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Atomic Force Microscopy Study of the Electrical Properties of Protein-Gold Nanoparticle Hybrids

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Dedication

This thesis is dedicated to my wonderful parents, Ibrahim and Maryam, who have raised me to be the person I am today. They have been with me every step of the way, through good times and bad. Thank you for all the unconditional love, guidance, and support that you have always given me, helping me to succeed and instilling in me the confidence that I am capable of doing anything I put my mind to. Thank you for everything. I love you!

Also I want to dedicate this thesis to my fiancé Anas for his love, patience, and his unending support along the way.

Mai Ibrahim Khalil Al-Maghalseh

Declaration:

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed: 

Mai Ibrahim Khalil Al-Maghalseh

Date: 6 / 9 / 2009

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Abstract

In the last decade, molecular nanoelectronics gained a growing attention in the field of electronic devices because of the need to have new devices with characteristics that overlap the limitations and disadvantages of the existed devices fabricated with common methods. In order to achieve building electronic devices using biological molecules it will be necessary to measure, control and understand the electron transport through these molecules. The purpose of this research was to study the morphological characteristics of a ring shaped like protein named stable protein 1 (SP1), and a building block that consists of gold nanoparticles (GNP) embedded in the central cavity of the SP1 protein. The morphological characteristics was studied on different four substrates which are mica, silicon, gold, and HOPG using Atomic Force Microscopy with its two modes; tapping and contact. Another aim of this research was to study the electrical characteristics of the SP1 and the building block (SP1-GNP) by performing direct electrical measurements for these molecules on HOPG substrate using conductive Atomic Force Microscopy measurement technique.

AFM results revealed that the average heights of SP1 molecules on mica and silicon were 2.4 ± 0.3 and 2.2 ± 0.2 nm respectively, while on gold and silicon SP1 monolayer was formed with average height equal to 2 ± 0.1 nm. For SP1-GNP molecules their average heights were found to be 3.7 ± 0.4 nm and 3.3 ± 0.1 nm on mica and silicon respectively, but on gold and HOPG substrates a monolayer of SP1-GNP molecules was formed with average height of 4 ± 0.2 nm above both substrates. The results of the direct electrical measurements showed an insulating current-voltage curves with different voltage ranges for both SP1 and SP1-GNP molecules when force-distance mode was performed with small load (Normal Force). The current-voltage curves performed with high load (N.F) showed a semiconductor behavior for SP1 molecules and an ohmic behavior for SP1-GNP molecules.

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Abbreviations

STM	Scanning Tunneling Microscopy
SPM	Scanning Probe Microscopes
AFM	Atomic Force Microscopy
DNA	Deoxyribonucleic Acid
NP	Nanoparticle
GNP	Gold Nanoparticle
SP1	Stable Protein One
EFM	Electrostatic Force Microscopy
His	Histidine
Cys	Cystein
HOPG	Hydrophobic Highly Oriented Pyrolytic Graphite
PSD	Position Sensitive Detector
DSP	Digital Signal Processing
VDW	Van der Waals
F-d	Force versus Distance
JIC	Jump In (To) Contact or “Snap-In” Point
C-AFM	Conductive AFM
I-V	Current- Voltage
KDa	Kilodalton
N.F	Normal Force
T.D.W	Triple Distilled Water