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Electronic Supplementary Information

A new reduction method based on simultaneous Ti_3AlC_2 support etching and metal deposition to prepare Pt catalysts for aqueous-phase selective hydrogenation of furfural to furfuryl alcohol

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Section 1

High resolution XPS spectra of C1s and O1s and detailed information on binding energies and deconvoluted peaks.

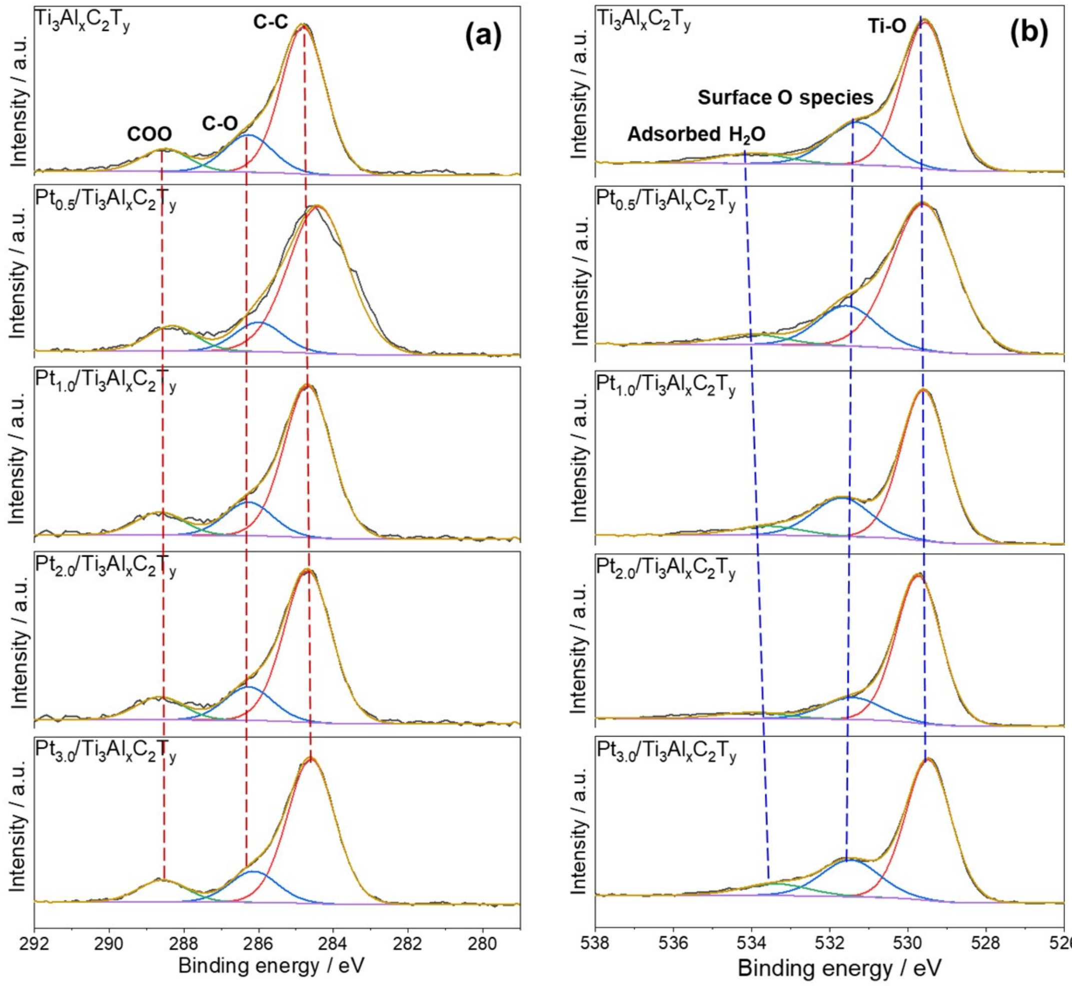

Figure s1. High resolution XPS spectra and deconvoluted peaks of C1s **(a)** and O1s **(b)** of samples $Ti_3Al_xC_2T_y$, $Pt_{0.5}/Ti_3Al_xC_2T_y$, $Pt_{1.0}/Ti_3Al_xC_2T_y$, $Pt_{2.0}/Ti_3Al_xC_2T_y$, and $Pt_{3.0}/Ti_3Al_xC_2T_y$.

