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博 士 学 位 论 文

纳米粒子形状控制合成功能分子在Pt单晶电极表面的吸附和反应特性：原子和分子层次研究

Study of adsorption and reaction of functional molecules on Pt single crystal electrodes at atomic and molecular level

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摘 要

纳米材料形状控制合成是制备功能纳米材料、特别是高性能催化剂的重要途径。在纳米材料形状控制合成中，覆盖剂（Citrate、PVP）以及还原剂（抗坏血酸）等功能分子起着决定性的作用，但其调控作用机制亟需深入研究。本论文运用电化学循环伏安（CV）、电化学原位红外光谱（FTIR）和扫描隧道显微镜（STM）等技术研究了纳米材料形状控制合成功能分子在Pt(hkl)和Pd/Pt(hkl)单晶电极表面的吸脱附和反应过程；结合Pt纳米粒子合成，探讨其在纳米材料形状控制合成中的作用机制。主要研究结果如下：

1、研究表明柠檬酸根在Pt单晶电极表面发生特性吸附，在不同晶面上具有不同的吸附行为。在Pt(311)和Pt(100)电极上，柠檬酸根从0.30V左右开始从表面脱附，到0.20V已经完全脱附；而在Pt(111)电极上，柠檬酸根从0.40V开始脱附，随电位负移逐渐脱附，到0.20V左右完全脱附。在纳米粒子表面柠檬酸根的吸脱附行为与在Pt(hkl)单晶电极表面的行为类似。柠檬酸根会增强H在(100)位点吸脱附峰的强度这一现象可以用于表征纳米粒子表面(100)位点的比例。

2、研究发现PVP在Pt单晶电极表面吸附具有结构选择性，在Pt(100)电极表面发生强吸附，而在Pt(111)电极表面是弱吸附。PVP在Pt(100)电极上吸附会抑制(100)平台位和台阶位氢的吸脱附；PVP在Pt(111)电极上吸附对氢在(111)平台位的吸脱附没有影响，但会抑制硫酸根/硫酸氢根、氢氧根等阴离子在(111)平台位的吸脱附。PVP在不同位点的吸附强弱具有以下的顺序：L(100)>S(100)×(111)≈S(111)×(100)≈S(111)×(111)>L(111)。STM研究结果指出，PVP在Pt(100)和Pt(111)表面的吸附结构类似，在表面的吸附是以一个整体吸附在表面，每个聚合物分子占据2~4nm的表面位，而且在小范围内以六方密堆积形式在表面排列。电化学原位红外光谱从分子水平诠释了PVP在Pt(100)和Pt(111)电极表面不同的吸附行为，在Pt(100)电极表面吸附的PVP羰基红外吸收峰位于1663cm-1，而在Pt(111)电极上这个谱峰蓝移至1671cm-1，证实了PVP在Pt(100)电极上吸附更强。在Pt(100)电极上PVP的吸附使CO的Stark系数从21cm-1●V-1降到9cm-1●V-1，而对于Pt(111)电极表面则没有影响。电极表面吸附PVP对

电催化活性存在较大影响，可以通过piranha溶液除去电极表面吸附的PVP。

3、研究证实使用“force deposit”方法可在Pt单晶电极表面沉积单层至多层Pd。柠檬酸根在Pd/Pt(100)和Pd/Pt(111)电极上的行为与硫酸根类似。PVP在Pd/Pt(111)的吸附与Pd原子层数相关；而在Pd/Pt(100)电极表面的吸附会抑制Pd-H峰。PVP在Pd/Pt(100)电极表面的吸附强于在Pd/Pt(111)上的吸附，与在Pt(hkl)电极表面得到的结果一致。

4、研究揭示抗坏血酸电氧化是表面结构敏感的过程，且在手性晶面上具有手性选择性。台阶原子密度高的Pt(311)电极上在较低电位就开始解离生成CO，台阶原子密度低的表面在0.28V出现抗坏血酸的脱附峰。在两组手性晶面Pt(321)和Pt(643)电极的研究发现，表面为R型的Pt(321)R和Pt(643)R两个晶面对L-抗坏血酸和D-异抗坏血酸都具有较高的催化活性。

本论文系统研究了纳米材料形状控制功能分子在表面原子排列结构明确的单晶表面的吸附规律，同时运用原位红外反射光谱和扫描隧道显微镜从分子水平和原子尺度揭示其吸附反应机理。研究结果对于进一步认识功能分子在纳米合成中的机理以及理性地设计和制备高性能纳米催化剂具有重要意义。

关键词：柠檬酸根；PVP；Pt(hkl)；原位FTIR；STM

Abstract

Nanoparticles shape controlled synthesis is an important way to prepare functional material, especially for high performance catalyst. The functional molecules as capping agent (Citrate, PVP) and reducing agent (ascorbic acid) play a key role in the synthesis. However, the mechanism of functional molecules is still unclear. The adsorption of functional molecules on Pt(hkl) and Pd/Pt(hkl) electrodes were investigated by using cyclic voltammetry, STM and in situ FTIR spectroscopy, to understand the mechanism of functional molecules in nanoparticles shape controlled synthesis combined with the synthesis process. The main results are summarized below:

1. Citrate behaves as a simple, specifically adsorbing anion and is sensitive to surface structure. On Pt(311) and Pt(100), citrate starts to desorb from surfaces at 0.3V and complete at 0.2V; the desorption potential on Pt(111) is from 0.4V to 0.2V; which indicated the adsorption of citrate on Pt(111) is weaker than that on Pt(311) and Pt(100). Citrate can be used to test the Pt(100) terrace contributions on nanoparticles as the intensity increase and narrowing of H UPD features associated with the Pt(100) terrace in the solution containing citrate.

2. It is found that the adsorption of PVP on Pt single crystal is surface sensitive. The adsorption of PVP on different Pt surface sites has the sequence: L(100)>S(100)×(111)≈S(111)×(100)≈S(111)×(111)>L(111). PVP is bonded strongly to Pt(100), but weakly on Pt(111). The adsorption structure of PVP on Pt(100) and Pt(111) are similar in the STM images, the polymer acts as a big domain on the surface which is about 2-4nm. With in situ FTIRS, we can distinguish that the bond between PVP and Pt(100) is stronger than Pt(111), as the carbonyl band is red shift to 1663cm-1 on Pt(100) compared with 1671cm-1 on Pt(111). We also use CO as “probe molecule”, and the result supports our conclusion. We have achieved the key of that why PVP can be served to control

the nanoparticles morphology.

3. We use “force deposit” method to achieve monolayer to multilayer Pd on Pt single crystal surfaces. The behavior of citrate on Pd/Pt(hkl) is similar to sulfate, as a simple, specifically adsorbing anion. PVP adsorbs strongly to Pd/Pt(100), but weakly to Pd/Pt(111).

4. The electro-oxidation of ascorbic acid depends strongly on Pt surface structure and is enantioselective to chiral surface. With long (100) terrace, L-ascorbic acid gives a peak at 0.28V on the 1st cycle CV curve, which is confirmed to be the desorption of ascorbate. L-ascorbic acid dissociates to produce CO on Pt(311) at lower potential which would poison the surface. The R type chiral surfaces Pt(321)R and Pt(643)R are more active to L-ascorbic acid and D-isoascorbic acid.

We have studied the adsorption of functional molecules on Pt single crystal surfaces, combined with in situ FTIRS and STM to reveal the mechanism of these molecules in nanoparticles shape controlled synthesis. It’s of importance to provide guidance on designing and preparing high performance nanocatalyst.

Keywords: citrate;PVP;Pt(hkl);in situ FTIR;STM

参考资料

[1] N Tian, Z Y Zhou, S G Sun, Y Ding, Z L Wang. Synthesis of tetrahexahedral platinum nanocrystals with high-index facets and high electro-oxidation activity [J]. Science, 2007, 316(5825): 732-735.

[2] Y J Deng, N Tian, Z Y Zhou, R Huang, Z L Liu, J Xiao, S G Sun. Alloy tetrahexahedral Pd-Pt catalysts: enhancing significantly the catalytic activity by synergy effect of high-index facets and electronic structure [J]. Chemical Science, 2012, 3(4): 1157-1161.

[3] V R Stamenkovic, B Fowler, B S Mun, G F Wang, P N Ross, C A Lucas, N M Markovic. Improved oxygen reduction activity on Pt3Ni(111) via increased surface site availability [J]. Science, 2007, 315(5811): 493-497.

[4] T K Sau, A L Rogach. Nonspherical Noble Metal Nanoparticles: Colloid-Chemical Synthesis and Morphology Control [J]. Advanced Materials, 2010, 22(16): 1781-1804.

[5] Z Y Zhou, Z Z Huang, D J Chen, Q Wang, N Tian, S G Sun. High-Index Faceted Platinum Nanocrystals Supported on Carbon Black as Highly Efficient Catalysts for Ethanol Electrooxidation [J]. Angewandte Chemie International Edition, 2010, 49(2): 411-414.

[6] Y X Chen, S P Chen, Z Y Zhou, N Tian, Y X Jiang, S G Sun, Y Ding, Z L Wang. Tuning the Shape and Catalytic Activity of Fe Nanocrystals from Rhombic Dodecahedra and Tetragonal Bipyramids to Cubes by Electrochemistry [J]. Journal of the American Chemical Society, 2009, 131(31): 10860-10862.

[7] N Tian, Z Y Zhou, N F Yu, L Y Wang, S G Sun. Direct Electrodeposition of Tetrahexahedral Pd Nanocrystals with High-Index Facets and High Catalytic Activity for Ethanol Electrooxidation [J]. Journal of the American Chemical Society, 2010, 132(22): 7580-7581.

[8] Y N Xia, X H Xia, Y Wang, S F Xie. Shape-controlled synthesis of metal nanocrystals [J]. Mrs Bulletin, 2013, 38(4): 335-344.

[9] Z Y Zhou, N Tian, J T Li, I Broadwell, S G Sun. Nanomaterials of high surface energy with exceptional properties in catalysis and energy storage [J]. Chemical Society reviews, 2011, 40(7): 4167-4185.

[10] C Fleury, M Neverova, S Collins, S Raimbault, O Champigny, C LeviMeyrueis, F Bouillaud, M F Seldin, R S Surwit, D Ricquier, C H Warden. Uncoupling protein-2: A novel gene linked to obesity and hyperinsulinemia [J]. Nature Genetics, 1997, 15(3): 269-272.

[11] S M Davis, F Zaera, G A Somorjai. Surface-Structure and Temperature-Dependence of N-Hexane Skeletal Rearrangement Reactions Catalyzed over Platinum Single-Crystal Surfaces - Marked Structure Sensitivity of Aromatization [J]. Journal of Catalysis, 1984, 85(1): 206-223.

[12] V Grozovski, J Solla-Gullon, V Climent, E Herrero, J M Feliu. Formic Acid Oxidation on Shape-Controlled Pt Nanoparticles Studied by Pulsed Voltammetry [J]. Journal of Physical Chemistry C, 2010, 114(32): 13802-13812.

[13] F J Vidal-Iglesias, A Lopez-Cudero, J Solla-Gullon, A Aldaz, J M Feliu. Pd-Modified Shape-Controlled Pt Nanoparticles Towards Formic Acid Electrooxidation [J]. Electrocatalysis, 2012, 3(3-4): 313-323.

[14] F J Vidal-Iglesias, R M Aran-Ais, J Solla-Gullon, E Garnier, E Herrero, A Aldaz, J M Feliu. Shape-dependent electrocatalysis: formic acid electrooxidation on cubic Pd nanoparticles [J]. Physical Chemistry Chemical Physics, 2012, 14(29): 10258-10265.

