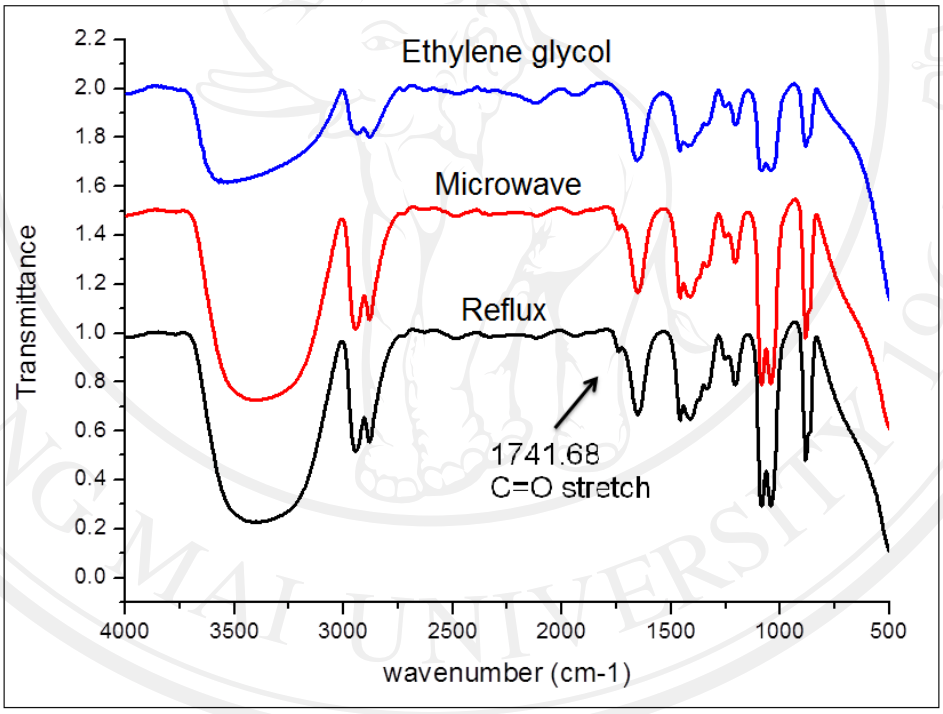
APPENDICES

APPENDIX A

Ethylene glycol solvent was selected because it can be used as reducing agent at near boiling point (198°C). At 170 °C, it will change to acetaldehyde and water as shown in equation 1. The acetaldehyde can reduce metal ions to metal alloy and change to diacetylas shown in equation 2[61].

$$CH_2OH\text{-}CH_2OH \rightarrow CH_3CHO + H_2O \quad (1)$$

$$2M^{+} + 2CH_3CHO \rightarrow 2M^{0} + CH_3COCOCH_3 + 2H^{+} \quad (2)$$



This figures showed FTIR spectrums from ethylene glycol,ethylene glycol after microwave with copper, and ethylene glycol after reflux with copper. The ethylene glycol after microwave and reflux were detected the band at 1741.68 cm^{-1}. The band was corresponded to vibration of C=O stretch. It confirm that after reaction was foundC=O functional group from diacetyl.

APPENDIX B

The Standard Reduction Potentials form http://www.webelements.com

$Pt^{2+} + 2e^- \rightarrow Pt$ $E^0 = 1.188$

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^0 = 0.34$

$Co^{2+} + 2e^- \rightarrow Co$ $E^0 = -0.28$

$Ni^{2+} + 2e^- \rightarrow Ni$ $E^0 = -0.257$

$Fe^{3+} + 3e^- \rightarrow Fe$ $E^0 = -0.04$

$Cr^{3+} + 3e^- \rightarrow Cr$ $E^0 = -0.74$

APPENDIX C

Joint committee on powder diffraction standard

[41-1487] PDF-2 Sets 1-86 Quality: I Wavelength: 1.540598

Carbon
Graphite-2H
cliftonite
plumbago
C.I. Pigment Black 10
C

Rad.: CuKa1 (1.54051) Filter: Beta Ni d-sp: Diffractometer
I/Icor.:7.78 Cutoff: 22.1 Int.: Diffractometer
Ref.: Sanc, I., Polytechna, Foreign Trade Corporation, Panska, Czechoslovakia.,
ICDD Grant-in-Aid, (1990)

