INTERCALATION OF FULLERENES INTO GRAPHITE

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Introduction

The discovery of fullerenes [1] and subsequent mass production [2] spurred intensive research to evaluate physical, chemical and electronic properties of this material. This resulted in the startling discovery that *insulator fullerenes* become conducting upon intercalation with alkali metals [3] and even superconducting at transition temperatures up to 33K [4]. Here we have synthesised for the first time a new highly conducting solid carbon composite by combining two carbon allotropes i.e. C_{60} and graphite. This composite material was decomposed to diamond like structure upon electron irradiation in transmission electron microscope (at 200 kV) without the application of high pressure and temperature. A unique combination of all three allotropes of carbon was observed in one solid during this transformation.

Experimental

About 50 mg of graphite was mixed with 100 mg of pure C_{60} (99.95%) and vacuum-sealed in a quartz tube. The reaction was performed at 600°C for two weeks. After the reaction, the intercalated graphite was cleaned first in toluene to remove any adsorbed C_{60} and then ultrasonically dispersed in ethanol for one hour. Transmission electron microscopy (at 200 kV) and Raman spectroscopy (488.5 nm, green Ar ion laser) were used to characterise the intercalated graphite.

Results and Discussion

High-resolution transmission electron microscopy (HRTEM) image of the intercalated graphite is shown in Fig. 1(a). The average distance between two adjacent parallel layers was 1.27 nm corresponding to a stage 1 intercalation compound. This hexagonal symmetry was also confirmed by selected area diffraction images. Assuming the diameter of C_{60} to be 0.71 nm and a the Van der Waals distance of 0.29 nm [3], the calculated C_{60} center-to-center distance is shown in Figure 1(b), in good agreement with the experimentally obtained value.

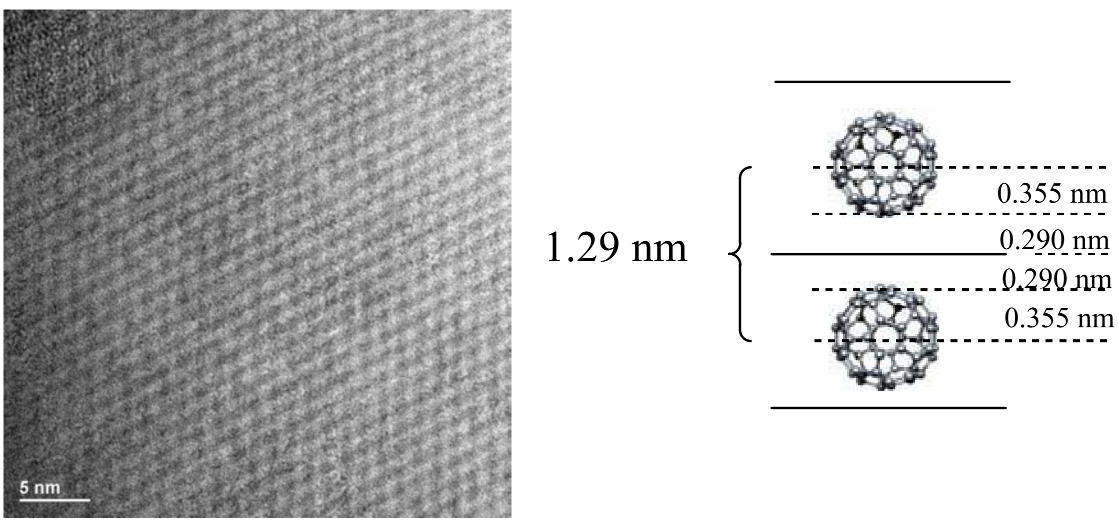

Figure 1. *(a) A transmission electron microscopy image of the stage-1 C_{60} intercalated graphite. (b) Calculation of the C_{60} centre-to-centre distance in the intercalated graphite.*

In this C_{60} intercalated graphite, Raman mode of graphite was shifted to 1589.1 cm^{-1} from its usual 1582 cm^{-1} position indicating a charge transfer. This carbon solid was decomposed to diamond like phase in few minutes under electron irradiation using TEM operating at just 200 kV as shown in Fig. 2.

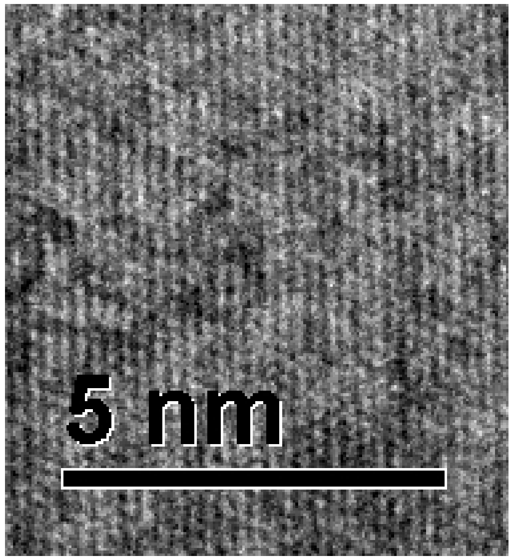

Figure 2 *High-resolution transmission electron microscopy images of the formed diamond like material (average interlayer distance is ~0.204 nm).*

Conclusions

This novel C_{60} intercalated graphite may show superconducting behaviour at low temperatures It can be potential host for new co-intercalation synthesis such as alkali-metal intercalation, and may lead to a new class of superconductors.

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References

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