[15] R R Adzic, N M Markovic, V B Vesovic. Structural Effects in Electrocatalysis - Oxygen Reduction on the Au(100) Single-Crystal Electrode [J]. Journal of Electroanalytical Chemistry, 1984, 165(1-2): 105-120.

[16] G A Somorjai, J Y Park. The impact of surface science on the commercialization of chemical processes [J]. Catalysis Letters, 2007, 115(3-4): 87-98.

[17] N D Spencer, R C Schoonmaker, G A Somorjai. Structure Sensitivity in the Iron Single-Crystal Catalyzed Synthesis of Ammonia [J]. Nature, 1981, 294(5842): 643-644.

[18] Y N Wen, H M Zhang. Surface energy calculation of the fcc metals by using the MAEAM [J]. Solid State Communications, 2007, 144(3-4): 163-167.

[19] J Wang, S Q Wang. Surface energy and work function of fcc and bcc crystals: Density functional study [J].

Surface Science, 2014, 630: 216-224.
[20] Y N Wen, J M Zhang. Surface energy calculation of the bcc metals by using the MAEAM [J]. Computational Materials Science, 2008, 42(2): 281-285.
[21] K S Choi. Shape control of inorganic materials via electrodeposition [J]. Dalton Transactions, 2008, 40: 5432-5438.
[22] C J Murphy. Nanocubes and nanoboxes [J]. Science, 2002, 298(5601): 2139-2141.
[23] Y G Sun, Y N Xia. Shape-controlled synthesis of gold and silver nanoparticles [J]. Science, 2002, 298(5601): 2176-2179.
[24] D L Lu, K Tanaka. Au, Cu, Ag, Ni, and Pd particles grown in solution at different electrode potentials [J]. Journal of Physical Chemistry B, 1997, 101(20): 4030-4034.
[25] D L Lu, K Tanaka. Different habits of Pt particles grown in salt solution at different electrode potentials [J]. Surface Science, 1997, 373(1): L339-L344.
[26] K Nielsch, F Muller, A P Li, U Gosele. Uniform nickel deposition into ordered alumina pores by pulsed electrodeposition [J]. Advanced Materials, 2000, 12(8): 582-586.
[27] F Favier, E C Walter, M P Zach, T Benter, R M Penner. Hydrogen sensors and switches from electrodeposited palladium mesowire arrays [J]. Science, 2001, 293(5538): 2227-2231.
[28] M T Reetz, W Helbig. Size-Selective Synthesis of Nanostructured Transition-Metal Clusters [J]. Journal of the American Chemical Society, 1994, 116(16): 7401-7402.
[29] M T Reetz, M Winter, R Breinbauer, T Thurn-Albrecht, W Vogel. Size-selective electrochemical preparation of surfactant-stabilized Pd-, Ni- and Pt/Pd colloids [J]. Chemistry A European Journal, 2001, 7(5): 1084-1094.
[30] M J Siegfried, K S Choi. Directing the architecture of cuprous oxide crystals during electrochemical growth [J]. Angewandte Chemie International Edition, 2005, 44(21): 3218-3223.
[31] M J Siegfried, K S Choi. Electrochemical crystallization of cuprous oxide with systematic shape evolution [J]. Advanced Materials, 2004, 16(19): 1743-1746.
[32] D F Liang, J J Mallett, G Zangari. Underpotential Codeposition of Fe-Pt Alloys from an Alkaline Complexing Electrolyte: Electrochemical Studies [J]. Journal of the Electrochemical Society, 2011, 158(3): D149-D157.
[33] K Leistner, S Fahler, H Schlorb, L Schultz. Preparation and characterization of electrodeposited Fe/Pt multilayers [J]. Electrochemistry Communications, 2006, 8(6): 916-920.
[34] M Rezaei, M Ghorbani, A Dolati. Electrochemical investigation of electrodeposited Fe-Pd alloy thin films [J]. Electrochimica Acta, 2010, 56(1): 483-490.
[35] S M Hwang, C H Lee, J J Kim, T P Moffat. Oxygen reduction reaction on electrodeposited Pt100-x-yNixPdy thin films [J]. Electrochimica Acta, 2010, 55(28): 8938-8946.
[36] E Gomez, S Pane, E Valles. Electrodeposition of Co-Ni and Co-Ni-Cu systems in sulphate-citrate medium [J]. Electrochimica Acta, 2005, 51(1): 146-153.
[37] Y N Xia, Y J Xiong, B Lim, S E Skrabalak. Shape-Controlled Synthesis of Metal Nanocrystals: Simple Chemistry Meets Complex Physics? [J]. Angewandte Chemie International Edition, 2009, 48(1): 60-103.
[38] J A Zhang, M R Langille, M L Personick, K Zhang, S Y Li, C A Mirkin. Concave Cubic Gold Nanocrystals with High-Index Facets [J]. Journal of the American Chemical Society, 2010, 132(40): 14012-14014.
[39] J Zeng, Y Q Zheng, M Rycenga, J Tao, Z Y Li, Q A Zhang, Y M Zhu, Y N Xia. Controlling the Shapes of Silver Nanocrystals with Different Capping Agents [J]. Journal of the American Chemical Society, 2010, 132(25): 8552-8553.
[40] W X Niu, L Zhang, G B Xu. Shape-Controlled Synthesis of Single-Crystalline Palladium Nanocrystals [J]. Acs Nano, 2010, 4(4): 1987-1996.
[41] J Turkevich, P C Stevenson, J Hillier. The formation of colloidal gold [J]. The Journal of Physical Chemistry, 1953, 57: 670-673.
[42] J Kimling, M Maier, B Okenve, V Kotaidis, H Ballot, A Plech. Turkevich Method for Gold Nanoparticle

Synthesis Revisited [J]. Journal of Physical Chemistry B, 2006, 110(32): 15700-15707.
[43] A Henglein, M Giersig. Formation of colloidal silver nanoparticles. Capping action of citrate [J]. Journal of Physical Chemistry B, 1999, 103(44): 9533-9539.
[44] S Kumar, K S Gandhi, R Kumar. Modeling of formation of gold nanoparticles by citrate method [J]. Industrial & Engineer Chemistry Research, 2007, 46(10): 3128-3136.
[45] T Ming, W Feng, Q Tang, F Wang, L Sun, J Wang, C Yan. Growth of tetrahexahedral gold nanocrystals with high-index facets [J]. Journal of the American Chemical Society, 2009, 131(45): 16350-16351.
[46] X Ji, X Song, J Li, Y Bai, W Yang, X Peng. Size Control of Gold Nanocrystals in Citrate Reduction: The Third Role of Citrate [J]. Journal of the American Chemical Society, 2007, 129(45): 13939-13948.
[47] W Patungwasa, J H Hodak. pH tunable morphology of the gold nanoparticles produced by citrate reduction [J]. Material Chemistry and Physics, 2008, 108(1): 45-54.
[48] L Pei, K Mori, M Adachi. Formation Process of Two-Dimensional Networked Gold Nanowires by Citrate Reduction of AuCl4- and the Shape Stabilization [J]. Langmuir, 2004, 20(18): 7837-7843.
[49] R Jin, Y Cao, C A Mirkin, K L Kelly, G C Schatz, J G Zheng. Photoinduced conversion of silver nanospheres to nanoprisms [J]. Science, 2001, 294(5548): 1901-3.
[50] Y Sun, Y Xia. Triangular nanoplates of silver: synthesis, characterization, and use as sacrificial templates for generating triangular nanorings of gold [J]. Advance Materials (Weinheim, Ger), 2003, 15(9): 695-699.
[51] C Kan, X Zhu, G Wang. Single-Crystalline Gold Microplates: Synthesis, Characterization, and Thermal Stability [J]. Journal of Physical Chemistry B, 2006, 110(10): 4651-4656.
[52] Y X Wang, J Y Fang. Selective Epitaxial Growth of Silver Nanoplates [J]. Angewandte Chemie International Edition, 2011, 50(5): 992-993.
[53] C G Tao, W G Cullen, E D Williams, S E Hunyadi, C J Murphy. Surface morphology and step fluctuations on Ag nanowires [J]. Surface Science, 2007, 601(21): 4939-4943.
[54] D S Kilin, O V Prezhdo, Y Xia. Shape-controlled synthesis of silver nanoparticles: Ab initio study of preferential surface coordination with citric acid [J]. Chemical Physics Letters, 2008, 458(1-3): 113-116.
[55] M Tsuji, S Gomi, Y Maeda, M Matsunaga, S Hikino, K Uto, T Tsuji, H Kawazumi. Rapid Transformation from Spherical Nanoparticles, Nanorods, Cubes, or Bipyramids to Triangular Prisms of Silver with PVP, Citrate, and H2O2 [J]. Langmuir, 2012, 28(24): 8845-8861.
[56] B Lim, M Jiang, J Tao, P H C Camargo, Y Zhu, Y Xia. Shape-controlled synthesis of Pd nanocrystals in aqueous solutions [J]. Advance Functional Materials, 2009, 19(2): 189-200.
[57] Y Xia, Y Xiong, B Lim, S E Skrabalak. Shape-controlled synthesis of metal nanocrystals: simple chemistry meets complex physics? [J]. Angewandte Chemie International Edition, 2009, 48(1): 60-103.
[58] A Henglein, M Giersig. Reduction of Pt(II) by H2: Effects of Citrate and NaOH and Reaction Mechanism [J]. Journal of Physical Chemistry B, 2000, 104(29): 6767-6772.
[59] O I Gonzalez-Pena, T W Chapman, Y M Vong, R Antano-Lopez. Study of adsorption of citrate on Pt by CV and EQCM [J]. Electrochimica Acta, 2008, 53(17): 5549-5554.
[60] D H Chen, J Y Ye, C D Xu, X Li, J T Li, C H Zhen, N Tian, Z Y Zhou, S G Sun. Interaction of citrate with Pt(100) surface investigated by cyclic voltammetry towards understanding the structure-tuning effect in nanomaterials synthesis [J]. Science China Chemistry, 2012, 55(11): 2353-2358.
[61] I W Yujie Xiong, Jingyi Chen, Honggang Cai, Zhi-Yuan Li,, Y Xia. Poly(vinyl pyrrolidone)_ A dual functional reductant and stabilizer for the facile synthesis of noble metal nanoplates in aqueous solutions [J]. Langmuir, 2006, 22(8563-8670.
[62] X H Xia, J Zeng, L K Oetjen, Q G Li, Y N Xia. Quantitative Analysis of the Role Played by Poly(vinylpyrrolidone) in Seed-Mediated Growth of Ag Nanocrystals [J]. Journal of the American Chemical Society, 2012, 134(3): 1793-1801.
[63] B Lim, Y J Xiong, Y N Xia. A water-based synthesis of octahedral, decahedral, and icosahedral Pd nanocrystals [J]. Angewandte Chemie International Edition, 2007, 46(48): 9279-9282.
[64] W A Al-Saidi, H J Feng, K A Fichthorn. Adsorption of Polyvinylpyrrolidone on Ag Surfaces: Insight into a

