

## **Dedication**

This research work is dedicated to:

My parents, brothers and sisters

My teachers

My friends

## **Acknowledgments**

First and foremost I would like to send my great gratitude and thanks to my supervisors Dr. Khaled Mohamed Haroun, and Prof. Dr. Mubarak Dirar Abdalla in the Physics Department, Faculty of Science, University of Science and Technology (Sustech) who were generous with time and provided much needed advices, encouragements, and direction. I would like to acknowledge the contribution of Assoc. Prof. Dr. Numan Salah of King Abdul-Aziz University who kindly sent and given us the permission to use the original image samples I have been produced using low pressure chemical vapour deposition LPCVD and scanning electron microscope SEM techniques at Centre of Nanotechnology, KAU. Also I would like to acknowledge all the friends at Faculty of Science, University of Sudan.

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## مستخلص البحث

في هذا البحث تم استخدام جهاز الترسيب بواسطة الأبخرة الكيميائية ذو الضغط المنخفض لتكوين أنابيب الكربون النانوية. استخدمت ستة عشر عينة من الحديد والكوبالت النانوية وتم تغيير تدفق معدل غاز الأستالين (10' 20' 30' و40 سنتيمتر مكعب لكل دقيقة) ومعدل درجات الحرارة (450' 650' 850' و950 درجة مئوية). وقد حللت النتائج بواسطة جهاز المجهر الإلكتروني. وقد تبين أن أفضل صنع لأنابيب الكربون النانوية تمت عندما كان معدل الأستالين 20 سنتيمتر مكعب لكل دقيقة وعند درجات الحرارة 950 درجة مئوية للحديد و650 درجة مئوية للكوبالت. وكذلك تم إيجاد قطر أنابيب الكربون النانوية بواسطة جهاز المجهر الإلكتروني بين 2 نانومتر الي 3 نانومتر بالنسبة للحديد و 2 نانومتر الي 3 نانومتر بالنسبة للكوبالت. ثم قورنت النتائج باستخدام طريقة التجزئة (الفراكتل). حيث بينت هذه الطريقة أن القطر يتراوح بين 1.62 نانومتر و1.8 نانومتر للحديد و1.62 نانومترو1.8 نانومتر للكوبالت. وهذا التشابه بين قيم المجهر الإلكتروني وقيم التجزئة تؤكد صحة النتائج.

## **Abstract**

In this research, low pressure chemical vapor deposition system(LPCVD) was used to produced carbon nanotubes. It has been used for sixteen samples of iron Fe and cobalt Co according to acetylene C<sub>2</sub>H<sub>2</sub> rates change of (10, 20, 30, and 40sccm) and with temperature rates varied of (450°C, 650°C, 850°C, and 950°C) respectively. The morphology was studied by using scanning electron microscope (SEM).

It has been found carbon nanotubes CNTs was produced when acetylene rates was 20sccm at 950°C for iron and 650°C for cobalt. Also; it was found that the diameter of the tubes were 2~3 nm by using scanning electron microscope for both Fe and Co. The result obtained was compared with fractal analysis where the diameter ranges from 1.62 nm to 1.8 nm for both Fe and Co. This conformity between the ranges confirms the reality of the results.

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## List of Notation and Abbreviation

LPCVD	Low Pressure Chemical Vapor Deposition System
SEM	Scanning Electron Microscope
SCCM	Standard Cubic Centimeter per Minutes
CNTs	Carbon Nano-tubes
SWCNTs	Single Wall Carbon nanotubes
MWCNTs	Multi Wall Carbon nanotubes
SAXS	Small Angle X-ray Scattering
CRT	Cathode Ray Tube.
Fe	Iron
Co	Cobalt
MF	Magnification Factor
NSP	Number of Self-Similar
D	Dimension
N ( $\epsilon$ )	Number of Box.
E	Number of Length
BWs	Band Widths
<b>Units</b>	
Å	Angstrom = $10^{-10}$ m
Nm	Nanometer = $10^{-9}$ m
$\mu\text{m}$	Micrometer = $10^{-6}$ m