CHAPTER V
CONCLUSIONS

Multiwall carbon nanotubes (MWCNTs) have been noncovalently modified with chitosan having different %*DD* (61%, 71%, 78%, 84%, 90% and 93%). Using chitosan having different %*DD* had a strong effect on the dispersion efficiency of the nanotubes. UV–Visible spectroscopy results suggest that the nanotubes dispersion was improved when using chitosan with a lower degree of deacetylation (61%*DD*) when compared with higher degree of deacetylation (93%*DD*). The MWCNT modified with the lower %*DD* also displayed the best stability against centrifugation. Zeta potential measurements finally confirmed that the amount of chitosan adsorbed onto the nanotubes surface was twice as high with the lower %*DD* as with the high %*DD*. These modified MWCNTs with chitosan biopolymer could be used to immobilize hydrophobic and hydrophilic drug for drug delivery application.

Molecular dynamic simulation was used as a complementary tool to predict the sedimentation and stability of modified singlewall carbon nanotube (SWCNT) with 60%*DD* chitosan in three pair species: a pristine-a pristine SWCNT, a pristine SWCNT-wrapped SWCNT with chitosan, and a wrapped SWCNT with chitosan- wrapped SWCNT with chitosan. The behavior of modified SWCNT with 60%*DD* chitosan in aqueous solution; in term of both sedimentation and stability, can be successfully proved. Two pristine carbon nanotubes were aggregated in the solution because of van der Waals force between intertubes which is confirmed by the closer distance in equilibrium. Nitrogen atoms on acetyl groups of N-acetyl-D-glucosamine units were located near the carbon atoms on nanotubes surface while nitrogen atoms on ammonium groups of D-glucosamine units were far away from the nanotube surface. These theoretical results support the previous experimental work which is noncovalently modified MWCNTs with chitosan having different %*DD* in the fact that the hydrophobic acetyl parts of chitosan favored to attach on the nanotube surface while the hydrophilic ammonium parts provided nanotubes stabilize in the solution by repulsive force to each others. Although the monolayer coating MWCNTs with low %*DD* chitosan was successful, their stability was inadequate to prepare as a drug carrier.

By carefully controlling the concentration of polyelectrolytes in solution, the layer-by-layer deposition of polyelectrolytes multilayers on MWCNT is simplified and do not requires the tedious centrifugation-sonication steps. Since the sufficient amount of PDADMAC and PSS were deposited on treated carbon nanotubes surface as a primary, secondary and tertiary layer, the modified MWCNT can then be prepared in large scale. The adsorption of the polyelectrolytes for each layer was monitored by turbidity measurement with a UV-Vis spectrophotometer and zeta potential. Using TEM imaging, the thickness of the three layers coating on the MWCNT was measured to be 13.4 nm which suggest the formation of loose polyelectrolyte network onto the MWCNT surface. This simple method can be used to coat large scales of MWCNT solutions for drug delivery applications.

With different charged type of functional groups on MWCNTs, the hydrophilic model drugs such as gentian violet and diclofenac were used to load on modified MWCNTs. Gentian violet was successfully loaded on negatively charged surface of MWCNTs while the diclofenac can not be achieved to load in any type of modified MWCNTs. The cytotoxicity of modified MWCNT with different functional groups was evaluated with L929 fibroblast cells by MTT assay. Treated MWCNTs were toxic to L929 cells when the concentration reached 25 μg/ml while primary coating MWCNTs with PDADMAC was toxic at concentration 12.5 μg/ml.