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(54) **ELECTROCHEMICALLY ACTIVE COMPOSITION, METHODS OF MAKING, AND USES THEREOF**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,869,312	A	3/1975	Moss	
3,878,083	A	4/1975	De Nora	
3,948,751	A	4/1976	Bianchi	
RE28,820	E	5/1976	Beer	
4,003,817	A	1/1977	Bianchi	
4,112,140	A	9/1978	Heikel	
4,203,810	A	5/1980	Warne	
4,214,971	A	7/1980	Heikel	
4,223,049	A	9/1980	Murray	
4,331,528	A	5/1982	Beer	
4,384,939	A	5/1983	Kim	
4,411,762	A	10/1983	Kline	
4,460,450	A	7/1984	Koziol	
4,481,097	A	11/1984	Asano	
4,502,936	A	3/1985	Hayfield	
4,517,068	A	5/1985	Hinden	
4,528,084	A	7/1985	Beer	
4,585,540	A	4/1986	Beer	
4,642,173	A	2/1987	Koziol	
4,696,731	A	9/1987	Tenhover	
4,708,888	A	11/1987	Mitchell	
4,797,182	A	1/1989	Beer	
4,913,973	A	4/1990	Geusic	
5,004,626	A	4/1991	Dong	
5,031,290	A	7/1991	Brereton	
5,098,546	A	3/1992	Kawashima	
5,156,726	A	10/1992	Nakada	
5,290,415	A	3/1994	Shimamune	
5,294,317	A	3/1994	Saito	
5,354,444	A	10/1994	Shimamune	
5,451,307	A	9/1995	Bennett	
5,503,663	A	4/1996	Tsou	
5,560,815	A	10/1996	Sekimoto	
5,672,394	A	9/1997	Hardee	
6,086,957	A	7/2000	Boyle et al.	
6,103,093	A	8/2000	Nidola	
6,103,299	A	8/2000	Shimamune	
6,165,331	A	12/2000	Hughes	
6,210,550	B1	4/2001	Nidola	
6,217,729	B1	4/2001	Zolotarsky	
6,231,731	B1	5/2001	Kondo	
6,527,939	B1	3/2003	Hardee	
6,936,155	B1	8/2005	Morimitsu	
7,247,229	B2	7/2007	Hardee	
7,258,778	B2	8/2007	Hardee	
2006/0263614	A1	11/2006	Andolfatto et al.	
2009/0288856	A1 *	11/2009	Sandoval et al.	174/126.2

FOREIGN PATENT DOCUMENTS

GB	2342099	4/2000
JP	4099294 A2	3/1992
JP	10287998 A2	10/1998
JP	2002158013	5/2002
JP	2002275697	9/2002
JP	2004238697	8/2004
JP	2007146215	6/2007
JP	2009293117	12/2009
JP	2010001556	1/2010
WO	WO 2005-095671	10/2005

OTHER PUBLICATIONS

"Stability of Iridium Oxide-Tantalum Oxide Coated Titanium Electrodes for Oxygen Evolution in Alkaline Solutions,"; M. Morimitsu, C. Murakami, K. Kawaguchi, R. Otogawa, and M. Matsunaga; <http:www.polymtl.ca/newmaterials/eng/ journal/ejournal/oct2004/art10.pdf>.

Titanium Anodes with Active Coatings Based on Iridium Oxides: The Chemical Composition of the Coatings and the Distribution of Their Components over Depth on Anodes Made of IrO2, IrO2 + TiO2, IrO2 + RuO2 + T1O2, and IrO2 + RuO2 + TiO2 + Ta2O5; vol. 39; Publication date: Oct. 2003; <http://www.springerlink.com/content/h2466442v8770747/>.

Igarash, T., "New iridium complex compound, i.e., facial complex, useful for organic electroluminescent device used for preparing image display device and plane light source", Database WPI Section Ch, Week 200856 Thomson Scientific, London, GB; AN 2008-J70739 (XP002544703).

Mattos-Costa, F.I., et al. "Characterisation of surfaces modified by sol-gel derived Ru(×)IR(1-31 ×)O(2) coatings for oxygen evolution in acid medium", Electrochimica Acta, vol. 44, 1998, pp. 1515-1523. Database WPI Week 200760 Thomson Scientific, London, GB; AN 2007-629251 (XP002542247).

ISR and Written Opinion from corresponding International Application No. PCT/US09/044342 dated Sep. 23, 2009.

* cited by examiner

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(57) **ABSTRACT**

Accordingly, in various embodiments, the present invention provides methods for making electrochemically active materials. Methods include making an electrochemically active material by reacting a platinum group metal salt in a organic solvent to yield a mixture, then heating the mixture to create a metal-organic solvent complex and an acid, followed by removing at least a portion of the acid, and yielding an electrochemically active material comprising the metal-organic solvent complex. In an exemplary embodiment, the resulting electrochemically active material may be used for coating an electrode.

12 Claims, 6 Drawing Sheets