Supporting Information

Figure S1. Red trace is a forward scan (from 0 ps to 6300 ps) of the sample TiN719DS probed at 1200 nm. Overlaid on top is the last scan in reverse (from 6300 ps to 0 ps) approximately one hour after the initial scan. Two more scans were recorded in between the first and last.

Figure S2. Sample TiN719DS probed at 1200 nm and excited with 580 nm pulses at two different intensities: 55 $\mu$J cm$^{-2}$ and at 90 $\mu$J cm$^{-2}$ per pulse. The higher intensity trace was multiplied by a
factor of 0.611 (55/90). The two traces coincide perfectly and hence the scaling is linear. This observation suggests no non-linear effects were present during the transient absorption measurements and no intensity-dependent processes were observed at the light intensities used.

Figure S3. Transient absorption change at 1200 nm of the TiC106DS sample at open circuit and short circuit conditions. The short circuit data was multiplied by 1.08 to match peak absorptions. Higher noise in this graph is observed compared to Figure S2 because a single forward scan was used here instead of an average of 4.
Figure S4. UV-Vis absorption spectrum of the full ZrO$_2$ devices.

Figure S5. UV-Vis absorption spectrum of the full TiO$_2$ devices.
Figure S6. Current-Voltage curves of the TiO$_2$ devices at 1 sun simulated spectrum (AM1.5).

Table S1. Solar cell parameters of the devices used in the experiments.

<table>
<thead>
<tr>
<th>Device</th>
<th>$V_{OC}$, V</th>
<th>$J_{SC}$, mA cm$^{-2}$</th>
<th>FF</th>
<th>Efficiency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiC106Li</td>
<td>0.478</td>
<td>8.0</td>
<td>0.37</td>
<td>7.3</td>
</tr>
<tr>
<td>TiC106DS</td>
<td>0.766</td>
<td>13.2</td>
<td>0.58</td>
<td>5.9</td>
</tr>
<tr>
<td>TiN719Li</td>
<td>0.486</td>
<td>13.6</td>
<td>0.45</td>
<td>3.0</td>
</tr>
<tr>
<td>TiN719DS</td>
<td>0.734</td>
<td>10.7</td>
<td>0.60</td>
<td>4.7</td>
</tr>
</tbody>
</table>

**Extinction coefficient calculation of the excited state of N719 dye on ZrO$_2$ in DS and in Li electrolytes**

Proportion of photons absorbed at 580 nm: $1 \cdot 10^{-0.54} = \sim 70\%$

Total energy per pulse (homogeneous in the range 150 - 500 µm pulse diameter): 46-48 µJ cm$^{-2}$

Total amount of photons per pulse: $1.4 \cdot 10^{14}$ cm$^{-2}$

Total amount of excited dye molecules: $1 \cdot 10^{14} = 1.65 \cdot 10^{10}$ mol

Concentration of excited dye molecules: $2.75 \cdot 10^{-4}$ M

Absorption amplitude at 1200 nm: $0.8 \cdot 10^{-3}$

Extinction coefficient at 1200 nm = $A / c / l = 0.0008 / 2.75e-4 / (6e-4) = 4850$ M$^{-1}$ cm$^{-1}$

Extinction coefficient at wavelengths 900 – 1000 nm = 3650 M$^{-1}$ cm$^{-1}$