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Study on Photo Electrochemical Characteristics of Some Chlorophyll Derivatives

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The great leader Kim Jong Il said:

"Unless the new materials sector is developed, it will be impossible to ensure Juche-oriented development of the electronics industry, bring about modernization of the machinery industry, and promote the development of up-to-date science and technology as a whole."

Dye-sensitized solar cell (DSSC) is an imitation of photosynthesis of plants, and a lot of studies are going on now to use chlorophyll derivatives as photo sensitizers[2, 3, 4]. We have studied on photo electrochemical characteristics of DSSC made by using some chlorophyll derivatives as photo sensitizers.

1. Material and method

Chlorophyll derivatives used as photo sensitizers are made from the chlorophyll separated from the spinach.

20% HCl (analytical degree) was used for demagnesiumation of chlorophyll and 10% methanol NaOH was used for saponification. Zinc acetate [$Zn(CH_3COO)_2$] and magnesium acetate [$Mg(CH_3COO)_2$] of analytical degree were used to substitute chlorophyll for metal.

The nano powder of dioxide titanium used to make photo electrode was for commercial purposes ("Degussa P25", Anatase 80%, Rutile 20%, specific surface 55m^2/g, particle size 15～25nm).

KI, I_2, tert-butylpyridine and γ-butyrolactone were used to make electrolyte. Counter electrode was made of hexachloroplatinic acid and isopropyl alcohol. Used as conductivity glass is the FTO (20～30Ω/cm^2) made in the solar cell department, the Electronics Research Institute of the State Academy of Sciences.

As for the source of light, sunlight was used and the intensity of light was measured by an illuminometer ("ЛЮКСМЕТР Ю116"). The open circuit voltage and closed circuit current were measured by digital tester ("DT-830B").

Nanocrystalline TiO_2 membrane was prepared by pasting TiO_2 on FTO by doctor blading method and sintering it for 30 min at the temperature of 450℃. For dye absorption, the electrode was immersed in dye solution (3×10^{-4}mol/L) overnight. The counter electrode was prepared by applying hexachloroplatinic acid solution on FTO with a glass rod, drying and sintering for 20 min at 400℃. For coupling, the counter electrode was placed against the dye-absorbed TiO_2 membrane and between them was injected electrolyte with a capillary tube to make an electric cell. This was connected to the digital tester with TiO_2 membrane as the negative pole and the counter electrode as positive. After that, the open circuit voltage and the closed circuit current were measured under natural sunlight.

2. Results and consideration

When chlorophyll derivatives were absorbed in nanocrystalline TiO_2 electrode, the photocurrent was measured as in Fig. 1.

As seen in Fig. 1, photocurrent decreases in the order of Zn-chlorine, Mg-chlorine, chlorine, pheophorbide and pheopytin. The difference in the level of the lowest excitation energy of chlorophyll derivatives is the explanation for the difference in the value of electric current.

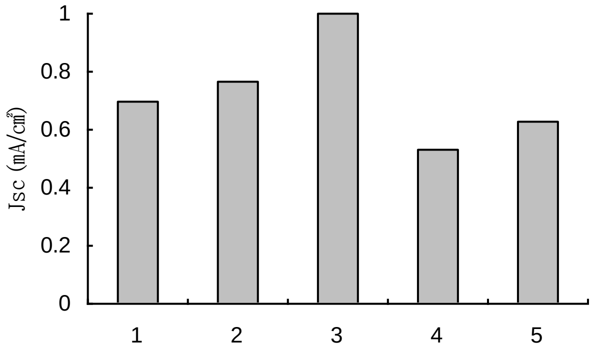

Fig. 1. Characteristics of photo current of chlorophyll derivatives

Luminous intensity 60 000 lx, 1—chlorine, 2—Mg-chlorine, 3—Zn-chlorine, 4—pheopytin, 5—pheophorbide

Fig. 2 shows the photo voltage when chlorophyll derivatives were absorbed into TiO_2 membrane. As shown above, the photo voltage decreases in the order of Zn-chlorine, Mg-chlorine, chlorine, pheopytin, pheophorbide. This is due to the difference in the LUMO levels of chlorophyll derivatives and the effect of some factors including the condition of making TiO_2 membrane, electrolyte etc.

