

# Polymer Nanocomposites



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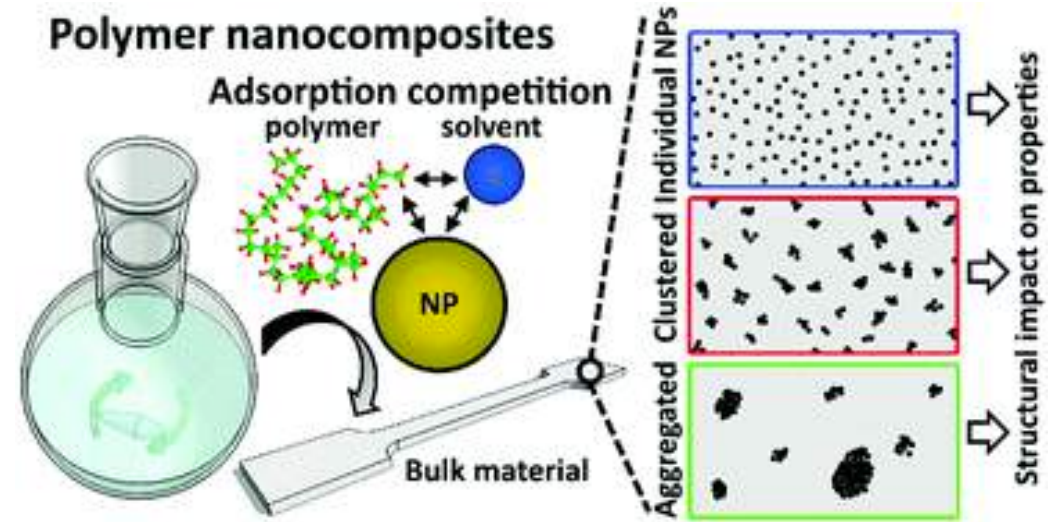
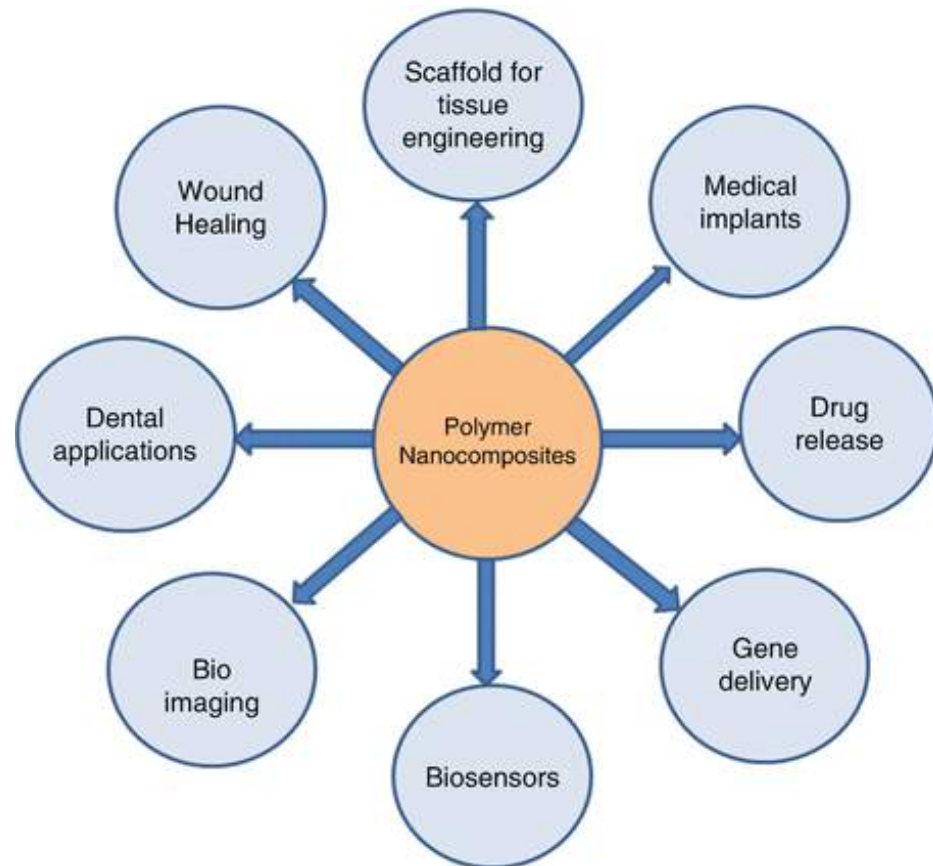
**MGCU, Bihar**

- Conducting polymers and Metal nanoparticles-based nanocomposites and their applications in electrocatalysis/fuel cells**
- Metallo-supramolecular polymers and nanoparticles-based nanocomposites for high ion conducting materials**

# What are Polymer Nanocomposites

Polymer nanocomposites (PNC) are usually a combination of a polymer or copolymer with nanoparticles/Nanowires/ or any nanostructure.