Structure-Directing Agent [J]. Nano letters, 2012, 12(2): 997-1001.
[65] H Song, F Kim, S Connor, G Somorjai, P Yang. Pt nanocrystals: shape control and Langmuir-Blodgett monolayer formation [J]. The journal of physical chemistry B, 2005, 109(1): 188-193.
[66] S E H Yuri Borodko, Matthias Koebel, Peidong Yang,Heinz Frei,, G A Somorjai. Probing the Interaction of Poly(vinylpyrrolidone) with Platinum Nanocrystals by UV−Raman and FTIR [J]. Journal of Physical Chemistry B, 2006, 110: 23052-23059.
[67] H S L Yuri Borodko, Sang Hoon Joo,Yawen Zhang, and Gabor Somorjai. Spectroscopic Study of the Thermal Degradation of PVP-Capped Rh and Pt Nanoparticles in H2 and O2 Environments [J]. Journal of Physical Chemistry B, 2010, 114: 1117-1126.
[68] J Y Xian, Q Hua, Z Q Jiang, Y S Ma, W X Huang. Size-Dependent Interaction of the Poly(N-vinyl-2-pyrrolidone) Capping Ligand with Pd Nanocrystals [J]. Langmuir, 2012, 28(17): 6736-6741.
[69] L H S Gasparotto, J F Gomes, G Tremiliosi-Filho. Cyclic-voltammetry characteristics of poly(vinyl pyrrolidone) (PVP) on single-crystal Pt surfaces in aqueous H2SO4 [J]. Journal of Electroanalytical Chemistry, 2011, 663(1): 48-51.
[70] C Susut, D J Chen, S G Sun, Y J Tong. Capping polymer-enhanced electrocatalytic activity on Pt nanoparticles: a combined electrochemical and in situ IR spectroelectrochemical study [J]. Physical chemistry chemical physics, 2011, 13(16): 7467-74.
[71] B H Wu, N F Zheng, G Fu. Small molecules control the formation of Pt nanocrystals: a key role of carbon monoxide in the synthesis of Pt nanocubes [J]. Chemical communications, 2011, 47(3): 1039-1041.
[72] M Chen, B H Wu, J Yang, N F Zheng. Small Adsorbate-Assisted Shape Control of Pd and Pt Nanocrystals [J]. Advanced Materials, 2012, 24(7): 862-879.
[73] H Lee, S E Habas, S Kweskin, D Butcher, G A Somorjai, P D Yang. Morphological control of catalytically active platinum nanocrystals [J]. Angewandte Chemie International Edition, 2006, 45(46): 7824-7828.
[74] M Ma, Y Zhang, N Cu. Peroxidase-like catalytic activity of cubic Pt nanocrystals [J]. Colloid Surface A, 2011, 373(1-3): 6-10.
[75] D P Minh, Y Oudart, B Baubet, C Verdon, C Thomazeau. Nanostructured Heterogeneous Catalysts: Well Defined Platinum Nanoparticles Supported on Alumina. Preparation, Characterization and Application to the Selective Hydrogenation of Buta-1,3-diene [J]. Oil & Gas Science and Technoloy, 2009, 64(6): 697-706.
[76] T K Sau, C J Murphy. Room temperature, high-yield synthesis of multiple shapes of gold nanoparticles in aqueous solution [J]. Journal of the American Chemical Society, 2004, 126(28): 8648-8649.
[77] B Nikoobakht, M A El-Sayed. Preparation and growth mechanism of gold nanorods (NRs) using seed-mediated growth method [J]. Chemistry of Materials, 2003, 15(10): 1957-1962.
[78] H C Chu, C H Kuo, M H Huang. Thermal aqueous solution approach for the synthesis of triangular and hexagonal gold nanoplates with three different size ranges [J]. Inorganic chemistry, 2006, 45(2): 808-813.
[79] Z J Wang, J H Yuan, M Zhou, L Niu, A Ivaska. Synthesis, characterization and mechanism of cetyltrimethylammonium bromide bilayer-encapsulated gold nanosheets and nanocrystals [J]. Applied Surface Science, 2008, 254(20): 6289-6293.
[80] M R Langille, M L Personick, J Zhang, C A Mirkin. Defining Rules for the Shape Evolution of Gold Nanoparticles [J]. Journal of the American Chemical Society, 2012, 134(35): 14542-14554.
[81] J Li, L H Wang, L Liu, L Guo, X D Han, Z Zhang. Synthesis of tetrahexahedral Au nanocrystals with exposed high-index surfaces [J]. Chemical communications, 2010, 46(28): 5109-5111.
[82] Y W Zhang, M E Grass, J N Kuhn, F Tao, S E Habas, W Y Huang, P D Yang, G A Somorjai. Highly selective synthesis of cataytically active monodisperse rhodium nanocubes [J]. Journal of the American Chemical Society, 2008, 130(18): 5868-5869.
[83] M L Personick, M R Langille, J Zhang, N Harris, G C Schatz, C A Mirkin. Synthesis and Isolation of {110}-Faceted Gold Bipyramids and Rhombic Dodecahedra [J]. Journal of the American Chemical Society, 2011, 133(16): 6170-6173.
[84] T S Ahmadi, Z L Wang, T C Green, A Henglein, M A ElSayed. Shape-controlled synthesis of colloidal

platinum nanoparticles [J]. Science, 1996, 272(5270): 1924-1926.
[85] J M Petroski, Z L Wang, T C Green, M A El-Sayed. Kinetically controlled growth and shape formation mechanism of platinum nanoparticles [J]. Journal of Physical Chemistry B, 1998, 102(18): 3316-3320.
[86] M L Flenniken, M Uchida, L O Liepold, S Kang, M J Young, T Douglas. A Library of Protein Cage Architectures as Nanomaterials [J]. Curr Top Microbiol, 2009, 327: 71-93.
[87] M R Jones, K D Osberg, R J Macfarlane, M R Langille, C A Mirkin. Templated Techniques for the Synthesis and Assembly of Plasmonic Nanostructures [J]. Chemical reviews, 2011, 111(6): 3736-3827.
[88] S R Whaley, D S English, E L Hu, P F Barbara, A M Belcher. Selection of peptides with semiconductor binding specificity for directed nanocrystal assembly [J]. Nature, 2000, 405(6787): 665-668.
[89] S Brown, M Sarikaya, E Johnson. A genetic analysis of crystal growth [J]. Journal of Molecular Biology, 2000, 299(3): 725-735.
[90] L A Gugliotti, D L Feldheim, B E Eaton. RNA-mediated metal-metal bond formation in the synthesis of hexagonal palladium nanoparticles [J]. Science, 2004, 304(5672): 850-852.
[91] L A Gugliotti, D L Feldheim, B E Eaton. RNA-mediated control of metal nanoparticle shape [J]. Journal of the American Chemical Society, 2005, 127(50): 17814-17818.
[92] C Y Chiu, Y J Li, L Y Ruan, X C Ye, C B Murray, Y Huang. Platinum nanocrystals selectively shaped using facet-specific peptide sequences [J]. Nature chemistry, 2011, 3(5): 393-399.
[93] G A Somorjai. Chemistry in Two Dimensions: Surfaces [M]. Cornell University Press, July 1981.
[94] L J Lipkowski, P N Ross. Structure of Electrified Interfaces [M]. Wiley-VCH Verlag GmbH, 1993.
[95] A Wieckowski. Interfacial Electrochemistry: Theory: Experiment, and Applications [M]. CRC Press, 1999.
[96] S G Sun, Y Lin. Kinetics of isopropanol oxidation on Pt(111), Pt(110), Pt(100), Pt(610) and Pt(211) single crystal electrodes - Studies of in situ time-resolved FTIR spectroscopy [J]. Electrochimica Acta, 1998, 44(6-7): 1153-1162.
[97] N Tian, Z Y Zhou, S G Sun. Platinum Metal Catalysts of High-Index Surfaces: From Single-Crystal Planes to Electrochemically Shape-Controlled Nanoparticles [J]. Journal of Physical Chemistry C, 2008, 112(50): 19801-19817.
[98] N M Markovic, P N Ross. Surface science studies of model fuel cell electrocatalysts [J]. Surface Science Reports, 2002, 45(4-6): 121-229.
[99] M Ahmed. Electrochemical Studies of Metal Deposition and Surface Chirality at Well-Defined Platinum Single Crystal Electrodes [D], 2013.
[100] G Gronchi, P Courbis, P Tordo, G Mousset, J Simonet. Spin Trapping in Electrochemistry - Non-Aqueous Electrochemical-Behavior of Nitroso Spin Traps [J]. The Journal of Physical Chemistry, 1983, 87(8): 1343-1349.
[101] G L Mcintire, H N Blount, H J Stronks, R V Shetty, E G Janzen. Spin Trapping in Electrochemistry .2. Aqueous and Non-Aqueous Electrochemical Characterizations of Spin Traps [J]. The Journal of Physical Chemistry, 1980, 84(8): 916-921.
[102] B B Damaskin, V A Safonov. Analysis of modern phenomenological approaches toward describing the structure and properties of the electrical double layer dense part on the metal solution interface [J]. Electrochimica Acta, 1997, 42(5): 737-746.
[103] S Trasatti. Systematic Trends in the Crystal-Face Specificity of Interfacial Parameters - the Cases of Ag and Au [J]. Journal of Electroanalytical Chemistry, 1992, 329(1-2): 237-246.
[104] B Piela, P K Wrona. Capacitance of the Gold Electrode in 0.5 M H2so4 Solution - Ac-Impedance Studies [J]. Journal of Electroanalytical Chemistry, 1995, 388(1-2): 69-79.
[105] L M Doubova, A Hamelin, L Stoicoviciu, S Trasatti. Temperature-Dependence of Double-Layer Parameters of the Silver (100) Face - Comparison with Other Silver Faces [J]. Journal of Electroanalytical Chemistry, 1992, 325(1-2): 197-205.
[106] W R Fawcett, A A Kloss, J J Calvente, N Marinkovic. SNIFTIRS studies of the electrical double layer at gold electrodes [J]. Electrochimica Acta, 1998, 44(6-7): 881-887.