Table s1. Detailed binding energies and fractions of sub-species deconvoluted from high-resolution XPS spectra of C1s and O1s.

Catalysts		C1s			O1s		
		C-C	C-O	COO	Ti-O	Surface O-species e.g. -OH	Adsorbed O-species e.g. H_2O
$Ti_3Al_xC_2T_y$	**BE / eV**	**284.8**	**286.3**	**288.5**	**529.6**	**531.3**	**533.9**
	Fractions / %	69.6	18.9	11.5	68.5	24.7	6.8
$Pt_{0.5}/Ti_3Al_xC_2T_y$	**BE / eV**	**284.4**	**286**	**288.3**	**529.6**	**531.6**	**534**
	Fractions / %	77.2	12.3	10.5	75.5	19	5.5
$Pt_{1.0}/Ti_3Al_xC_2T_y$	**BE / eV**	**284.6**	**286**	**288.6**	**529.6**	**531.7**	**533.7**
	Fractions / %	70.8	18.2	11	71	22.9	6.1
$Pt_{2.0}/Ti_3Al_xC_2T_y$	**BE / eV**	**284.7**	**286.3**	**288.6**	**529.7**	**531.4**	**534**
	Fractions / %	72.8	16.1	11.1	79.7	15.4	4.9
$Pt_{3.0}/Ti_3Al_xC_2T_y$	**BE / eV**	**284.6**	**286.1**	**288.6**	**529.5**	**531.5**	**533.4**
	Fractions / %	73.2	15.7	11.1	68.7	22.9	8.4

Table s2. Ratio of metallic Pt and oxidized Pt quantified by XPS analysis

Catalyst	**Bulk Pt loading / wt% (by ICP)**	**Metallic Pt / % (by XPS)**	**Pt-oxidized / % (by XPS)**
$Pt_{0.5}/Ti_3Al_xC_2T_y$	0.38	89.5	10.5
$Pt_{1.0}/Ti_3Al_xC_2T_y$	0.76	89.4	10.6
$Pt_{2.0}/Ti_3Al_xC_2T_y$	1.45	96.7	3.3
$Pt_{3.0}/Ti_3Al_xC_2T_y$	2.62	95.4	4.6

Section 2

Table s3: Detailed information on catalysts and calculation reaction rates.

Samples	Real loading of Pt / wt%	Catalyst mass / mg	Pt mass / mg_{Pt}	Reaction rate / $mmol_{FUR}\cdot h^{-1}$	Reaction rate / $mmol_{FUR}\cdot g_{Pt}^{-1}\cdot h^{-1}$
$Pt_{0.5}$/ $Ti_3Al_xC_2T_y$	0.38	100	0.38	0.223	586.0
$Pt_{1.0}$/ $Ti_3Al_xC_2T_y$	0.76	100	0.76	0.514	676.3
$Pt_{2.0}$/ $Ti_3Al_xC_2T_y$	1.45	100	1.45	0.667	459.8
$Pt_{3.0}$/ $Ti_3Al_xC_2T_y$	2.62	100	2.62	0.667	254.5
3.0%Pt/ $Ti_3Al_xC_2T_y$	0.63	100	0.63	0.183	291.0
3.0%Pt/TiO_2	1.84	100	1.84	0.165	89.9
3.0%Pt/AC	0.78	100	0.78	0.3	384.6

Section 3

The N_2 adsorption-desorption isotherms and pore size distributions of selected samples of Ti_3AlC_2 (0.6 m^2/g), $Ti_3Al_xC_2T_y$ (2.9 m^2/g) and $Pt_{2.0}/Ti_3Al_xC_2T_y$ (12.7 m^2/g).

