

Supporting Information for

Upcycling Disposed Sunscreen Waste into

Supported Catalysts for Environmental

Purification

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Experimental methods

Materials

Cosmetic grade ZnO samples (untreated and dimethicone modified) were purchased from Tayca Corporation. Hexachloroplatinic(IV) acid (H_2PtCl_6), was purchased from FUJIFILM Wako Pure Chemical Corporation. Ethanol ($\text{C}_2\text{H}_5\text{OH}$) was purchased from Sigma-Aldrich Japan G.K. These chemicals were used without any pretreatment.

Pt/ZnO prepared from pristine ZnO, and functionalized ZnO

ZnO powder or sunscreen products (ZnO basis 0.5 g) was stirred into 45 mL ultrapure water and ethanol 30 mL. The suspension was ultra sonicated. Then, 1.28 mL of 0.04 M H_2PtCl_6 aqueous solution was added, which corresponded to 1 wt%. The suspension was irradiated with 370 nm UV-LED (Asahi Spectra Co., Ltd.; CL-1501) for 12 h with stirring. After UV irradiation, suspension was suction-filtered and dried in an oven at 60 °C overnight. Sample was then calcined at 550 °C for 4h, and Pt/ZnO was obtained.

CO oxidation reaction

Prior to activity measurements, all samples were pelletized with 60:1 Al_2O_3 :catalyst interpellet dilution¹ and sieved to a particle diameter of 250–500 μm . Each sample (80 mg) was placed in a quartz tube with inner diameter of 4 mm suspended by quartz wool. The quartz reactor was then placed in a furnace. Before reaction, reduction of catalyst was conducted under H_2 at 300 °C for 30 min. Reaction was conducted for CO partial pressure of 0.10 kPa, O_2 partial pressure of 10 kPa, and balanced with Ar with total flowrate of 100 mL min^{-1} at 170 °C.

Characterizations

The absorption spectra of sunscreens were obtained by UV–vis measurements (V-770, JASCO Corp.). Inductively coupled plasma optical emission spectrometry measurements were also performed (ICP-OES, Agilent 5110 VDV). Thermogravimetry differential thermal analysis (TG-DTA) was performed on a Shimadzu DTG-60H. Samples were placed in an alumina pan and heated to 800 °C at a rate of 10 °C min⁻¹ under an air flow of 100 mL min⁻¹. XRD spectra (Rigaku, RINT-2000) were measured using Cu K α radiation at 25 °C. The samples were scanned from 20° to 60° at 10° min⁻¹, and the average of 10 measurements was taken. XAS was carried out at the beamline BL14B2 at SPring-8 in Hyogo, Japan. Transmission electron microscopy (TEM) images were obtained using a JEOL JEM-ARM200F (accelerating voltage: 200 kV) equipped with a CCD camera. The specimens for TEM were prepared by placing drops of the sample dispersed in EtOH onto a 200-mesh copper grid coated with an amorphous carbon film with holes. X-ray photoelectron spectroscopy (XPS; JPS9030, JEOL Ltd) was performed using Al K α radiation, and the binding energy scale was calibrated using the C 1s peak at 285.0 eV

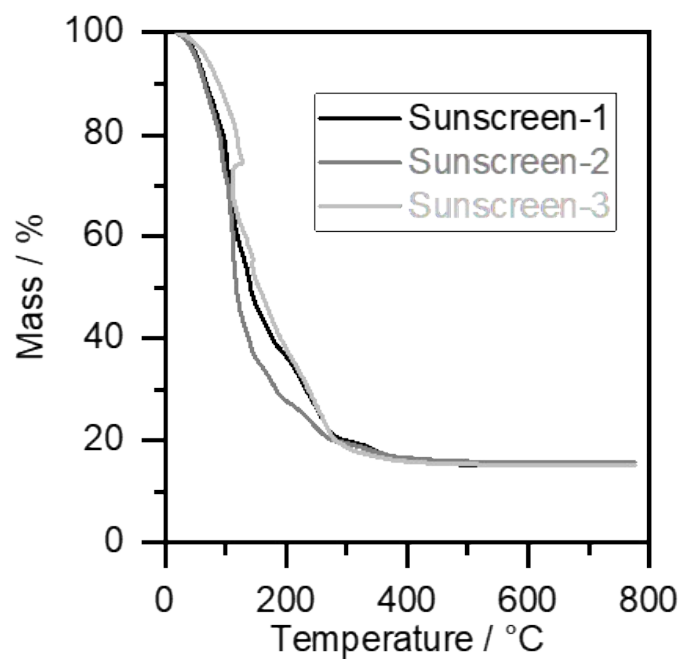


Figure S1. Thermogravimetry profiles of sunscreen products. Gas condition: air.

