

Supporting Information

Facile electrochemical synthesis of titanium dioxide dendrites and its electrochemical properties

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Contents

1. Experimental

- A. Materials
- B. Preparation of titanium dioxide
- C. Characterization

2. Supplementary data

Experimental

Materials: Titanium chloride (20% in 3% hydrochloric acid, TiCl_3) was purchased from Alfa Aesar Co., USA. Potassium nitrate, sodium sulphate, and hydrochloric acid (37%) were purchased from Aldrich Chemical Co. Hydrogen peroxide (35 %), sulfuric acid (95 %), ethanol, and acetone were purchased from Samchun Chemical Co., Korea.

Preparation of Titanium Dioxide: Titanium dioxide films were cathodically deposited onto gold plate (1 cm^2) from 30 mM H_2O_2 , 30 mM TiCl_3 , and 75 mM KNO_3 aqueous solution in a three-cell system that consisted of platinum plate, gold plate, and Ag/AgCl (saturated with KCl) electrodes as a counter electrode, working electrode, and reference electrode, respectively. Distance between the working electrode and counter electrode was 0.5 cm. The pH of the solution was controlled by the addition of HCl. The Au plate was treated with sulfuric acid, acetone, and ethanol. The electrodeposition was carried out using two different modes (Figure S1): constant potential (CP) at -1.6 V for 100 min, pulse potential (PP) at -1.6 V, and 1.6 V with 0.5/1 sec interval time for 50 min in order to obtain a similar amount of coating mass, $\sim 1.2 \text{ mgcm}^{-2}$.

Characterizations: The morphology of the TiO_2 film was observed using a FE-SEM (JSM7000F, JEOL). Their chemical compositions and crystal structure were analyzed using XPS (ESCA2000, VG Microtech) and XRD (D8 Advance, Bruker), respectively. A QCM (QCM922, Seiko Japan) was used for the in-situ analysis of the weight increase of TiO_2 during electrodeposition.

A three-electrode cell system was used to evaluate the electrochemical properties using a potentiostat (VSP, Princeton Applied Research, USA). Tests were performed in a 0.5 M Na_2SO_4 aqueous solution, and a gold plate, a platinum plate, and an Ag/AgCl (saturated with KCl) electrode were used as a working electrode, counter electrode, and reference electrode, respectively. Cyclic voltammetry test was performed between 0 and 0.8 V. The specific capacitance (C in Fg^{-1}) was obtained from the following equation [1]:

$$C = I \cdot \Delta t / \Delta V \cdot m$$

where I is the current loaded (A); Δt is the time (s); ΔV is the potential change during the process; and m is the mass of active material in a single electrode (g). The areal capacitance (C in Fcm^{-2}) is calculated from area of electrode instead of loading mass.

Supplementary data

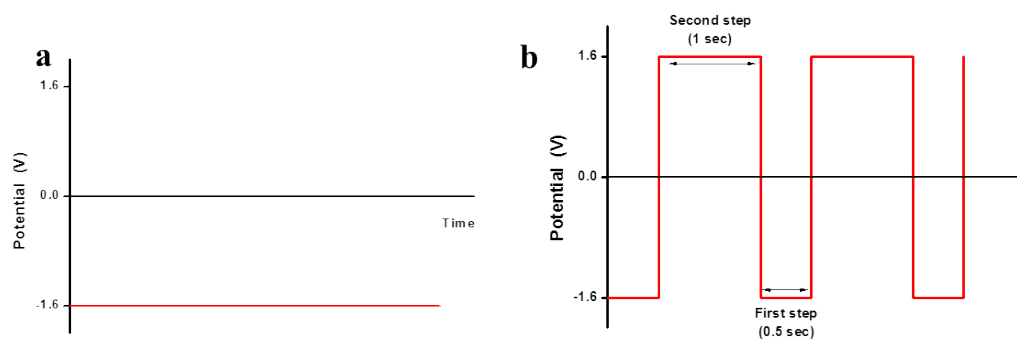


Figure S1. The patterns of applying potential; (a) constant potential (CP) at -1.6 V; (b) pulse potential (PP) at -1.6/1.6 V