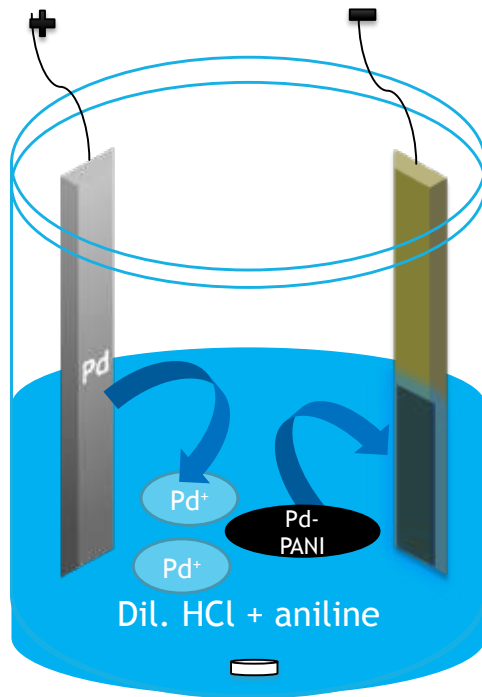
The nanostructure must have at least one dimension less than 100 nm



*c.f., Polymer Nanocomposites for Biomedical and Biotechnology Applications, Springer, 2016  
Lepcio et. al., Soft Matter, 2018,14, 2094-2103*

# Metal-polymer nanocomposites (Pd metal)

Noble metal nanoparticles-conjugated polymer nanocomposites for electrocatalysis applications and fuel cells

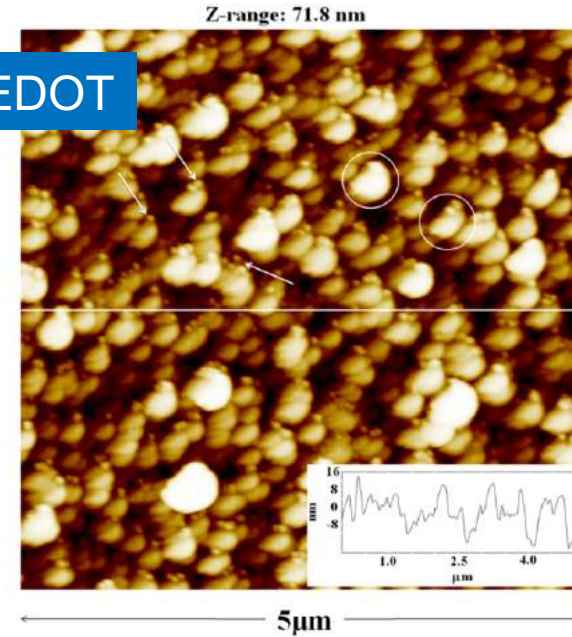
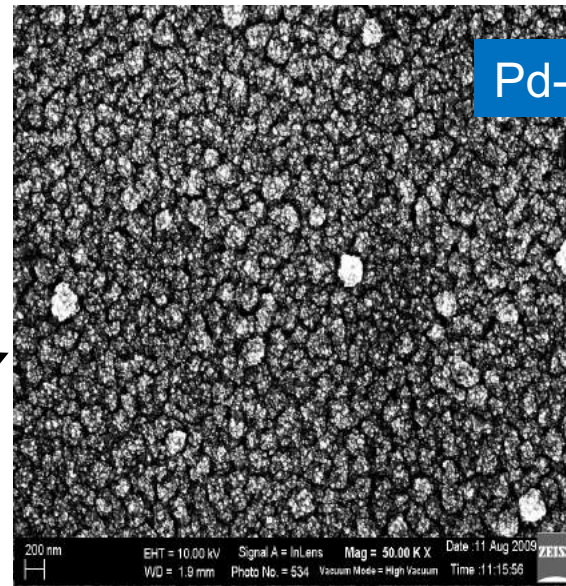


This is a one pot synthesis protocol for the preparation of metal and conducting polymer nanocomposites:

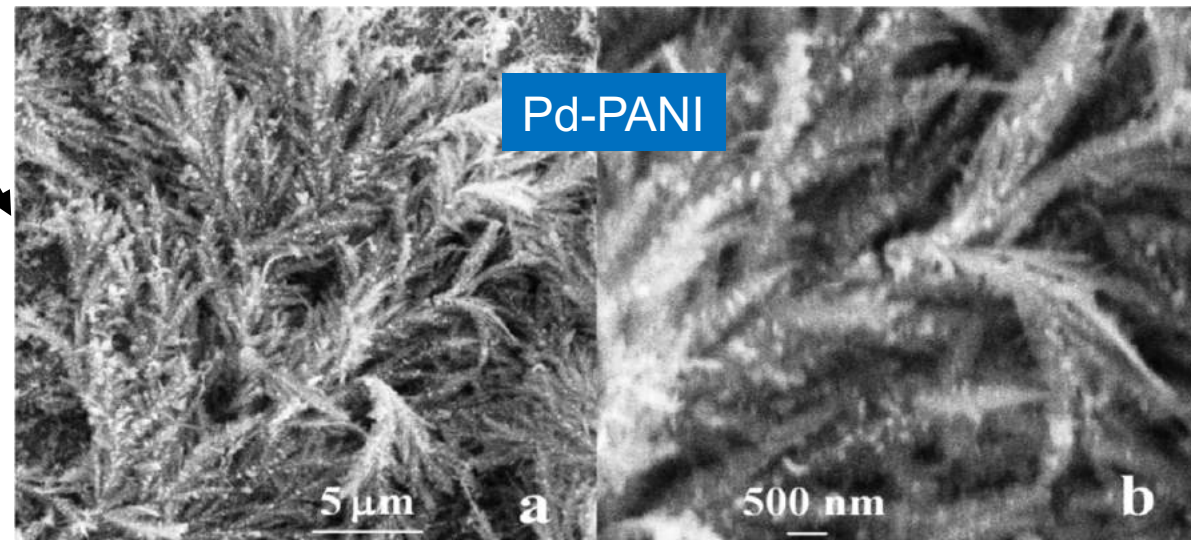
$\text{Pd}^+ + \text{Chloride} = \text{Chloropalladate}$   
 $\text{Chloropalladate} + \text{Aniline} = \text{Pd-PANI nanocomposite}$

