Graphene vs Graphite: The Stark Difference

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With the introduction of Graphene by Andre Geim and Konstantin Novoselov in 2010 and the advancement of nanomaterials since… There has been much confusion on the difference between carbon allotropes. For example, what is the difference between Graphene and Graphite, aren't both Carbon? Breaking down the science, we can start to understand the difference between allotropes, and how different they are.

What is Graphene? The International Standards Organization (ISO) defines Graphene as the "single layer of carbon atoms with each atom bound to three neighbors in a honeycomb structure" also noted as "an important building block of many carbon nano-objects" (International Standards Organization, 2021). We can see the molecular structure of Graphene as a 2-dimensional plane [FIGURE 1].

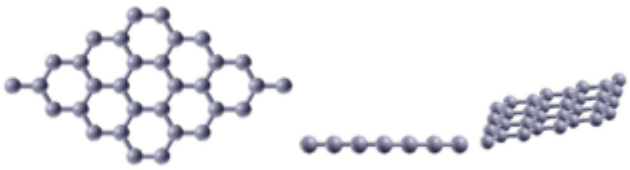

FIGURE 1
Graphene structure as a "single layer of carbon atoms."

Graphene carbon atoms are connected to three other carbon atoms on a linear plane.

What is Graphite? Whereas the ISO defines Graphite as an "allotrope form of the element carbon, consisting of graphene layers (3.1.2.1) stacked parallel to each other in a three-dimensional, crystalline, long-range order" (International Standards Organization, 2021). You can see the stacking of Graphene layers in Graphite in [FIGURE 2].

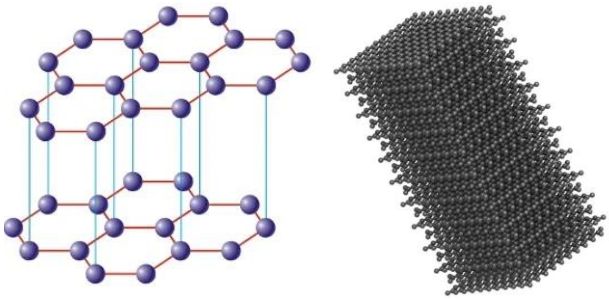

FIGURE 2
Graphite structure as "stacked layers of Graphene atoms."

Graphite carbon atoms are connected to three carbon atoms linearly as well as 1-2 carbon atoms vertically.

Therefore, we can ascertain that Graphene is the foundation or "building block" which Graphite is formed.

What is Diamond? Let us look at one last

allotrope of carbon and how molecular structure changes the scope of the material. When we stack allotropes of carbon in a cubic formation such as the next illustration, we get diamond. “A mineral consisting essentially of carbon, crystallized in the isometric (cubic) crystal system” (International Standards Organization, 2021). Diamond carbon atoms are interlaced in a cubic manner connecting to four carbon atoms.

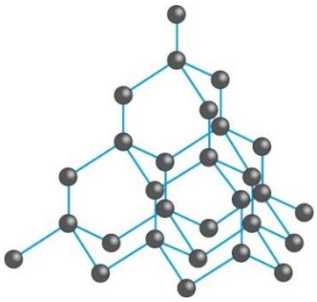

FIGURE 3
Diamond structure as a “cubic stack of carbon atoms.”

Summary: If by stacking allotropes of carbon in different formations results in materials with such varied degrees of hardness (for example Graphite is very soft at 1-2 Mohs’ whereas the Diamond has a hardness of 10 Mohs’), gravity, refractive indices, lubricity, impermeability, and so on, how can we not test and study each material independently? Likewise, only one of the materials listed above is included in the other two, that is Graphene, the “building block” of the other two. For example, Graphite does not exist in the Diamond, however, the reverse also works in the same manner, Diamond does not contain Graphite, however, both the Diamond and Graphite contain Graphene.

All three of these materials are substantially different, yet they are all made up of carbon. By adding, removing, and shifting these allotropes we can manipulate the materials to behave or react in specific ways, say for example how the material interacts or bonds with other chemicals.

Graphene in Oil: Graphene shows promise in lubricating oils for several reasons beyond what Graphite can produce. Due to the molecular structure of Graphene, lubricity, wear, and corrosion are all enhanced for a benefit over Graphite. See “Graphene: a new emerging lubricant” and how “Macro-scale tribological studies clearly demonstrated how graphene is different from graphite in reducing friction and wear irrespective of atmospheric conditions (humid or dry) and also acting as a perfect passivation layer inhibiting the corrosion induced wear (tribo-corrosion) in case of steel contacts” (Berman, Erdemir, & Sumant, 2014).

Works Cited

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