Electronic Supplementary Information (ESI)

# Unusual enhancement in efficiency of DSSC upon modifying photoanode with reduced graphene oxide

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**Table S1** Literature survey of different materials used for enhancement in efficiencies of DSSC

| Sr. No. | Materials used for Photoanode | PCE (%) | **Features of Materials used to improve efficiency in DSSC** | Ref. |
|---|---|---|---|---|
| 1 | $TiO_2$ | 5.01 | • **Active material used- 2D Graphene oxide**<br>• **Active material preparation method**- Graphite with $KMnO_4$ as reducing agent<br>• **Anode fabrication**- 0.6 % weight mixed during $TiO_2$ paste preparation<br>• Morphology- 2D<br>• 2D materials is more beneficial when compared with 1D | [1] |
| | Grapheneoxide in $TiO_2$ | 6.97 | | |
| 2 | $TiO_2$ | 5.78 | • **Active material used- RGO**<br>• **Active material preparation method-** single-layer graphene oxide (SGO) to RGO by heat treatment<br>• **Anode fabrication**- 3 % weight mixed during $TiO_2$ paste preparation<br>• Morphology- not explained | [2] |
| | RGO in $TiO_2$ | 7.49 | | |
| 3 | $TiO_2$ | 0.32 | • **Active material used- Graphene sheet**<br>• **Active material preparation method-** Graphite to GO and further exploited to Graphene sheets via sonication<br>• **Anode fabrication**- 0.01-0.05 mg/mL mixed in $TiO_2$ suspension<br>• Morphology- single sheets | [3] |
| | Graphene sheets in $TiO_2$ | 1.68 | | |
| 4 | $TiO_2$ | 8.45 | • **Active material used- Graphene Purchased**<br>• **Active material preparation method**- NA<br>• **Anode fabrication**- 0.1% Graphene in mixed in $TiO_2$ suspension<br>• Morphology- agglomerate of Graphene and $TiO_2$ | [4] |
| | Graphene in $TiO_2$ | 9.45 | | |
| 5 | ZnO | 2.31 | • **Active material used- Graphene oxide**<br>• **Active material preparation method**- Graphite to GO by modified Hummers method<br>• **Anode fabrication**- 1.2 wt % of graphene scaffolds incorporated into ZnO hierarchically structured nanoparticle (HSN) (In situ generation) | [5] |
| | Grapheneoxide in ZnO | 3.19 | | |
| 6 | $TiO_2$ | 4.2 | • **Active material used- rGO**<br>• **Active material preparation method**- Graphite to GO by modified Hummers methods<br>• **Anode fabrication**- 0.75 Wt% mixed during $TiO_2$ paste preparation | [6] |
| | rGO in $TiO_2$ | 5.5 | | |
| 7 | $TiO_2$ | 4.54 | • **Active material used- multi-walled carbon nanotubes**<br>• **Active material preparation method**- Graphite to multi-walled carbon nanotubes by Staudenmaier's method followed by heat treatment<br>• **Anode fabrication**- composite of multi-walled carbon nanotubes pastes were prepared for doctoral blading $TiO_2$ particle | [7] |
| | multi-walled carbon nanotubes in $TiO_2$ | 6.11 | | |
| 8 | $TiO_2$ | 1.79 | • **Active material used- Graphene oxide**<br>• **Active material preparation method-** Modified Hummers methods<br>• **Anode fabrication**- 0.21 wt % GO | [8] |
| | Grapheneoxide in $TiO_2$ | 2.78 | | |

| | | | | |
|---|---|---|---|---|
| | | | mixed with $TiO_2$ particle | |
| 9 | $TiO_2$ Fibers | 6.3 | ● **Active material- Graphene Purchased**<br>● **Active material preparation method- NA**<br>● **Anode fabrication-** Electrospinning of conductive $TiO_2$-graphene composites in combination with PVP as a carrier solution resulting in well-defined and structurally stable fibers. | [9] |
| | Graphene in $TiO_2$ Fibers | 7.6 | | |
| 10 | $TiO_2$ | 6.08 | ● **Active material used- rGO**<br>● **Active material preparation method-** Chemically reduced graphene oxide<br>● **Anode fabrication-** Simple spin coating of RGO at FTO/$TiO_2$ interface | Present work |
| | rGO spin coated at Interface | 8.19 | | |
| 11 | $TiO_2$ | 6.08 | ● **Active material used- rGO**<br>● **Active material preparation method-** Chemically reduced graphene oxide<br>● **Anode fabrication-** Simple spin coating of RGO at FTO/ $TiO_2$ interface | Present work |
| | rGO spin coated at Interface | 8.03 | | |

