Chapter 5
Synthesis of Carbon Nanotubes via Plasma Arc Discharge Method

Adeel Aabir
University of Agriculture, Faisalabad, Pakistan

Muhammad Yasin Naz
University of Agriculture, Faisalabad, Pakistan

Shazia Shukrullah
University of Agriculture, Faisalabad, Pakistan

ABSTRACT

CNTs are the element that exists with predominant physio-chemical properties, which have been extensive researched today. These properties make carbon nanotubes (CNTs) valuable in a wide potential range of applications. The production of high-quality carbon nano-tubes (CNTs) via different precursors has been reported for many years. The arc discharge is a pristine technique to form CNTs with a high-quality yield. This technique has been elucidated for a long time, but the growth condition and mechanism of affected synthesized parameters and coorelation between synthesized parameters and nucleation of carbon have not been explored. In this chapter, the authors present the factors affecting temperature, geometry, grain size, electrodes, pressure, catalyst, arc current, power supply, and growth mechanism of CNTs. The variation in parameters has been elicited along with challenges and gaps.

DOI: 10.4018/978-1-7998-8398-2.ch005

1. INTRODUCTION

Carbon nanotubes possess extensive chemical, mechanical, optical, and thermal properties listed in Table 1. They are broadly classified as SWCNTs, MWCNTs, and DWCNTs. Moreover, SWCNTs are divided into three kinds, namely arm-chair, zigzag, and chiral carbon nanotubes. CNTs can show metallic or semiconducting behavior, depending on the nature of the structure or chirality. While armchair carbon nanotubes are always metallic with indices m=n=3q, others can be metallic or semiconductors. The indices n and m identify the electronic structure and q be the integer. In arm-chair carbon nanotubes, there is no band-gap between the valence and the conduction band but in the case of zig-zag and chiral carbon nanotubes, a narrow bandgap exists which is the nature of the semiconductor materials.

Researchers devised different ways to synthesize CNTs via various precursors. The most popular synthesis methods are arc discharge, laser ablation, and chemical vapor deposition (Chau et al., 2020). Hydro-thermal, ball milling and electrolysis have also been used to synthesize CNTs. CNTs were synthesized by lijima via the arc discharge method (Bahgat et al., 2011). While the literature has no more comprehensive research on the formation mechanism of CNTs. There is a need of an elevated correlation between parameters and growth conditions of nano-tubes. Yoshinori et al. (Yoshinori, 2010) presented the chronological feature of CNTs under hydrogen atmosphere. Tessonnier (Tessonnier & Su, 2011) revealed the growth and nucleation process during production. Journet et al. (Journet et al., 2012) explained medium and low-temperature routes to synthesized CNTs. In this literature, the growth mechanism of CNTs formation has been extensively explained.

2. SYNTHESIZED TECHNIQUE, PARAMETERS AND THEIR EFFECTS ON YIELD

2.1 Arc Discharge Setup

The arc discharge is an old technique to generate plasma using electric current, firstly it was used for the production of CNTs by Iijima. A model of the arc discharge chamber is presented in Figure 1. It consisted of two electrodes, anode and cathode having positive or negative charges respectively. The anode was filled-up with the precursor of carbon and catalyst, the cathode electrode was typically a graphite rod and the chamber was usually filled with a gas. An intermediate gap of 1 mm to 2 mm was maintained to generate arc discharge between the electrodes whenever a power supply of alternating or direct current (AC, DC) was applied. For a steady arc discharge, a uniform supply of current was maintained which was supportive