Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

A special designed Li-H_2O_2 semi-fuel cell: a potential choice for electric vehicle propulsion

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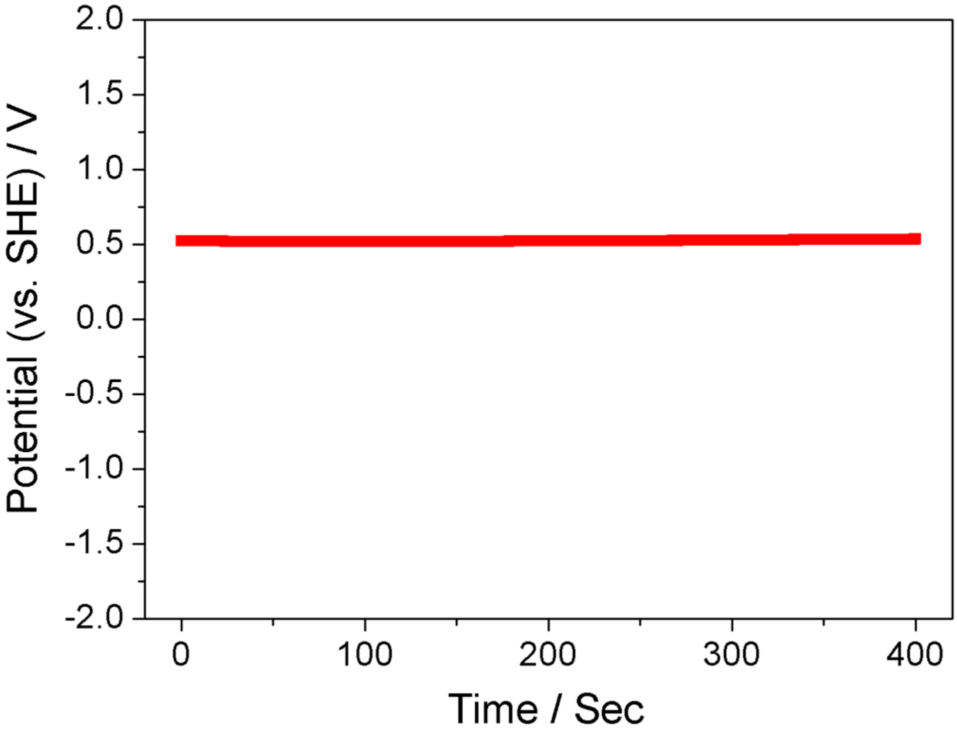

Figure S1. Open circuit potential (OCP) curves for cathode (H_2O_2). It can be detected from figure S1 that the observed OCP of cathode was about 0.50~0.54 V, which is much lower than 1.78 V given by equation 2.

