Triazine and Thiophene Based Conjugated Polymer Network: Electrochromic and Electrocatalytic Properties

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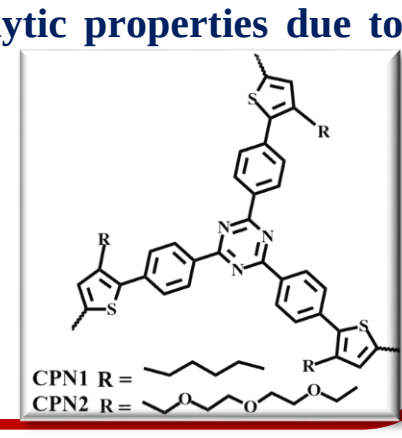
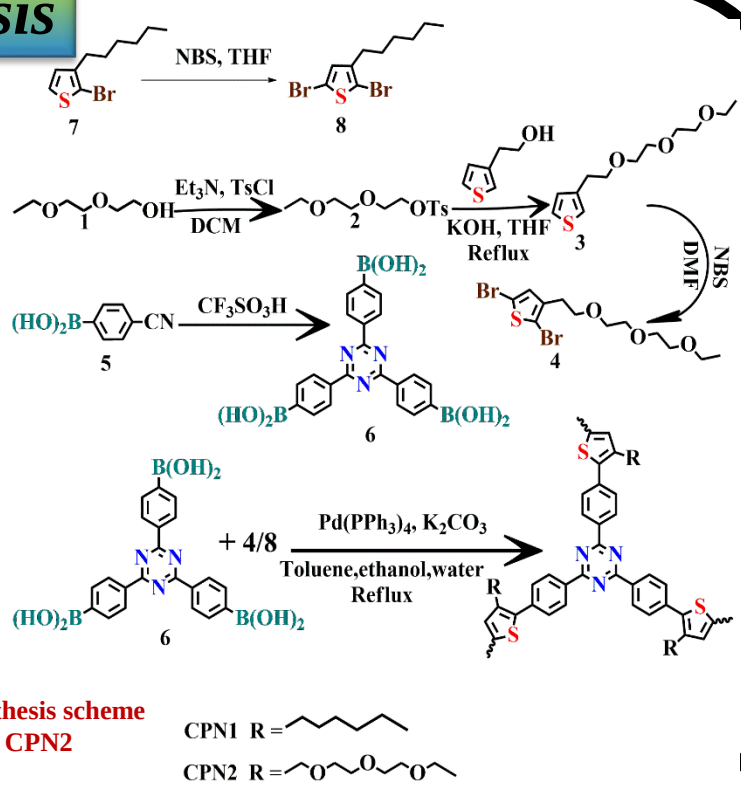
Introduction

- **Conjugated polymer networks (CPN)[1,2] which belong to the family of porous organic polymer[3], are an emerging class of materials that exhibits promising electrochromic and electrocatalytic properties due to extended π conjugation, interconnected porous structure and high surface area.**
- Herein, we have demonstrated **electrochromic (Vis to NIR)** and **electrocatalytic (Oxygen evolution reaction)** property of two triazine and thiophene-based solution processable CPN by coupling the thiophene (donor) unit with a triazine ring (acceptor) through a phenyl ring spacer. **The effect of sidechain polarity and functionality** on both the properties also systematically studied.



Synthesis



Scheme 1: synthesis scheme of CPN1 and CPN2

Characterization

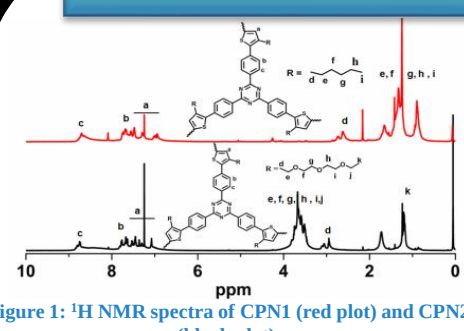


Figure 1: ^{1}H NMR spectra of CPN1 (red plot) and CPN2 (black plot).

