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Visible light driven water splitting using electron irradiated silica and titania based polymeric material

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1. Introduction

Hydrogen has been noticed as a clean and renewable energy source. Fossil fuel, which is the most widely used energy source, has two defects. One is CO_2 emission causing global warming.[1] The other is exhaustion. On the other hand, hydrogen causes no CO_2 emission and can be made from water, renewable and easily obtainable source.

However, about 95% of hydrogen is derived from fossil fuel.[2] It means that hydrogen is not an energy source, but just energy carrier. To maximize the merits of hydrogen, renewability and no CO_2 emission, it is needed to enhance the technology to produce the hydrogen using water splitting without using fossil fuel. The photocatalytic water-splitting is one of the potent options. Photocatalytic water-splitting that uses hole/electron pairs of semiconductor is expectable way to produce clean and renewable hydrogen from solar energy.[3]

2. Methods and Results

In this section experimental procedures to produce hydrogen using photocatalytic reaction are described. The hydrogen production results of the reaction are also summarized.

2.1 Preparation of photocatalyst using electron irradiation

The photocatalyst we used is silica and titania based polymeric material. The material shows the enhancement of photocatalytic reactivity when electron is irradiated on it. Two different ways to fabricate electron irradiated photocatalyst are used. The first method is to irradiate electron on the liquid material spread on the wafer surface. The other way is to irradiate the electron on the powdered photocatalyst. In this method, liquid material is at first dried for 3hours in the oven at 333 K. Then the film obtained by drying is grinded. The grinded powder is spread on the wafer and irradiated by electron. The second method has merit to fabricate more than twice amount of irradiated photocatalyst at once compared with the formal way. However the thickness of spread powder has some variances compared with spread liquid. It can cause the differences of characteristic among the irradiated powder over the location of each powder.

2.2 Photocatalytic reaction condition

We used methanol as a sacrificial reagent. Solution in which photocatalytic reactions were carried out is composed of 15% methanol and 85% pure water. 500W Xe lamp is used as a visible light and UV source and 200W Hg lamp is equipped to check photocatalytic reaction under UV. Under Xe lamp, increase of temperature influenced the gas generation rate. To avoid the temperature effect, we cooled the vessel by setting the water circulation cooler under the vessel.

2.3 Results and discussion

When 500W Xe lamp is used as a light source, temperature increases to about 335K. It makes the air dissolved in water evaporate as solubility of water decreases. Figure 1 shows the role of temperature under 500W Xe lamp. With bottom cooling, about 30μmol/g/h gas was produced. However, without bottom cooling, the amount of gas generated increases rapidly. Therefore most of the gas generated without cooling doesn't seem to be caused by photocatalytic reaction. So, most of the gas isn't hydrogen but air dissolved in water. Red dots of the Fig. 1 show the slight increase of gas production rate after putting photocatalyst sample in.

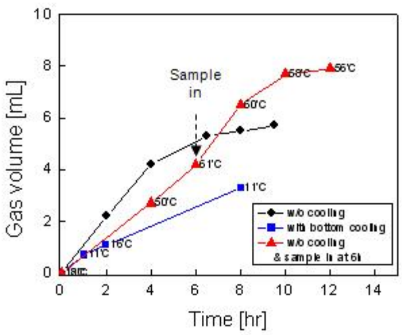

Fig. 1. Gas generation rate of photocatalytic reaction of electron irradiated silica and titania based polymeric material under Xe lamp(500W). 0.1g of photocatalyst is loaded in 15% MeOH solution. 50 keV, 16 mA/cm^2 electron is irradiated on the powdered photocatalyst.

We found that photocatalytic reaction under visible light is relatively small. However, under UV lamp, much more gases were generated by photocatalytic reaction. During UV irradiation, there was no temperature increase. Therefore most of the gas produced is hydrogen. Table I shows the gas production rate of photocatalytic reaction derived by silica and titania based polymeric material.

Table I: Gas production rate under visible light and UV

Lamp	Irradiation Condition	Production rate (μmol/g/h)
200W Hg	50keV, 6.37μA/cm^2, 20hr	167
200W Hg	50keV, 6.37μA/cm^2, 10hr	312.5
500W Xe	50keV, 14.0μA/cm^2, 2.5hr	30

All the reaction included in Table I is progressed near the room temperature and used 15% MeOH solution as sacrificial reagent. From the results, we found that the photocatalyst is sensitive to UV, but not to visible light.

3. Conclusions

Silica and titania based polymeric material can be used as photocatalyst. It shows good photocatalytic reactivity under UV irradiation. However there were some variances among the experiment and under visible light, photocatalytic reactivity decreases. We need to enhance the reactivity under visible light, because more than 90% of sun light is visible light. The silica and titania based polymeric material has lots of probabilities to be used as photocatalyst under not only UV but visible light.

REFERENCES

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