Fig. 3 shows the results of the examination of the stability of photocell system using chlorophyll derivatives under natural sunlight.

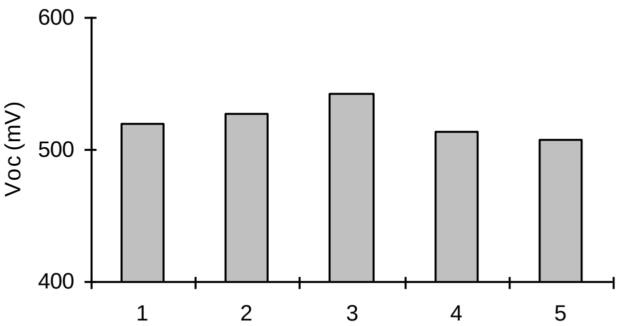

Fig. 2. Characteristics of photo voltage of chlorophyll derivatives

Luminous intensity 60 000 lx, 1—chlorine, 2—Mg-chlorine, 3—Zn-chlorine, 4—pheopytin, 5—pheophorbide

As Fig. 3 shows, photocurrents in chlorophyll derivatives decreased as time went by. This may be attributed to the fact that the chlorophyll derivatives degenerate during the long process of oxidation-reduction or a leak of electrolyte caused by a mistake in sealing.

The change in the photocurrent of Zn-chlorine, which has the most marked photoelectron chemical cha-

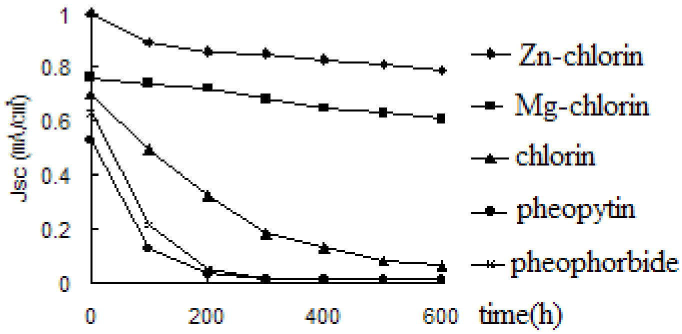

Fig. 3. photocurrent curve of chlorophyll derivatives according to the time of light irradiation (luminous intensity 60 000 lx)

racteristics among chlorophyll derivatives, when it was absorbed into TiO_2 membrane is shown in Fig. 4. As is shown, the value photocurrent of Zn-chlorine increased nearly fanwise along with the luminous intensity.

The change in its photo voltage according to luminous intensity is as Fig. 5.

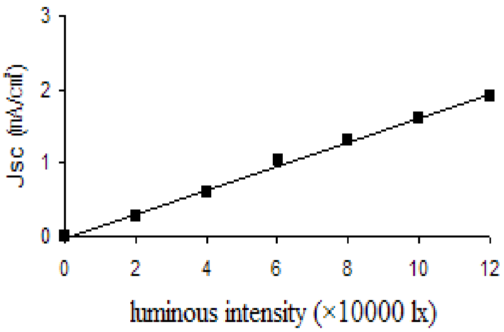

Fig. 4. photocurrent curve of Zn-chlorine depending on luminous intensity

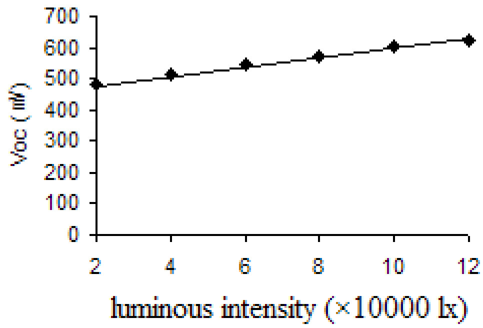

Fig. 5. Change in the photo voltage depending on luminous intensity in case of Zn-chlorine

As Fig. 5 shows, the photo voltage of Zn-chlorine increased slowly with the increase of the luminous intensity.

This conforms to the typical case of the voltage and current of the dye-sensitized solar cell.

Conclusion

The photocurrent of Zn-chlorine is $1mA/cm^2$ and its photo voltage is 543mV, the highest of the chlorophyll derivatives.

References

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