# Metal-polymer nanocomposites: Imaging

Scanning Electron Microscopy (SEM) images of Pd-polyethylene dioxythiophene (Pd-PEDOT) and Pd-polyaniline (Pd-PANI)



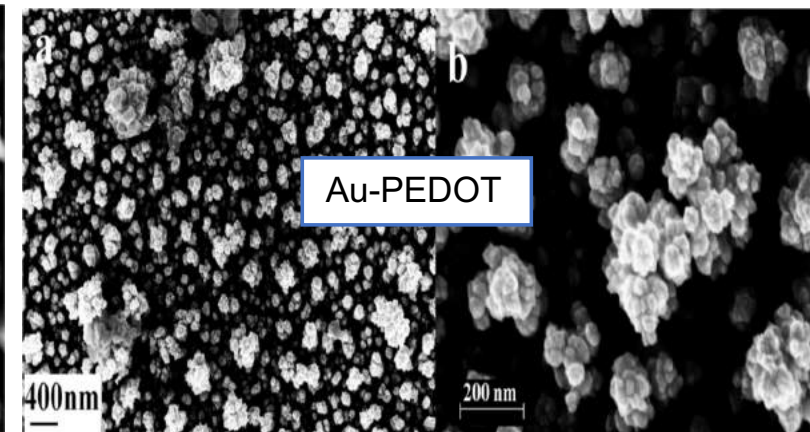
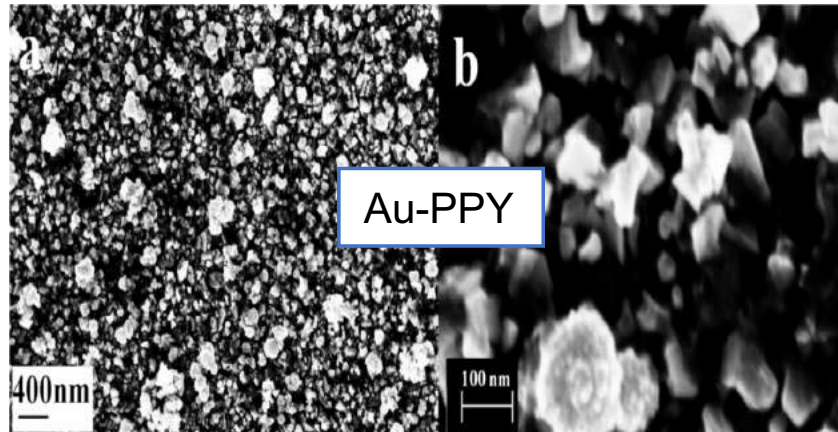
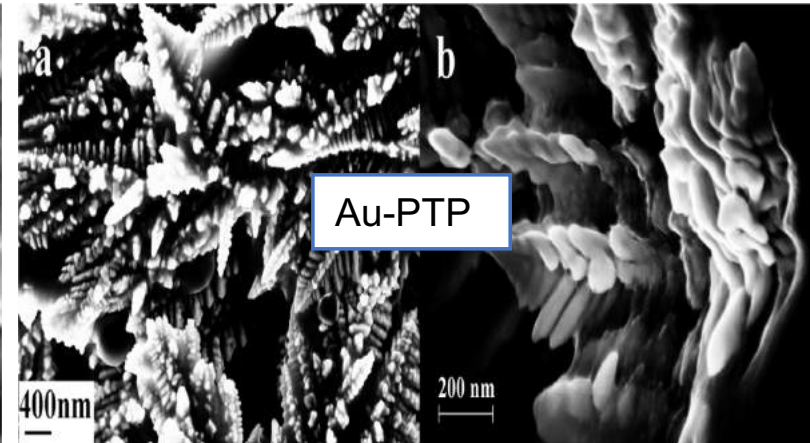
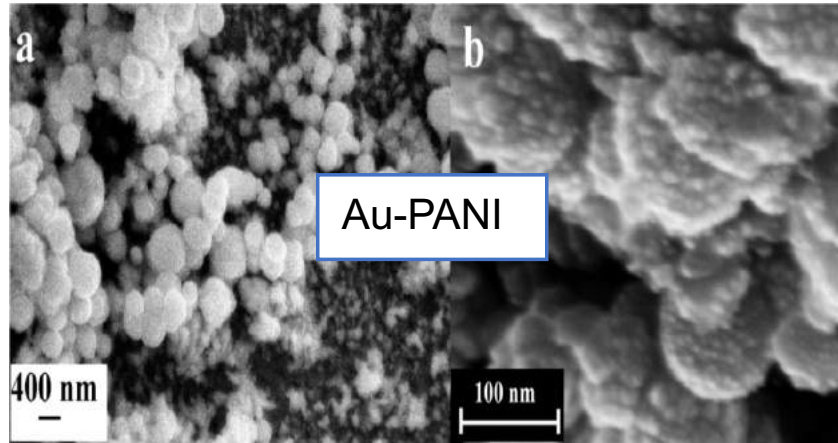
Atomic Force Microscopy (AFM) images of Pd-PEDOT