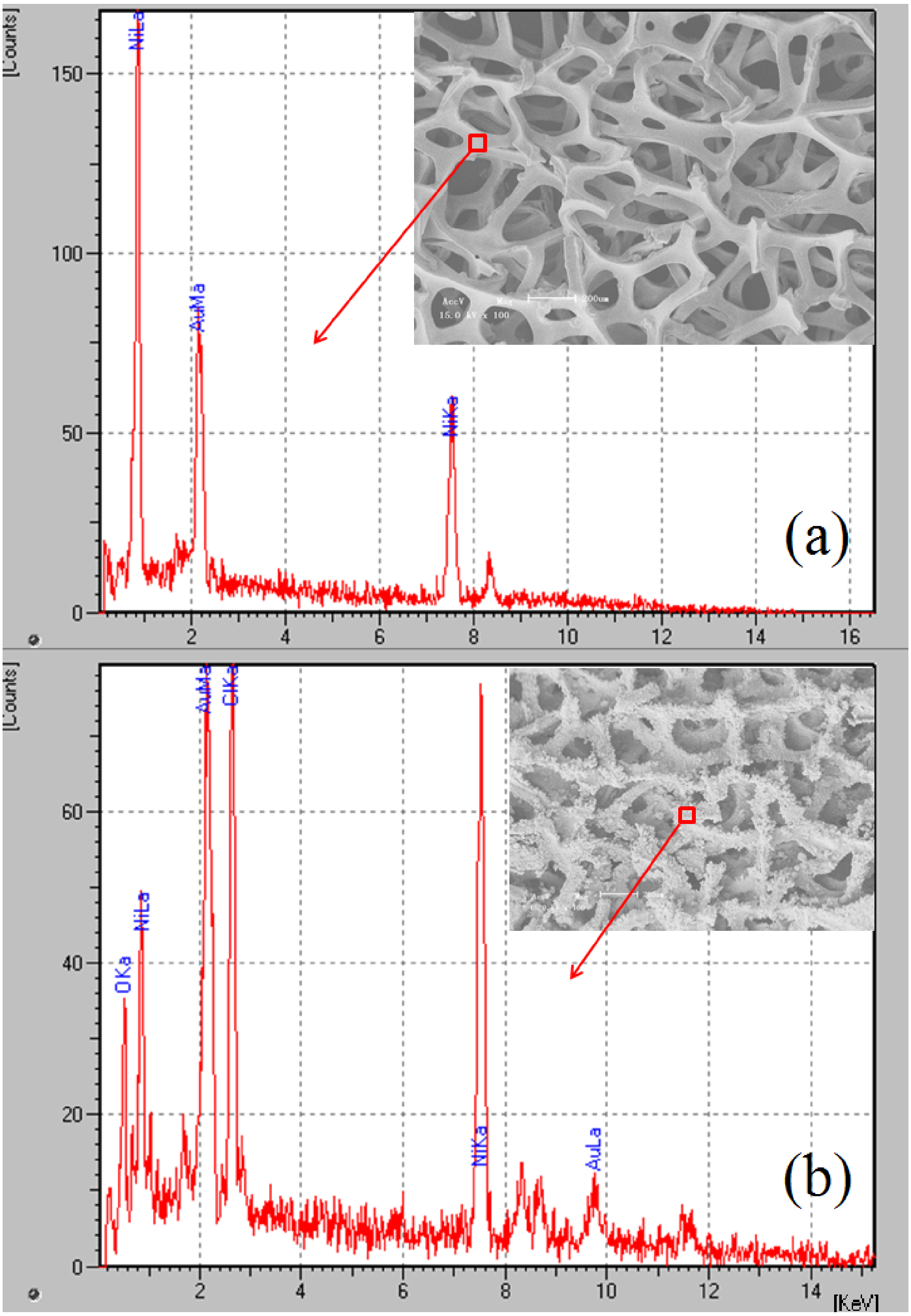

Figure S2. EDS results and SEM images of Ni foam. (a) pristine; (b) used in Li-H_2O_2 semi-fuel cell for 30 days. Ni foams had been thoroughly washed with deionized water before test. Au element came from the spraying process during SEM sample preparations.

Dimensions of the Ni foam sheet used are 1 cm×1 cm×0.5 mm. Pores Per Linear Inch (PPI) of the Ni foam is 110. A single Ni foam sheet was used in the cell. Areal density of the Ni foam is 300 ± 20 g/m^2. Surface of the pristine Ni foam was clean and smooth, on which only Ni element was detected. Surface for the Ni foam used in the cell for 30 days was very rough, and Ni, O and Cl elements were detected. The results indicated that Ni foam immersed in the catholyte (H_2O_2 and LiCl solution) had been corroded.

