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Enhancing of Transparent Sandwich Layer Structure in Bifacial Dye-Sensitized Solar Cells with Graphene Nanoparticles

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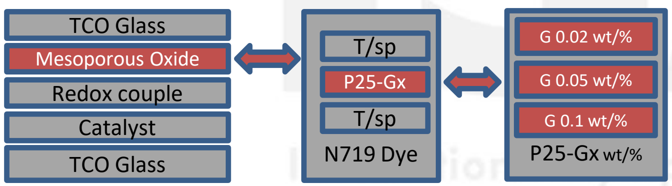
P03

INTRODUCTION

Dye-sensitized solar cells (DSSCs) hold promise for solar energy conversion with cost-effective manufacturing, high efficiency, and flexibility. However, their power conversion efficiency falls short of predictions due to electron-hole recombination, hindering electrons from reaching the lowest unoccupied molecular orbital (LOMO). This study focuses on enhancing electron mobility in bifacial DSSC electrodes by incorporating graphene nanoparticles into the semiconductor matrix to reduce bandgap and improve mobility. The (T/sp-P25-T/sp) or simply TPT stacked configuration is utilized, and graphene is introduced during P25 paste synthesis in varying proportions to optimize performance.



MATERIALS

Titanium dioxide P25 Nanopowder, < 25 nm particle size, 99.7 trace metals basis, rath. Graphene Nanoparticles ±21nm sheet thickness. FTO transparent conductive glass 10 cm x 10 cm. Ruthenium-based Dye N719 solaronix 1g platinum solaronix Platisol T 50 ml, electrolyte iodide/ triiodide arbor scientific 15ml, T/sp TiO_2 commercial solaronix.

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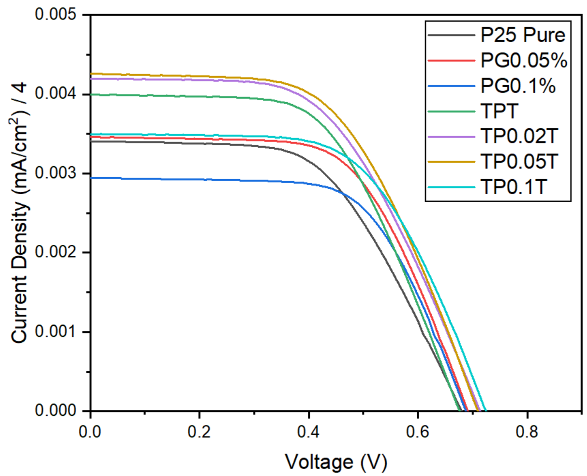
Method

TiO_2 graphene nanocomposites were synthesized in our lab using a 2018-developed doping method, refined since. Three P25Gx nanocomposite variants were created, with graphene at 0.02wt%, 0.05wt%, and 0.1wt% in TiO2 P25 matrix. Post FTO glass preparation (cutting, cleaning, drying), electrodes sandwiching T/sp and P25Gx layers were applied, sintered at 450° C for 30 mins. Resulting electrodes were immersed in N719 dye for 24 hrs at room temperature. The counter electrode contained platinum nanoparticles on FTO glass, sintered likewise. After introducing iodine/triiodide redox couple between electrodes, cells were sealed with epoxy to prevent evaporation, ready for testing.

	J_{sc} [mA/cm²]	V_{oc} [V]	FF [-]	PCE [%]	J_{max} [mA/cm²]	V_{max} [V]
P25	13.64	0.680	0.555	**5.1464**	11.97	0.43
$PG_{0.05}$	13.83	0.700	0.602	**5.8271**	12.14	0.48
$PG_{0.1}$	13.64	0.680	0.555	**5.1464**	11.97	0.43
TPT	15.99	0.680	0.566	**6.1564**	13.99	0.44
$TP_{0.02}T$	16.79	0.720	0.537	**6.4892**	14.42	0.45
$TP_{0.05}T$	17.03	0.710	0.557	**6.7321**	14.64	0.46
$TP_{0.1}T$	13.98	0.730	0.595	**6.0727**	12.15	0.5



RESULTS & DISCUSSION

Cells were tested under air mass (1.5 mW) light conditions on both front and back sides. Initially, P25 standard, $P25G_{0.05wt/\%}$, and $P25G_{0.1wt/\%}$ layers were evaluated, followed by a complete $TP_{Gxwt/\%}T$ electrode stack. Results indicated power conversion efficiencies (PCE) of **5.1%** for P25, **5.8%** for $G_{0.05wt\%}$, and **5.1%** for $G_{0.1wt\%}$. The stacked structure showed enhanced PCE, reaching **6%** for TPT, **6.1%** for $TPG_{0.02wt/\%}T$, **6.7%** for $TPG_{0.05wt/\%}T$, and **6.4%** for $TPG_{0.1wt/\%}T$, with back illumination varying from **3.5%** to **4%**. This PCE improvement is attributed to graphene integration into the TiO2 matrix, enhancing electron mobility and reducing bandgap. The transparent nature of T/sp facilitates increased light absorption, enabling deeper penetration of photons into the active region, while P25's light distribution, coupled with higher electron mobility, promptly redirects and reflects photons across the active zone.

CONCLUSION

The introduction of graphene into the already motioned in the previous Poster (iSAMN2023) study has increased the efficiency rapidly due to reduction in bandgap and increase in electron mobility as shown in J_{sc} increment due to 0.05wt/% of graphene in the TiO_2 matrix.

ACKNOWLEDGEMENTS

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