[107] D Eberhardt, E Santos, W Schmickler. Impedance studies of reconstructed and non-reconstructed gold single crystal surfaces [J]. Journal of Electroanalytical Chemistry, 1996, 419(1): 23-31.
[108] C M Vitus, A J Davenport. In-Situ Scanning-Tunneling-Microscopy Studies of the Formation and Reduction of a Gold Oxide Monolayer on Au(111) [J]. Journal of the Electrochemical Society, 1994, 141(5): 1291-1298.
[109] W L Desimone, J J Breen. Structures of Iodine on Pt(110) Single-Crystal Electrode Surfaces [J]. Langmuir, 1995, 11(11): 4428-4432.
[110] F Silva, A Martins. Surface reconstruction of gold single crystals: electrochemical evidence of the effect of adsorbed anions and influence of steps and terraces [J]. Electrochimica Acta, 1998, 44(6-7): 919-929.
[111] M L Lynch, R M Corn. Surface Phase-Transition of Ordered Iodine Monolayers on a Pt(111) Electrode as Studied by Normal Incidence Optical 2nd Harmonic-Generation [J]. Journal of Electroanalytical Chemistry, 1991, 318(1-2): 379-386.
[112] A V Tripkovic, K D Popovic, J D Momcilovic, D M Drazic. Kinetic and mechanistic study of methanol oxidation on a Pt(111) surface in alkaline media [J]. Journal of Electroanalytical Chemistry, 1996, 418(1-2): 9-20.
[113] J. Lipkowski, P Ross. Adsorption of Molecules at Metal Electrodes [M]. VCH Publishing, 1992.
[114] J Lipkowski, P Ross. Imaging of Surfaces and Interfaces [M]. John Wiley and Sons Ltd, United States, 1999.
[115] D M Kolb. An atomistic view of electrochemistry [J]. Surface Science, 2002, 500(1-3): 722-740.
[116] R Parsons, T Vandernoot. The Oxidation of Small Organic-Molecules - a Survey of Recent Fuel-Cell Related Research [J]. Journal of Electroanalytical Chemistry, 1988, 257(1-2): 9-45.
[117] E Herrero, L J Buller, H D Abruna. Underpotential deposition at single crystal surfaces of Au, Pt, Ag and other materials [J]. Chemical reviews, 2001, 101(7): 1897-1930.
[118] C Korzeniewski, V Climent, J M Feliu. Electrochemistry at Platinum Single Crystal Electrodes [J]. Electroanalytical Chemistry, 2012, 24: 75-169.
[119] V Climent, J M Feliu. Thirty years of platinum single crystal electrochemistry [J]. Journal of Solid State Electrochemistry, 2011, 15(7-8): 1297-1315.
[120] A M Gomez-Marin, R Rizo, J M Feliu. Oxygen reduction reaction at Pt single crystals: a critical overview [J]. Catalysis Science & Technology, 2014, 4(6): 1685-1698.
[121] R Rizo, E Herrero, J M Feliu. Oxygen reduction reaction on stepped platinum surfaces in alkaline media [J]. Physical Chemistry Chemical Physics, 2013, 15(37): 15416-15425.
[122] A Kuzume, E Herrero, J M Feliu. Oxygen reduction on stepped platinum surfaces in acidic media [J]. Journal of Electroanalytical Chemistry, 2007, 599(2): 333-343.
[123] 孙世刚, 立足基础、瞄准方向、持之以恒——关于物理化学学科如何开展系统性、原创性研究工作的体会, “物理化学发展的瓶颈与思路”论坛, 厦门, 2006.
[124] A Wieckowski, S D Rosasco, B C Schardt, J L Stickney, A T Hubbard. Preparation of Well-Defined Surfaces at Atmospheric-Pressure - Studies by Electrochemistry and Leed of Pt(100) Pretreated with Iodine [J]. Inorganic chemistry, 1984, 23(5): 565-569.
[125] J L Stickney, D A Stern, B C Schardt, D C Zapien, A Wieckowski, A T Hubbard. Electrodeposition of Pb onto Pt (111) Surfaces Containing Iodine Adlattices - Studies by Low-Energy Electron-Diffraction and Auger-Spectroscopy [J]. Journal of Electroanalytical Chemistry, 1986, 213(2): 293-300.
[126] J L Stickney, S D Rosasco, B C Schardt, A T Hubbard. Electrodeposition of Silver onto Pt(100) Surfaces Containing Iodine Ad-Lattices - Studies by Low-Energy Electron-Diffraction, Auger-Spectroscopy, and Thermal-Desorption [J]. The Journal of Physical Chemistry, 1984, 88(2): 251-258.
[127] D G Frank, O M R Chyan, T Golden, A T Hubbard. Auger Emission Angular-Distributions from a Silver Monolayer in the Presence and Absence of an Iodine Overlayer - Evidence for the Predominance of Inhomogeneous Inelastic-Scattering of Auger Electrons by Atoms [J]. The Journal of Physical Chemistry, 1994, 98(7): 1895-1903.

[128] C A Doyle, O M R Chyan, D G Frank, A T Hubbard. Auger-Electron Angular-Distributions from Pt(111) - the Effect of Adsorbed Iodine Monolayers [J]. Surface and Interface Analysis, 1994, 21(2): 123-130.
[129] J L Stickney, S D Rosasco, A T Hubbard. Electrodeposition of Copper on Platinum(111) Surfaces Pretreated with Iodine - Studies by Leed, Auger-Spectroscopy, and Electrochemistry [J]. Journal of the Electrochemical Society, 1984, 131(2): 260-267.
[130] U W Hamm, D Kramer, R S Zhai, D M Kolb. On the valence state of bismuth adsorbed on a Pt(111) electrode: an electrochemistry, LEED and XPS study [J]. Electrochimica Acta, 1998, 43(19-20): 2969-2978.
[131] J Clavilier, R Faure, G Guinet, R Durand. Preparation of Mono-Crystalline Pt Microelectrodes and Electrochemical Study of the Plane Surfaces Cut in the Direction of the (111) and (110) Planes [J]. Journal of Electroanalytical Chemistry, 1980, 107(1): 205-209.
[132] J Clavilier, D Armand, S G Sun, M Petit. Electrochemical Adsorption Behavior of Platinum Stepped Surfaces in Sulfuric-Acid-Solutions [J]. Journal of Electroanalytical Chemistry, 1986, 205(1-2): 267-277.
[133] 白春礼. 扫描隧道显微术及其运用 [M]. 上海: 上海科学出版社, 1991.
[134] R Schumacher. The Quartz Microbalance - a Novel-Approach to the Insitu Investigation of Interfacial Phenomena at the Solid Liquid Junction [J]. Angewandte Chemie-International Edition in English, 1990, 29(4): 329-343.
[135] P M Saville, M Gonsalves, A R Hillman, R Cubitt. Dynamic neutron reflectivity measurements during redox switching of nickel hydroxide films [J]. Journal of Physical Chemistry B, 1997, 101(1): 1-4.
[136] Y Y Tong, E Oldfield, A Wieckowski. Exploring electrochemical interfaces [J]. Analytical Chemistry, 1998, 70(15): 518a-527a.
[137] Y Y Yang, S G Sun, Y J Gu, Z Y Zhou, C H Zhen. Surface modification and electrocatalytic properties of Pt(100), Pt(110), Pt(320) and Pt(331) electrodes with Sb towards HCOOH oxidation [J]. Electrochimica Acta, 2001, 46(28): 4339-4348.
[138] Y J Gu, S G Sun, S P Chen, C H Zhen, Z Y Zhou. Adsorption of serine on Pt single-crystal electrodes in sulfuric acid solutions [J]. Langmuir, 2003, 19(23): 9823-9830.
[139] C H Zhen, S G Sun, C J Fan, S P Chen, B W Mao, Y J Fan. In situ FTIRS and EQCM studies of glycine adsorption and oxidation on Au(111) electrode in alkaline solutions [J]. Electrochimica Acta, 2004, 49(8): 1249-1255.
[140] Y J Fan, C J Fan, C H Zhen, S P Chen, S G Sun. Electrochemical characterization of kinked Pt(751) surface in acidic media [J]. Electrochimica Acta, 2006, 52(3): 945-950.
[141] Q W Zheng, C H Fan, C H Zhen, Z Y Zhou, S G Sun. Irreversible adsorption of Sn adatoms on basal planes of Pt single crystal and its impact on electrooxidation of ethanol [J]. Electrochimica Acta, 2008, 53(21): 6081-6088.
[142] I R de Moraes, F C Nart. Sulfate ions adsorbed on Au(hkl) electrodes: in situ vibrational spectroscopy [J]. Journal of Electroanalytical Chemistry, 1999, 461(1-2): 110-120.
[143] N Hoshi, A Sakurada, S Nakamura, S Teruya, O Koga, Y Hori. Infrared reflection absorption spectroscopy of sulfuric acid anion adsorbed on stepped surfaces of platinum single-crystal electrodes [J]. Journal of Physical Chemistry B, 2002, 106(8): 1985-1990.
[144] N Hoshi, M Kuroda, O Koga, Y Hori. Infrared reflection absorption spectroscopy of the sulfuric acid anion on low and high index planes of palladium [J]. Journal of Physical Chemistry B, 2002, 106(35): 9107-9113.
[145] A Lachenwitzer, N Li, J Lipkowski. Determination of the acid dissociation constant for bisulfate adsorbed at the Pt(111) electrode by subtractively normalized interfacial Fourier transform infrared spectroscopy [J]. Journal of Electroanalytical Chemistry, 2002, 532(1-2): 85-98.
[146] M Weber, I R de Moraes, A J Motheo, F C Nart. In situ vibrational spectroscopy analysis of adsorbed phosphate species on gold single crystal electrodes [J]. Colloid Surface A, 1998, 134(1-2): 103-111.
[147] G A Attard, A Brew, K Hunter, J Sharman, E Wright. Specific adsorption of perchlorate anions on Pt{hkl} single crystal electrodes [J]. Physical Chemistry Chemical Physics, 2014, 16(27): 13689-13698.
[148] S Yang, H Noguchi, K Uosaki. Interfacial electronic structure of CO absorbed on a platinum electrode in

electrochemical environment probed by double resonance sum frequency generation spectroscopy [J]. Abstracts of Papers of American Chemical Society, 2014, 247
[149] G Samjeske, K Komatsu, M Osawa. Dynamics of CO Oxidation on a Polycrystalline Platinum Electrode: A Time-Resolved Infrared Study [J]. Journal of Physical Chemistry C, 2009, 113(23): 10222-10228.
[150] A Lopez-Cudero, A Cuesta, C Gutierrez. Potential dependence of the saturation CO coverage of Pt electrodes: The origin of the pre-peak in CO-stripping voltammograms. Part 2: Pt(100) [J]. Journal of Electroanalytical Chemistry, 2006, 586(2): 204-216.
[151] A Cuesta, A Couto, A Rincon, M C Perez, A Lopez-Cudero, C Gutierrez. Potential dependence of the saturation CO coverage of Pt electrodes: The origin of the pre-peak in CO-stripping voltammograms. Part 3: Pt(poly) [J]. Journal of Electroanalytical Chemistry, 2006, 586(2): 184-195.
[152] A Lopez-Cudero, A Cuesta, C Gutierrez. Potential dependence of the saturation CO coverage of Pt electrodes: The origin of the pre-peak in CO-stripping voltammograms. Part 1: Pt(111) [J]. Journal of Electroanalytical Chemistry, 2005, 579(1): 1-12.
[153] V Grozovski, V Climent, E Herrero, J M Feliu. The role of the surface structure in the oxidation mechanism of methanol [J]. Journal of Electroanalytical Chemistry, 2011, 662(1): 43-51.
[154] A Santasalo, F J Vidal-Iglesias, J Solla-Gullon, A Berna, T Kallio, J M Feliu. Electrooxidation of methanol and 2-propanol mixtures at platinum single crystal electrodes [J]. Electrochimica Acta, 2009, 54(26): 6576-6583.
[155] J Hernandez, J Solla-Gullon, E Herrero, A Aldaz, J M Feliu. Methanol oxidation on gold nanoparticles in alkaline media: Unusual electrocatalytic activity [J]. Electrochimica Acta, 2006, 52(4): 1662-1669.
[156] A Miki, S Ye, T Senzaki, M Osawa. Surface-enhanced infrared study of catalytic electrooxidation of formaldehyde, methyl formate, and dimethoxymethane on platinum electrodes in acidic solution [J]. Journal of Electroanalytical Chemistry, 2004, 563(1): 23-31.
[157] C Korzeniewski, C L Childers. Formaldehyde yields from methanol electrochemical oxidation on platinum [J]. Journal of Physical Chemistry B, 1998, 102(3): 489-492.
[158] H Okamoto, N Tanaka. Potential Oscillation Mechanism for Formaldehyde Oxidation on Platinum [J]. Electrochimica Acta, 1993, 38(4): 503-509.
[159] P Olivi, L O S Bulhoes, J M Leger, F Hahn, B Beden, C Lamy. New Results in the Electrooxidation of Formaldehyde on a Platinum-Electrode in an Acid-Medium [J]. Journal of Electroanalytical Chemistry, 1994, 370(1-2): 241-249.
[160] J V Perales-Rondon, E Herrero, J M Feliu. On the activation energy of the formic acid oxidation reaction on platinum electrodes [J]. Journal of Electroanalytical Chemistry, 2015, 742: 90-96.
[161] E Berlin, S Garbarino, D Guay, J Solla-Gullon, F J Vidal-Iglesias, J M Feliu. Electrodeposited platinum thin films with preferential (100) orientation: Characterization and electrocatalytic properties for ammonia and formic acid oxidation [J]. Journal of Power Sources, 2013, 225: 323-329.
[162] F J Vidal-Iglesias, A Lopez-Cudero, J Solla-Gullon, J M Feliu. Towards More Active and Stable Electrocatalysts for Formic Acid Electrooxidation: Antimony-Decorated Octahedral Platinum Nanoparticles [J]. Angewandte Chemie International Edition, 2013, 52(3): 964-967.
[163] V Grozovski, F J Vidal-Iglesias, E Herrero, J M Feliu. Adsorption of Formate and Its Role as Intermediate in Formic Acid Oxidation on Platinum Electrodes [J]. Chemphyschem : a European journal of chemical physics and physical chemistry, 2011, 12(9): 1641-1644.
[164] C Buso-Rogero, E Herrero, J M Feliu. Ethanol Oxidation on Pt Single-Crystal Electrodes: Surface-Structure Effects in Alkaline Medium [J]. Chemphyschem : a European journal of chemical physics and physical chemistry, 2014, 15(10): 2019-2028.
[165] S Beyhan, K Uosaki, J M Feliu, E Herrero. Electrochemical and in situ FTIR studies of ethanol adsorption and oxidation on gold single crystal electrodes in alkaline [J]. Journal of Electroanalytical Chemistry, 2013, 707(89-94.
[166] V Del Colle, V Grozovski, E Herrero, J M Feliu. Unusually High Activity of Pt Islands on Rh(111) Electrodes for Ethanol Oxidation [J]. Chemcatchem, 2013, 5(6): 1350-1353.