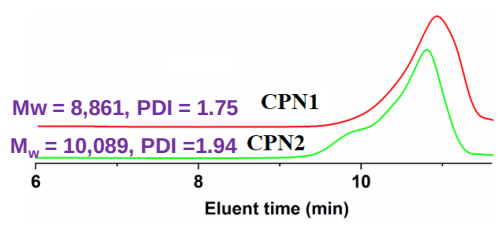


Figure 2: GPC traces of CPN1 and CPN2

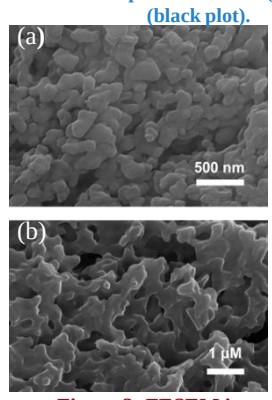


Figure 3: FESEM images of CPN1 and CPN2

FESEM image show Interconnected nanospheres

Further characterization performed

- FTIR study and XPS study confirms the inclusion of triazine ring in the polymer.
- CPN1 and CPN2 exhibit BET surface area of 34.68 and 15.54 m^2/g with average pore of 2.44 and 1.52 nm respectively.
- The powder X-ray diffraction (PXRD) analysis revealed amorphous structure indicating interconnected porous structure instead of unimodal pore

UV-vis to NIR Electrochromism

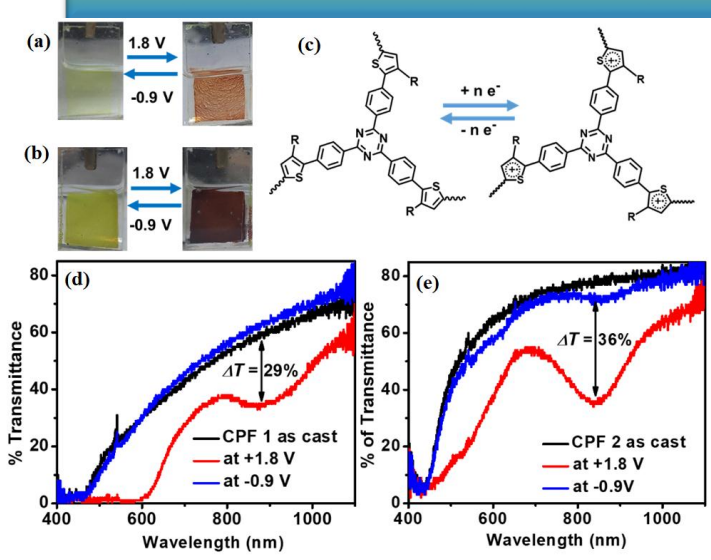


Figure 4: Reversible EC colour change of (a) CPN1 and (b) CPN2 film. (c) Probable mechanism. Transmittance changes of (d) CPN1, and (e) CPN2 film during potential sweeping.

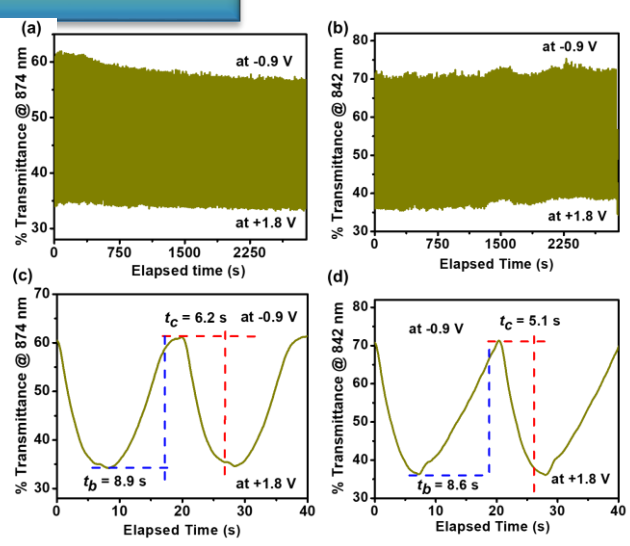


Figure 5: The change in the transmittance with time upon potential switching between +1.8 V and −0.9 V of (a) CPN1 and (b) CPN2 with the electrochromic switching response of (c) CPN1 and (d) CPN2 based ECDs at 874 nm and 842 nm, respectively.

Table 2. A summary of the EC parameters of CPN thin-films

Sample	Tb	Tc	t_b(sec)	t_c (sec)	Qd (mC/cm^2)	Qc (mC/cm^2)	Coloration Efficiency (cm^2/C)
CPN1	62.8	33.8	8.9	6.2	2.3	3.0	116.9
CPN2	74.2	34.9	8.6	5.1	2.0	2.8	163.7

- The CPN1 exhibits yellow to golden-brown vis-to-NIR EC colour change, whereas, CPN2 exhibits yellow to deep-brown vis-to-NIR EC colour change
- Both the CPFs exhibited excellent cycling performances with a negligible loss of optical contrast over 150 cycles.