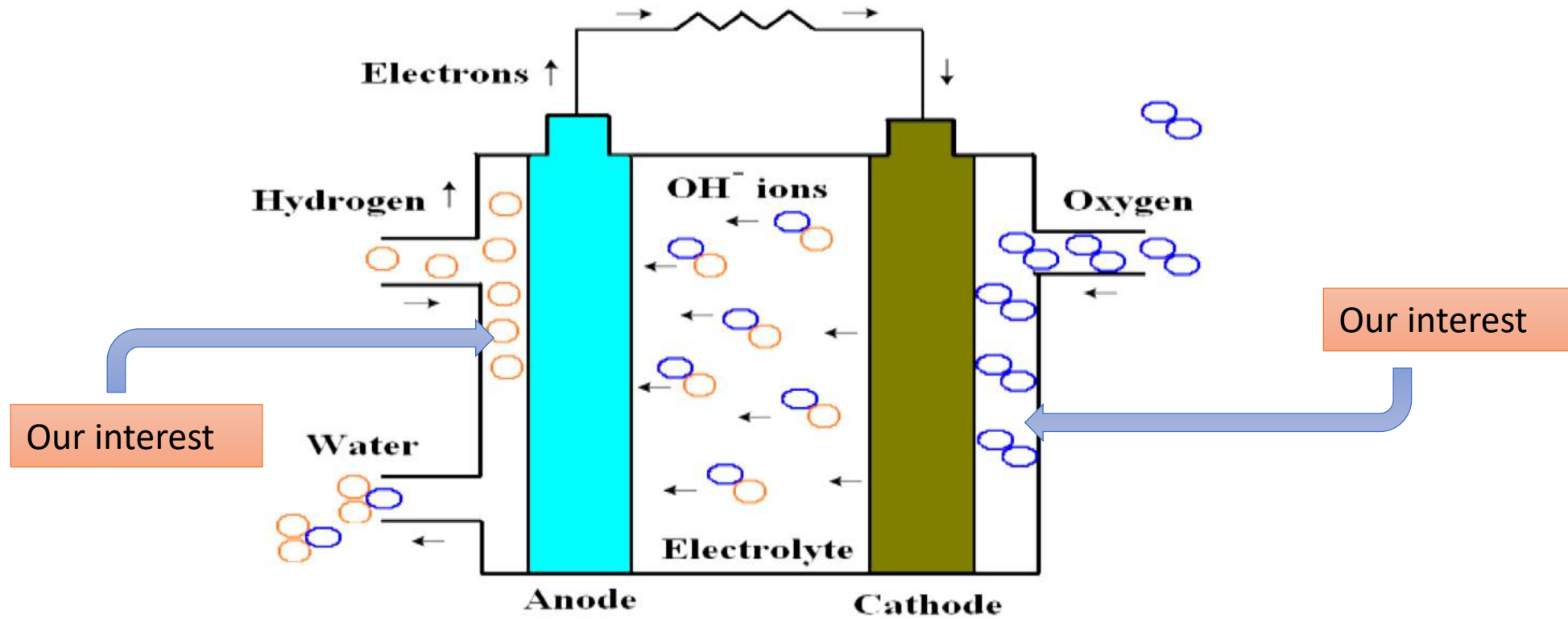
# Metal-polymer nanocomposites: Imaging

Scanning Electron Microscopy (SEM) images of Au with different conducting polymers

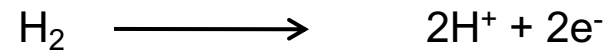


# Applications of polymer nanocomposites: Fuel cell and electrocatalysis

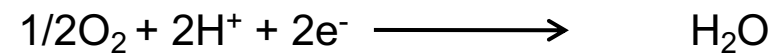
Fuel cell is basically an electrochemical device that converts chemical energy to electrical energy



Anode:

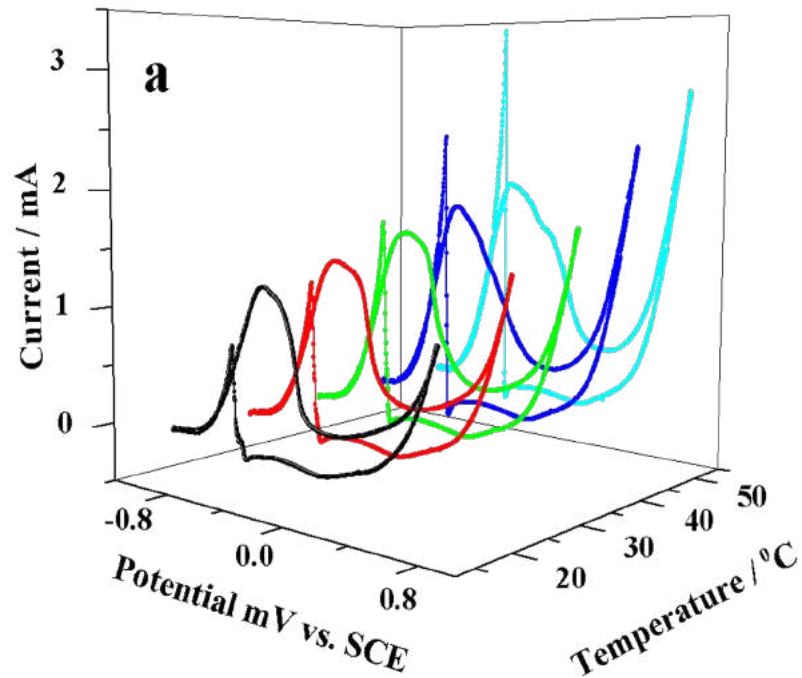


Cathode:

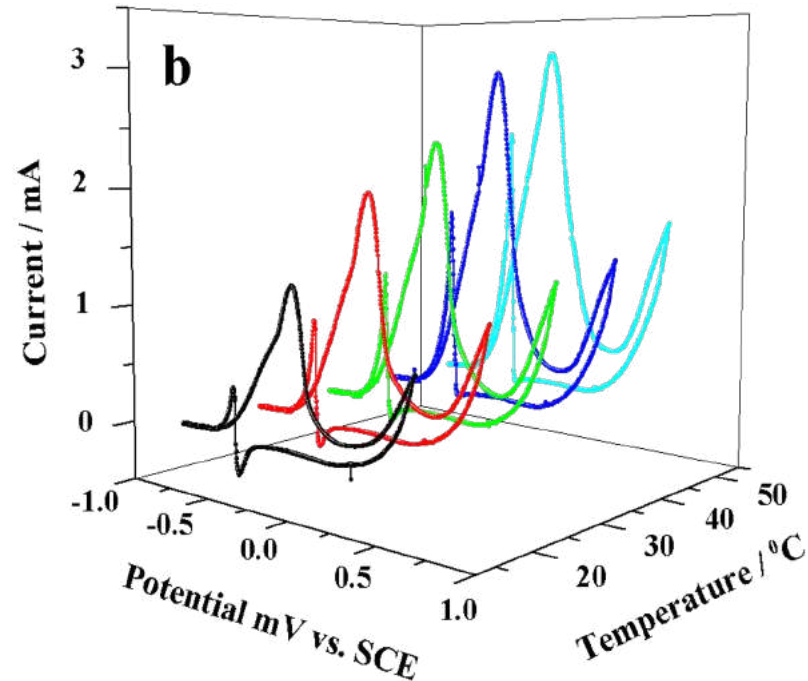


# Electrocatalysis using Metal-polymer nanocomposites

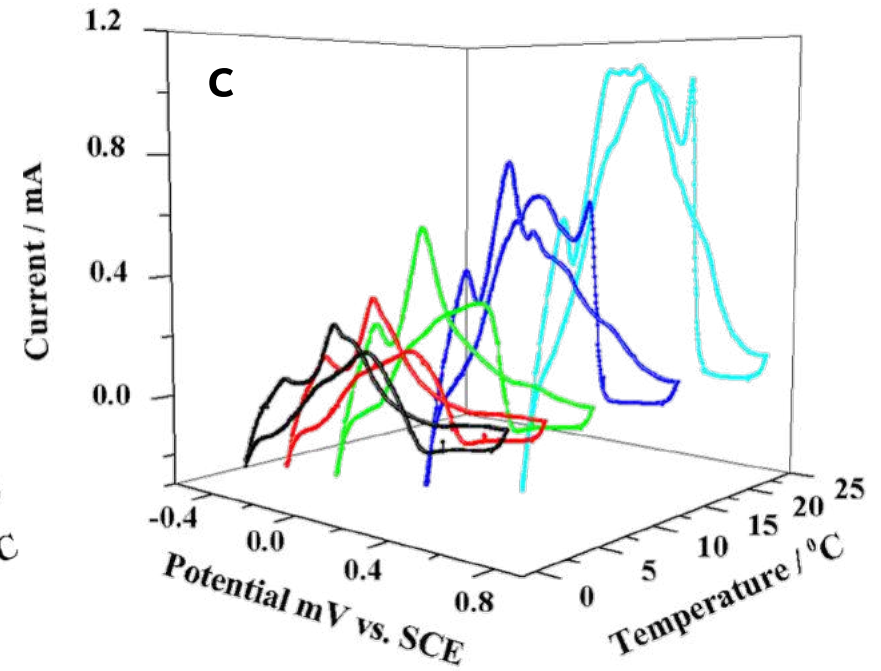
Cyclic voltammetry is a technique that can be utilized to know the efficiency of the polymer nanocomposite for electro-oxidation:  
More current and low onset potential suggests a higher efficiency



Ethanol



Methanol



Formic acid



# Metal-polymer nanocomposites (Au metal) Ethanol electro-oxidation

Comparison of the electro-oxidation power of different polymer nanocomposites for ethanol oxidation

Nanocomposite	Onset Potential / V		Peak Potential / V		Peak Current / mAcm <sup>-2</sup>	
	1 <sup>st</sup> cycle	200 <sup>th</sup> cycle	1 <sup>st</sup> cycle	200 <sup>th</sup> cycle	1 <sup>st</sup> cycle	200 <sup>th</sup> cycle
Au-PANI	-0.34	-0.34	0.314	0.286	3.36	3.5
Au-PPY	-0.35	-0.4	0.144	0.128	2.02	2.0
Au-PTP	-0.40	-0.4	0.17	0.20	1.63	1.68
Au-PEDOT	-0.36	-0.36	0.118	0.124	2.93	1.8