[167] J Souza-Garcia, E Herrero, J M Feliu. Breaking the C-C Bond in the Ethanol Oxidation Reaction on Platinum Electrodes: Effect of Steps and Ruthenium Adatoms [J]. Chemphyschem : a European journal of chemical physics and physical chemistry, 2010, 11(7): 1391-1394.
[168] F Colmati, G Tremiliosi, E R Gonzalez, A Berna, E Herrero, J M Feliu. The role of the steps in the cleavage of the C-C bond during ethanol oxidation on platinum electrodes [J]. Physical Chemistry Chemical Physics, 2009, 11(40): 9114-9123.
[169] X K Gu, B Liu, J Greeley. First-Principles Study of Structure Sensitivity of Ethylene Glycol Conversion on Platinum [J]. Acs Catalysis, 2015, 5(4): 2623-2631.
[170] E Sitta, R Nagao, I Z Kiss, H Varela. Impact of the Alkali Cation on the Oscillatory Electro-Oxidation of Ethylene Glycol on Platinum [J]. Journal of Physical Chemistry C, 2015, 119(3): 1464-1472.
[171] V E Kazarinov, Y B Vassiliev, V N Andreev, G Horanyi. Electrochemical and Adsorption Behavior of Ethylene-Glycol and Its Oxidative Derivatives at Platinum-Electrodes .1. Adsorption and Chemisorption Processes [J]. Journal of Electroanalytical Chemistry, 1983, 147(1-2): 247-261.
[172] B Beden, F Kadirgan, A Kahyaoglu, C Lamy. Electrocatalytic Oxidation of Ethylene-Glycol in Alkaline-Medium on Platinum-Gold Alloy Electrodes Modified by Underpotential Deposition of Lead Adatoms [J]. Journal of Electroanalytical Chemistry, 1982, 135(2): 329-334.
[173] A P Sandoval, M F Suarez-Herrera, J M Feliu. IR and electrochemical synthesis and characterization of thin films of PEDOT grown on platinum single crystal electrodes in [EMMIM]Tf2N ionic liquid [J]. Beilstein Journal of Organic Chemistry, 2015, 11: 348-357.
[174] J C Hidalgo-Acosta, V Climent, J M Feliu. Adsorption and first stages of polymerization of aniline on platinum single crystal electrodes [J]. Synthetic Metals, 2014, 196: 61-67.
[175] A P Sandoval, M F Suarez-Herrera, J M Feliu. Hydrogen redox reactions in 1-ethyl-2,3-dimethylimidazolium bis(trifluoromethylsulfonyl)imide on platinum single crystal electrodes [J]. Electrochemistry Communications, 2014, 46: 84-86.
[176] M F Suarez-Herrera, M Costa-Figueiredo, J M Feliu. Voltammetry of Basal Plane Platinum Electrodes in Acetonitrile Electrolytes: Effect of the Presence of Water [J]. Langmuir, 2012, 28(11): 5286-5294.
[177] M F Suarez-Herrera, M Costa-Figueiredo, J M Feliu. Electrochemical and electrocatalytic properties of thin films of poly(3,4-ethylenedioxythiophene) grown on basal plane platinum electrodes [J]. Physical Chemistry Chemical Physics, 2012, 14(41): 14391-14399.
[178] M C Figueiredo, F J Vidal-Iglesias, J Solla-Gullon, V Climent, J M Feliu. Nitrate Reduction on Platinum (111) Surfaces Modified with Bi: Single Crystals and Nanoparticles [J]. Zeitschrift fur Physikalische Chemie, 2012, 226(9-10): 901-917.
[179] M Rodriguez-Lopez, J Solla-Gullon, E Herrero, P Tunon, A Aldaz, J M Feliu, A Carrasquillo. Electrochemical reactivity of aromatic molecules at nanometer sized surface domains: From Pt(hkl) single crystal electrodes to preferentially oriented platinum nanoparticles [J]. Abstracts of Papers of American Chemical Society, 2011, 241
[180] S G Sun, Y Lin. In situ FTIR spectroscopic investigations of reaction mechanism of isopropanol oxidation on platinum single crystal electrodes [J]. Electrochimica Acta, 1996, 41(5): 693-700.
[181] L Proenca, M I S Lopes, I Fonseca, A Rodes, R Gomez, A Aldaz. On the oxidation of D-sorbitol on platinum single crystal electrodes: a voltammetric and in situ FTIRS study [J]. Electrochimica Acta, 1998, 44(6-7): 1163-1171.
[182] V Climent, A Rodes, J M Orts, J M Feliu, A Aldaz. The electrochemistry of nitrogen-containing compounds at platinum single crystal electrodes - Part 3. Carbohydrazide on Pt(hkl) electrodes [J]. Journal of Electroanalytical Chemistry, 1999, 467(1-2): 20-29.
[183] V Climent, A Rodes, J M Orts, J M Feliu, A Aldaz. The electrochemistry of nitrogen-containing compounds at platinum single crystal electrodes: Part 2. Semicarbazide on Pt(100) electrodes [J]. Journal of Electroanalytical Chemistry, 1997, 436(1-2): 245-255.
[184] R Gomez, J M Orts, A Rodes, J M Feliu, A Aldaz. The Electrochemistry of Nitrogen-Containing

Compounds at Platinum Single-Crystal Electrodes .1. Hydrazine Behavior on Platinum Basal Planes in Sulfuric-Acid-Solutions [J]. Journal of Electroanalytical Chemistry, 1993, 358(1-2): 287-305.
[185] F Huerta, E Morallon, J M Perez, J L Vazquez, A Aldaz. Oxidation of methylamine and ethylamine on Pt single crystal electrodes in acid medium [J]. Journal of Electroanalytical Chemistry, 1999, 469(2): 159-169.
[186] V Climent, A Rodes, J M Orts, A Aldaz, J M Feliu. Urea adsorption on Pt(111) electrodes [J]. Journal of Electroanalytical Chemistry, 1999, 461(1-2): 65-75.
[187] C K Rhee. Adsorption of Urea on Pt(Poly), Pt(111) and Pt(100) - Voltammetric and Uhv Study [J]. Journal of the Electrochemical Society, 1992, 139(1): C13-C16.
[188] F Huerta, E Morallon, J L Vazquez, A Aldaz. Electrochemical behaviour of amino acids on Pt(hkl). A voltammetric and in situ FTIR study Part IV. Serine and alanine on Pt(100) and Pt(110) [J]. Journal of Electroanalytical Chemistry, 1999, 475(1): 38-45.
[189] F Huerta, E Morallon, J L Vazquez, J M Perez, A Aldaz. Electrochemical behaviour of amino acids on Pt(hkl). A voltammetric and in situ FTIR study. Part III. Glycine on Pt(100) and Pt(110) [J]. Journal of Electroanalytical Chemistry, 1998, 445(1-2): 155-164.
[190] J F Richer, A Chen, J Lipkowski. Quantitative studies of benzonitrile adsorption at the low-index gold single crystal electrodes [J]. Electrochimica Acta, 1998, 44(6-7): 1037-1052.
[191] E Sitta, J M Feliu. The Role of PtOH on H2O2 Interactions with Platinum Surfaces in an Electrochemical Environment [J]. Chemelectrochem, 2014, 1(1): 55-58.
[192] C Buso-Rogero, V Grozovski, F J Vidal-Iglesias, J Solla-Gullon, E Herrero, J M Feliu. Surface structure and anion effects in the oxidation of ethanol on platinum nanoparticles [J]. Journal of Materials Chemistry A, 2013, 1(24): 7068-7076.
[193] C A Angelucci, F C Nart, E Herrero, J M Feliu. Anion re-adsorption and displacement at platinum single crystal electrodes in CO-containing solutions [J]. Electrochemistry Communications, 2007, 9(5): 1113-1119.
[194] J Mostany, E Herrero, J M Feliu, J Lipkowski. Thermodynamic studies of anion adsorption at stepped platinum(hkl) electrode surfaces in sulfuric acid solutions [J]. Journal of Physical Chemistry B, 2002, 106(49): 12787-12796.
[195] L J Buller, E Herrero, R Gomez, J M Feliu, H D Abruna. Anion effects and induced adsorption of chloride by submonolayer amounts of copper on deliberately stepped platinum surfaces [J]. Journal of Physical Chemistry B, 2000, 104(25): 5932-5939.
[196] A Rodes, M A Climent, J M Perez, M J Valls, J M Feliu, A Aldaz. Ftir Study of Surface-Structure Influence on the Electrochemical-Behavior of the Ascorbate Anion at Platinum-Electrodes in Neutral Solutions [J]. Journal of Electroanalytical Chemistry, 1994, 374(1-2): 263-268.
[197] T Senna, N Ikemiya, M Ito. In situ IRAS and STM of adsorbate structures on an Ir(111) electrode in sulfuric acid electrolyte [J]. Journal of Electroanalytical Chemistry, 2001, 511(1-2): 115-121.
[198] 万立骏. 电化学扫描隧道显微术及其运用 [M]. 北京: 科学出版社, 2005.
[199] 孙世刚, 陈声培. 电化学催化中的表面微观结构与特殊反应性能 [J]. 厦门大学学报(自然科学版), 2001, 40(2): 398-405.
[200] 孙世刚, J Clavilier. 铂单晶(210) , (310) 和(610) 阶梯晶面在甲酸氧化中的电催化特性 [J]. 高等学校化学学报, 1990, 11(9): 998-1002.
[201] S G Sun, A C Chen, T S Huang, J B Li, Z W Tian. Electrocatalytic Properties of Pt(111), Pt(332), Pt(331) and Pt(110) Single-Crystal Electrodes Towards Ethylene-Glycol Oxidation in Sulfuric-Acid-Solutions [J]. Journal of Electroanalytical Chemistry, 1992, 340(1-2): 213-226.
[202] S G Sun, A C Chen. Effects of Ethylene-Glycol (Eg) Concentration and Ph of Solutions on Electrocatalytic Properties of Pt(111) Electrode in Eg Oxidation - a Comparison Study with Adjacent Planes of Platinum Single-Crystal Situated in [1(1)over-Bar-0] and [01(1)over-Bar] Crystallographic Zones [J]. Electrochimica Acta, 1994, 39(7): 969-973.
[203] A J Gellman, J D Horvath, M T Buelow. Chiral single crystal surface chemistry [J]. Journal of Molecular Catalysis A-Chemical, 2001, 167(1-2): 3-11.