Sys.: Hexagonal S.G.: P63/mmc (194) V(redu): 35.5
a: 2.4704(15) b: c: 6.7244(38) C: 2.7220
A: B: C: Z: 4 mp:
Dx: 2.243 Dm: 2.160 SS/FOM: F10= 18.4 (0.042, 13)
Ref.: Aust. J. Chem., 42, (1989), 479

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ea: nwB: ey: Sign: 2V:
Color: Black

Specimen from Netolice, Czechoslovakia. To replace 1-640, 1-646, 2-456, 3-401,
23-64, 25-284 and 34-567 and // validated by calculated pattern 25-284. //
Pattern taken at 25(1) C.

Hanawalt: 3.38/X 2.04/1 1.68/1 1.23/1 1.16/1 2.14/1 1.81/1 1.55/1 1.12/1 1.06/1
Max-d: 3.38/X 2.14/1 2.04/1 1.81/1 1.68/1 1.55/1 1.23/1 1.16/1 1.12/1 1.06/1

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d[A]	2Theta	Int.	h	k	l	d[A]	2Theta	Int.	h	k	l
3.3756	26.382	100	0	0	2	1.5478	59.694	1	1	0	3
2.1386	42.223	2	1	0	0	1.2341	77.245	3	1	1	0
2.0390	44.393	6	1	0	1	1.1604	83.186	3	1	1	2
1.8074	50.453	< 1	1	0	2	1.1208	86.826	< 1	0	0	6
1.6811	54.543	4	0	0	4	1.0567	93.597	< 1	2	0	1

[4-802] PDF-2 Sets 1-86 Quality: * Wavelength: 1.540598

Platinum
Platinum, syn
Pt

Rad.: CuKa1 (1.54056) Filter: Beta Ni d-sp:
I/Icor.: Cutoff: Int.: Diffractometer
Ref.: Swanson, Tatge., Natl. Bur. Stand. (U.S.), Circ. 539, I, (1953), 31

Sys.: Cubic S.G.: Fm3m (225) V(redu): 15.0
a: 3.9231 b: c:
A: B: C: Z: 4 mp:
Dx: 21.472 Dm: 21.370 SS/FOM: F 9= 143.2 (.0070, 9)

ea: nwB: ey: Sign: 2V:
Color: Light gray metallic

Sample prepared at NBS, Gaithersburg, MD, USA, and estimated to be // more than 99.99% pure. // Pattern taken at 26 C. Opaque mineral optical data on specimen from unspecified locality: RR2Re=70.3, Disp.=16, VHN50=122-129, Color values=.318, .324, // 70.7, Ref.: IMA Commission on Ore Microscopy QDF.

Hanawalt: 2.27/X 1.96/5 1.18/3 1.39/3 0.80/3 0.90/2 0.88/2 1.13/1 0.98/1 0.00/1
Max-d: 2.27/X 1.96/5 1.39/3 1.18/3 1.13/1 0.98/1 0.90/2 0.88/2 0.80/3 0.00/1

d[A]	2Theta	Int.	h	k	l	d[A]	2Theta	Int.	h	k	l
2.2650	39.764	100	1	1	1	0.9808	103.511	6	4	0	0
1.9616	46.244	53	2	0	0	0.9000	117.716	22	3	3	1
1.3873	67.456	31	2	2	0	0.8773	122.812	20	4	2	0
1.1826	81.289	33	3	1	1	0.8008	148.271	29	4	2	2
1.1325	85.715	12	2	2	2						