Electrocatalytic activity towards OER

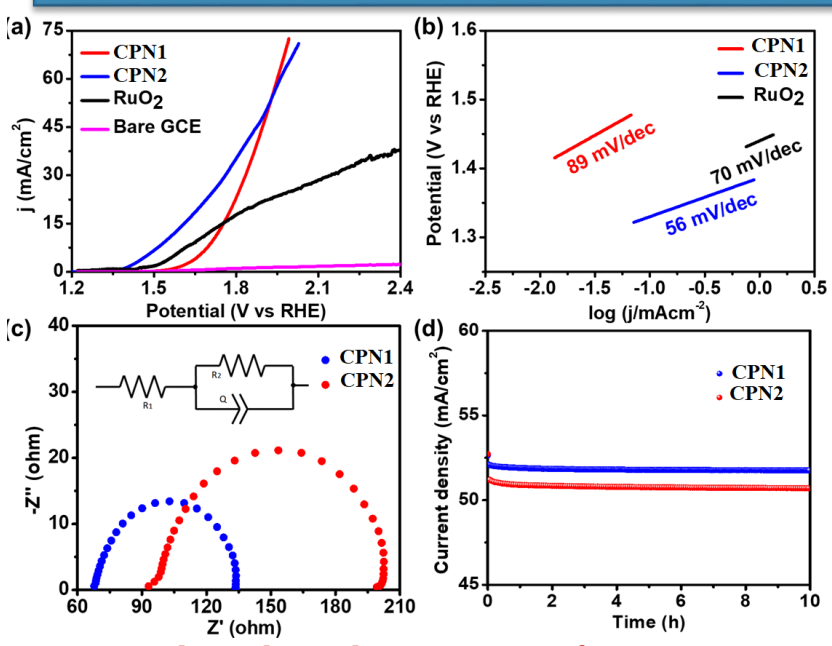


Figure 6: Electrochemical OER activities of CPN1, CPN2, RuO_2, and GCE. (a) LSVs, (b) Tafel plots, (c) EIS Nyquist plot in 1.0 M KOH electrolyte. The corresponding equivalent circuit is given in the inset. (d) The chronoamperometry curves.

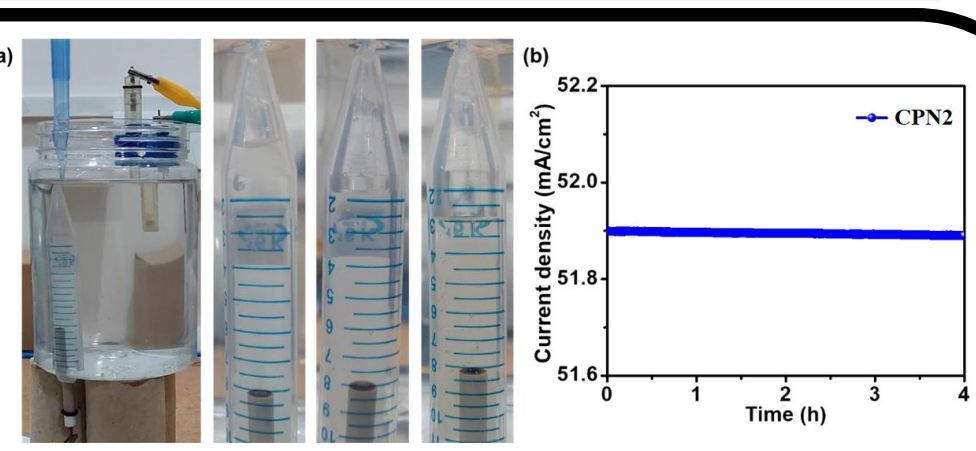


Figure 7: (a) Measurement of the evolved oxygen after 1, 3 and 4 h (b) corresponding chronoamperometry plot.

- CPN2 with ethylene glycol side chain attached to thiophene moiety shows superior electrocatalytic performance with a current density of 10 mA/cm^2 at an overpotential of 328 mV compared to CPN1 (10 mA/cm^2 at an overpotential (η) of 488 mV) having hexyl sidechain.
- The achieved OER activity by CPF2 in an alkaline medium is comparable to or even better than that of other well-reported metal-free catalysts with excellent durability.

Conclusion

- Here, we have demonstrated two solution processable CPN based on triazine and thiophene which exhibit UV-vis to NIR electrochromism and OER electrocatalytic activity that are highly dependent on polarity and functionality of the side chain .
- We believe these materials have potential scope as electrochromic materials for next generation smart window technology and metal free OER electrocatalyst for fuel cell and zinc air battery .

References and Acknowledgement

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