[204] G A Attard. Electrochemical studies of enantioselectivity at chiral metal surfaces [J]. Journal of Physical Chemistry B, 2001, 105(16): 3158-3167.
[205] O A Hazzazi, C A Harris, P B Wells, G A Attard. Electrooxidation of D- and L-Glucose at Well-Defined Chiral Bimetallic Electrodes [J]. Topics in Catalysis, 2011, 54(19-20): 1392-1402.
[206] A Ahmadi, G Attard, J Feliu, A Rodes. Surface reactivity at "chiral" platinum surfaces [J]. Langmuir, 1999, 15(7): 2420-2424.
[207] A Alderson, K L Alderson, D Attard, K E Evans, R Gatt, J N Grima, W Miller, N Ravirala, C W Smith, K Zied. Elastic constants of 3-, 4-and 6-connected chiral and anti-chiral honeycombs subject to uniaxial in-plane loading [J]. Composites Science and Technology, 2010, 70(7): 1042-1048.
[208] G A Attard. A study of the role of chiral defect sites at supported platinum nanoparticles in the enantioselective hydrogenation of alpha-ketoesters. [J]. Abstracts of Papers of the American Chemical Society, 2003, 225: U683-U683.
[209] G A Attard, D Watson, E A Seddon, S M Cornelius, E Herrero, J Feliu. Photoemission studies of chiral metal surfaces using circularly polarized synchrotron radiation [J]. Physical Review B, 2001, 64(11): 115408
[210] G S Attard, K Araki, J J Mouraramos, G Williams, A C Griffin, A M Bhatti, R S L Hung. Dielectric and Electrooptical Properties of a Chiral Liquid-Crystalline Polymer [J]. Acs Symposium Series, 1989, 384: 255-264.
[211] O A Hazzazi, G A Attard, P B Wells. Molecular recognition in adsorption and electro-oxidation at chiral platinum surfaces [J]. Journal of Molecular Catalysis A : Chemical, 2004, 216(2): 247-255.
[212] Z Sljivancanin, K V Gothelf, B Hammer. Density functional theory study of enantiospecific adsorption at chiral surfaces [J]. Journal of the American Chemical Society, 2002, 124(49): 14789-14794.
[213] A Martins, V Ferreira, A Queiros, I Aroso, F Silva, J Feliu. Enantiomeric electro-oxidation of D- and L-glucose on chiral gold single crystal surfaces [J]. Electrochemistry Communications, 2003, 5(9): 741-746.
[214] W Y Cheong, A J Gellman. Enantiospecific Desorption of R- and S-Propylene Oxide from D- or L-Lysine Modified Cu(100) Surfaces [J]. Langmuir, 2012, 28(43): 15251-15262.
[215] J D Horvath, A J Gellman. Enantiospecific desorption of chiral compounds from chiral Cu(643) and achiral Cu(111) surfaces [J]. Journal of the American Chemical Society, 2002, 124(10): 2384-2392.
[216] J D Horvath, A J Gellman. Enantiospecific desorption of R- and S-propylene oxide from a chiral Cu(643) surface [J]. Journal of the American Chemical Society, 2001, 123(32): 7953-7954.
[217] C F McFadden, P S Cremer, A J Gellman. Adsorption of chiral alcohols on "chiral" metal surfaces [J]. Langmuir, 1996, 12(10): 2483-2487.
[218] G A Attard, C Harris, E Herrero, J Feliu. The influence of anions and kink structure on the enantioselective electro-oxidation of glucose [J]. Faraday Discussions, 2002, 121(253-266.
[219] N Hoshi, E Sato, Y Hori. Electrochemical reduction of carbon dioxide on kinked stepped surfaces of platinum inside the stereographic triangle [J]. Journal of Electroanalytical Chemistry, 2003, 540(105-110.
[220] S Pons. The Use of Fourier-Transform Infrared-Spectroscopy for Insitu Recording of Species in the Electrode Electrolyte Solution Interphase [J]. Journal of Electroanalytical Chemistry, 1983, 150(1-2): 495-504.
[221] A Bewick. Insitu Infrared-Spectroscopy of the Electrode Electrolyte Solution Interphase [J]. Journal of Electroanalytical Chemistry, 1983, 150(1-2): 481-493.
[222] A Bewick, K Kunimatsu, B S Pons. Infrared-Spectroscopy of the Electrode-Electrolyte Interphase [J]. Electrochimica Acta, 1980, 25(4): 465-468.
[223] A Bewick, K Kunimatsu. Infrared-Spectroscopy of the Electrode-Electrolyte Interphase [J]. Surface Science, 1980, 101(1-3): 131-138.
[224] R G Greenler. Infrared Study of Adsorbed Molecules on Metal Surfaces by Reflection Techniques [J]. The Journal of Chemical Physics, 1966, 44(1): 310-315.
[225] K Ashley, S Pons. Infrared Spectroelectrochemistry [J]. Chemical reviews, 1988, 88(4): 673-695.
[226] T Iwasita, F C Nart. In situ infrared spectroscopy at electrochemical interfaces [J]. Progress in Surface Science, 1997, 55(4): 271-340.
[227] E Kretschmann. The determination of the optical constants of metals by excitation of surface plasmons [J].

European Physical Journal A 1971, 241(4): 313-324.
[228] P A Brooksby, W R Fawcett. Determination of the electric field intensities in a mid-infrared spectroelectrochemical cell using attenuated total reflection spectroscopy with the Otto optical configuration [J]. Analytical Chemistry, 2001, 73(6): 1155-1160.
[229] 田莉. Pt(100)和Pt(110)单晶电极上CN-和CO吸附与共吸附过程的循环伏安和原位红外光谱研究 [D], 2011.
[230] H Neff, P Lange, D K Roe, J K Sass. A Modulated Infrared-Atr Spectroscopic Study of Water in the Electric Double-Layer [J]. Journal of Electroanalytical Chemistry, 1983, 150(1-2): 513-519.
[231] P Lange, V Glaw, H Neff, E Piltz, J K Sass. Infrared Attenuated Total Reflection Spectroscopy at the Metal Electrolyte Interface [J]. Vacuum, 1983, 33(10-1): 763-766.
[232] A Miki, S Ye, M Osawa. Surface-enhanced IR absorption on platinum nanoparticles: an application to real-time monitoring of electrocatalytic reactions [J]. Chemical communications, 2002, 14): 1500-1501.
[233] K Kunimatsu, H Seki, W G Golden. Polarization-Modulated Ft Ir-Spectra of Cyanide Adsorbed on a Silver Electrode [J]. Chemical Physics Letters, 1984, 108(2): 195-199.
[234] A Hatta, Y Sasaki, W Suetaka. Polarization Modulation Infrared Spectroscopic Measurements of Thiocyanate and Cyanide at the Silver Electrode Aqueous-Electrolyte Interface by Means of Kretschmann Atr Prism Configuration [J]. Journal of Electroanalytical Chemistry, 1986, 215(1-2): 93-102.
[235] J N Chazalviel, B H Erne, F Maroun, F Ozanam. New directions and challenges in modern electrochemistry: in situ infrared spectroscopy of the semiconductor vertical bar electrolyte interface [J]. Journal of Electroanalytical Chemistry, 2001, 502(1-2): 180-190.
[236] M Osawa, K Yoshii. In situ and real-time surface-enhanced infrared study of electrochemical reactions [J]. Applied Spectroscopy, 1997, 51(4): 512-518.
[237] P Christensen, A Hamnett. In-situ techniques in electrochemistry - ellipsometry and FTIR [J]. Electrochimica Acta, 2000, 45(15-16): 2443-2459.
[238] J G Li, J Daschbach, J J Smith, M D Morse, S Pons. The Infrared-Spectra of Surface Metal Atom Vibrations - Sniftirs Studies in the Far Infrared Region Using Time Resolved Ftir Techniques [J]. Journal of Electroanalytical Chemistry, 1986, 209(2): 387-390.
[239] J T Lu, A Bewick. Insitu Ir Spectroscopy with a Gas-Diffusion Cell - Co Adsorption and Oxidation on Pt [J]. Journal of Electroanalytical Chemistry, 1989, 270(1-2): 225-235.
[240] T M Vess, D W Wertz. Spectroelectrochemistry Using a Movable Electrode [J]. Journal of Electroanalytical Chemistry, 1991, 313(1-2): 81-94.
[241] R J Nichols, A Bewick. Sniftirs with a Flow Cell - the Identification of the Reaction Intermediates in Methanol Oxidation at Pt Anodes [J]. Electrochimica Acta, 1988, 33(11): 1691-1694.
[242] G Binnig, H Rohrer, C Gerber, E Weibel. Tunneling through a Controllable Vacuum Gap [J]. Applied Physical Letters, 1982, 40(2): 178-180.
[243] H Brune. Microscopic view of epitaxial metal growth: nucleation and aggregation [J]. Surface Science Reports, 1998, 31(4-6): 121-229.
[244] D M Kolb. Electrochemical surface science [J]. Angewandte Chemie International Edition, 2001, 40(7): 1162-1181.
[245] D M Kolb. Reconstruction phenomena at metal-electrolyte interfaces [J]. Progress in Surface Science, 1996, 51(2): 109-173.
[246] J Wiechers, T Twomey, D M Kolb, R J Behm. An Insitu Scanning Tunneling Microscopy Study of Au(111) with Atomic Scale Resolution [J]. Journal of Electroanalytical Chemistry, 1988, 248(2): 451-460.
[247] Herrero E, Mostany J, Feliu J M, et al. Thermodynamic studies of (Bi)sulfate adsorption at Pt(111) vicinal surfaces. [J]. Abstracts of Papers of the American Chemical Society, 2003, 225: U677-U677.
[248] Corrigan D S, Leung L W H, Weaver M J. Single Potential-Alteration Surface Infrared-Spectroscopy - Examination of Adsorbed Species Involved in Irreversible Electrode-Reactions [J]. Analytical Chemistry, 1987, 59(18): 2252-6.