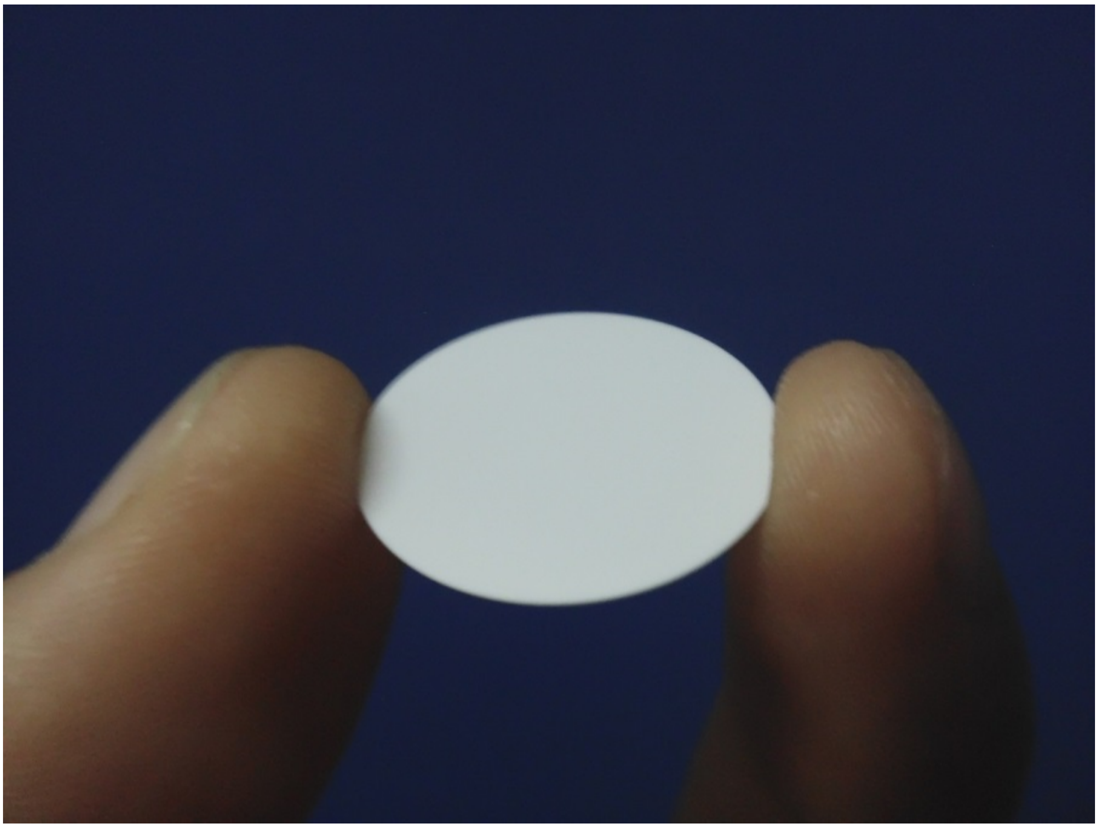

Figure S3. A picture of the commercial LTAP pellet.