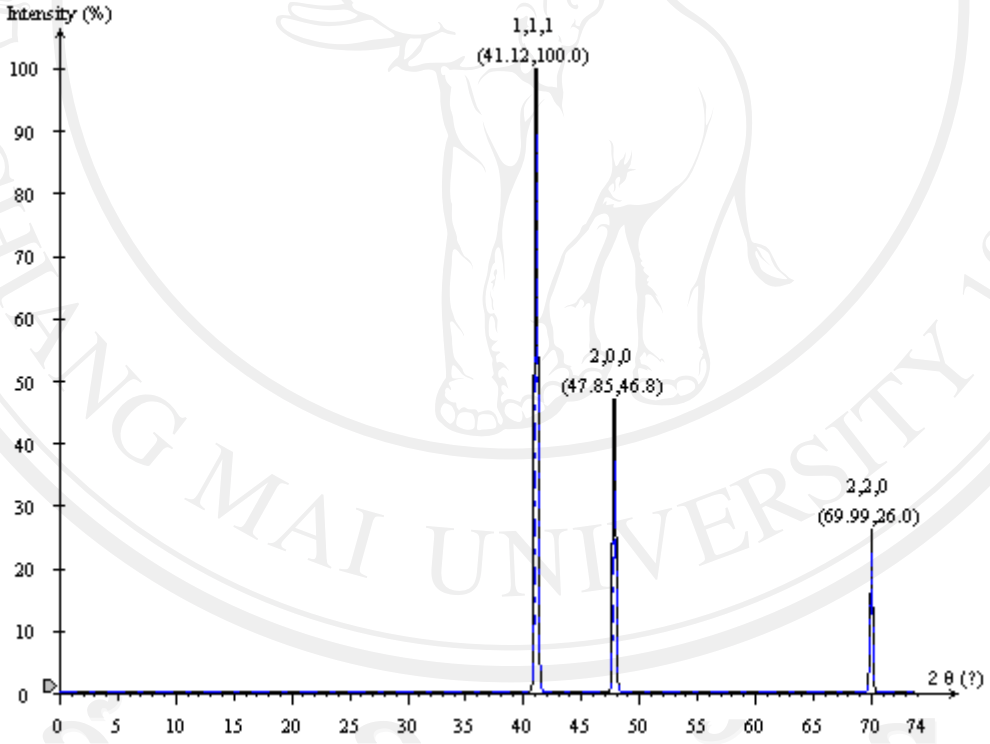
PatentNumber 5,178,971

TABLE

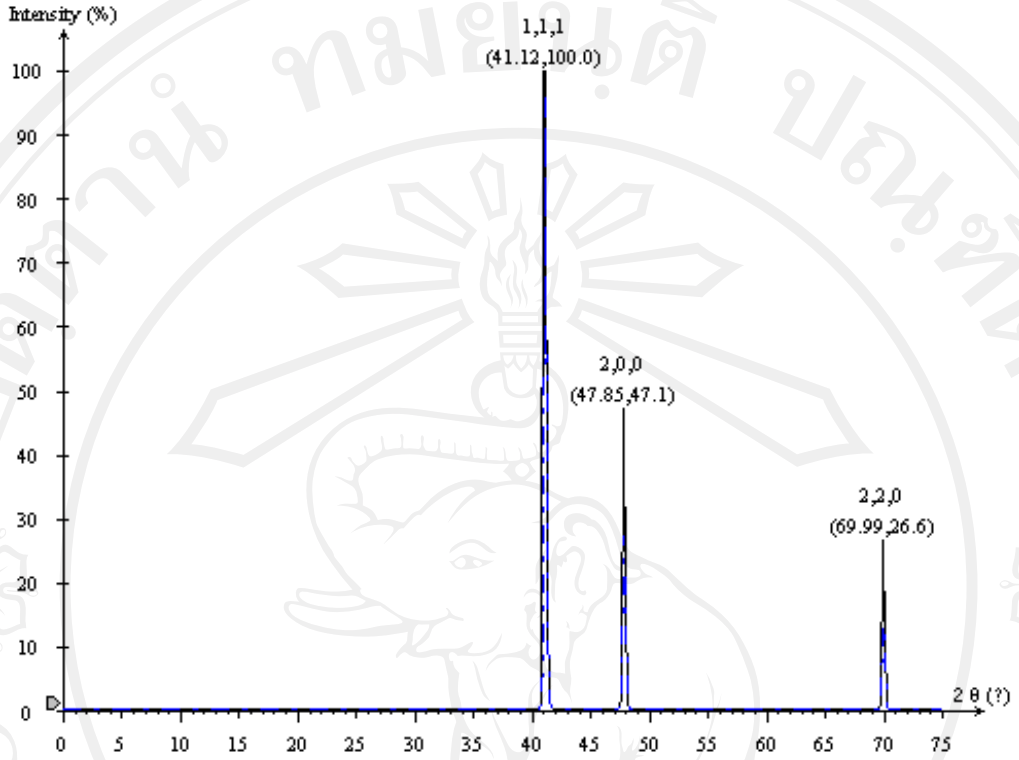
Properties of supported platinum catalyst and supported platinum binary or ternary alloy catalysts

