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1. Calculation of activation energy

The activation energy of a catalytic reaction can be calculated by the following experimental Arrhenius equation based on rate constant and temperature

\[ k = A e^{-E_{a}/RT} \]  

(1)

Generally, \( A \) and \( E_{a} \) are constant, and represent pre-exponential factor and experimental activation energy respectively. \( R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} \) and \( K \) represents absolute temperature.

To calculate \( A \) and \( E_{a} \), the equation (1) is commonly changed as its logarithmic form

\[ \log k = -\frac{E_{a}}{2.303R} \cdot \frac{1}{T} + \log A \]  

(2)

Therefore, it will be convenient to obtain \( A \) and \( E_{a} \) if two \( T (T_{1}, T_{2}) \) and \( k (k_{1}, k_{2}) \) are known by

\[ \log k_{1} = -\frac{E_{a}}{2.303R} \cdot \frac{1}{T_{1}} + \log A \]  

(3)

\[ \log k_{2} = -\frac{E_{a}}{2.303R} \cdot \frac{1}{T_{2}} + \log A \]  

(4)

When (4) – (3), (5) is obtained

\[ \log \left( \frac{k_{2}}{k_{1}} \right) = -\frac{E_{a}}{2.303R} \cdot \left( \frac{1}{T_{2}} - \frac{1}{T_{1}} \right) \]  

(5)

For the present system, the temperature of the suspension after 1 h irradiation under \( \lambda \geq 500 \text{ nm} \) reaches to \( \sim 54 \text{ °C} \) due to the high intensity of Xe-lamp. However, the he temperature of the suspension after 1 h irradiation under monochromatic light irradiation (\( \lambda = 685, 700 \text{ or } 760 \pm 10 \text{ nm} \)) can maintain as room temperature (\( \sim 25 \text{ °C} \)) due to the low transmission light intensity. Generally, the activation energy (\( E_{a} \)) for a system is a constant and has nothing to do with reaction conditions. Therefore, it is reasonable to use equation (5) to calculate \( E_{a} \) according to the two reaction rates and temperatures under \( \lambda \geq 500 \text{ nm} \) and monochromatic light irradiation respectively. Take Zn-tri-PcNe-2-Pt/g-C_{3}N_{4} as example, the \( k_{1} = 173.3 \mu \text{mol/h} \) (which is obtained by the linear fitting of first 10 h of Figure 5) and \( T_{1} = 327 \text{ K} \) under \( \lambda \geq 500 \text{ nm} \), and the \( k_{2} = 27.7 \mu \text{mol/h} \) and \( T_{2} = 298 \text{ K} \) under \( \lambda = 700 \pm 10 \text{ nm} \). Therefore, the activation energy (\( E_{a} \)) for Zn-tri-PcNe-2-Pt/g-C_{3}N_{4} is 50.72 kJ/mol. Accordingly, the activation energy (\( E_{a} \)) for the six system of Zn-tri-PcNe-2-Pt/g-C_{3}N_{4}, Zn-tri-PcNe-1-Pt/g-C_{3}N_{4}, Zn-tri-PcNe-3-Pt/g-C_{3}N_{4}, Zn-tetrad-Nc-3- Pt/g-C_{3}N_{4}, Zn-tetrad-Pc-1- Pt/g-C_{3}N_{4} and Zn-tetrad-Pc-2- Pt/g-C_{3}N_{4} are 50.72, 41.63, 58.50, 69.81, 38.73 and 88.06 kJ/mol respectively.

2. EIS analysis
Figure S1. EIS spectra of the six dyes sensitized g-C$_3$N$_4$.

Figure S2. Bode plots of the six dyes sensitized g-C$_3$N$_4$.

Table S1. Photoelectrochemical Data of the six dyes sensitized g-C$_3$N$_4$.

<table>
<thead>
<tr>
<th>System</th>
<th>$R_2$ (Ω)</th>
<th>$f$ (Hz)</th>
<th>$\tau_n$ (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn-tri-PcNc-2-g-C$_3$N$_4$</td>
<td>1573</td>
<td>5.486</td>
<td>28.9</td>
</tr>
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<td>Zn-tri-PcNc-1-g-C$_3$N$_4$</td>
<td>1235</td>
<td>6.643</td>
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</tr>
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<td>Zn-tri-PcNc-3-g-C$_3$N$_4$</td>
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<td>8.071</td>
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<tr>
<td>Zn-tetrad-Nc-3-g-C$_3$N$_4$</td>
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<tr>
<td>Zn-tetrad-Pc-1-g-C$_3$N$_4$</td>
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<td>11.91</td>
<td>13.4</td>
</tr>
<tr>
<td>Zn-tetrad-Pc-2-g-C$_3$N$_4$</td>
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<td>14.36</td>
<td>11.1</td>
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