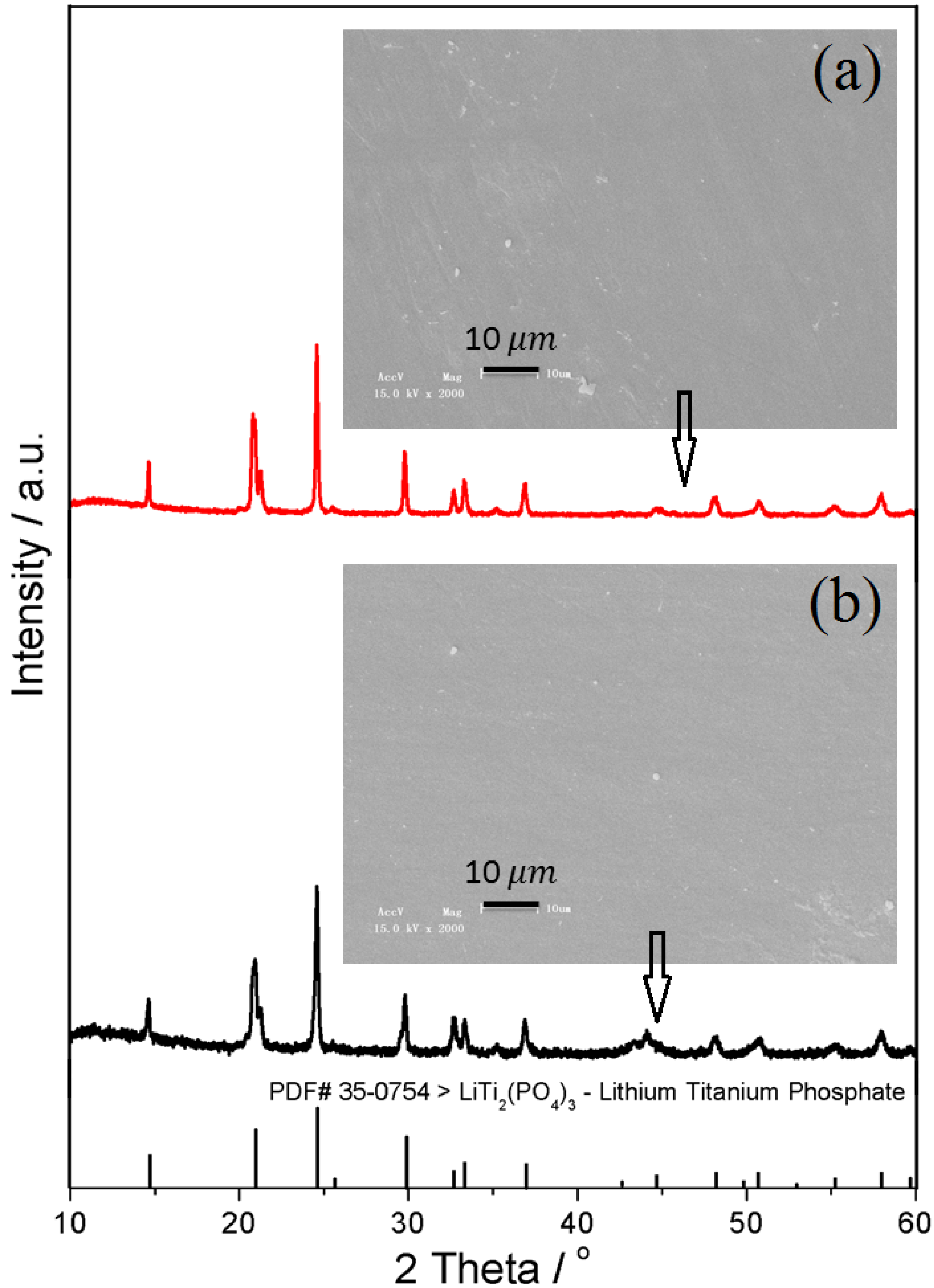

Figure S4. XRD results and SEM images of the LTAP pellets. (a) pristine; (b) used in Li-H_2O_2 semi-fuel cell for 34 days.

The solid lithium ion conductor, $Li_{1+x+y}Al_x(Ti,Ge)_{2-x}Si_yP_{3-y}O_{12}$ (LTAP), was purchased from Ohara Inc., Japan, it was a single phase with $LiTi_2(PO_4)_3$-type structure. The thickness and diameter of the LTAP pellet was ca. 0.15 mm and 15 mm, respectively. The ionic conductivity of the LTAP pellet was ca. $1 \times 10^{-4}\ S \cdot cm^{-1}$.

There was no significant difference between the LTAP pellets before and after use. The results indicated that LTAP pellet was stable in the catholyte.

Derivation from Nernst equation to equation (6):

The relationship between OCV and H_2O_2 concentration can be well explained. According to Nernst equation, the electromotive force of Li-H_2O_2 semi-fuel cell with a cell reaction of $2Li+H_2O_2+2H^+ \rightarrow 2Li^++2H_2O$ is:

$$E = E^{\circ} - \frac{RT}{2F} ln \frac{a_{Li^+}^2 \cdot a_{H_2O}}{a_{H^+}^2 \cdot a_{H_2O_2} \cdot a_{Li}^2} \qquad (S1)$$

where E° (standard electromotive force), R (gas constant), F (Faraday constant) and T (temperature) are constants, and activities of Li, Li^+, H_2O and H^+ can be treated as constants. Equation (S1) is simplified to equation (S2) where the activity of H_2O_2 is replaced by concentration approximately:

$$E=A+B\cdot lnc(H_2O_2) \qquad (S2)$$

where A and B are constants. OCV is usually lower than electromotive force, and the better reversibility of the electrode, the smaller gap between OCV and electromotive force. It's reasonable to suggest a relationship like equation (S2) between OCV and H_2O_2 concentration:

$$OCV=A'+B'\cdot lnc(H_2O_2) \qquad (S3)$$

where A' and B' are constants.

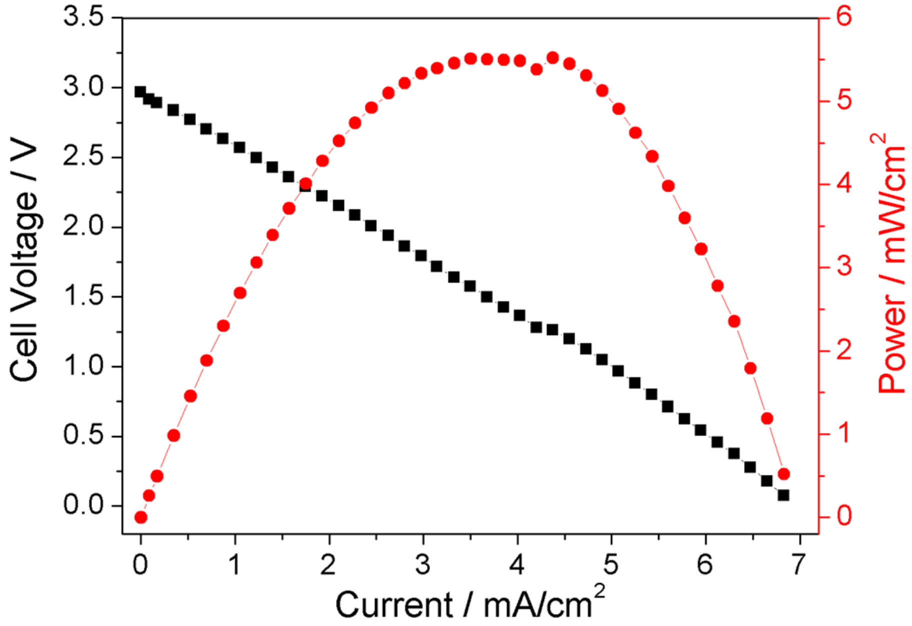

Figure S5. Polarization curve of the Li-H_2O_2 semi-fuel cell. Anolyte: 1.0 M $LiPF_6$ in EC-DEC (1:1 by volume). Catholyte: 0.1 M H_2O_2 + 2 M LiCl. Flow rate: 10 mL/min; Operation temperature: 25 °C.