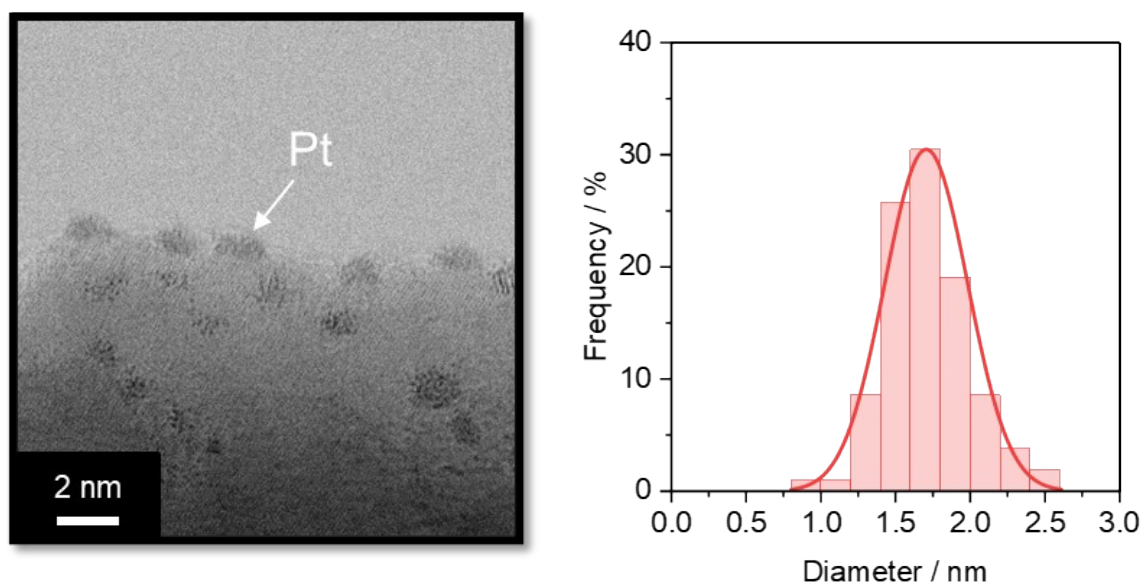


Figure S2. (a) HR-TEM image and (b) Pt particle size distribution over Pt/ZnO derived from unmodified ZnO.

