Removal of Chromium With CNT Coated Activated Carbon for Waste Water Treatment

Nassereldeen A Kabbashi, International Islamic University Malaysia, Kuala Lumpur, Malaysia
Abdurahman H Nour, University of Malaysia Pahang, Pekan, Pahang, Malaysia
Ma'an Al-Khatib and Md Abdul Maleque, International Islamic University of Malaysia, Kuala Lumpur, Malaysia

Introduction

Since the discovery of carbon nanotubes by Ijama in 1991, a researcher with the Nippon Electric Company (NEC) Laboratory in Tsukuba, Japan (Zhao *et al.*, 2006) has been in the focus of material research due to their unique electronic and mechanical properties in combination with the chemical stability. Carbon nanotubes (CNTs) are nanostructures resulting from revolved graphene planes and have a range of attractive chemical and physical properties. CNTs exist as single (SWNTs), and multi-walled (MWNTs) structures. CNTs theoretically is well known of its high electrical conductivity, very high tensile strength, highly flexibility where it can be bent considerably without damage, very elastic ~18% elongation to failure, high thermal conductivity, low thermal expansion coefficient, good field emission of electrons and high aspect ratio (length to diameter ratio more than 1,000,000) (Dresselhaus *et al.*, 2000; AzoNano, 2005; Danafar *et al.*, 2009).

Hexavalent chromium (Cr^{6+}) is far more mobile than the trivalent (Cr^{3+}) chromium (Selvi *et al.*, 2001). Increased concentrations of these elements in environment prove to be toxic. The main route of chromium excretion in human body is via kidneys into urine, and via bile duct into feces. Irrespective of the manner of intake, Cr^{3+} is absorbed too a far lesser degree than Cr^{6+}. Furthermore, Cr^{6+} is highly toxic when entering through dermal contact and through respiratory tract, respectively. The hexavalent chromium Cr(VI) poses a threat as a hazardous metal and its removal from aquatic environments through biosorption has gained attention as a viable technology of bioremediation (Al-Homaidan *et al.*, 2018).

Conventional methods have been found to be ineffective, particularly when the metal concentrations have been in the range of 1–10 mg/L. In addition, these techniques produce immense quantities of chemicals. They are also not cheap and impractical to be used widely in low income countries. This study has been emphasized on the application of carbon nanotubes coated by activated carbon (AC) for chromium Cr(VI) removal from the wastewater. The significance of this study is to have a better understanding in the applications of carbon nanotubes in preserving the environment and also to hold paramount the safety, health and welfare of the society. Furthermore, this study was conducted in order to determine the optimization of the purification process of the aqueous wastewater treatment.

Malaysia is rich in water resources, receiving an annual average of 990 billion m^3, of which 360 billion m^3 or 36 % returns to the atmosphere as evapo-transpiration, while 566 billion m^3 or 57% appears as surface runoff and the remaining 64 billion m^3, or 7% goes to recharge groundwater. However, an overall water demand is growing at a rate of 4% annually, and is projected to be about 20 billion m^3 by 2020 (Abdullah, 1999). Quantitatively, this is less than 4% of annual runoff, but due to the variation in rainfall, some regions of high water demand are approaching the limits of readily available water and water stress has become more prevalent over the past few years, culminating in the water crisis affecting some parts of the country in early 1998. In the year 2004, Department of Environment Malaysia (DOE) has recorded 17,991 water pollution point sources in Malaysia comprising mainly sewage treatment plants (8414: 54%), manufacturing industries (8203: 38%), animal farms (904: 5%) and agro-based industries (470: 3%) (Seo *et al.*, 2003).

Furthermore, common pollutants generated by industrial activities are heavy or trace metals such as mercury, arsenic, cadmium, chromium, lead, zinc and copper. Therefore, states with high industrial development (Pulau Pinang, Johor and Perak) have high levels of heavy metal (lead and mercury) contamination (Department of Environment, 2004). The usual concentration of chromium in wastewater in Malaysia is between the ranges of 0.2–0.5 mg/l (Abdullah, 1999). There are several methods which can be used for removal of chromium from wastewater include reduction, precipitation, ion exchange and solvent extraction. However, all of these treatments are said to be high in cost and low feasibility for small scale industries. Therefore, these treatments are not widely practiced. Another method is activated carbon (AC) for the removal of heavy metals from wastewater which is more efficient and widely used technique.

Production of Carbon Nanotubes and its Coating

The production of carbon nanotubes is conducted in two horizontal tubular reactors. The horizontal reactors are a quartz tube of 50 mm in diameter and 1200 mm in length and heated by silicon carbide heating element. The catalyst was fixed at the first reaction chamber while the second reaction chamber was used for the reaction and growth processes. Two types of gases used in this system are hydrogen as a reacting gas and the argon for flushing the air from the system, and both of them were controlled by a flow meter (Chen *et al.*, 2006).

CNT Coated Activated Carbon

For the growth of carbon materials on the surface of the AC, an impregnation process was conducted first. The function of impregnation is to fix the catalyst on the activated carbon at nanoscale level which is then known as nanocatalyst. The method

 doi:10.1016/B978-0-12-803581-8.10785-4