Measurement of Single Molecular Conductance by "Point Contact Method" with Scanning Tunnelling Microscopy

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Precise measurement of single molecule conductivity has been one of the major focuses in molecular electronics. To realize the single-molecule-conductivity measurement, reliable fabrication of single molecular junction, in which a molecule is chemically connected with two electrodes to reduce contact resistance, has been the key point in recent research. Here, we propose a new reliable fabrication method of single molecular junction to form a low contact resistance by the combination of scanning tunnelling microscopy (STM) with self–assembled monolayer (SAM) technique. As a demonstration, we measured the conductance of α, ω-bisacetylthio-terthiophene (3TS2) molecule, which has thiol groups at both ends. By immersion of a Au(111) substrate into mixed solution containing 3TS2 and Octanethiol (C8) molecules, a C8 film, in which isolated 3TSe molecules were embedded, was formed as shown Fig.1(a). For STM observation, we first placed a Au STM tip over a single 3TS2 molecule, and subsequently the tip was brought contact with the molecule. Since the thiol group of 3TS2 molecule is exposed toward the STM tip, a single molecular junction can be formed, by the chemical connection of the thiol group with the Au tip (Fig. 1(b)). After the connection being formed, I-V measurement was performed several times to measure the conductance. All measurements were performed under UHV condition at room temperature. Figures. 2(a) and 2(b) show the I-Z curves obtained on C8 and 3TS2 molecules, respectively. Tunnelling current increased exponentially when the STM tip was approached to the C8 film area, in contrast, abrupt jump in tunnelling current was observed in the case of a single 3TS2 molecule. It is strongly suggested that the observed current jump in the case of 3TS2 molecule is caused by the formation of a Au tip-S chemical bonding which provides a single molecular junction. It was also found that the current observed for a 3TS2 molecule was insensitive to further approach of the STM tip, about 0.2nm after the formation of the single molecular junction, as shown in Fig.2 (b), indicating that the change of tip-molecule distance had little influence on the conductivity measurement. Conductance histogram calculated from I-V curve measurements is shown in Fig.2(c), where one obvious peak is shown at 496 ± 256 nS, which is the value derived from single 3TS2 molecules. Since we can directly fabricate a single molecular junction with confirmation of the target molecule by STM, we believe that our "point contact method" is the reliable and desired method to realize the measurement of single molecular conductance.

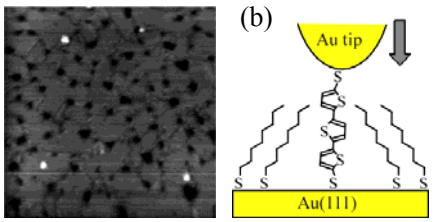

Fig. 1. (a) STM image of isolated 3TS2 molecules (bright spots) embedded in a C8 film (75nm×75nm). (b) Schematic of the "point contact method" by STM.

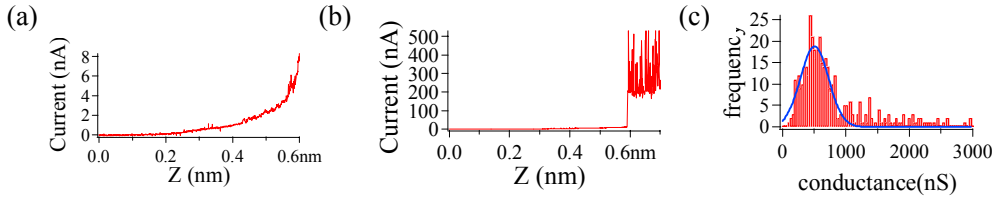

Fig. 3. I-Z curves obtained for (a) C8 and (b) 3TS2 molecules, respectively. (c) Histogram of conductance from the ohmic region (±0.1V) of I-V curves obtained for 3TS2 molecules.