Production Example No.	Catalyst (atomic ratio)	Catalyst No.	Solid solution alloy: Crystal form	Solid solution alloy: Ordering	Alloy lattice constant a(Å)	Crystallite size by XRD (Å)
1	Pt/C	C-1*	F.c.c		3.923	23
8	Pt—Co(50:50)/C	C-13*	f.c.c.	disordered	3.827	32
8	Pt—Ni(50:50)/C	C-14*	f.c.c.	disordered	3.786	26
8	Pt—Cu(50:50)/C	C-15*	F.c.c.	ordered	3.794	37
9	Pt—Co—Ni(50:25:25)/C	C-16*	f.c.c.	disordered	3.789	32
9	Pt—Co—Cu(50:25:25)/C	C-17*	f.c.c.	disordered	3.808	34
9	Pt—Ni—Cu(50:25:25)/C	C-18*	f.c.c.	disordered	3.799	40
10	Pt—Cr—Co(50:25:25)/C	C-19*	cubic	ordered	3.827	36
10	Pt—Fe—Co(50:25:25)/C	C-20*	cubic	ordered	3.817	35
10	Pt—Cr—Ga(50:25:25)/C	C-21*	cubic	ordered	3.860	35

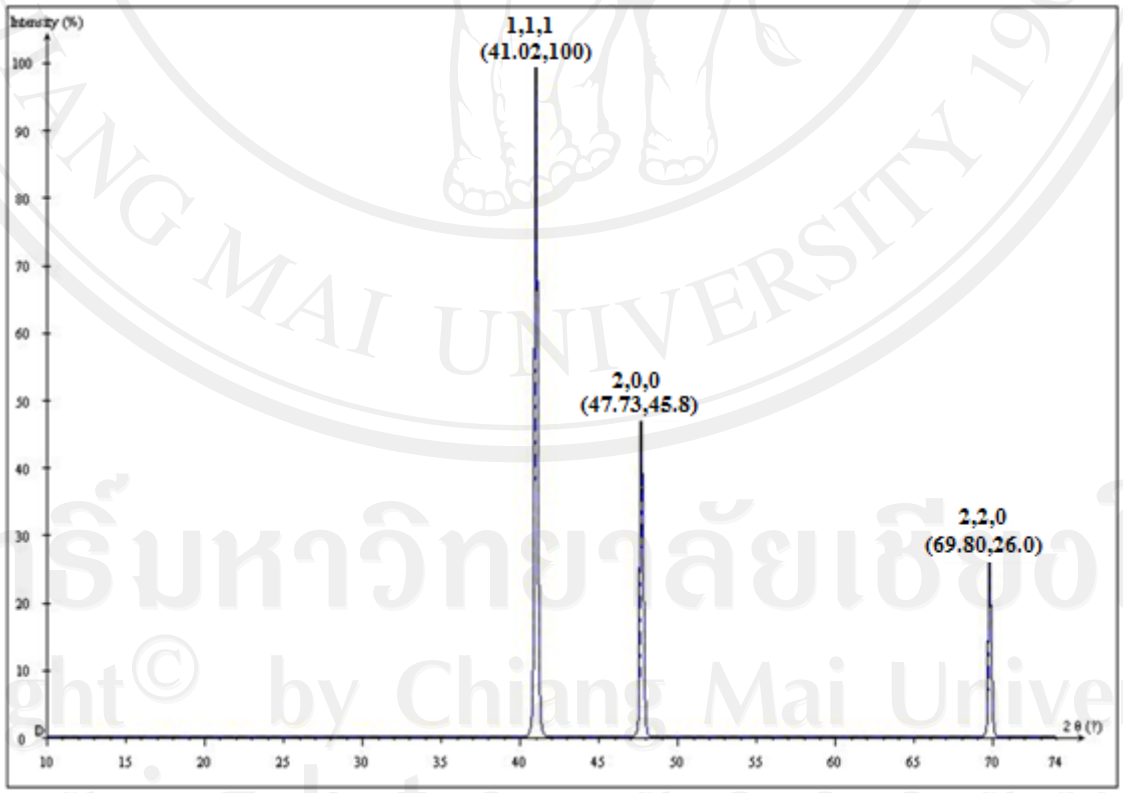
PtCuNi 2:1:1



PtCuNi6:1:1



PtCoCu 2:1:1



APPENDIX D

Weights of catalyst on carbon supporter were loading on membrane by spay technique