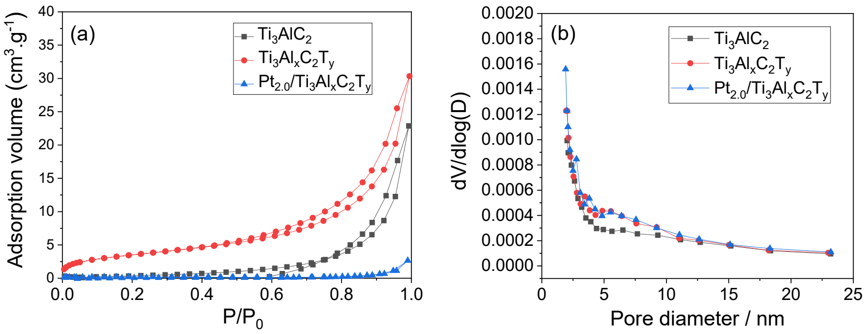

Figure s2. **(a)** The N_2 adsorption-desorption curves and **(b)** the pore size distributions of three selected samples: Ti_3AlC_2, $Ti_3Al_xC_2T_y$ and $Pt_{2.0}/Ti_3Al_xC_2T_y$.

Section 4

The SEM images of catalysts showed that most products were fibrous nanomaterials as expected, which were conducive to recycle from aqueous reaction systems.

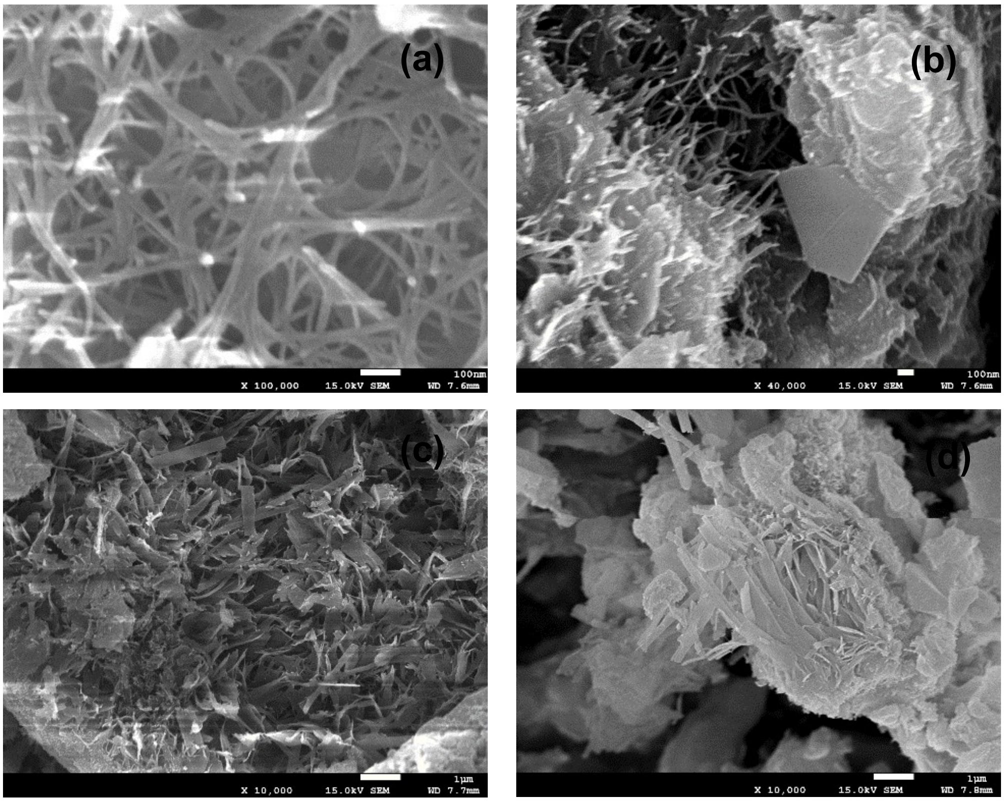

Figure s3. SEM images of **(a)** $Pt_{0.5}/Ti_3Al_xC_2T_y$, **(b)**$Pt_{1.0}/Ti_3Al_xC_2T_y$, **(c)**$Pt_{2.0}/Ti_3Al_xC_2T_y$, **(d)** $Pt_{3.0}/Ti_3Al_xC_2T_y$

Section 5

The Pt particle sizes of benchmark catalysts of Pt/TiO_2 and Pt/AC were analyzed on the basis of TEM images using the same method. The histograms of them were shown in **Figure s4** as insets, which demonstrated that the size of Pt NPs was 3-10 nm on TiO_2 and was 2-9 on AC.