It can be seen that the OCV was about 3.0 V, and at a current density of 6.9 mA/cm^2, the operating voltage reduced to 0.01 V. At a current density of 4.4 mA/cm^2, the cell reached its maximum power density of 5.5 mW/cm^2.

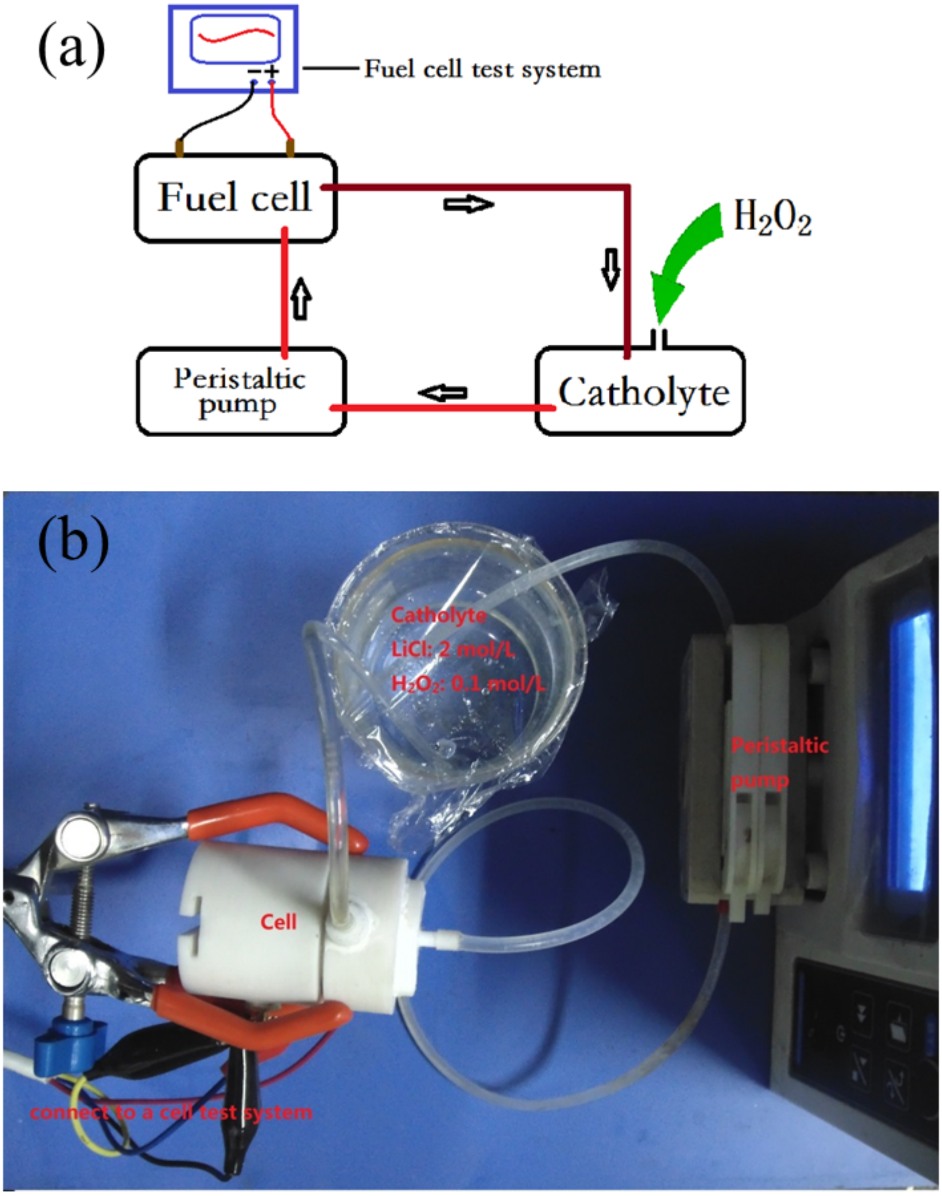

Figure S6. Schematic diagram (a) and picture (b) of Li-H_2O_2 semi-fuel cell test set-up with recycling electrolyte. The data was recorded by a fuel cell test system (CT2001A 5V/10mA, from Wuhan LAND Electronics Co., Ltd.).