



# SYNTHESIS AND CHARACTERIZATION OF PLATINUM NANOPARTICLES SUPPORTED VULCAN CARBON BASED CONDUCTIVE BIPOLYMERIC NANOCOMPOSITES

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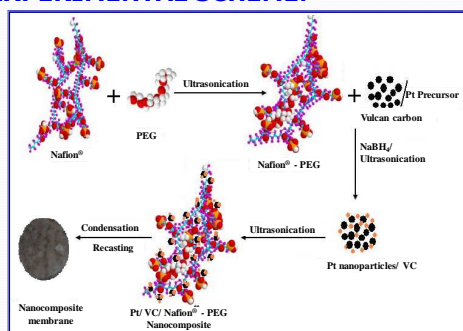
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**ABSTRACT :** The physical interactions of Platinum nanoparticles anchored on Vulcan<sup>®</sup> carbon XC – 72 (VC) over Nafion<sup>®</sup> - Polyethylene glycol - 6000 (PEG) polymer matrix nanocomposite were characterized by Fourier Transform – Infrared (FT-IR) spectra technique and surface morphology by Scanning Electron Microscope (SEM) analyses. The conductivity of the Pt nanoparticles embedded polymer nanocomposite membranes was measured using Electrochemical Impedance Spectroscopy (EIS) and the ORR studies were investigated using Cyclic Voltammetry (CV) and Linear Scan Voltammetry (LSV) under hydrodynamic conditions. The results show that VC over Nafion<sup>®</sup>-PEG polymer matrix nanocomposite exhibited a better improvement on their conductivity and comparable with neat Nafion<sup>®</sup> membranes hinting the possible use of the carbon over Nafion<sup>®</sup>-PEG matrix for improving the fuel cell efficiency for ORR with different Pt loading conditions.

## INTRODUCTION:

- ❖ The state of the art of PEMFC technology is mostly laid down on membrane materials.
- ❖ Perfluorinated ionomer of Nafion<sup>®</sup> is widely used polymer material in PEMFCs.
- ❖ But these materials are too expensive due to complex fluorine chemistry involved in fabrication.
- ❖ PEG is a hydrophilic polymer and its segments provide high selectivity and gas permeability.
- ❖ Fabrication of new membranes based on polymer blends can be achieved and enhanced the properties that cannot be obtained by individual polymers.

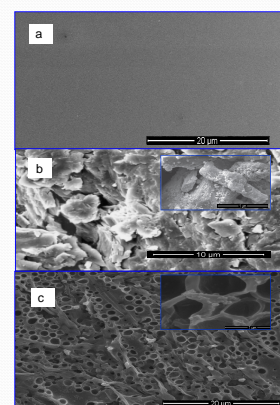
## EXPERIMENTAL SCHEME:



Synthesis procedure of Pt nanoparticles embedded Vulcan carbon over Nafion<sup>®</sup> - PEG biopolymer nanocomposite.

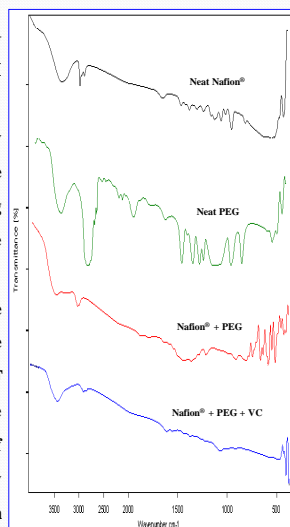
## SEM ANALYSIS:

- ❖ Figure. a show the SEM image of neat Nafion<sup>®</sup>.
- ❖ Figure. b shows the SEM images of neat PEG 6000.
- ❖ Figure. c shows the SEM images of Pt embedded over Vulcan carbon/ Nafion<sup>®</sup> - PEG 6000 nanocomposite.
- ❖ This SEM shows a fine spherical porous morphology uniformly distributed throughout the surface.



## FT- IR ANALYSIS:

- ❖ Neat Nafion<sup>®</sup> and neat PEG shows deeper peaks for OH stretching frequency.
- ❖ OH stretching frequency decreased with shift in wave number values indicating strong interactions between the two polymeric forms.
- ❖ The clusters peaks in the finger print region due to the bending vibrations of C-H, C-F for neat polymers were diminished at blending of polymers shows compatibility of the composite with Vulcan carbon.



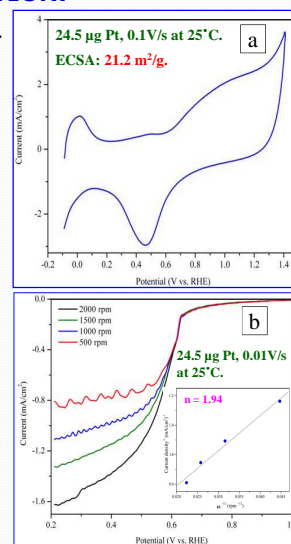
## EIS ANALYSIS:

- ❖ Figure. a show the impedance spectra of carbon supported Pt NPs over Nafion<sup>®</sup>-PEG nanocomposite membrane (Inset: EIS for neat Nafion<sup>®</sup> σ:  $1.40 \times 10^{-2} \text{ S cm}^{-1}$ ).
- ❖ The table shows the conductivity values of different wt% of carbon dispersed Nafion<sup>®</sup> - PEG (25:75) nanocomposite membrane.

VC content (%)	Membrane thickness (μm)	Resistance (Ω)	Conductivity (S cm <sup>-1</sup> )
2	50	87.1	$4.57 \times 10^{-4}$
4	30	30.3	$7.86 \times 10^{-4}$
6	40	0.61	$5.22 \times 10^{-2}$
8	30	0.64	$3.73 \times 10^{-2}$
10	40	1.24	$2.57 \times 10^{-2}$

## ORR INVESTIGATION:

- ❖ Figure. a show the CV of carbon supported Pt NPs over Nafion<sup>®</sup> - PEG matrix in N<sub>2</sub> saturated 0.5 M H<sub>2</sub>SO<sub>4</sub>.
- ❖ Figure. b shows the LSV of the same in O<sub>2</sub>, (Inset: K-L plot).
- ❖ Mass activity: 5.4 mA/mg and Specific activity: 0.26 mA/cm<sup>2</sup>.
- ❖ Tafel slope: 129 mV/dec, α: 0.47 and i<sub>0</sub>:  $3.92 \times 10^{-7} \text{ A/cm}^2$ .



## Summary:

- ✓ From FT-IR and SEM analysis, the compatibility of and the dispersion of carbon were investigated.
- ✓ The conductivity of nanocomposite are nearer to neat Nafion<sup>®</sup> investigated.
- ✓ The two electron transfer was envisaged from ORR studies.

## References:

- > Journal of Membrane Science, 280, 501–508, 2006.
- > Journal of Membrane Science, and Technology, 1:3, 2011.
- > Biomacromolecules, 4, 173-180, 2003.
- > Journal of Applied Polymer Science, Vol. 98, 1344 - 1350, 2005.
- > Journal of Applied Polymer Science ,110, 1093 –1098, 2008.
- > Langmuir, 24, 2663-2670, 2008.

**Support:** This work was funded by the Board of research in nuclear sciences (BRNS), Department of Atomic Energy (DAE), Govt. of India.



Paper presented in the "International Conference on Advanced Materials" (ICAM – 2011) during December 12- 16, 2011, PSG College of technology, Coimbatore.

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