

Supporting Information

Durable Tungsten Carbide Support for Pt-based Fuel Cells Cathodes

Oran Lori, Shmuel Gonon, Omree Kapon, and Lior Elbaz*

Department of Chemistry, Bar-Ilan University, Ramat-Gan 5290002, Israel

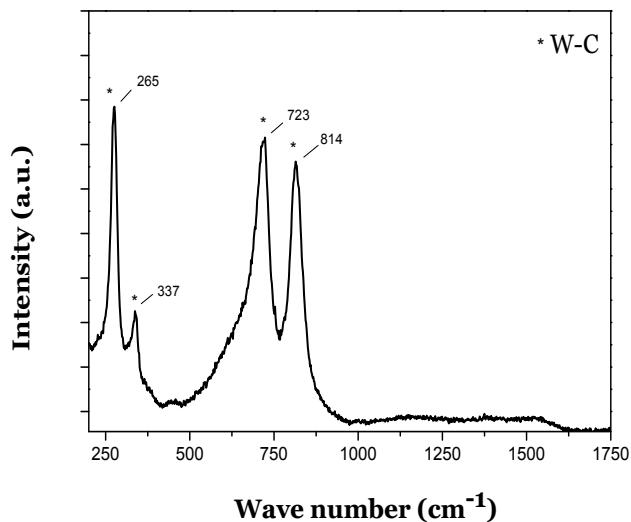


Figure S1. Raman spectrum of tungsten carbide synthesized via mPAD route.

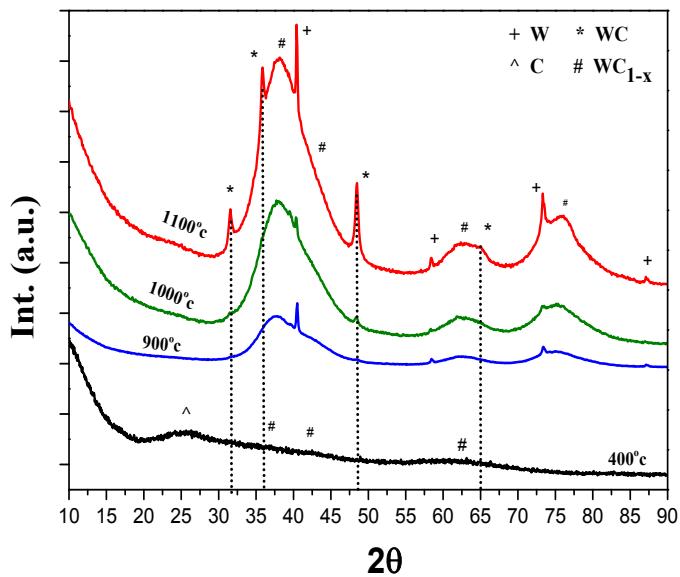
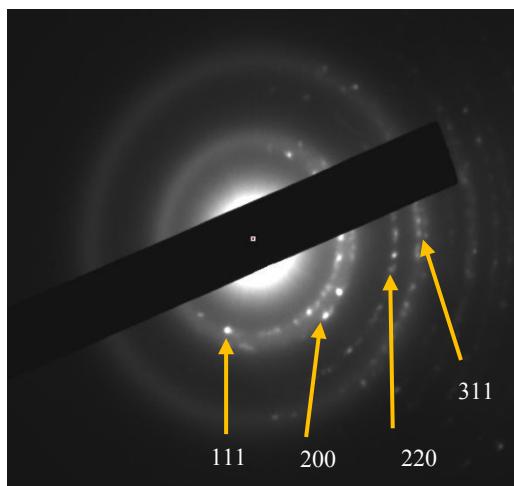


Figure S2. X-ray diffraction of tungsten carbide synthesized via mPAD route at different temperatures. (WC peaks are marked with dash lines)



d-Spacing (nm)	Rec. Pos. (1/nm)	Corresponding crystal plane
0.2319	4.312	111
0.1983	5.043	200
0.1405	7.116	220
0.1200	8.333	311

Figure S3. Selected area diffraction of PtNPs corresponding to figure 3c. The table refers to the crystal lattice parameters extracted from the above SEAD.

Table S1. Tungsten carbide species reported in the literature for ORR

Species	BET (m ² /g)	Particle size (nm) (TEM)	Pt size (nm) (XRD)	Pt size (nm) (TEM)	E _{onset} (V)	ECSA (m ² /g)	Durability test	Durability		Electrolyte	Ref
								ECSA loss	E _{1/2} shift		
WC-G		5	2.9	2.6	1.05	77	6000 cy 0.6-1.2 V	11%	7 mV	HClO ₄	1
W _x C-C		5		6	1.02		300 cy		25 mV	KOH	2
WC-C	384	10		2	0.75		2000 cy 0-1 V		50 mV	H ₂ SO ₄	3
WC-C		<12.2	2.3-3.4	2.3-3.4	1.03	62.4	1000 cy		9 mV	HClO ₄	4
WC, WC _{1-x} (Pd)	44.6- 58.1	7			1		2000 cy 0.6-1.1 V		30mV	NaOH	5
WC/G		10		3	1.035	97.2	2000 cy 0.6-1.2 V	15%	8 mV	HClO ₄	6
WC-WC _{1-x}	31.6	2-25	4.5	3-6	1.04	19.2	5000 cy 0.6-1.3 V	45%	15 mV	H ₂ SO ₄	This work

- 1 . He, C.; Shen, P. K., Pt loaded on truncated hexagonal pyramid WC/graphene for oxygen reduction reaction. *Nano Energy* **2014**, *8*, 52-61.
- 2 . Kok Poh, C.; Hua Lim, S.; Tian, Z.; Lai, L.; Ping Feng, Y.; Shen, Z.; Lin, J., Pt-WxC nano-composites as an efficient electrochemical catalyst for oxygen reduction reaction. *Nano Energy* **2013**, *2* (1), 28-39.
- 3 . Zhu, Q.; Zhou, S.; Wang, X.; Dai, S., Controlled synthesis of mesoporous carbon modified by tungsten carbides as an improved electrocatalyst support for the oxygen reduction reaction. *J. Power Sources* **2009**, *193* (2), 495-500.
- 4 . Xie, M.; Zhang, M.; Wei, W.; Jiang, Z.; Xu, Y., Angstrom-sized tungsten carbide promoted platinum electrocatalyst for effective oxygen reduction reaction and resource saving. *RSC Advances* **2.96488-96494** ,(117) 5 ,015
- 5 . Ko, A. R.; Lee, Y.-W.; Moon, J.-S.; Han, S.-B.; Cao, G.; Park, K.-W., Ordered mesoporous tungsten carbide nanoplates as non-Pt catalysts for oxygen reduction reaction. *Applied Catalysis A: General* **2014**, *477*, 102-108.
- 6 . Li, Z ;Liu, Z.; Li, B.; Liu, Z.; Li, D.; Wang, H.; Li, Q., Hollow hemisphere-shaped macroporous graphene/tungsten carbide/platinum nanocomposite as an efficient electrocatalyst for the oxygen reduction reaction. *Electrochim. Acta* **2016**, *221*, 31-40.