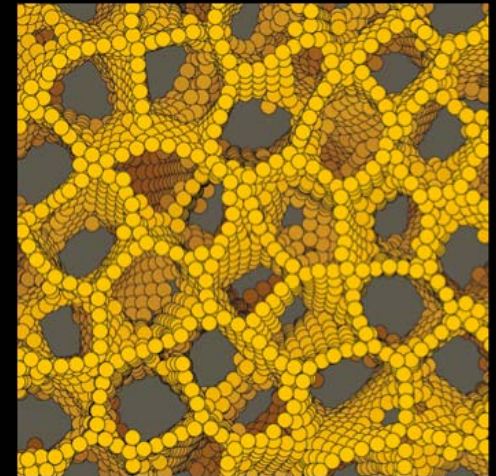
PERFORMANCE

LOAD CARRYING CAPACITY

- ❖ Oil alone -----500 lbs
- ❖ Oil with boron nitride----- 1250 lbs
- ❖ Oil with PTFE----- 2500 lbs
- ❖ Oil with ester/nanoparticulate borate----- 4000 lbs
- ❖ Water-based emulsion with nanoparticulate borate----- 4000lbs

EMULSION LUBRICANT

- ❖ Easy to spray
- ❖ No VOC
- ❖ Excellent lubricity – COF 0.037
- ❖ Very little odor
- ❖ Non-toxic
- ❖ Non-flammable
- ❖ Biodegradable
- ❖ Made from renewable resources



NEW TECHNOLOGY

NEW OPPORTUNITIES

- ❖ Allows new formulations of new products eliminating toxic anti-wear and extreme pressure AW/EP additives
- ❖ Formulate readily biodegradable and non-toxic lubes and greases
- ❖ Outperforms AW/EP additives presently used in lubricants
- ❖ Lower the bottom line while offering a superior product

AVAILABLE FOR CONSUMERS

- ❖ Although directed towards industry for new product development we have made it available for the public
- ❖ Add 1.12 oz per quart of oil or 6 oz for aver 5 qt sump
- ❖ MPG gains are realized due to the dramatic drop in friction
- ❖ Wear is reduced upwards of 90%
- ❖ Increased power is realized
- ❖ Less emissions
- ❖ Use at every oil drain, very cost effective



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