Characterisation on Spontaneous Redox-state Transition Property of Phosphomolybdic Acid Molecule Functionalised on Carbon Nanotube

Osaka Univ. [1], ◦(M2C) Kian-Lian Goh[1], (PC) Yuji Kuwahara[1], (PC) Megumi Akai-Kasaya[1]

E-mail: kasaya@prec.eng.osaka-u.ac.jp

Polyoxometalate (POM) is molecule that displays various properties such as multi-redox, luminescence, catalysis, and magnetism.[1)] Due to these remarkable properties, development of super-capacitor, flash-type memory cell, solar cell, light-emitting device, and water oxidation system using POM has been made possible.[2)] Furthermore, certain types of POM have been reported to have anti-tumor and anti-HIV effect.[3,4)] Among various POM, we set our target on phosphomolybdic acid (hereinafter PMo_{12}) that has shown to display 24-electron multi-redox property.[1)] Due to this exceptionally high electron storing ability, PMo_{12} has been implemented as high-capacity cathode material in molecular cluster battery.[1)] Our research group has also previously reported the generation of unique random telegraph signal (RTS) due to the redox state fluctuation of a single PMo_{12} molecule adsorbed to the sidewall of carbon nanotube (CNT).[5)] Despite these interesting discoveries, the charge transfer process through PMo_{12} molecule has not been examined comprehensively. Motivated by the discovery of 24-electron multi-redox property in PMo_{12}, we created a system that is made up of CNT/PMo_{12} device in order to study the charge transfer process through PMo_{12}. A.C. dielectrophoresis technique was applied to position few CNTs across 1μm-gapped electrodes. This device was then soaked in PMo_{12} solution to allow the formation of "PMo_{12} junction" between CNT and electrode, as illustrated in Fig. 1. When DC bias of few tens of millivolt was applied to this CNT/PMo_{12} device, we observed output current response with spontaneous transition between "OFF state" at nearly 0 A and "ON state" at certain maximum current range, accompanied by occasional appearance of intermediate states, as depicted in Fig. 2. This spontaneous switching in conductance is speculated to originate from the spontaneous redox-state transition of a single PMo_{12} junction, suggesting that the multi-redox property governs the charge transfer process through PMo_{12}. This newly discovered relationship deserves further analysis for the fundamental understanding and characterisation on the multi-redox property of PMo_{12}.

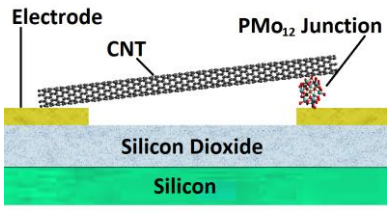

Fig. 1: Side-view of CNT/PMo_{12} device

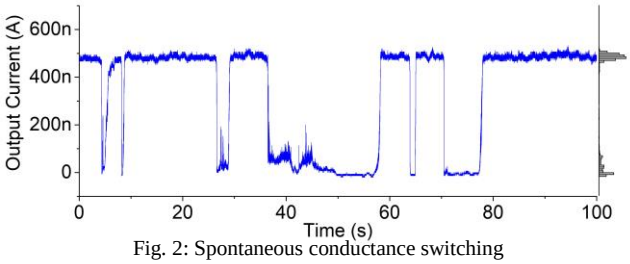

Fig. 2: Spontaneous conductance switching

References:

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