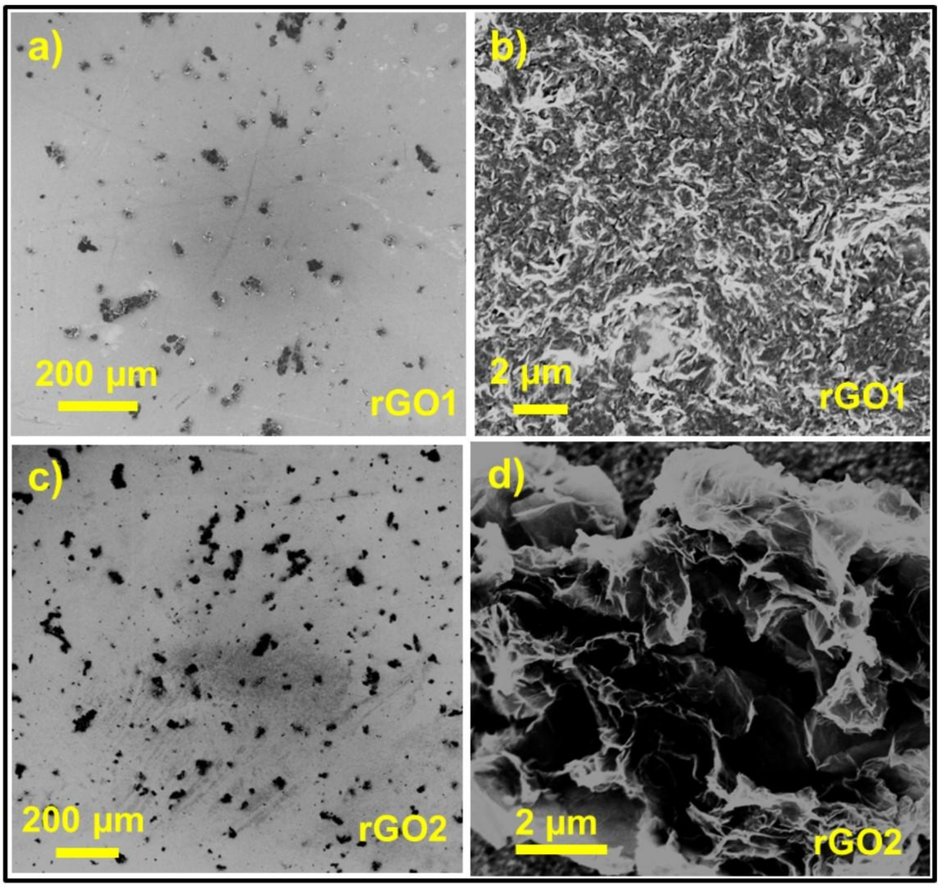



**Figure S1** FESEM images of spin coated rGO1 (a) and rGO2 (c) on FTO after calcination at 500 $^{o}C$ in open air whereby rGO particles are clearly visible with retention of morphology (zoomed-in FESEM images are presented b and d). Calcination was carried out to check the sustainability of rGO materials in photoanode fabrication process.