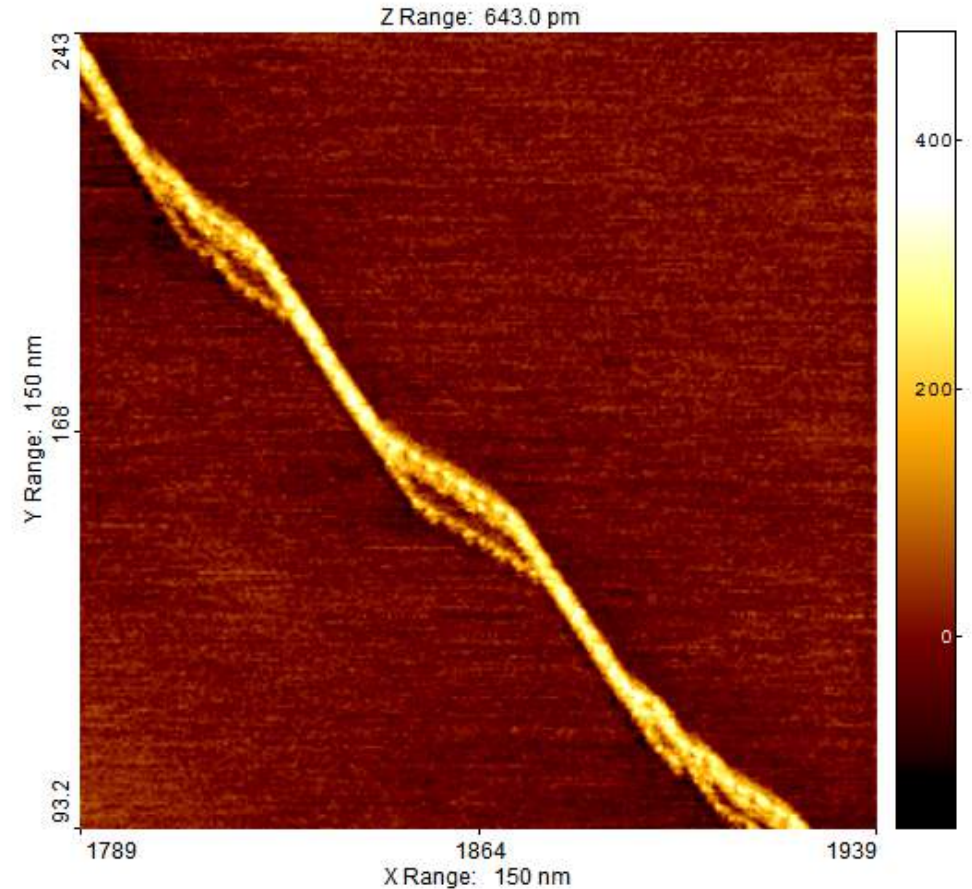
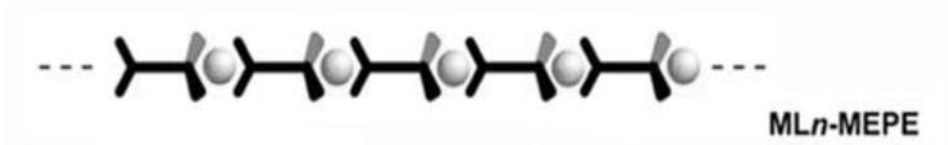
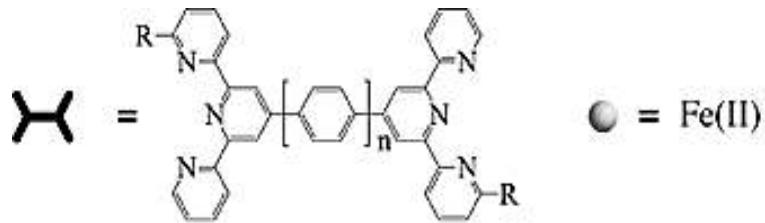
*R. K. Pandey et al. Materials Research Bulletin, 2014, 50, 413.*

*R. K. Pandey et al. Applied Catalysis-B, Environmental, 2012. 125, 271.*

# Metallo-supramolecular Polymers

## Self-assembly of Metal ions and Ligands in solution

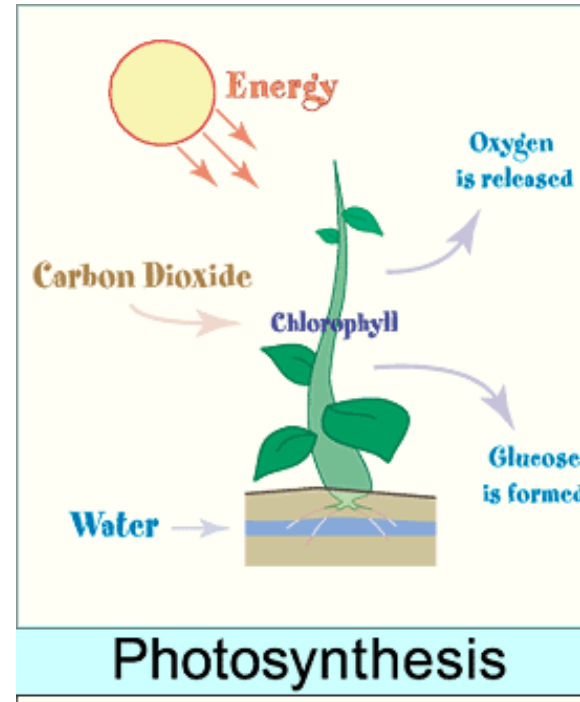
Functional elements: Metals  
Processability: Polymers



Known for their electrochromic, optical and electrochemical properties

# Ionic conductivity / Proton conductivity: Examples

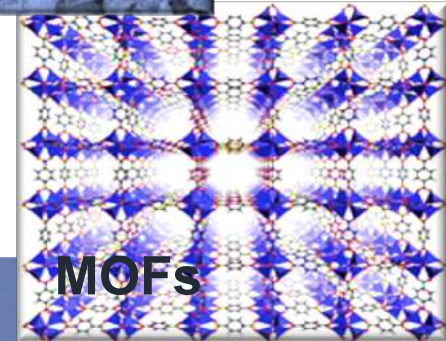
Most electrochemical conversion and storage devices, such as fuel cells, redox-flow, and alkaline ion batteries, rely on the amazing properties of ion conducting polymer membranes.



