# Analytical Applications for PEMFC

Polymer electrolyte membrane fuel cells (PEMFCs) are devices constructed by a large number of materials, such as electrolyte membranes, catalysts and gas diffusion layers (GDLs). By applying various analyses for the purpose such as the new material search or the material estimation with the degradation test, it is possible to clarify "phenomenon" and "degradation part".

1. Material search

Estimation purposes	Evaluation items	Analytical methods
Validation of preparing MEA	Layer thickness, uniformity	SEM, EPMA, SEM-EDX
	Dispersion state of catalyst	TEM, TEM-tomography
Design of catalyst layer	Dispersion of ionomer and void	AFM-IR, TEM, TEM-EDX
	Quantitative analysis of void	Mercury intrusion method
	Dispersion of ionomer in catalyst ink	AFM, GPC, NMR
Retrieval of electrolyte membrane	Cluster size analysis	DSC, XRD, TEM
	Chemical structure analysis	NMR, solid-state NMR
Porosity, wettability, water-shedding quality	Volume of void	Mercury intrusion method, SEM (slice & view)
	Wettability, permeability of water	Contact angle, Perm-porometry
Evaluation of catalyst	Crystallite diameter, alloying degree	XRD
	Distribution of core-shell catalyst	TEM, TEM-EDX
	Chemical state of catalyst	XAFS, XPS
	Chemical state of carbon support	Raman, XPS, XAFS

■3D reconstruction image of catalyst layer by TEM-tomography

Red : Ionomer
Gray : Carbon
Yellow : Pt particle
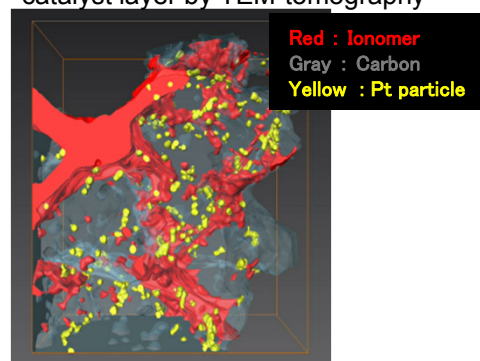
Quantitative analyses

·Ionomer coverages
　Carbon surface area = 95336 (nm^2)
　Ionomer area in contact with carbon
　　　　　　　　　　 = 36604 (nm^2)
　Ionomer coverage to carbon = 38 (%)
·Ionomer thickness
　Average thickness = 10.2 (nm)

2. Durability test and stability test

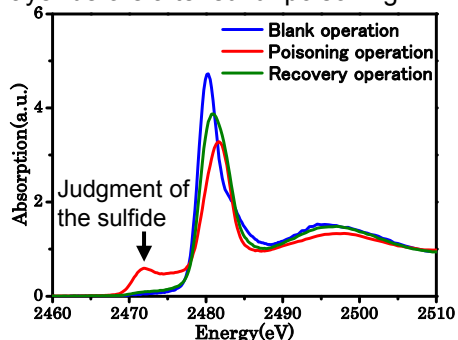| Methods	Examination contents	Conditions
H_2O_2 exposure test	·Test of chemical stability of electrolyte ·Elucidation of degradation mechanism	Temperature：30 ~ 100℃ Humidity：10 ~ 95%RH
Mechanical test of electrolyte membrane	Tensile strength, coefficient of expansion, compression test	Temperature：30 ~ 80℃ Humidity：30 ~ 95%RH
Dissolution test	Identification of eluted material (Bipolar plate, GDL)	Dissolution test, ICP-MS

■H_2O_2 exposure test
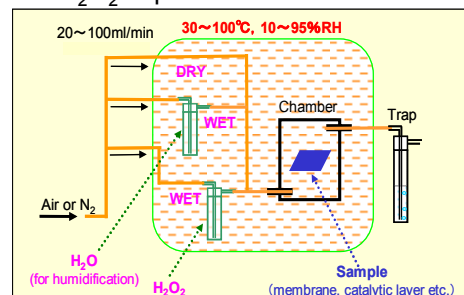
*S. Honmura, et. al., Polymer Preprints, Japan vol. 54, No.2 (2005).

After exposure test, to various analyzes

3. Degradation

Materials	Degradation phenomena	Analytical methods
Electrolyte membrane	Deposition of catalyst in electrolyte membrane	SEM, EPMA, TEM
	Structural change	Raman, IR, NMR
	Condition and mobility of water in membrane	NMR, DSC
Ionomer	Qualitative & quantitative analysis of decomposition products	NMR, LC/MS/MS, IR, IC
	Change in molecular weight	GPC
Catalyst layer	Change of particle size in catalyst	TEM, XRD
	Dissolution and degradation of catalyst	TEM, XRD, XAFS, ICP
	Corrosion of carbon support	Raman, IR. XPS
	Impurity effect	ICP-MS, XPS, XAFS

■S K-edge XANES spectra of catalyst layer before/after sulfur poisoning

Judgment of the sulfide

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