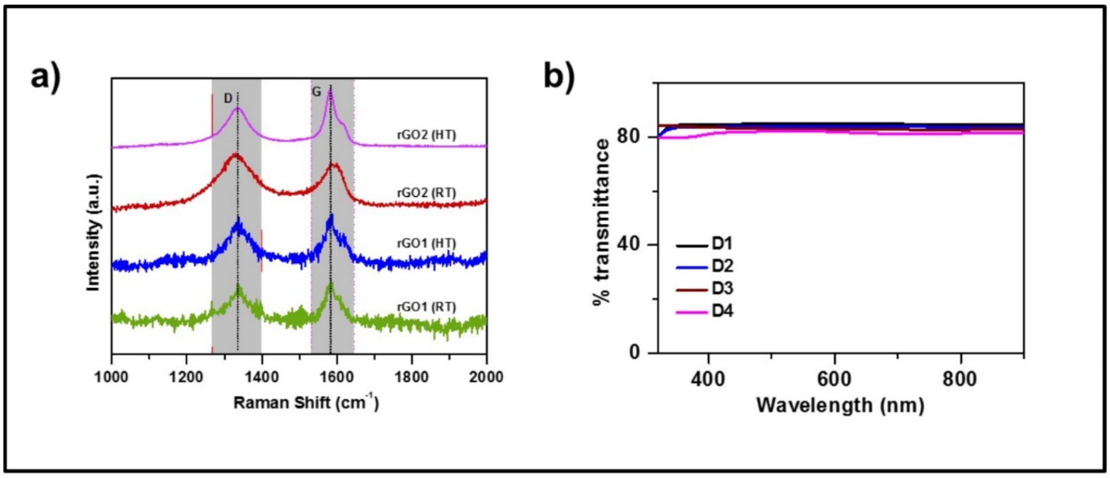



**Figure S2** (a) Raman spectra of rGO1 and rGO2 where RT indicate before heating and HT after heating at 500 $^{o}$C in open air, respectively. (b) Absorbance spectra of blank FTO (D1), $TiCl_4$ treated (D2), spin coated rGO1 (D3) and rGO2 (D4) systems.

