UNIVERSITI TEKNOLOGI MARA

CONTROLLED GROWTH OF VERTICALLY ALIGNED CARBON NANOTUBES FROM PALM OIL PRECURSOR USING THERMAL CHEMICAL VAPOUR DEPOSITION METHOD AND ITS FIELD ELECTRON EMISSION PROPERTIES

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Thesis submitted in fulfillment of the requirements
for the degree of
Doctor of Philosophy

Faculty of Applied Sciences

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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and agree to be subjected to the disciplinary rules and regulations of Universiti Teknologi MARA.

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Abstract

Vertically aligned carbon nanotubes (VACNT) were synthesized using palm oil as an environmentally friendly starting material. The synthesis was carried out in a thermal chemical vapour deposition reactor. Parametric studies were done to determine the optimum parameters to obtain VACNT with favourable properties at high volume. The parameters included seeded and floated catalyst preparation method, stacking substrate configuration (lower and upper growth), synthesis temperature (700-900°C), palm oil vaporization temperature (300-600°C), synthesis time (5-90 min), different carbon precursor (palm oil and waste cooking palm oil), substrate positioning (position 1-6), ferrocene concentration (0.67-5.33 wt%) and different carrier gas (argon and nitrogen). The carbon nanotubes (CNT) products were then characterized using several analytical techniques which were electron microscopy, energy dispersive x-ray analysis, micro-Raman and Fourier transform infrared (FTIR) spectroscopy, thermogravimetry analysis (TGA) and CHNS-O analysis. Prior to the synthesis process, several analyses such as TGA, gas chromatography–mass spectrometry and FTIR characterizations were done on the carbon precursor namely palm oil and waste cooking palm oil in order to facilitate the optimization procedures of VACNT. For every synthesis parameter, the nanotubes growth rates were measured and the nucleation as well as termination factor were investigated. CNT diameter, degree of alignment, crystallinity and purity were extensively studied as they were found to be greatly affected by the synthesis parameters. Based on the inspection of the morphology and crystallinity of CNT it was found that the following parameters can be considered as the optimized parameter to produce higher quality of bulk VACNT in our reactor; the floated catalyst and lower growth approach at the synthesis temperature in range of 750-800°C, precursor vaporization temperature in the range of 400-500°C, the synthesis temperature of 15 to 35 mins, sample position at P2 and P3, and ferrocene concentration of 1.33 - 5.33 wt%. Synthesizing VACNT within nitrogen ambient produces higher VACNT growth rate with considerably more bamboo-liked structure as compared to argon ambient. In this study, we have also demonstrated that waste cooking palm oil from domestic

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