Weights(mg/cm^2)	Anode	Cathode
STD	4.8	4.8
PtCuNiN2Na	9.2	6.5
PtCuNiN6Na	3.2	7.5
PtCuNiN2Re	6.6	4.3
PtCuNiN6Re	5.3	6.0
PtCuNiV2Na	6.7	3.7
PtCuNiV6Na	5.9	5.3
PtCuNiV2Re	9.0	4.0
PtCuNiV6Re	8.7	2.6

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B.Sc. (Chemistry)	Chiang Mai University, Thailand, 2003
M.Sc. (Chemistry)	Chiang Mai University, Thailand, 2007
Ph.D. (Chemistry)	Chiang Mai University, Thailand, 2012

InternationalPublished:

1. Electron Microscopy Study of the Formation of Dendrite Cu_6Sn_5 Powders Synthesized by Solution Route Method, S. Thungprasert, T. Sarakonsri, and T. Tunkasiri, *Chiang Mai Journal of Science*, 34(1) (2007) 29-33 (Impact Factor 0.34)

2. Solution Route Synthesis of Dendrite Cu_6Sn_5 Powders, Anode Material for Lithium-Ion Batteries, T. Sarakonsri, T. Apirattanawan, S. Tungprasurt and T. Tunkasiri, *J. Mater Sci.*, 41 (2006) 4749–4754 (Impact Factor 1.855)

3. Microwave-Assisted Pt–Co–Cr/C Ternary Compound Preparation Applied as a Cathode Catalyst for PEMFC,T.Sarakonsri, S.Thungprasert, W.Klysubun and T.Vilaithong, *Phys. Scripta.*,T139(2010) 014007 (Impact Factor 0.982)

4. Preparation of Pt-Based Ternary Catalyst as Cathode Material for Proton Exchange Membrane Fuel Cell by Solution Route Method, S.Thungprasert, T.Sarakonsri, W. Klysubun and T.Vilaithong,*J Alloy. Compd.*,509 (2011) 6812–6815 (Impact Factor 2.134)

International Conference:

1. Electron Microscopy Study of the Formation of Dendrite Cu_6Sn_5 Powders Synthesized by Solution Route Method, 11th Asian Chemical Congress (11th ACC), 24-26 August 2005 Seoul Korea

2. Preparation and Characterization of Pt-Co-Cr Catalyst Supported on Carbon Black for PEMFC, International Conference on Smart Materials-Smart/Intelligent Materials and Nano Technology & 2nd International Workshop on Functional Materials and Nanomaterials (SmartMat-'08 & IWOFM-2),22-25 April 2008 Chiang Mai Thailand

3. The Preparation Pt-based ternary catalysts support on both treated carbon and untreated carbon for PEMFC, The 3rd International Symposium on Functional Materials[ISFM2009] 15-18 June 2009, Jinju, KOREA

4. The Preparation Pt-based ternary catalysts support on both treated carbon and untreated carbon for PEMFC, The International Congress for Innovation in Chemistry (PERCH-CIC CONGRESS VI)3-6 May 2009,Pattaya, Thailand

5. The Preparation Pt-Based Ternary Catalysts Support on both Treated and Untreated Carbon by Solution Route Method,German-Thai Symposium on Nanoscience and Nanotechnology 2009, 21-22 September 2009,Chiang Mai, Thailand

6. The Preparation Pt-Based Ternary Catalysts Support on Treated Carbon N115 by Reflux Method for PEMFC, The Third International Symposium on Organic and Inorganic Electronic Materials and Related Nanotechnologies (EM-NANO 2010), 22-25 June 2010,Toyama, Japan

7.The Preparation Pt-based ternary catalysts support on both treated carbon and untreated carbon for PEMFC,The International Congress for Innovation in Chemistry (PERCH-CIC CONGRESS VII),3-6 May 2011...,Pattaya, Thailand

8. The Preparation and Characterization Pt-Co-Cu Catalysts Supported on Treated Carbon by Reflux Method, the 6th Pure and Applied Chemistry International Conference 2012, 11-13 January 2012, Chiang Mai, Thailand