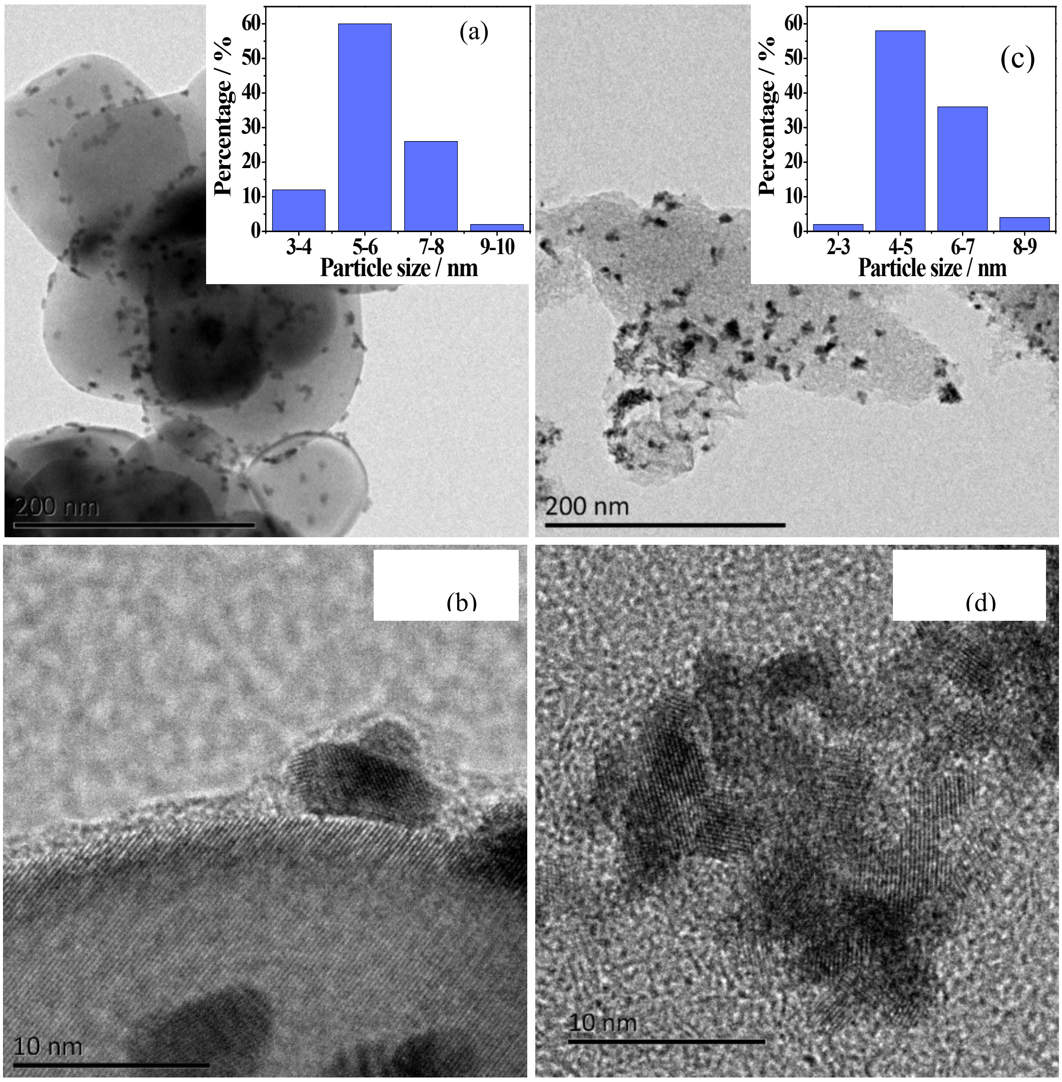

Figure s4. The TEM image **(a)** and the HR TEM image **(b)** of 3%Pt/TiO_2 (mean size: 6.3 nm); the TEM image **(c)** and the HR TEM image **(d)** of 3%Pt/AC (mean size 5.8 nm).