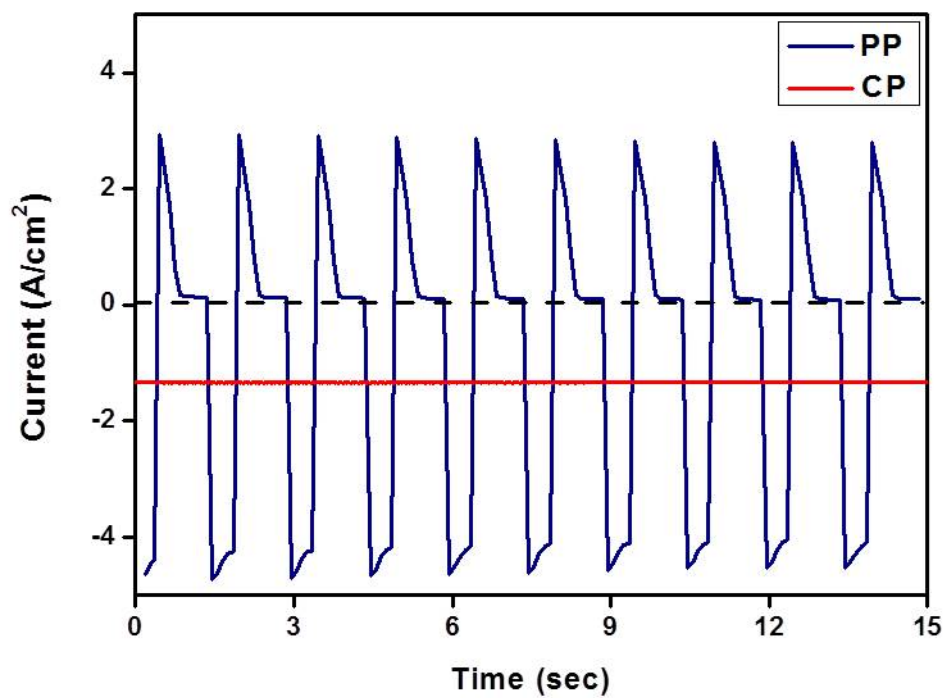


Figure S2. Current vs time graph during electrodeposition at PP mode and CP mode

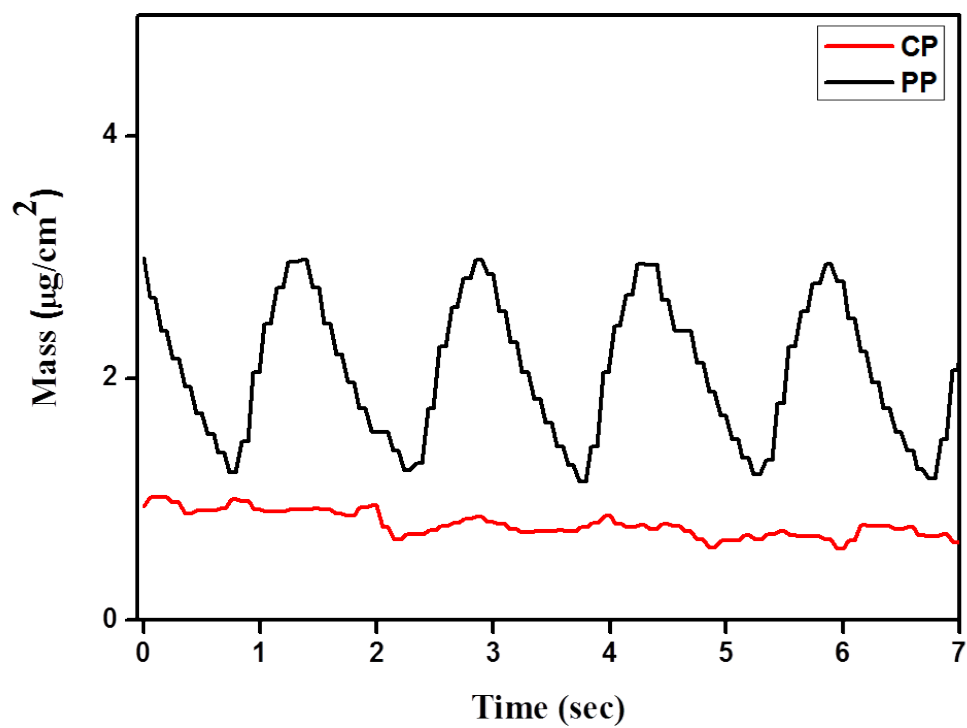


Figure S3. Weight variation of the electrode as a function of time in the aqueous solution of Ti(IV) hydroxyl species without using KNO_3 .

