# CHAPTER I
# INTRODUCTION

## 1.1 Introduction

As the concern grows over fossil usage, in terms of global warming from combustion and resource depletion, there will be a progress swing to renewable energy. This will necessitate the development of improved methods for storing electricity. Electrochemical energy production is under serious consideration as an alternative energy and power source, as long as this energy consumption is designed to be more sustainable and more environmentally friendly. Systems for electrochemical energy storage and conversion include fuel cells, batteries and capacitors. Although the energy storage and conversion mechanism are different, there are electrochemical similarities of these three systems. Common features are that the energy-providing processes take place at the phase boundary of the electrode/electrolyte interface and that electron and ion transport are separated. At the present, batteries have been found the most application market due to their usefulness in widely applications. The storage of electrochemical energy in battery, chemical inter-conversions of the electrode materials occur usually with concomitant phase changes. Even though the overall energy changes can be conducted in a relatively reversible thermodynamic route, the charge and discharge processes in a storage battery often involve irreversibility in inter-conversions of the chemical electrode-reagents. Accordingly, the cycle life of storage batteries is usually limited. On the contrary, traditional capacitors have an almost unlimited recyclability, that typically between $10^5$–$10^6$ times. But traditional capacitors can store only a very small amount of charge unless they are large. As a result, traditional capacitors have a substantially low energy density. However, charged capacitor electrode/solution interfaces contain double layers that have capacitance of 16-50 $\mu F.cm^{-2}$, and with the sufficient surface area of electrode is realized with the large surface area (1,000-2,000 $m^2/g$). In this case, the large surface area is the important factor in achieving the high capacitance. Carbon in general and especially, carbon nanotubes (CNTs) form an attractive material as they have a large active area determining the capacitive performance. Moreover, they are relatively cheap, low density, friendly environmental and highly polarisable materials. The practical realization of CNTs properties has led to the development of a new type of capacitors termed as electrochemical capacitors (ECs) or supercapacitors. At the present, these capacitors are progressing as energy devices to complement the storage batteries. Importantly, ECs are used as energy storage devices for lasers, camera flash equipment and as back up power sources for computer memory.

This work focuses on the synthesis and preparation of nanocrystalline composites for ECs by chemical reduction of metal salts and functionalized multi-walled naonotubes (MWNTs). The structure, and morphology of MWNTs and these composite electrodes were studied. Moreover, the electrochemical capacitances of various nanocrystalline metal oxides on functionalized MWNTs were also studied.

## 1.2 Research Objectives

1. To synthesize nanocrystalline metal oxides/MWNTs composites, which provide the effective capability, for use as electrochemical capacitors.
2. To study morphological characteristic and electrochemical property of the synthesized composites.

## 1.3 Scope of Research

To achieve the research objectives, the following scope was set:

1. To prepare and synthesize various composite materials in many ratios: $TiO_2$/MWNTs, FeO/MWNTs, NiO/MWNTs, FeO-$TiO_2$/MWNTs and NiO-$TiO_2$/MWNTs.
2. To study structural and morphological characteristics of as received MWNTs, functionalized MWNTs and the synthesized composite materials by fourier transform infrared spectrophotometer (FTIR), x-ray diffraction (XRD), scanning electron microscopy (SEM) and transmission electron microscopy (TEM), respectively.

3. To study electrochemical capacitance of functionalized MWNTs electrode and the synthesized composite electrodes by cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and galvanostatic, respectively.