Section 6

TEM images of four catalysts: $Pt_{0.5}/Ti_3Al_xC_2T_y$, $Pt_{1.0}/Ti_3Al_xC_2T_y$, $Pt_{2.0}/Ti_3Al_xC_2T_y$, and $Pt_{3.0}/Ti_3Al_xC_2T_y$, with different magnifications were provided to give more information on the morphologies and particle sizes of Pt NPs.

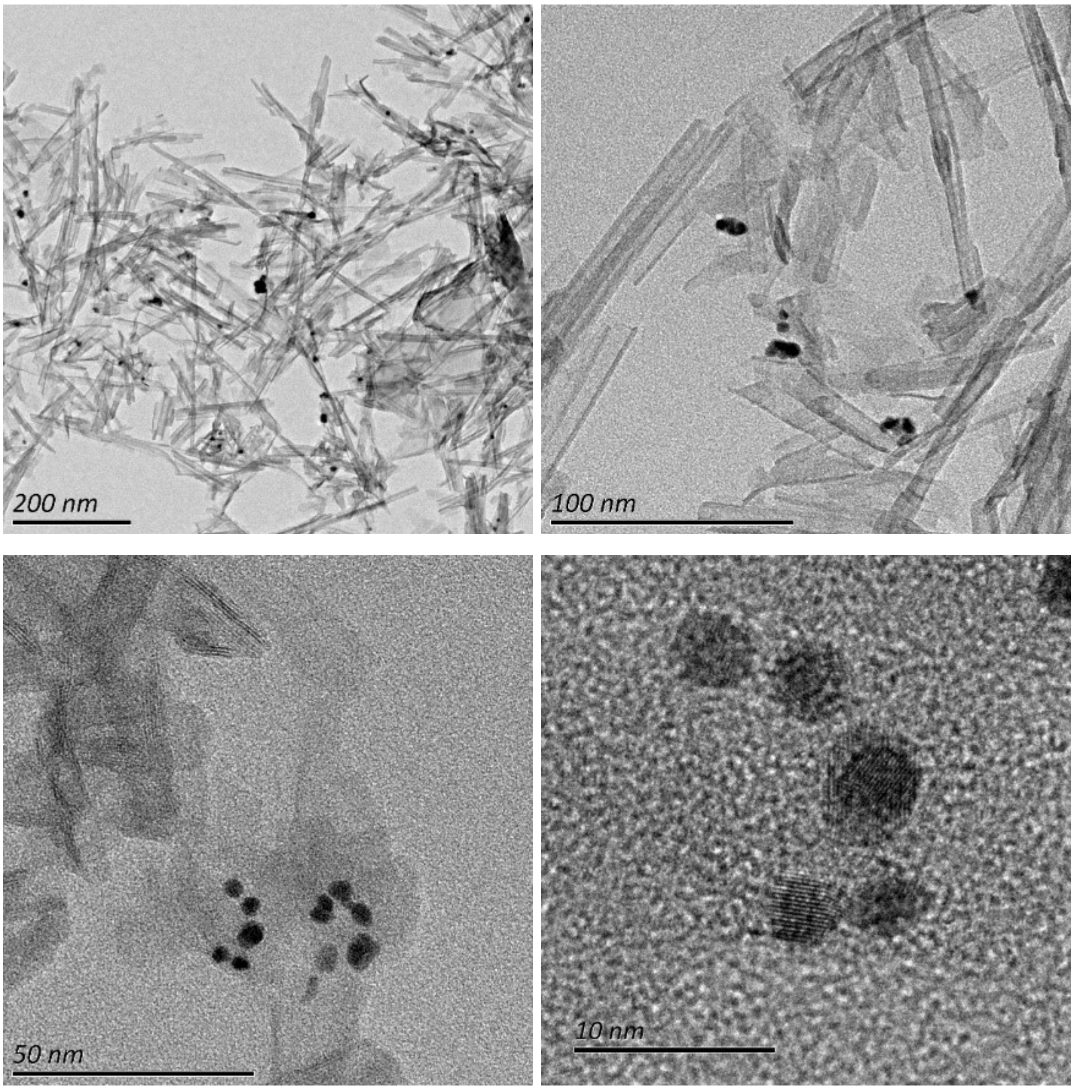

Figure s5. TEM images of $Pt_{0.5}/Ti_3Al_xC_2T_y$ catalysts