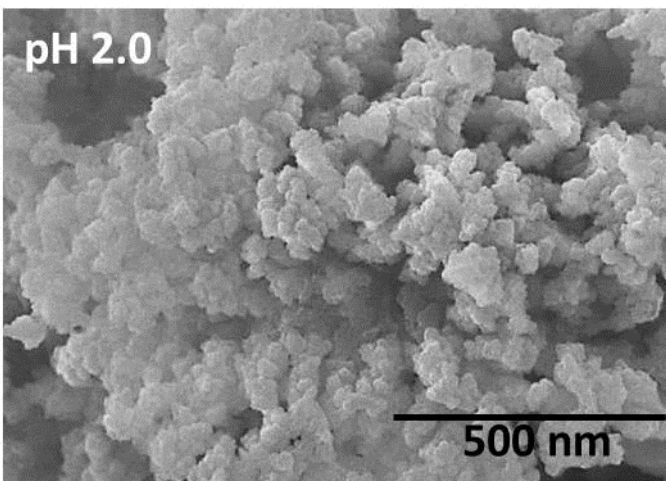
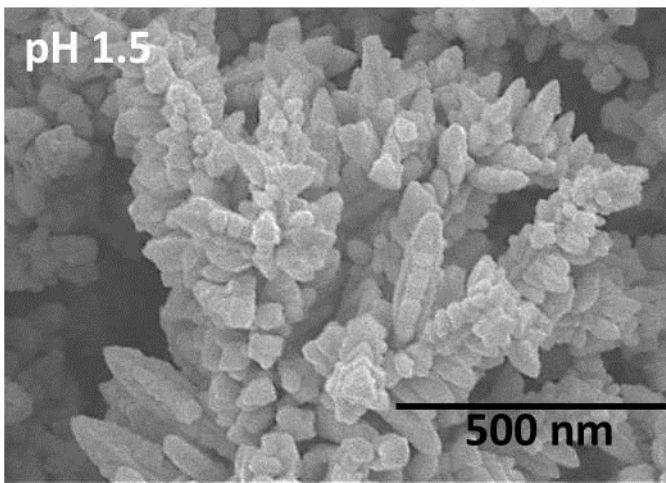
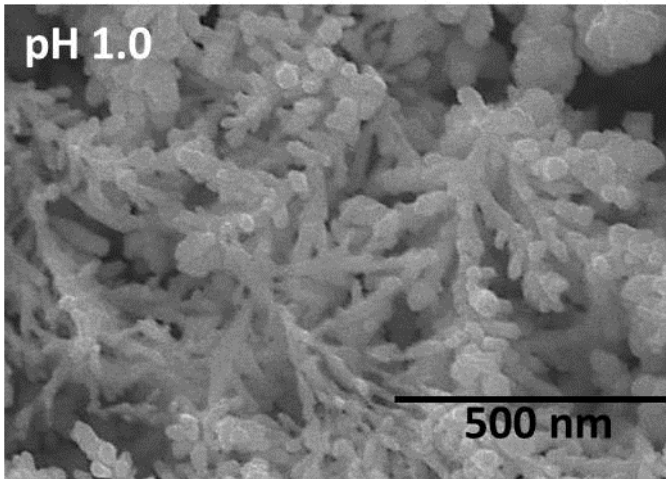


Figure S4. SEM image of TiO₂ prepared by PP with a various pH condition: pH 1.0; pH 1.5; pH 2.0.

