Photofuel Cells Consisting of a Particulate TiO_2 Photoanode with Using Cellulose as a Direct Fuel

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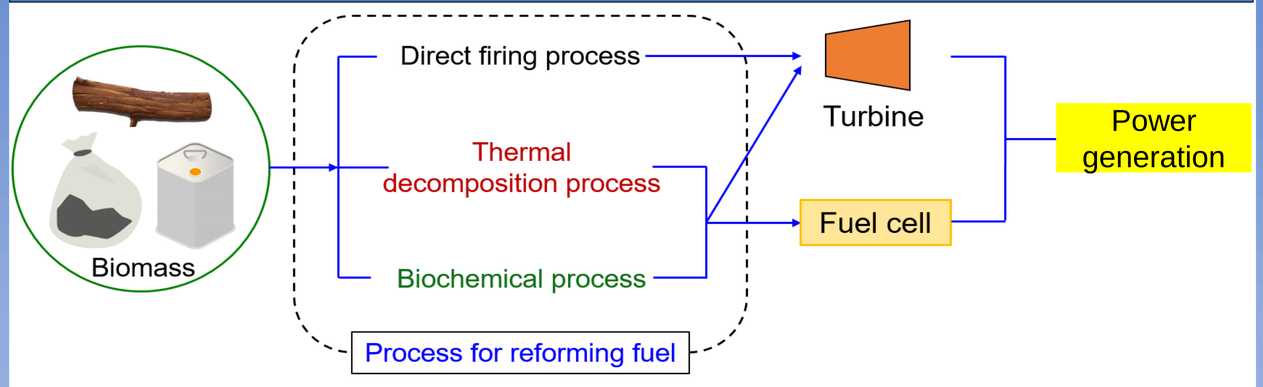
Introduction



✓ Direct firing process

Low temperature , resulting in the low generation power efficiency by using only biomass

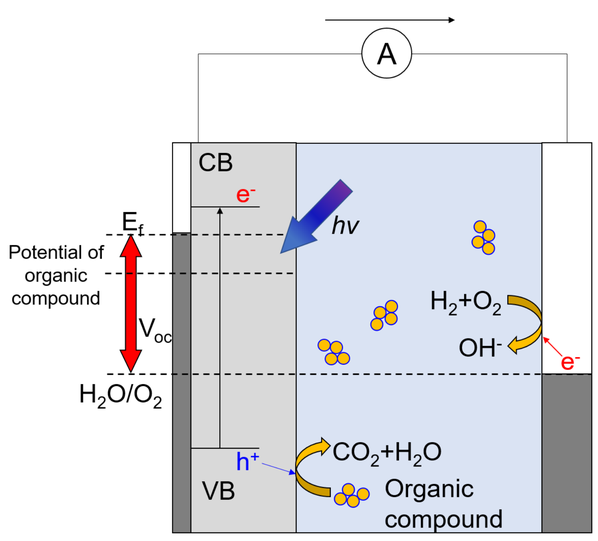
✓ Thermal decomposition ,biochemical process

An expensive and complicated system for the reforming process from biomass to fuel

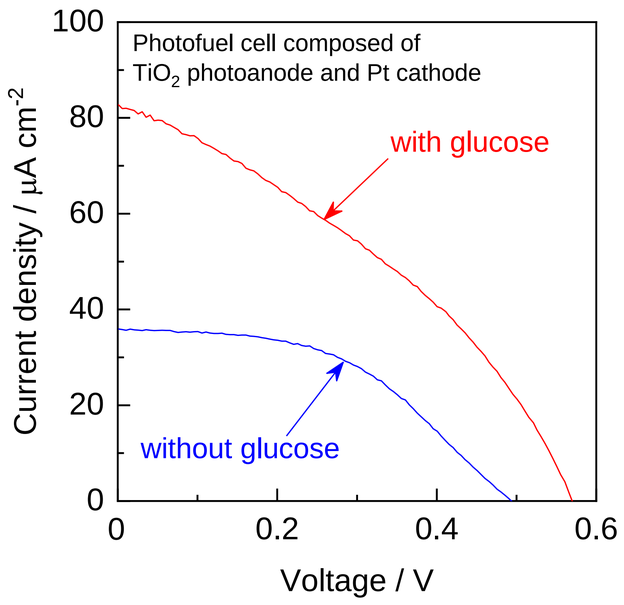
It is desirable to develop an energy conversion system that can generate electricity directly from biomass-based waste

