

## Quasi-solid Dye-sensitized Solar Cells with Composite Electrolyte

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### Education

Degree	Institution	Date
Ph.D.	Nagoya University, Japan	1996
M.E.	Institute of Electronics, Chinese Academy of Sciences, China	1990
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### Professional experience

Title	Organization	Date
Associate Professor	Tsinghua University, Beijing	2004-
NEDO Fellow	National Institute of Advanced Industrial Science and Technology, Japan	2000-2004
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Here, we reported a composite quasi-solid electrolyte by adding layered  $\alpha$ -zirconium phosphate ( $\alpha$ -ZrP) into the iodide/triiodide ionic liquid, 1-methyl-3-propylimidazolium dihydrophosphate (MPIDP), electrolyte including 4-tert butylpyridine (TBP), which markedly improved photovoltaic properties of quasi-solid dye-sensitized solar cells (DSSC). When adding 6 wt%  $\alpha$ -ZrP relative to TBP, the photoenergy conversion efficiency of the DSSC was up to 2.61%, increased a factor of more than 2 compared with a DSSC without  $\alpha$ -ZrP.

Dye-sensitized solar cells (DSSC) have gained considerable interests since reported by Grätzel in 1991 [1]. The low production costs and high photoenergy conversion efficiency make DSSC become a promising alternative for conventional photovoltaic devices. Recently, growing attention has been paid to quasi-solid DSSC using ionic liquids due to their favorable properties such as thermal stability, nonflammability, high ionic conductivity and negligible vapor pressure. Very recently, to improve the photovoltaic properties and the stability of quasi-solid DSSC, some important efforts have been made by adding inorganic nanomaterials into various ionic liquid electrolytes [2]. We first introduced layered  $\alpha$ -zirconium phosphate ( $\alpha$ -ZrP) to quasi-solid DSSC [3].

Fig. 1 is the photocurrent-voltage characteristic curves of quasi-solid DSSC with various contents of  $\alpha$ -ZrP in the composite quasi-solid electrolyte. It is found that photoenergy conversion efficiency ( $\eta$ ) can be markedly enhanced by the composite quasi-solid electrolyte. When the content of  $\alpha$ -ZrP is 6 wt%,  $\eta$  is up to the maximum, 2.61 %, which enhances  $\eta$  by a factor of more than 2 compared with a DSSC without

$\alpha$ -ZrP. On the other hand, the dark current results from the reduction of triiodide by the conduction band electrons of TiO<sub>2</sub>:



which occurs at the surface of TiO<sub>2</sub> particles. The onset of the dark current (figure not shown) of DSSC with 6 wt%  $\alpha$ -ZrP occurs at the highest forward bias, 330mV, which shifted ca. 110 mV from 220 mV, which is the onset of the dark current of DSSC without  $\alpha$ -ZrP. This indicates that 6 wt%  $\alpha$ -ZrP can suppress the dark reaction the most efficiently between the TiO<sub>2</sub> conduction band electrons and I<sub>3</sub><sup>-</sup> ions.

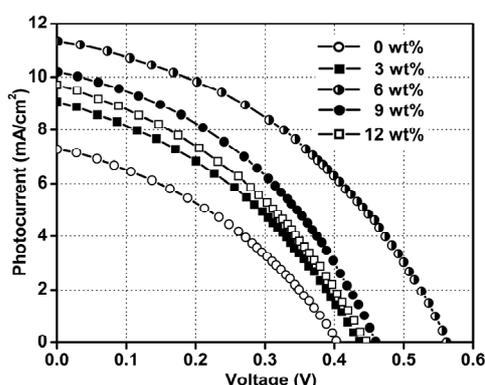


Fig 1. (a) Photocurrent-voltage characteristics curves of DSSC with various contents of  $\alpha$ -ZrP; (b) Dark current-voltage characteristic curves of DSSC with various contents of  $\alpha$ -ZrP.

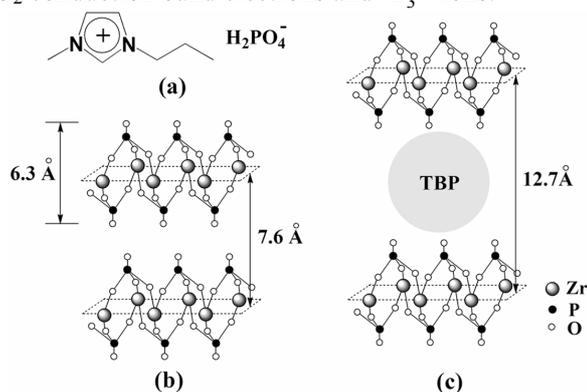


Fig. 2. (a) Molecular structure of 1-methyl-3-propylimidazolium dihydrophosphate, MPIDP; (b) Molecular structure of layered  $\alpha$ -ZrP; (c) Intercalation schematic of TBP into layered  $\alpha$ -ZrP.

The intercalation behavior of TBP into layered  $\alpha$ -ZrP (Fig. 2) can contribute to the enhancement of the exchange current density  $I_0$  and the diffusion coefficient  $D_{I_3^-}$  of I<sub>3</sub><sup>-</sup> (data have been got in the experiment, figures not shown), which will depress the concentration of triiodide ions around mesoscopic TiO<sub>2</sub> film. The enhancement of  $I_0$  value, with the addition of  $\alpha$ -ZrP, can be due to the increase of the active area of electrolyte/ $\alpha$ -ZrP interlamellar interface after the intercalation of TBP into  $\alpha$ -ZrP. The confinement effect by the nanochannels in the interlayer of  $\alpha$ -ZrP may be the reason for the enhancement of  $D_{I_3^-}$ . Further, the composite quasi-solid electrolyte including  $\alpha$ -ZrP could efficiently suppress the dark reaction derived from the reduction of I<sub>3</sub><sup>-</sup> by the conduction band electrons. Hence, the short-circuit current, the open-circuit voltage and the corresponded photoenergy conversion efficiency of DSSC are markedly enhanced.

The study on the lifetime of electron in mesoscopic TiO<sub>2</sub> film further proves the rationality of above-mentioned explanation. The composite ionic liquid electrolyte with the addition of  $\alpha$ -ZrP might be a good alternative for the quasi-solid electrolyte used in quasi-solid DSSC.

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## References

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