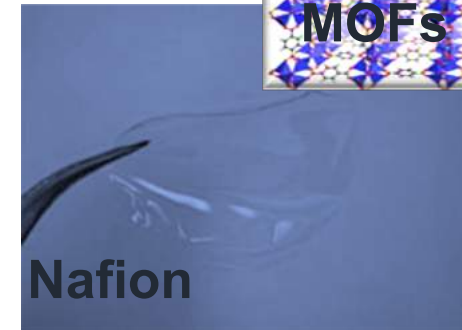
Molecular motor action driven by proton conduction



Ceramics

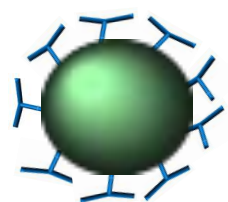
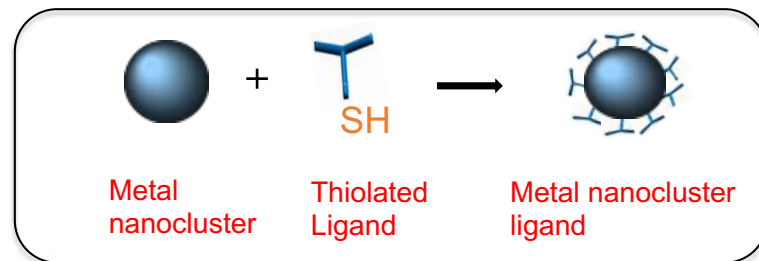


MOFs

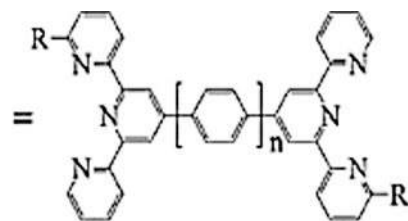


Nafion

# Nanocluster metallo-supramolecular polymers and metal nanoparticles



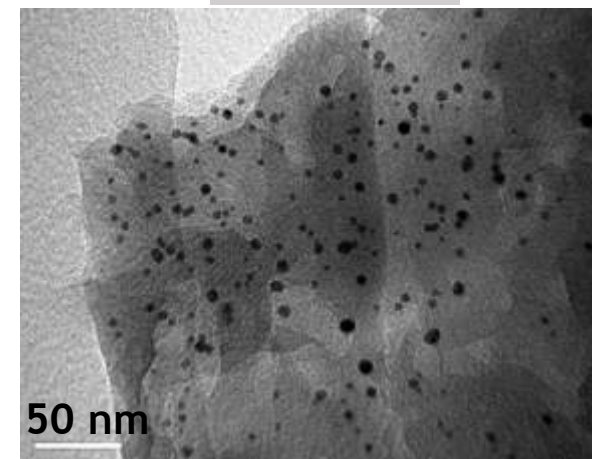
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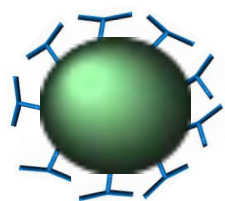
+ Metal ions



polyAuFe1

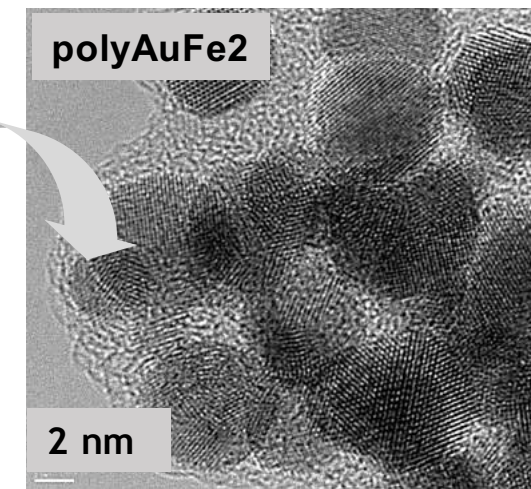
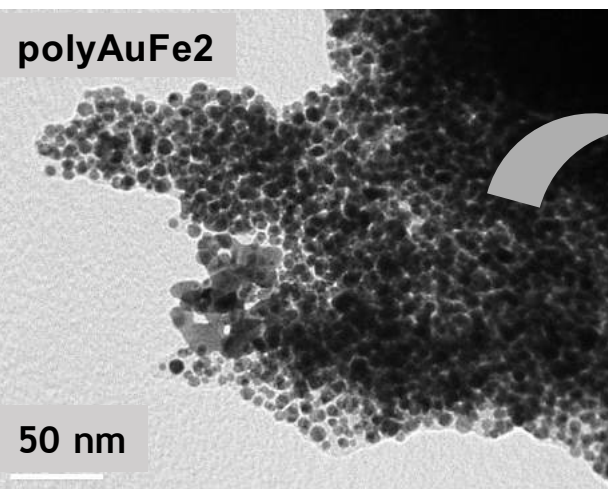