Concept of this study

Energy diagram of the photofuel cell with organic compounds as a fuel



I-V curves of the Photofuel cells



✓Photon＋biomass → electric energy

✓Higher open circuit voltage (V_{OC}) than conventional fuel cell

✓Photoexcited holes with high oxidizing power

On-site utilization of biomass-based waste as a fuel without purification

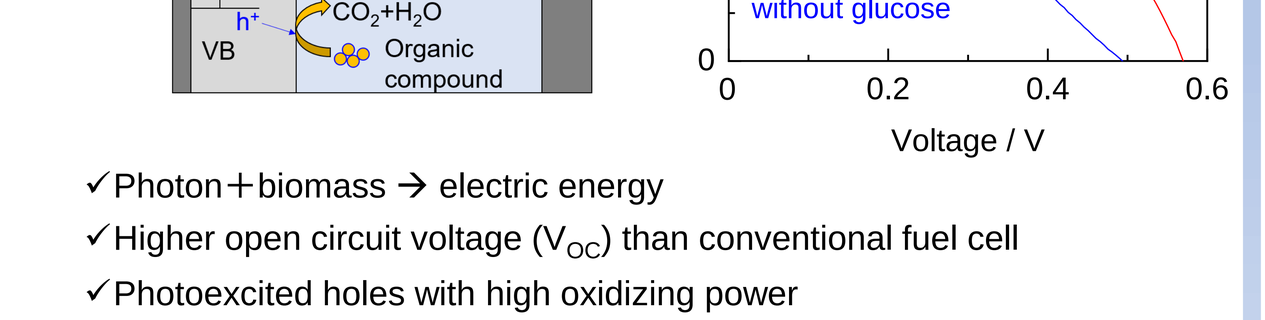
Objective of this study

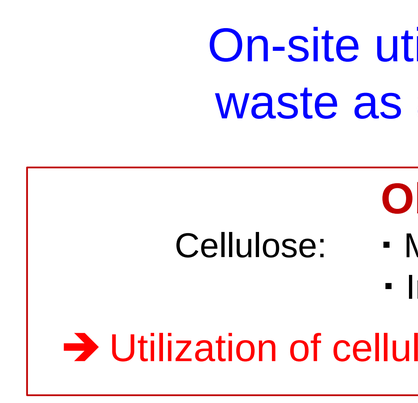
Cellulose:
- Major component in biomass-based waste
- Insoluble in almost all solvents

➔ Utilization of cellulose as a direct fuel for the photofuel cell

Results and discussion

Method for photoanode preparation





Immersion in water

➢Cellulose is insoluble in almost all solvents except ionic liquid

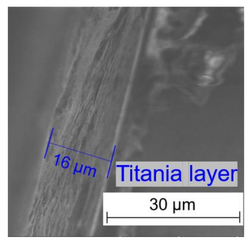
➢Solubility in water : ionic liquid＞cellulose

➔ Regenerating cellulose thin film by applying cellulose ion liquid solution on titania electrode and removing only ionic liquid

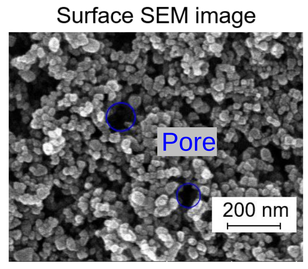
Characterization for the titania electrode with cellulose film

