New approach for CO2 reduction

Research converting carbon oxide (CO_2) into low-molecular-weight organic compounds is extremely important because this research can not only reduce the concentration of CO_2 in the atmosphere but can also convert CO_2 into useful organic compounds.

And, no report in which a large amount of organic compounds has been generated by reducing CO_2 with inexpensive catalyst in air under irradiation of solar light at room temperature and atmospheric pressure is founded.

Author succeeded in reducing CO_2 into low-molecular-weight organic compounds (formaldehyde and methanol) with TiO_2/ZrO_2 composites covered with very thin water layer under solar irradiation in air.

The method is unique and provided large amount of reduced products (approximately 300?mol/(g·300 s)).

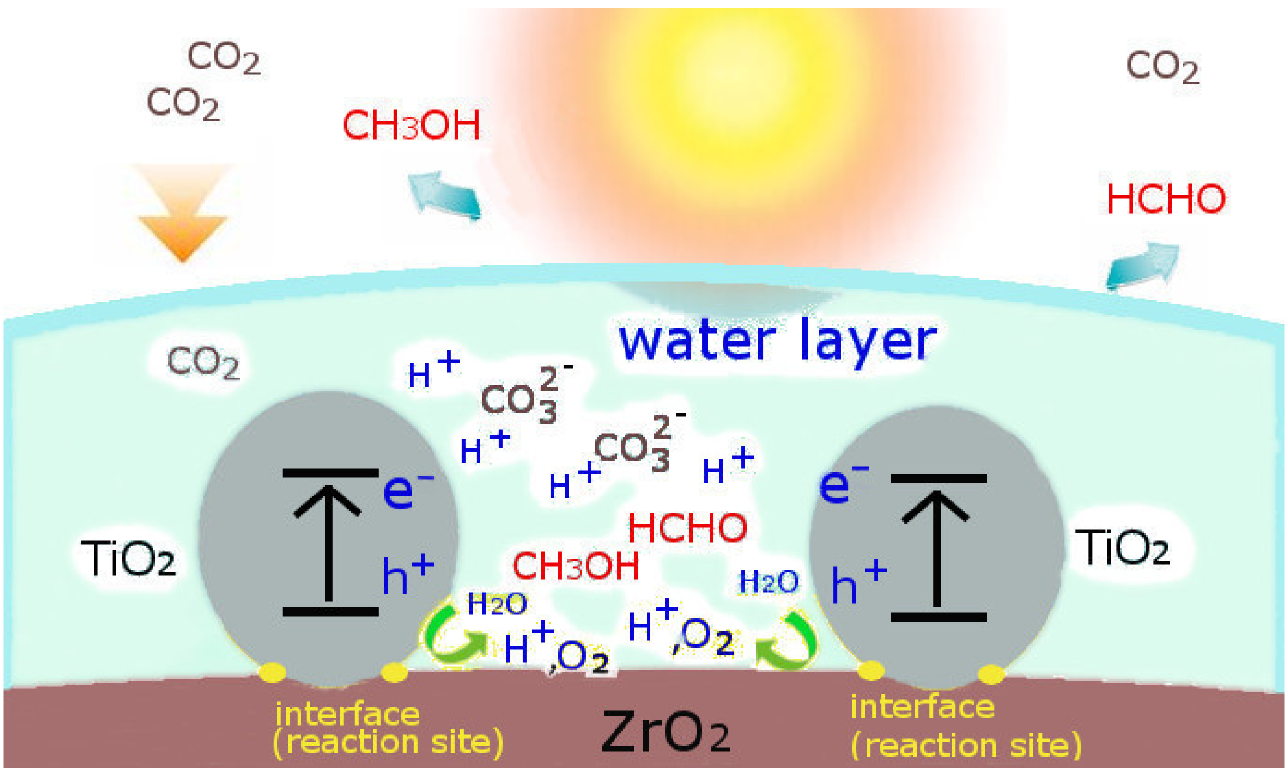

Fig. 1. Conceptual rendering of author's method.

Figure 1 shows possible macro mechanism of author’s method by illustration.

Features of the method are following.

First, Suitable weight ratio of TiO_2/ZrO_2 composite is 6/4-5/5, that is, ZrO_2 as additive component is used in large amounts.

Second, formation of thin water layer over composite is performed via condensation of water vapor in air.

Third, reactant is not CO_2 but CO_3^{2-} ion that CO_2 in air dissolved and dissociated in the thin water layer.

When CO_3^{2-} is used as reactant, as the standard electrode potentials (E^0) of reducing reactions are positive, thus, the standard Gibbs energy transitions are negative, so, the reactions proceed spontaneously.

Fourth, reduced products volatilize from the thin water layer.

As surface area of the thin water layer is very large, the volatilization is very active, thus, accelerate chain reaction composed of generation of CO_3^{2-} ions, reducing reactions in the thin water layer, volatilization of the reduced products and keeping the reducing reaction in equilibrium.(For further explanation about the chain reaction, see discussion section in report published.)

Fifth, reaction site converting CO_3^{2-} ions into reduced products exists at interface generated by TiO_2 particle and ZrO_2 one.

Sixth, electrons generated by photo-catalyst effort of TiO_2 move to the interface, and, accelerate the reducing reaction because of high energy (high reducing force), that is, this method is catalytic reaction enhanced by the TiO_2 photo-catalyst.

Possible macro mechanism is following.

> Dissolve and dissociate of CO_2 in air into the thin water layer on the surface of composite, and generation of CO_3^{2-} ions in the thin water layer.
> Physical adsorbing of CO_3^{2-} ion to the ZrO_2
> Movement of adsorbing species to the interface formed from TiO_2 particle and ZrO_2
> Catalytic reducing reaction of adsorbing species at the interface.

High energy e^- generated by TiO_2 photocatalytic effect strongly accelerates the catalytic reducing reaction.

> Desorption of reduced products (low-molecular-weight organic compounds) from the interface into thin water layer.

Evaporation of reduced products from the thin water layer into air.
Repeating of 1-6.

The fact that a large amount of reduced products was obtained from CO_2 and H_2O in air under irradiation of only real solar light at room temperature and atmosphere pressure is a novel and important finding.

Moreover, author’s method is also new approach for artificial photosynthesis.

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Publication

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