[249] Ahmed M, Attard G A, Wright E, et al. Methanol and formic acid electrooxidation on nafion modified Pd/Pt{111}: The role of anion specific adsorption in electrocatalytic activity [J]. Catalysis Today, 2013, 202: 128-134.
[250] Clavilier J, Elachi K, Rodes A. Insitu Probing of Step and Terrace Sites on Pt(S)-[N(111)X(111)] Electrodes [J]. Chemical Physics, 1990, 141(1): 1-14.
[251] Shimizu R, Hitosugi T, Hashizume T, et al. Preparation of Superconducting Niobium Tips for Atomic-Resolution Scanning Tunneling Microscopy/Spectroscopy [J]. Japanese Journal of Applied Physics, 2010, 49(2): 028004.
[252] Hansma P K, Tersoff J. Scanning Tunneling Microscopy [J]. Journal of Applied Physics, 1987, 61(2): R1-R23.
[253] Bewick A, Kunimatsu K, Pons B S, et al. Electrochemically Modulated Infrared-Spectroscopy (Emirs) - Experimental Details [J]. Journal of Electroanalytical Chemistry, 1984, 160(1-2): 47-61.
[254] Clavilier J, Elachi K, Petit M, et al. Electrochemical Monitoring of the Thermal Reordering of Platinum Single-Crystal Surfaces after Metallographic Polishing from the Early Stage to the Equilibrium Surfaces [J]. Journal of Electroanalytical Chemistry, 1990, 295(1-2): 333-56.
[255] Clavilier J, Elachi K, Rodes A. Insitu Characterization of the Pt(S)-[N(111)X(111)] Electrode Surfaces Using Electrosorbed Hydrogen for Probing Terrace and Step Sites [J]. Journal of Electroanalytical Chemistry, 1989, 272(1-2): 253-61.
[256] Hazzazi O A, Huxter S E, Taylor R, et al. Electrochemical studies of irreversibly adsorbed ethyl pyruvate on Pt{h k l} and epitaxial Pd/Pt{h k l} adlayers [J]. Journal of Electroanalytical Chemistry, 2010, 640(1-2): 8-16.
[257] Hourani M, Wieckowski A. Electrochemistry of the Ordered Rh (111) Electrode - Surface Preparation and Voltammetry in Hclo4 Electrolyte [J]. Journal of Electroanalytical Chemistry, 1987, 227(1-2): 259-64.
[258] Pons S, Davidson T, Bewick A. Vibrational Spectroscopy of the Electrode Electrolyte Interface .4. Fourier-Transform Infrared-Spectroscopy - Experimental Considerations [J]. Journal of Electroanalytical Chemistry, 1984, 160(1-2): 63-71.
[259] Rodes A, Elachi K, Zamakhchari M A, et al. Hydrogen Probing of Step and Terrace Sites on Pt(S)-[N(111) X (100)] [J]. Journal of Electroanalytical Chemistry, 1990, 284(1): 245-53.
[260] Sun S G, Lin Y. Kinetic Aspects of Oxidation of Isopropanol on Pt Electrodes Investigated by in-Situ Time-Resolved Ftir Spectroscopy [J]. Journal of Electroanalytical Chemistry, 1994, 375(1-2): 401-4.
[261] Bjorling A, Herrero E, Feliu J M. Electrochemical Oxidation of Pt(111) Vicinal Surfaces: Effects of Surface Structure and Specific Anion Adsorption [J]. Journal of Physical Chemistry C, 2011, 115(31): 15509-15.
[262] Farias M J S, Buso-Rogero C, Gisbert R, et al. Influence of the CO Adsorption Environment on Its Reactivity with (111) Terrace Sites in Stepped Pt Electrodes under Alkaline Media [J]. Journal of Physical Chemistry C, 2014, 118(4): 1925-34.
[263] Ibe J P, Bey P P, Brandow S L, et al. On the Electrochemical Etching of Tips for Scanning Tunneling Microscopy [J]. Journal of Vacuum Science & Technology A, 1990, 8(4): 3570-5.
[264] Hofmann T, Welker J, Giessibl F J. Preparation of light-atom tips for scanning probe microscopy by explosive delamination [J]. Journal of Vacuum Science & Technology B, 2010, 28(3):
[265] Bardeen J. Tunnelling from a Many-Particle Point of View [J]. Physical Review Letters, 1961, 6(2): 57.
[266] Binnig G, Quate C F, Gerber C. Atomic Force Microscope [J]. Physical Review Letters, 1986, 56(9): 930-3.
[267] Binnig G, Rohrer H, Gerber C, et al. 7x7 Reconstruction on Si(111) Resolved in Real Space [J]. Physical Review Letters, 1983, 50(2): 120-3.
[268] Tersoff J, Hamann D R. Theory and Application for the Scanning Tunneling Microscope [J]. Physical Review Letters, 1983, 50(25): 1998-2001.
[269] Kuk Y, Silverman P J. Scanning Tunneling Microscope Instrumentation [J]. Review of Scientific Instruments, 1989, 60(2): 165-80.
[270] Williams E D, Bartelt N C. Thermodynamics of Surface-Morphology [J]. Science, 1991, 251(4992): 393-400.

[271] Julia Uppenbrink D C. Single molecules [J]. Science (Washington, DC, U S), 1999, 283(5408): 1667.
[272] Taylor R J. A study on the surface adsorbates of an enantioselective, hererogeneously catalysed, hydrogenation reaction [D]; Cardiff University, 2010.
[273] Valle N G-A G d. From thermodynamics towards the microscopic description of the platinum|solution interphase [D]; University de Alicante, 2007.
[274] Abon M, Bertolini J C, Montes H. Aes and Sims Surface Characterization of Pt-Ni Single-Crystal Alloys [J]. Applied Surface Science, 1988, 32(4): 343-51.
[275] Vogel R, Kamphausen I, Baltruschat H. A Stm Investigation of Pt-Single Crystal-Surfaces in Air and Electrolyte-Solutions [J]. Berichte der Bunsengesellschaft f ü r physikalische Chemie, 1992, 96(4): 525-30.
[276] Will F G. Citation Classic - Investigation of Hydrogen and Oxygen-Adsorption Layers on Platinum-Electrodes with a New Non-Steady State Method [J]. Cc/Phys Chem Earth, 1984, 25): 16-.
[277] Gomez-Marin A M, Schouten K J P, Koper M T M, et al. Interaction of hydrogen peroxide with a Pt(111) electrode [J]. Electrochemistry Communications, 2012, 22(153-6.
[278] Souza-Garcia J, Angelucci C A, Climent V, et al. Electrochemical features of Pt(S)[n(110) x (100)] surfaces in acidic media [J]. Electrochemistry Communications, 2013, 34(291-4.
[279] Aran-Ais R M, Figueiredo M C, Vidal-Iglesias F J, et al. On the behavior of the Pt(100) and vicinal surfaces in alkaline media [J]. Electrochimica Acta, 2011, 58: 184-192.
[280] Attard G A, Price R, Alakl A. Palladium Adsorption on Pt(111) - a Combined Electrochemical and Ultra-High-Vacuum Study [J]. Electrochimica Acta, 1994, 39(11-12): 1525-30.
[281] Gomez-Marin A M, Feliu J M. Oxide growth dynamics at Pt(111) in absence of specific adsorption: A mechanistic study [J]. Electrochimica Acta, 2013, 104: 367-377.
[282] Schmidt T J, Stamenkovic V, Arenz M, et al. Oxygen electrocatalysis in alkaline electrolyte: Pt(hkl), Au(hkl) and the effect of Pd-modification [J]. Electrochimica Acta, 2002, 47(22-23): 3765-76.
[283] Figueiredo M C, Aran-Ais R M, Feliu J M, et al. Pt catalysts modified with Bi: Enhancement of the catalytic activity for alcohol oxidation in alkaline media [J]. Journal of Catalysis, 2014, 312: 78-86.
[284] Conway B E, Barnett B, Angersteinkozlowska H, et al. A Surface-Electrochemical Basis for the Direct Logarithmic Growth Law for Initial-Stages of Extension of Anodic Oxide-Films Formed at Noble-Metals [J]. Journal of Chemical Physics, 1990, 93(11): 8361-73.
[285]Armand D, Clavilier J. Electrochemical-Behavior of the (110) Orientation of a Platinum Surface in Acid-Medium - the Role of Anions [J]. Journal of Electroanalytical Chemistry, 1989, 263(1): 109-26.
[286]Attard G A, Bannister A. The Electrochemical-Behavior of Irreversibly Adsorbed Palladium on Pt(111) in Acid-Media [J]. Journal of Electroanalytical Chemistry, 1991, 300(1-2): 467-85.
[287] Clavilier J, Feliu J M, Fernandezvega A, et al. Electrochemical-Behavior of the Pt (111)-as System in Acidic Medium - Adsorbed Hydrogen and Hydrogen Reaction [J]. Journal of Electroanalytical Chemistry, 1990, 294(1-2): 193-208.
[288] Feliu J M, Valls M J, Aldaz A, et al. Alkali-Metal Cations and Ph Effects on a Splitting of the Unusual Adsorption States of Pt(111) Voltammograms in Phosphate Buffered Solutions [J]. Journal of Electroanalytical Chemistry, 1993, 345(1-2): 475-81.
[289] Hayden B E, Murray A J, Parsons R, et al. UHV and electrochemical transfer studies on Pt(110)-(1X2): The influence of bismuth on hydrogen and oxygen adsorption, and the electro-oxidation of carbon monoxide [J]. Journal of Electroanalytical Chemistry, 1996, 409(1-2): 51-63.
[290] Lebedeva N P, Koper M T M, Herrero E, et al. CO oxidation on stepped Pt[n(111) x (111)] electrodes [J]. Journal of Electroanalytical Chemistry, 2000, 487(1): 37-44.
[291] Motoo S, Furuya N. Electrochemistry of Platinum Single-Crystal Surfaces .1. Structural-Change of the Pt (111) Surface Followed by an Electrochemical Method [J]. Journal of Electroanalytical Chemistry, 1984, 172(1-2): 339-58.
[292] Stern D A, Baltruschat H, Martinez M, et al. Characterization of Single-Crystal Electrode Surfaces as a Function of Potential and Ph by Auger-Spectroscopy and Leed - Pt(111) in Aqueous Cacl2 and Hcl Solutions

[J]. Journal of Electroanalytical Chemistry, 1987, 217(1): 101-10.
[293] Vidal-Iglesias F J, Al-Akl A, Watson D, et al. Electrochemical characterization of PtPd alloy single crystal surfaces prepared using Pt basal planes as templates [J]. Journal of Electroanalytical Chemistry, 2007, 611(1-2): 117-25.
[294] Wasberg M, Palaikis L, Wallen S, et al. Leed Auger Verification of the Insitu Method of Preparation of Pt (111) Single-Crystal Electrodes [J]. Journal of Electroanalytical Chemistry, 1988, 256(1): 51-63.
[295] Arthur T. Hubbard R M I, James Katekaru. Study of platinum electrodes by means of electrochemistry and low-energy electron diffraction: Part II. Comparison of the electrochemical activity of Pt(100) and Pt(111) surfaces [J]. Journal of Electroanalytical Chemistry and Interfacial Electrochemistry, 1978, 86(2): 218-88.
[296] AlAkl A, Attard G A. Anion effects in the UPD of copper on Pd/Pt(111) bimetallic electrodes [J]. Journal of Physical Chemistry B, 1997, 101(23): 4597-606.
[297] Markovic N M, Lucas C A, Grgur B N, et al. Surface electrochemistry of CO and H-2/CO mixtures at Pt(100) interface: Electrode kinetics and interfacial structures [J]. Journal of Physical Chemistry B, 1999, 103(44): 9616-23.
[298] Ahmed M, Morgan D, Attard G A, et al. Unprecedented Structural Sensitivity toward Average Terrace Width: Nafion Adsorption at Pt{hkl} Electrodes [J]. Journal of Physical Chemistry C, 2011, 115(34): 17020-7.
[299] Rodriguez-Lopez M, Solla-Gullon J, Herrero E, et al. Electrochemical Reactivity of Aromatic Molecules at Nanometer-Sized Surface Domains: From Pt(hkl) Single Crystal Electrodes to Preferentially Oriented Platinum Nanoparticles [J]. Journal of the American Chemical Society, 2010, 132(7): 2233-42.
[300] Vasic D, Pasti I, Gavrilov N, et al. DFT study of interaction of O, O-2, and OH with unreconstructed Pt(hkl) (h, k, l=0, 1) surfaces-similarities, differences, and universalities [J]. Russian Journal of Physical Chemistry A, 2013, 87(13): 2214-8.
[301] van der Vliet D F, Koper M T M. Electrochemistry of Pt (100) in alkaline media: A voltammetric study [J]. Surface Science, 2010, 604(21-22): 1912-8.
[302] Hazzazi O A, Harris C A, Wells P B, et al. Electrooxidation of D- and L-Glucose at Well-Defined Chiral Bimetallic Electrodes [J]. Topics in Catalysis, 2011, 54(19-20): 1392-402.
[303] F. G. Will C A K. Untersuchung von Adsorptionserscheinungen an Rhodium, Iridium, Palladium und Gold mit der potentiostatischen Dreieckmethode [J]. Zeitschrift f ü r Elektrochemi, 1960, 64(2): 270-5.
[304]陈德皓. Citrate、CTAB和PVP在Pt单晶表面吸附过程的电化学和原位红外光谱研究 [D]; 厦门大学, 2013.
[305] van der Niet M J T C, den Dunnen A, Juurlink L B F, et al. Co-adsorption of O and H2O on Nanostructured Platinum Surfaces: Does OH Form at Steps? [J]. Angewandte Chemie International Edition, 2010, 49(37): 6572-5, S/1-S/3.
[306] Pierozynski B. Electrochemical Behaviour of Urea at Pt(111) Single-Crystal Surface in 0.1 M NaOH [J]. Electrocatalysis, 2013, 4(1): 37-41.
[307] Climent V, Garcia-Araez N, Feliu J M. Influence of alkali cations on the infrared spectra of adsorbed (bi)sulphate on Pt(111) electrodes [J]. Electrochemistry Communication, 2006, 8(10): 1577-82.
[308] Garcia-Araez N, Climent V, Feliu J M. Potential-dependent water orientation on Pt(111) stepped surfaces from laser-pulsed experiments [J]. Electrochimica Acta, 2009, 54(3): 966-77.
[309] Hoshi N, Suzuki T, Hori Y. Step density dependence of CO2 reduction rate on Pt(S)-[n(111) × (111)] single crystal electrodes [J]. Electrochimica Acta, 1996, 41(10): 1647-53.
[310] Pierozynski B. On the Ethanol Electrooxidation Reaction on Catalytic Surfaces of Pt in 0.1 M NaOH [J]. Int J Electrochem Sc, 2012, 7(5): 4261-71.
[311] Berna A, Rodes A, Feliu J M. Oxalic acid adsorption and oxidation at platinum single crystal electrodes [J]. Journal of Electroanalytical Chemistry, 2004, 563(1): 49-62.
[312] Funtikov A M, Stimming U, Vogel R. Anion adsorption from sulfuric acid solutions on Pt(111) single crystal electrodes [J]. Journal of Electroanalytical Chemistry, 1997, 428(1-2): 147-53.
[313] Clavilier J. The role of anion on the electrochemical behavior of a {111} platinum surface; an unusual

