Large voltage generator from water movement by single-layer MoS_2

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Water conserve tremendous amount clean energy in its dynamic forms. Recently, the effort to directly extract energy from water motion is gaining large interest. Two-dimensional (2D) materials, such as graphene and transition metal dichalcogenides (TMDCs), are promising materials as energy harvester for this purpose due to their exceptional electrical properties and sensitivity to the environment. For instances, graphene is reported could harvest energy from the movement of a small water droplet.[1,2] However, the generated voltage using graphene-based system is usually small (millivolt order). Here, we demonstrated an alternative approach by employing single-layer MoS_2, another 2D materials, film to harvest the energy from liquid movement. We obtained a larger voltage over 5 V by using MoS_2 compared with graphene-based generator reported so far.

First, the large-area single-layer MoS_2 were synthesized by chemical vapor deposition (CVD) method using solid MoO_3 (5 mg) and S (200 mg) powder as the precursor. A c-plane sapphire was placed face down on top of MoO_3 precursor boat in the center of a furnace while the S powder was placed in the upstream. Then, the furnace was heated to the growth temperature (680 ºC), and a ribbon heater in the upstream was heated to 180 ºC to vaporize the sulfur. Finally, the synthesized MoS_2 was transferred onto flexible polyethylene naphthalate (PEN) substrate with polystyrene film as a support (Fig. 1a).

Figures 1a,b show photograph of the device and schematic view of the experimental setup of voltage generation by liquid movement. The voltage can be generated from liquid movement either by dragging 1M aqueous NaCl on MoS_2 film with motor stage or by dropping liquid onto MoS_2 film to mimic raindrops. The generated voltage of ~5.9 V was obtained by dropping 50 µL of liquids (green shaded area in Fig. 1c). When the device was inclined at 45º, the liquid moved on MoS_2 film hydrophobicity of MoS_2. Finally, the output power of 1.75 nW could be harvested by connecting to load resistors (Fig. 1d).

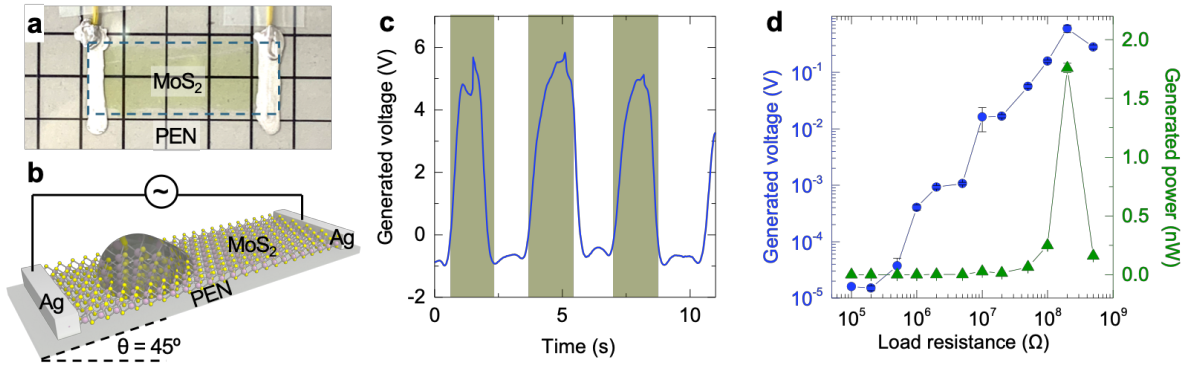

Figure 1. (**a**) Photograph and (**b**) schematic views of the device. (**c**) Generated voltages harvested by dropping 50 µL of 1M NaCl droplets. (**d**) Output voltage and power as a function of external load resistance.

Reference:
[1] J. Yin *et al*., *Nat. Nanotechnol.***9**, 378 (2014). [2] S. Kwak *et al.*, *ACS Nano* **10**, 7297 (2016)

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