OR



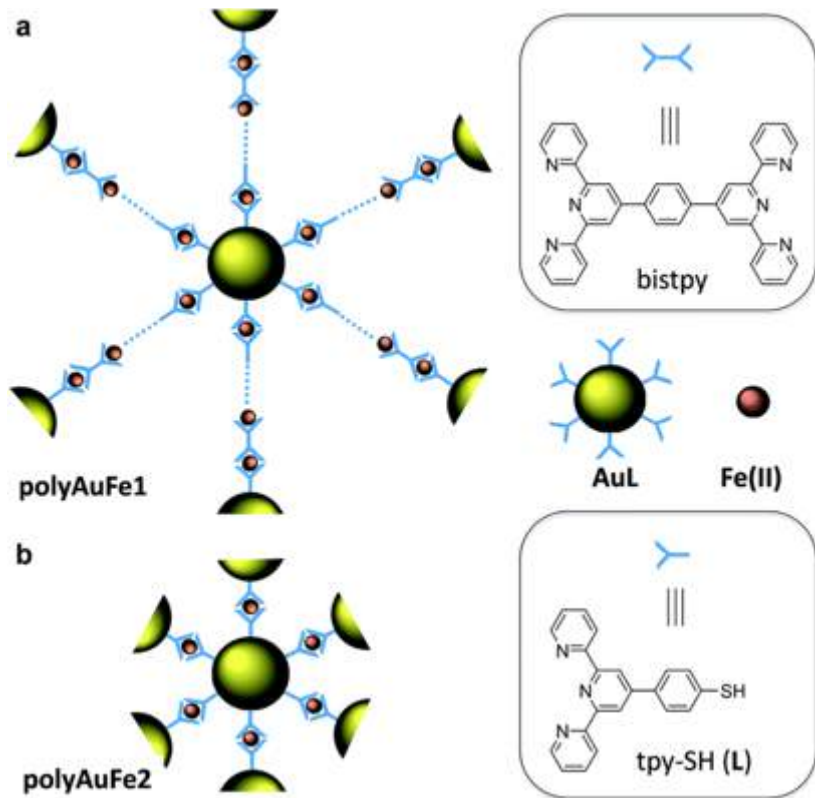
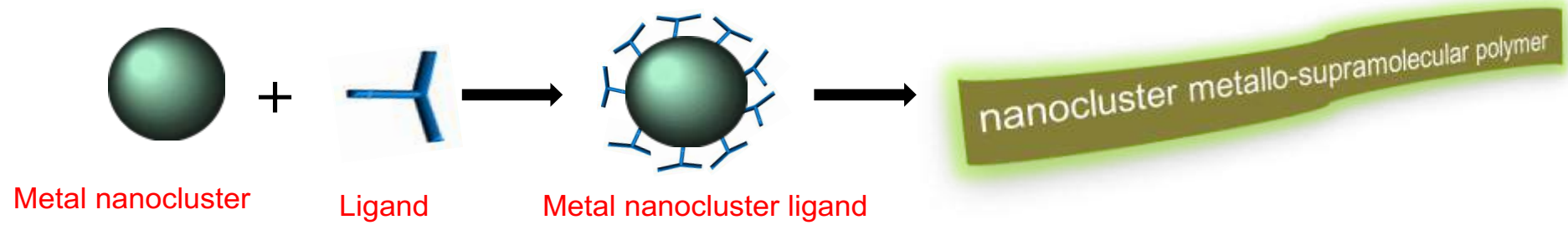
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Metal ions

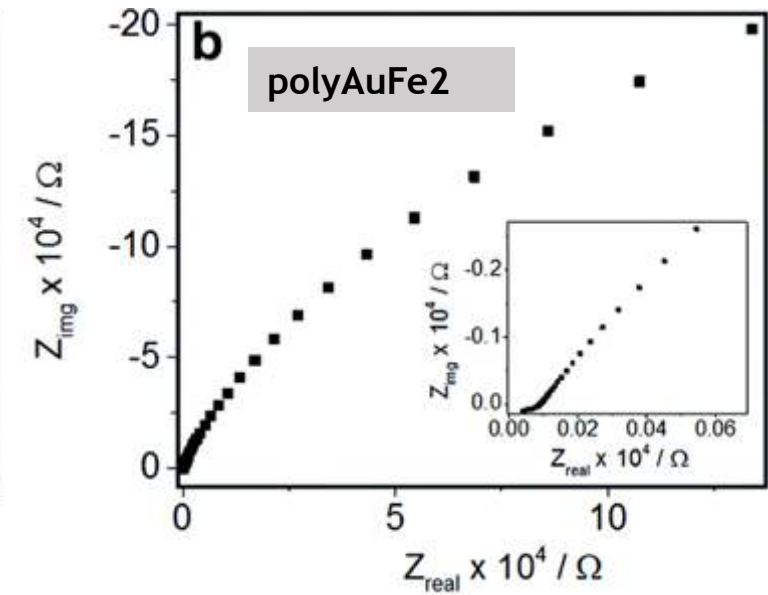
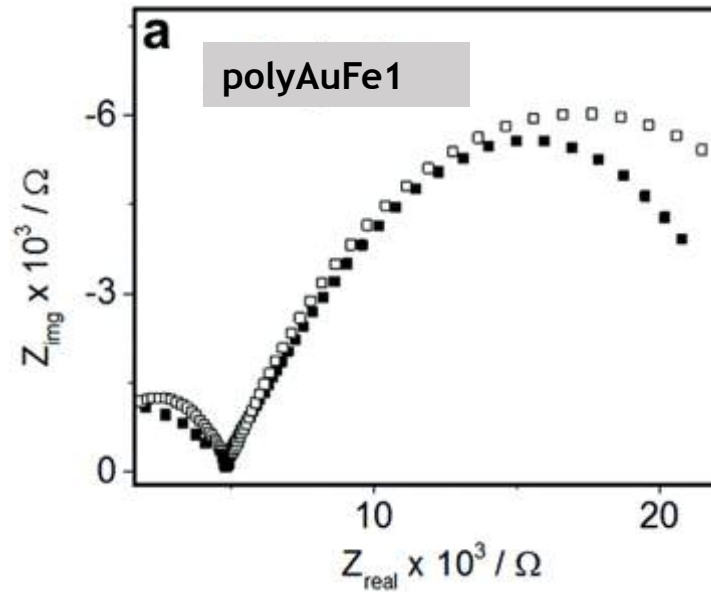




# Nanocluster metallo-supramolecular polymers and metal nanoparticles: High ionic conductivity



More than an order higher ionic conductivity than the original polymer



## References

- 1) *Advances in Polymer Nanocomposites-Metal-Polymer nanocomposites*, G. Heness, 2012, Woodhead publishing , Elsevier.
- 2) R. K. Pandey et al. *J. Phys. Chem. C*, 2009, 113, 21596
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- 4) R. K. Pandey et al. *Materials Research Bulletin*, 2014, 50, 413
- 5) R. K. Pandey et al. *Applied Catalysis-B, Environmental*, 2012. 125, 271
- 6) R. K. Pandey et al. *Journal of Materials Chemistry A*, 2016, 4, 4398