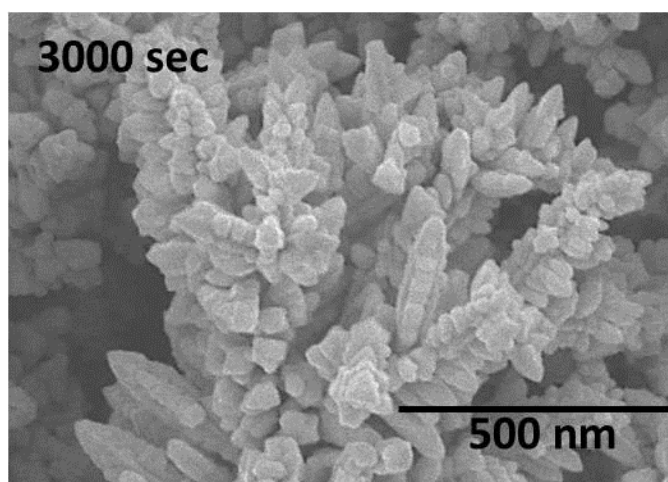
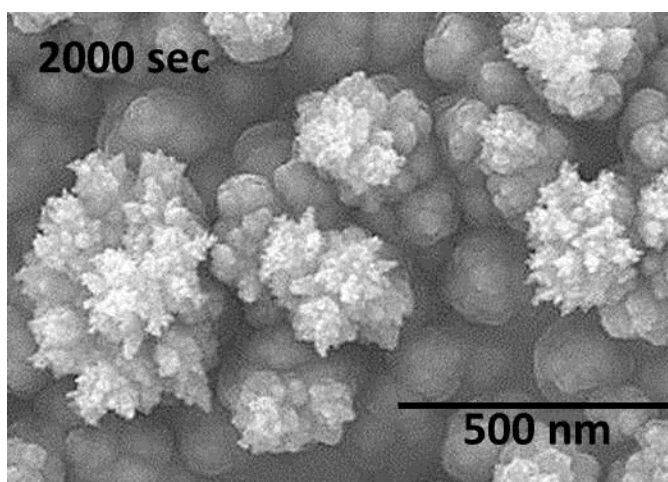
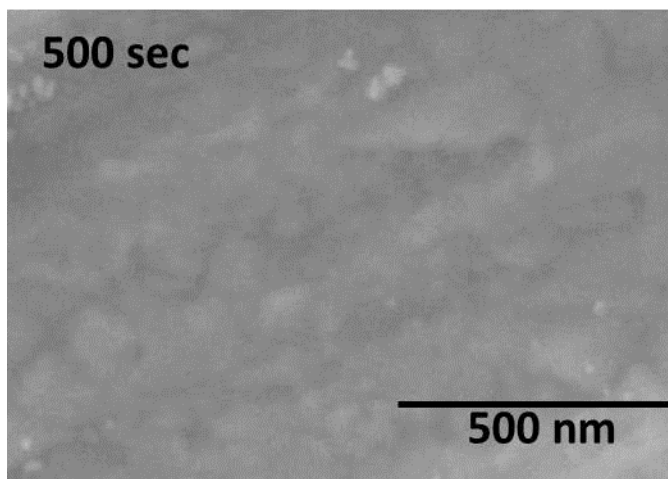