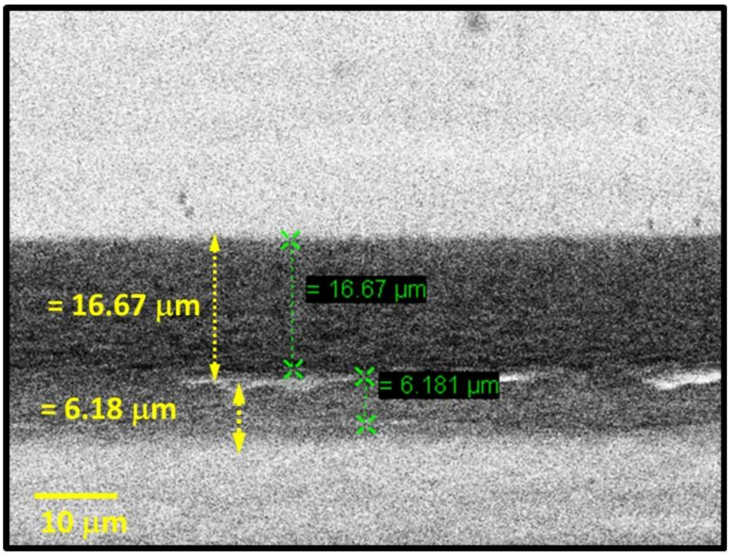



**Figure S3** Cross-sectional FESEM image of the photoanode of the D3 device.

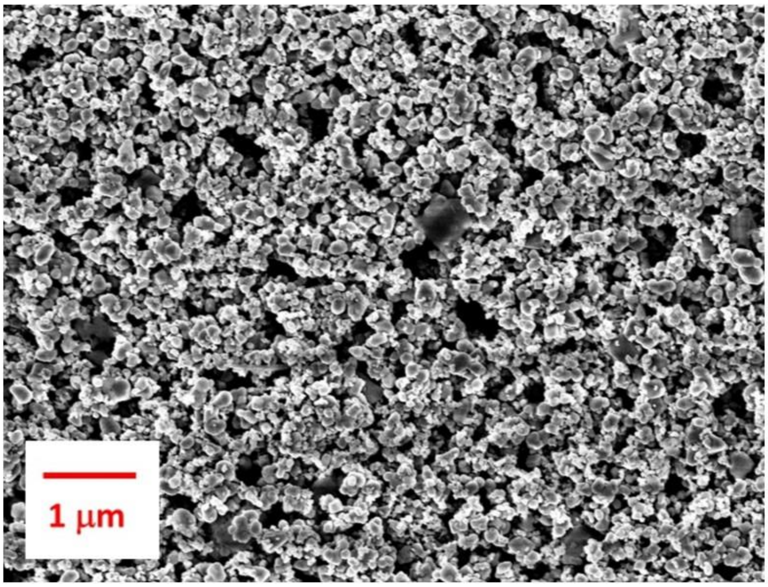



**Figure S4** FESEM image of the photoanode of the D3 device.

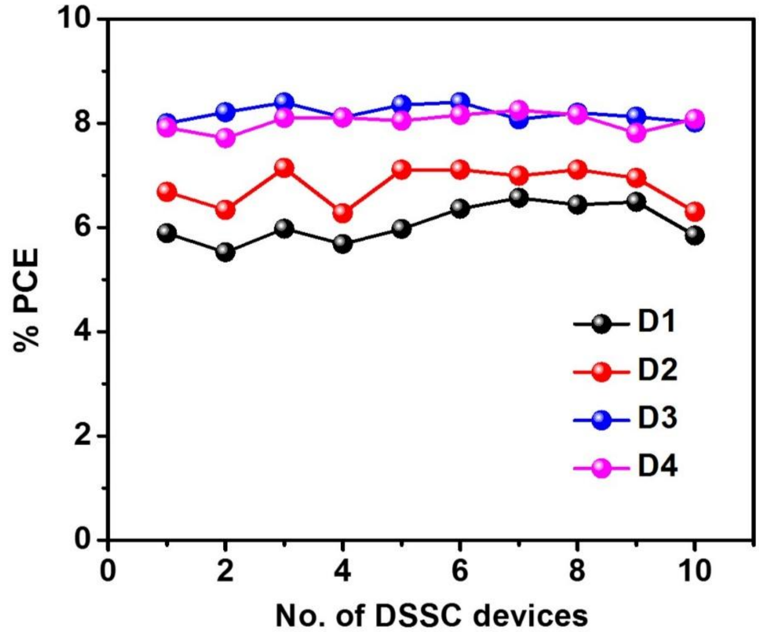



**Figure S5** % PCE values of each 10 devices of D1, D2, D3 and D4.

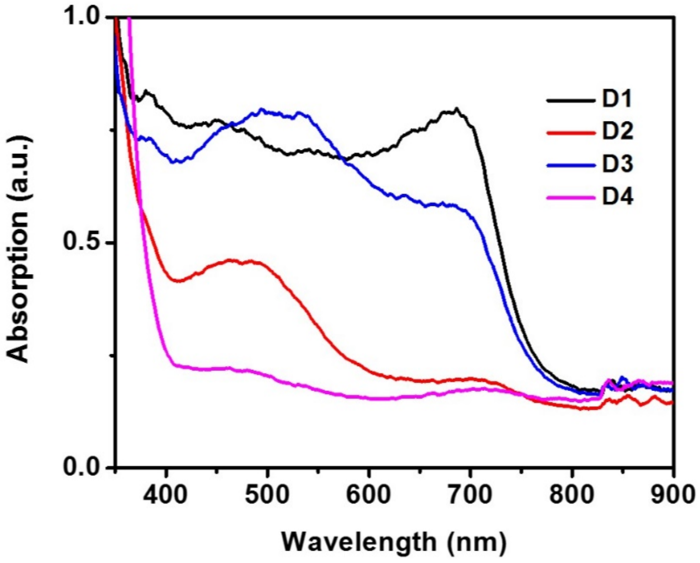
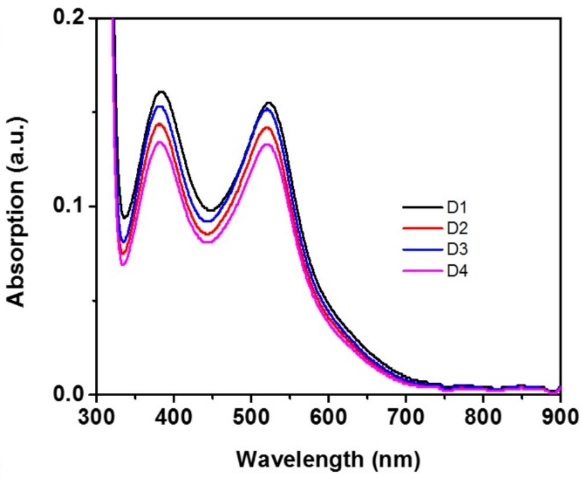



**Figure S6** Solid-state UV-vis spectra of photoanodes of D1, D2, D3 and D4 devices.

a)




b)

| Photoanode | Amount of dye loaded mole/cm$^{-2}$ |
|---|---|
| D1 | 1.31*10$^{-7}$ |
| D2 | 1.20*10$^{-7}$ |
| D3 | 1.28*10$^{-7}$ |
| D4 | 1.11*10$^{-7}$ |

**Figure S7** (a) UV-vis spectra of de-absorbed dye from photoanodes of D1, D2, D3 and D4 devices. (b) Table showing the amount of dye loading in D1, D2, D3 and D4 devices.

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