splitting of the voltammogram in the hydrogen region [J]. Journal of Electroanalytical Chemistry and Interfacial Electrochemistry, 1980, 107(1): 211-16.
[314] Rodes A, El Achi K, Zamakhchari M A, et al. Hydrogen probing of step and terrace sites on platinum(S)-[n(111)x(100)] [J]. Journal of Electroanalytical Chemistry and Interfacial Electrochemistry, 1990, 284(1): 245-53.
[315] Gomez R, Orts J M, Alvarez-Ruiz B, et al. Effect of Temperature on Hydrogen Adsorption on Pt(111), Pt(110), and Pt(100) Electrodes in 0.1 M HClO4 [J]. Journal of Physical Chemistry B, 2004, 108(1): 228-38.
[316] Kolics A, Wieckowski A. Adsorption of Bisulfate and Sulfate Anions on a Pt(111) Electrode [J]. Journal of Physical Chemistry B, 2001, 105(13): 2588-95.
[317] Mostany J, Herrero E, Feliu J M, et al. Thermodynamic Studies of Anion Adsorption at Stepped Platinum(hkl) Electrode Surfaces in Sulfuric Acid Solutions [J]. Journal of Physical Chemistry B, 2002, 106(49): 12787-96.
[318] Ahmed M, Morgan D, Attard G A, et al. Unprecedented Structural Sensitivity toward Average Terrace Width: Nafion Adsorption at Pt{hkl} Electrodes [J]. Journal of Physical Chemistry C, 2011, 115(34): 17020-7.
[319] Vidal-Iglesias F J, Solla-Gullon J, Orts J M, et al. SERS on (111) Surface Nanofacets at Pt Nanoparticles: The Case of Acetaldehyde Oxime Reduction [J]. Journal of Physical Chemistry C, 2012, 116(19): 10781-9.
[320] Morallon E, Vazquez J L, Aldaz A, et al. Behavior of Pt(111) in the Presence of the Sulfate Anions in Naoh Solution [J]. Journal of Electroanalytical Chemistry, 1993, 360(1-2): 89-100.
[321] Pierozynski B, Kowalski I M. Electrochemical reactivity of formamidoxime on Pt(111) and (100) single-crystal surfaces in 0.1 M NaOH solution [J]. Journal of Electroanalytical Chemistry, 2011, 662(2): 432-6.
[322] Jin W, Du H, Zheng S L, et al. Comparison of the Oxygen Reduction Reaction between NaOH and KOH Solutions on a Pt Electrode: The Electrolyte-Dependent Effect [J]. Journal of Physical Chemistry B, 2010, 114(19): 6542-8.
[323] Gasteiger H A, Markovic N M, Ross P N, Jr. Bromide Adsorption on Pt(111): Adsorption Isotherm and Electrosorption Valency Deduced from RRDPt(111)E Measurements [J]. Langmuir, 1996, 12(6): 1414-18.
[324] Salaita G N, Stern D A, Lu F, et al. Structure and composition of a platinum(111) surface as a function of pH and electrode potential in aqueous bromide solutions [J]. Langmuir, 1986, 2(6): 828-35.
[325] Al-Akl A, Attard G, Price R, et al. Electrochemical and UHV characterisation of stepped Pt{100} electrode surfaces [J]. Physical Chemistry Chemical Physics, 2001, 3(16): 3261-8.
[326] Tao C G, Cullen W G, Williams E D, et al. Surface morphology and step fluctuations on Ag nanowires [J]. Surface Science, 2007, 601(21): 4939-43.
[327] 孙世刚. 原子和分子水平层次的表面电化学和电催化研究 [J]. 电化学, 1998, 4(1): 88-93.
[328] 孙世刚. 原子和分子水平表面电化学和电催化研究进展 [J]. 电化学, 1998, 4(1): 1-4.
[329] Monzo J, Koper M T, Rodriguez P. Removing polyvinylpyrrolidone from catalytic Pt nanoparticles without modification of superficial order [J]. Chemphyschem, 2012, 13(3): 709-15.
[330] Gomez-Marin A M, Feliu J M. Pt(111) surface disorder kinetics in perchloric acid solutions and the influence of specific anion adsorption [J]. Electrochimica Acta, 2012, 82(558-69.
[331] Iwasita T. Electrocatalysis of methanol oxidation [J]. Electrochimica Acta, 2002, 47(22-23): 3663-74.
[332] Xia X H, Iwasita T, Ge F, et al. Structural effects and reactivity in methanol oxidation on polycrystalline and single crystal platinum [J]. Electrochimica Acta, 1996, 41(5): 711-8.
[333] Rodes A, Clavilier J, Orts J M, et al. Electrochemical-Behavior of Pt(100) in Various Acidic Media .2. On the Relation between the Voltammetric Profiles Induced by Anion Specific Adsorption Studied with a Transfer Technique Preserving Surface Cleanliness and Structure [J]. Journal of Electroanalytical Chemistry, 1992, 338(1-2): 317-38.
[334] Tian L, Li J T, Ye J Y, et al. In situ FTIR studies of coadsorption of CN- and CO on Pt(110) electrode surface [J]. Journal of Electroanalytical Chemistry, 2011, 662(1): 137-42.
[335] Garcia-Araez N, Climent V, Rodriguez P, et al. Thermodynamic evidence for K+-SO42- ion pair formation on Pt(111). New insight into cation specific adsorption [J]. Physical Chemistry Chemical Physics,

2010, 12(38): 12146-52.
[336] Markovic N M, Lucas C A, Rodes A, et al. Surface electrochemistry of CO on Pt(111): anion effects [J]. Surface Science, 2002, 499(2-3): L149-L58.
[337] Lai S C S, Lebedeva N P, Housmans T H M, et al. Mechanisms of carbon monoxide and methanol oxidation at single-crystal electrodes [J]. Topical in Catalytic, 2007, 46(3-4): 320-33.
[338]Vidaliglesias F, Alakl A, Watson D, et al. A new method for the preparation of PtPd alloy single crystal surfaces [J]. Electrochemistry Communications, 2006, 8(7): 1147-50.
[339] Souza-Garcia J, Ticianelli E A, Climent V, et al. Nitrate reduction on Pt single crystals with Pd multilayer [J]. Electrochimica Acta, 2009, 54(7): 2094-101.
[340] Vidal-Iglesias F J, Solla-Gullon J, Herrero E, et al. Formic acid oxidation on Pd-modified Pt(100) and Pt(111) electrodes: A DEMS study [J]. J Appl Electrochem, 2006, 36(11): 1207-14.
[341] Wang Y, Peng H C, Liu J Y, et al. Use of Reduction Rate as a Quantitative Knob for Controlling the Twin Structure and Shape of Palladium Nanocrystals [J]. Nano letters, 2015, 15(2): 1445-50.
[342] Strbac S, Johnston C M, Lu G Q, et al. In situ STM study of nanosized Ru and Os islands spontaneously deposited on Pt(111) and Au(111) electrodes [J]. Surface Science, 2004, 573(1): 80-99.
[343] Feliu J M, Alvarez B, Climent V, et al. Electrochemical properties of Pd/Pt(111) adlayers [J]. Thin Films: Preparation, Characterization, Applications, 2002, 37-52.
[344] Attard G A, Jenkins D J, Hazzazi O A, et al. Enantioselectivity and catalyst morphology [J]. Catalysis in Application, 2003, 70-7.
[345] Attard G A, Ahmadi A, Jenkins D J, et al. The characterisation of supported platinum nanoparticles on carbon used for enantioselective hydrogenation: A combined electrochemical - STM approach [J]. Chemphyschem, 2003, 4(2): 123-30.
[346] Kokoh K B, Hahn F, Metayer A, et al. FTIR spectroelectrochemical investigation of the electrocatalytic oxidation of ascorbic acid at platinum electrodes in acid medium [J]. Electrochimica Acta, 2002, 47(24): 3965-9.
[347] Attard G A, Ye J-Y, Jenkins P, et al. Citrate adsorption on Pt{hkl} electrodes and its role in the formation of shaped Pt nanoparticles [J]. Journal of Electroanalytical Chemistry, 2013, 688(249-56.
[348] Xing X K, Bae I T, Shao M J, et al. Electrooxidation of L-Ascorbic-Acid on Platinum in Acid-Solutions - an Insitu Ftirras Study [J]. Journal of Electroanalytical Chemistry, 1993, 346(1-2): 309-21.
[349] Henglein A, Giersig M. Reduction of Pt(II) by H-2: Effects of citrate and NaOH and reaction mechanism [J]. Journal of Physical Chemistry B, 2000, 104(29): 6767-72.
[350] Solla-Gull ó n J, Vidal-Iglesias F, L ó pez-Cudero A, et al. Shape-dependent electrocatalysis: methanol and formic acid electrooxidation on preferentially oriented Pt nanoparticles [J]. Physical chemistry chemical physics, 2008, 10(25): 3689-98.
[351] Vidal-Iglesias F, Ar á n-Ais R, Solla-Gull ó n J, et al. Shape-dependent electrocatalysis: formic acid electrooxidation on cubic Pd nanoparticles [J]. Physical chemistry chemical physics, 2012, 14(29): 10258-65.