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Graphene layers dramatically reduce wear and friction on sliding steel surfaces

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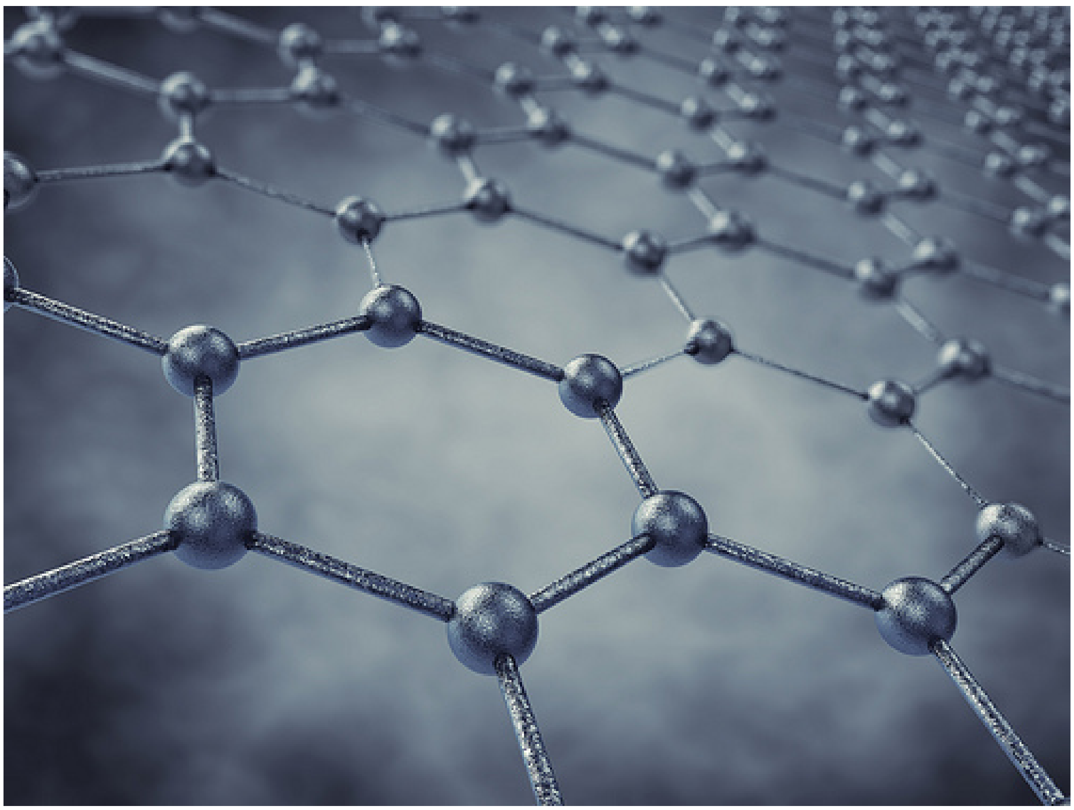

Graphene's hexagonal structure makes it an excellent lubricant.

(Phys.org) —Sometimes, all it takes is an extremely small amount of material to make a big difference. Scientists at Argonne National Laboratory have recently discovered that they could substitute one-atom-thick graphene layers for oil-based lubricants on sliding steel surfaces, enabling a dramatic reduction in the amount of wear and friction.

New studies led by Argonne materials scientists Anirudha Sumant and Ali Erdemir showed that graphene is able to drastically reduce the wear rate and the coefficient of friction (COF) of steel. The marked reductions in friction and wear are attributed to the low shear and highly protective nature of graphene, which also prevented oxidation of the steel surfaces when present at sliding contact interfaces.

Stainless steel ball bearings form an integral part of many moving mechanical machines, ranging from table fans to giant wind turbines.

"Reducing energy and materials losses in these moving mechanical systems due to friction and wear remains one of the greatest engineering challenges of our time," Sumant said.

Current lubricants reduce friction and wear either through the use of environmentally unfriendly additives, or in some cases, solid lubricants such as molybdenum disulfide or boric acid. The oil-based lubricants need to be consistently reapplied, producing additional waste. The cost of applying solid lubricant coatings is rather high and due to finite thickness, they do not last very long and must also be expensively reapplied.

On the other hand, coatings made of graphene flakes are not harmful to the environment and can last a considerable length of time due to the flakes' ability to reorient themselves during initial wear cycles, providing a low COF during sliding.

Sumant and Erdemir estimated that the reduced loss of energy to friction offered by new materials would yield a potential energy savings of 2.46 billion kilowatt-hours per year, equivalent to 420,000 barrels of oil.

"Applying or reapplying the graphene coating does not require any additional processing steps other than just sprinkling a small amount of solution on the surface of interest, making this process simple, cost-effective, and environmentally friendly," said Diana Berman, a postdoctoral researcher at Argonne's Center for Nanoscale Materials (CNM).

"It is interesting to see how a one-atom-thick material affects the properties at a larger scale," Sumant said. "I believe that graphene has potential as a solid lubricant in the automotive industry and, once fully developed, it could have positive impacts on many mechanical applications that could lead to a tremendous savings of energy."

Sumant is associated with Argonne's CNM, while Erdemir works for Argonne's Energy Systems Division. Funding came from Argonne's Laboratory-Directed Research and Development office.

The team recently published their findings in two consecutive papers in the high impact journal *Carbon*.

More information: D. Berman, A. Erdemir, A.V. Sumant: Few layer graphene to reduce wear and friction on sliding steel surfaces. *Carbon*, 54, 454-459 (2013)

D. Berman, A. Erdemir, A.V. Sumant: Reduced Wear and Friction Enabled by Graphene Layers on Sliding Steel Surfaces in Dry Nitrogen, *Carbon*, in press. www.sciencedirect.com/science/ … ii/S0008622313002108

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