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Commentary

Synthesis of Multiwalled Carbon Nanotube (MWCNT) by Arc Discharge Process

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DESCRIPTION

Methane (CH_4) is used as both the background and feedstock gas in an investigation into the arc discharge technique which is used to create Multiwalled Carbon Nanotubes (MWCNT). When using currents of 50, 70, and 90 A with ambient pressures of 100, 300, and 500 torr, the arc discharge is conducted between two graphite electrodes. Main thing is to determine the impact of physical factors like arc current and ambient pressure on the plasma dynamics and formation of MWCNT. An increase in plasma temperature and density is associated with an increase in applied arc current and ambient pressure.

X-ray diffraction, transmission electron microscopy, scanning electron microscopy, Raman spectroscopy, and Fourier transform infrared spectroscopy are used to analyse the produced samples of MWCNT under various experimental conditions. With an increase in CH_4 ambient pressure and arc current, a reduction in the diameter and an enhancement in the structural quality and development of MWCNT are seen. The well-aligned and straight MWCNT together with graphene stakes are observed for CH_4 ambient pressure of 500 torr and arc current of 90 A. Because of their exceptional electrical, thermal, and mechanical characteristics, Carbon Nanotubes (CNTs) are a prospective contender for use in a variety of technological applications. Structured-controlled CNT has been synthesised after great effort. A number of techniques, including arc discharge, Chemical Vapour Deposition (CVD), and laser ablation, have been developed to produce CNT. Arc discharge is a promising technique that can be used to create high-quality CNT among various technologies. High temperatures and a large influx of plasma species are essential for the creation of nanostructures.

Understanding the growth mechanism and the effects of physical factors (such as ambient pressure, electrode geometry, applied current and voltage, gas flow, inter electrode distance, dynamics of plasma species, etc.) on the growth of nanostructures is desirable in order to realise and optimise the application of CNT. The key factors in the arc discharge synthesis of MWCNT are the arc current, ambient gas, and ambient pressure. The anode receives energy from the arc current, which causes the anode surface to evaporate and arc plasma to develop. In the absence of ambient gas, the MWCNT with sizes primarily distributed in the range of 40-60 nm are seen for arc discharge. The ambient gas serves as a buffer gas during arc discharge evaporation and affects the growth and diameter distribution of MWCNT.

To regulate and enhance their growth, several conditions are explored to better understand the arc discharge technique used to synthesise MWCNT. For instance, in a helium and argon atmosphere, changing the gas mixture from argon to helium results in a greater diameter distribution, while increasing the argon-helium ratio results in an average diameter decrease. For low arc current, spherical nanostructures with small diameter are observed in a liquid nitrogen environment, whereas for high arc current, CNTs. A layer of soot developed at the surface of the water, which included elongated, spherical carbon structures like nanoonions with some polyhedron structures and MWCNT. No cathode deposit was seen during discharge in de-ionized water. No significant variation in the shapes and structures of CNT is seen in an ammonia environment. The CVD and Plasma enhanced Chemical Vapour Deposition (PCVD) methods are frequently used to produce CNTs.

The increase in arc current boosts energy flux at the anode surface and speeds up the evaporation of highly energetic particles, which helps to raise plasma temperature and density. With an increase in atmospheric pressure, there is a noticeable increase in electron temperature and density. The nature of residual gas and the electron heating mechanisms within plasma can be used to explain why plasma temperature and density increase as ambient pressure increases. The two forms of electron heating mechanisms used in capacitive discharge plasmas are stochastic heating and ohmic (collision) heating. In the stochastic heating mechanism, the electrons from the bulk interact with the oscillating electron sheath, transfer momentum to the sheath, and produce stochastic heating at the sheath edge, whereas the ohmic heating is produced by the collision of the electron with the neutral in the bulk. At low pressure, the stochastic heating mechanism predominates. As ambient pressure rises, the stochastic heating mechanism gives way to the ohmic heating mechanism, which raises the plasma temperature.

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Additionally, as ambient pressure rises, the electron energydensity function is modified, resulting in an increase in average-energy electrons and a decrease in very high and very low-energy electrons.