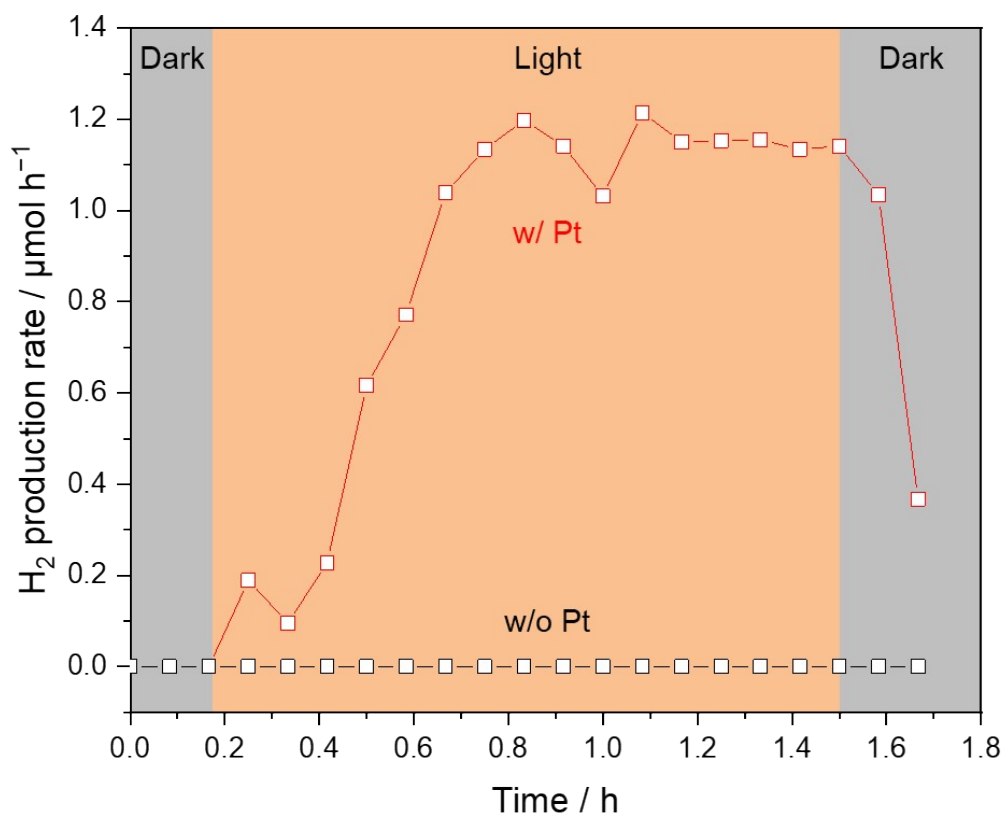


Figure S3. Photocatalytic hydrogen production performance during Pt/ZnO synthesis. Reactions solution: ZnO (30 mg) + H₂O (3 mL) + EtOH (2 mL) + 0.04 M H₂PtCl₆ aqueous solution (40 μL).

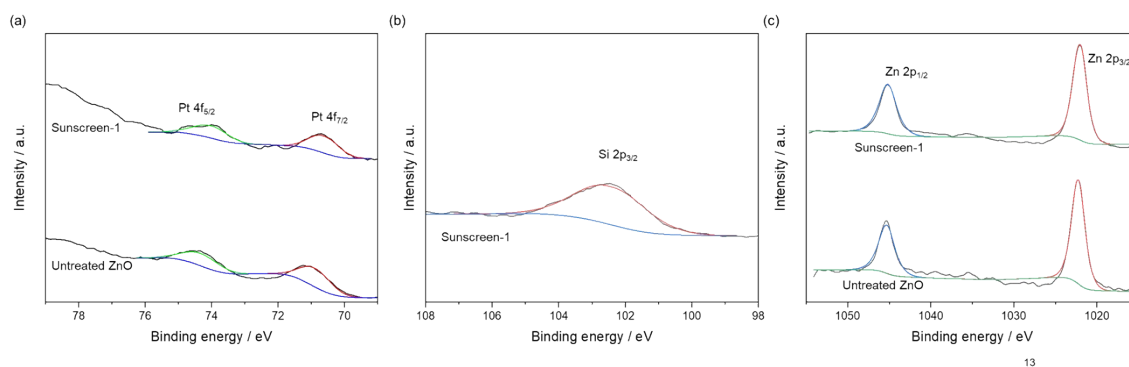


Figure S4. XPS spectra of Pt deposited ZnO derived from untreated ZnO and Sunscreen-1 in the region of (a) Pt 4f, (b) Si 2p, and (c) Zn 2p.

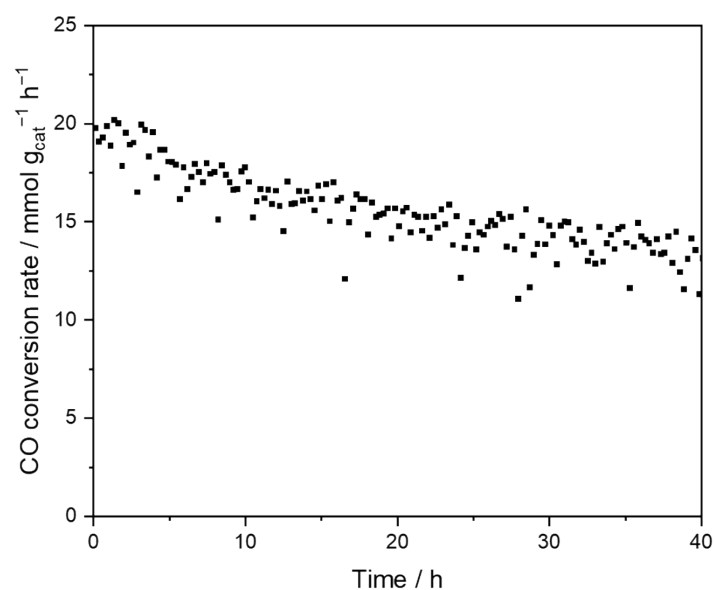


Figure S5. CO oxidation performance of Pt deposited ZnO catalysts derived from the sunscreen product-1. Reaction conditions: Catalyst weight=1.3 mg (diluted by 78.7 mg of Al₂O₃; dilution ratio = 60). Pretreatment condition: pure H₂, 300 °C, 30 min. Reaction condition: CO=0.10 kPa and O₂=10 kPa (Ar balance), flow rate 100 mL min⁻¹ (WHSV = 4615 L g⁻¹ h⁻¹), 170 °C.

- 1 A. D. Allian, K. Takanabe, K. L. Furdala, X. Hao, T. J. Truex, J. Cai, C. Buda, M. Neurock and E. Iglesia, *J. Am. Chem. Soc.*, 2011, **133**, 4498–4517.