SEM images for photoelectrode

Cross section SEM



Surface SEM image

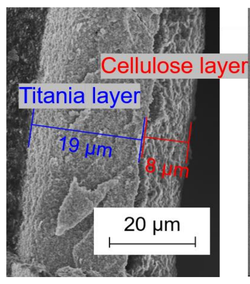


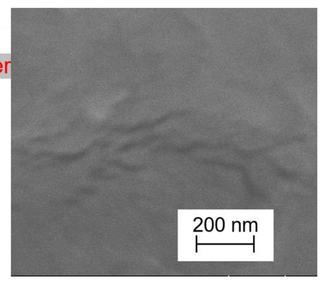
➢Titania electrode

✓P25 particles with a particle size of several tens of nm

✓Pore diameter of about 50 ~ 150 nm

✓Approximately 16 nm of film thickness





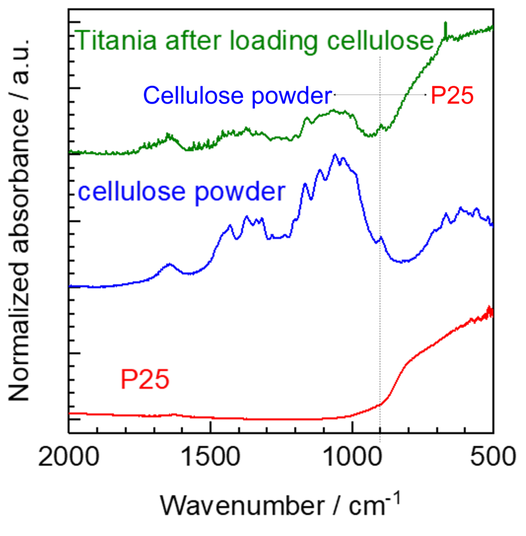
➢Titania electrode with cellulose

✓Smooth surface without pores

✓Titania film 19μm, cellulose film 8μm

IR spectra of titania particles after loading cellulose

IR spectra of P25, cellulose, and P25 loaded with cellulose



Titania after loading cellulose

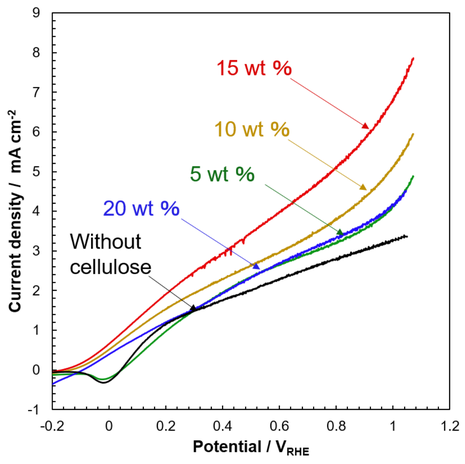
✓A broad peak assigned to P25 was observed at < 900 cm^{-1}

✓Peaks assigned to cellulose were observed at 900—1700 cm^{-1}

Successful deposition of cellulose was confirmed

Photoelectrochemical measurements

Current density versus potential curves



➢Titania electrode with cellulose film electrode
Onset potential: higher than titania only
Photocurrent: gradual increase according to cellulose amounts (up to 6.8 mA cm^{-2} at 1.0 V_{RHE})

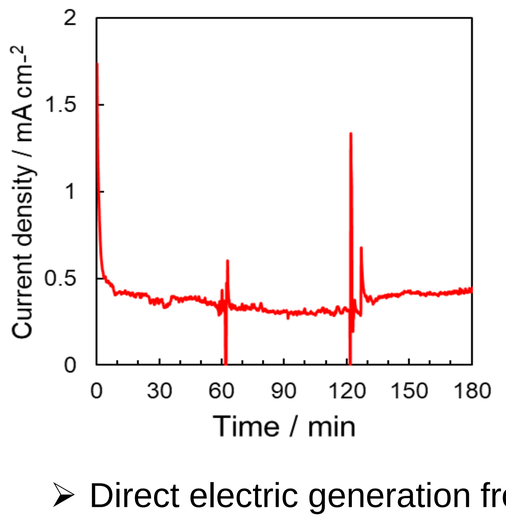
➢Oxygen production on titania electrode without cellulose

➢Decomposition of cellulose deposited on titania layer

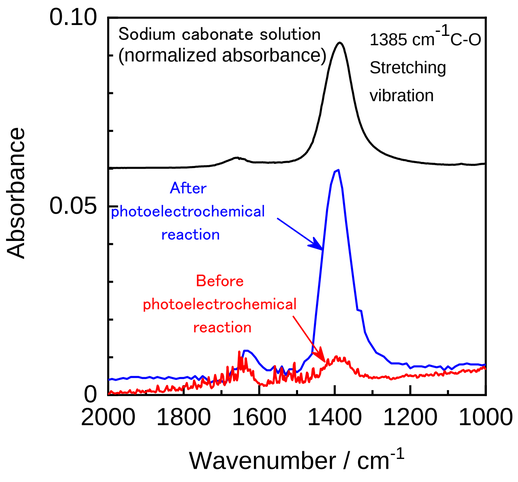
➔ thermodynamically easier reaction of cellulose decomposition than water oxidation

Analysis of products after photoelectrochemical reaction

Current density versus time curves



IR peak pattern of products after reaction



➢ Direct electric generation from photon energy and cellulose

➢ CO_3^{2-} in the electrolyte after PEC reaction

CO_2 as an main products of cellulose decomposition

conclusion

➢ Characterization using SEM and IR confirmed successful deposition of cellulose on the titania electrode

➢ Cellulose deposition on the titania electrode improved photovoltaic performances of the photofuel cells

Reference

H. Nishikiori, et. al., *Chem. Lett.*, **2012**, 41, 725., H. Nishikiori, et. al., *Applied Clay Science*, **2015**, 107, 138., H. Nishikiori, et al., *Chem. Lett.*, **2017**, 46 659.