Figure S5. SEM image of TiO₂ prepared by PP according to deposition time

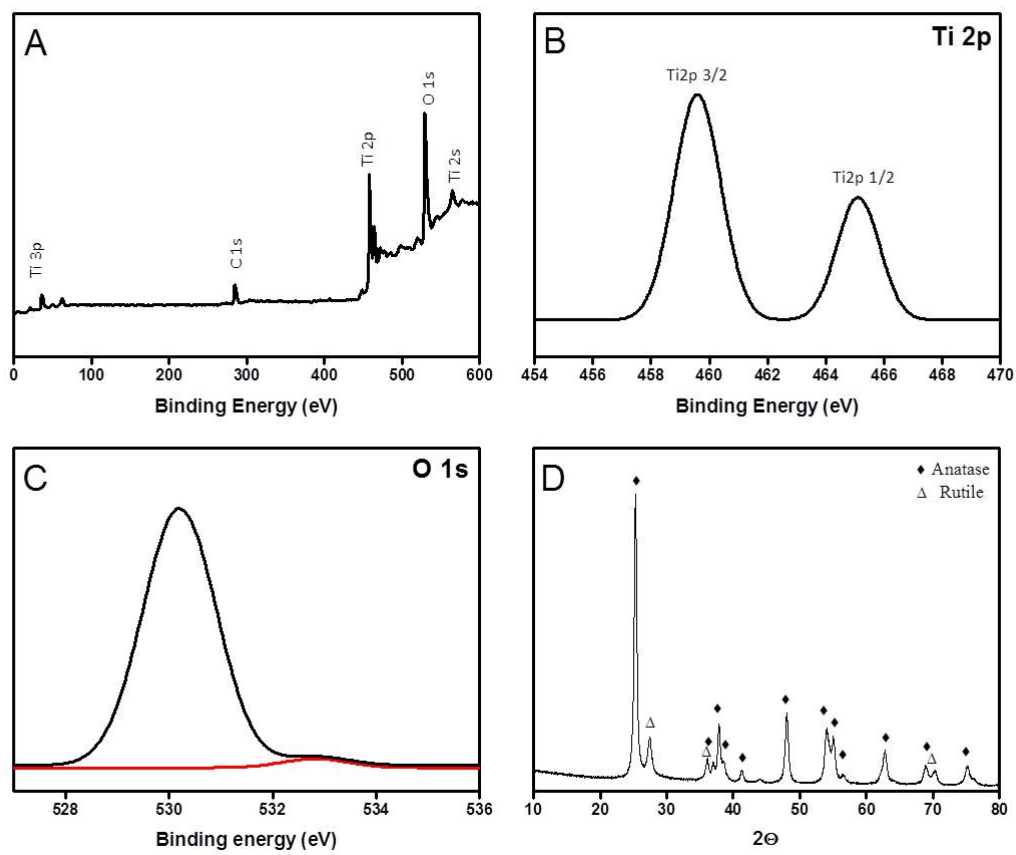


Figure S6. (a) XPS spectrum of the TiO₂ dendrite; (a-c) XPS spectra of (b) Ti 2p and (c) O 1s; (d) XRD spectrum of the TiO₂ dendrite

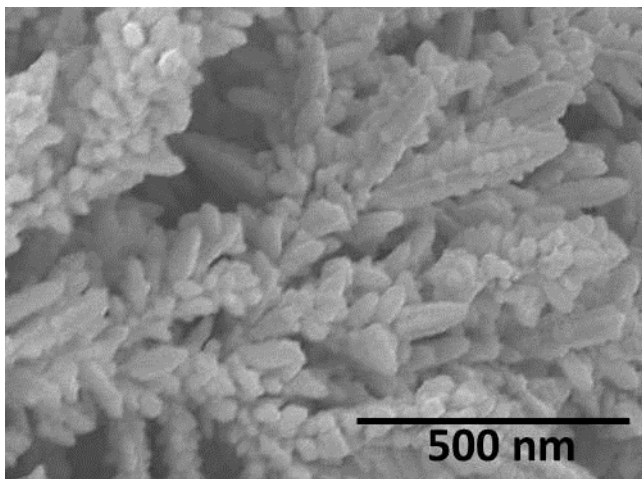


Figure S7. SEM image of TiO₂ dendrite after annealing

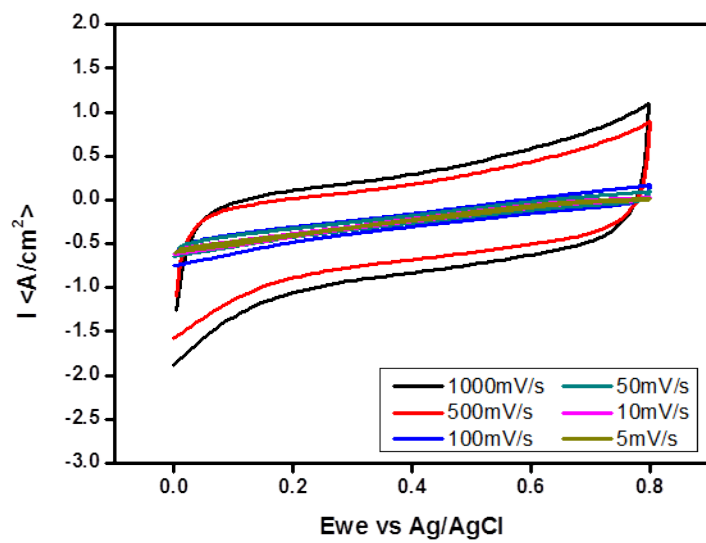


Figure S8. Cyclic voltammetry of the TiO_2 film according to scan rate