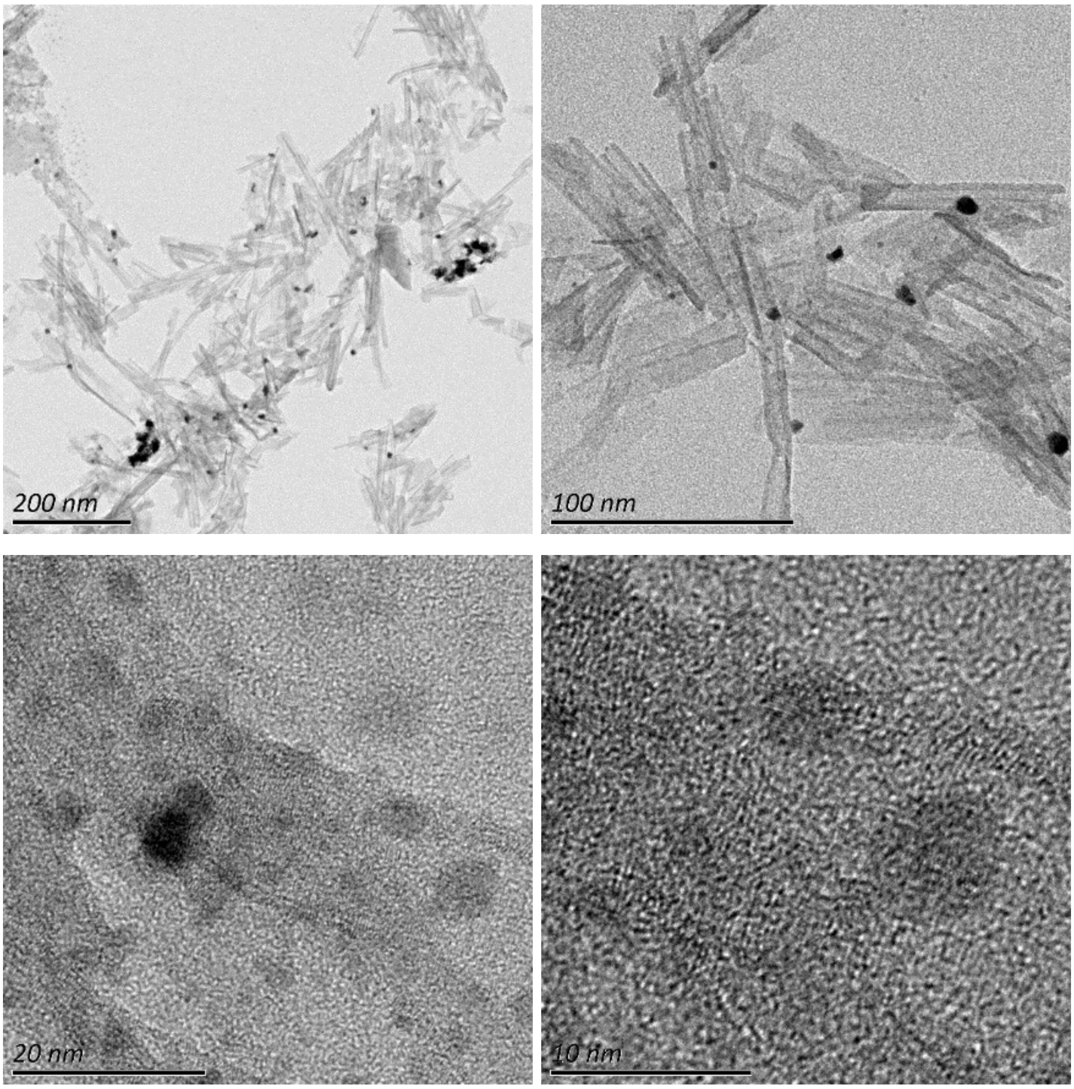

Figure s6. TEM images of $Pt_{1.0}/Ti_3Al_xC_2T_y$ catalysts

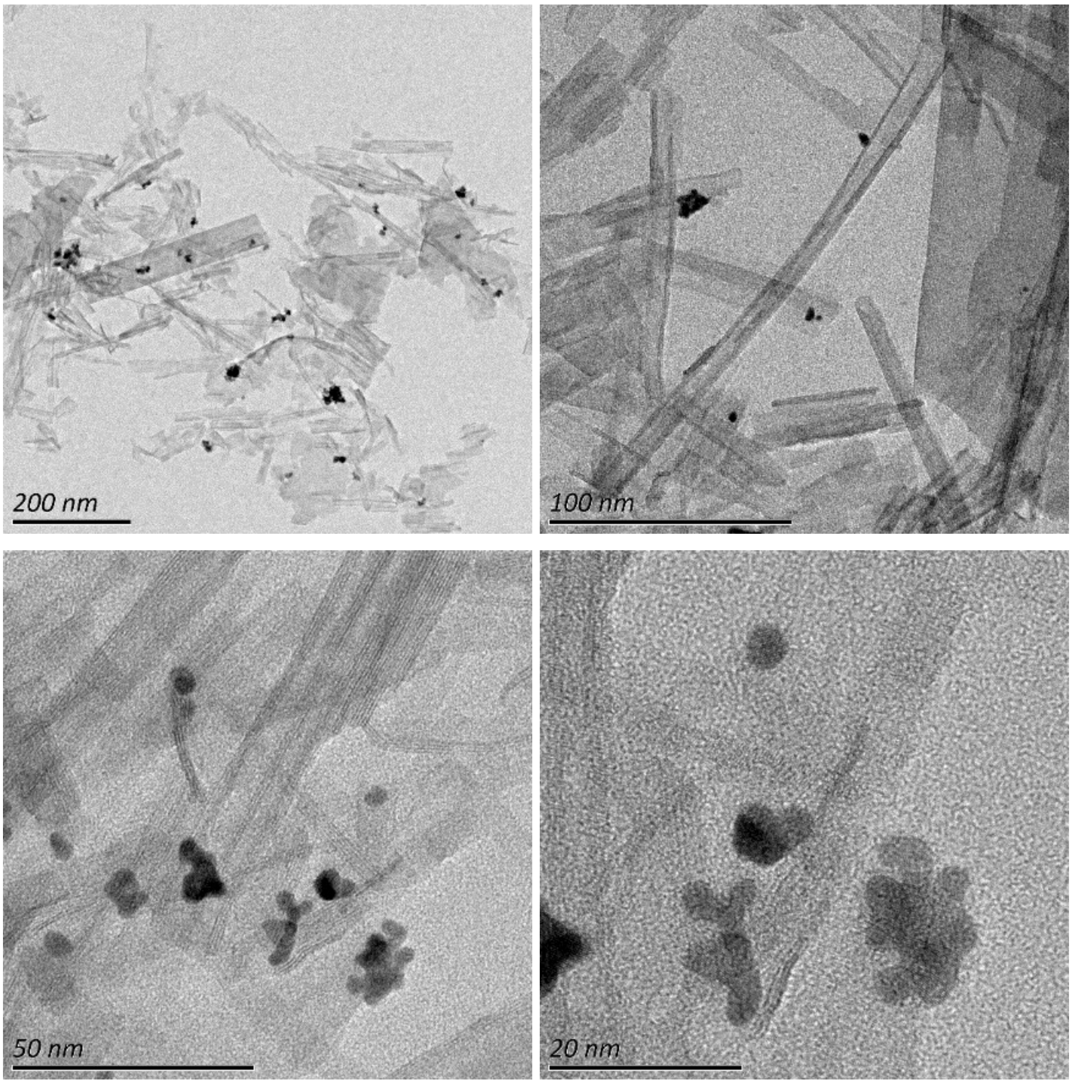

Figure s7. TEM images of $Pt_{2.0}/Ti_3Al_xC_2T_y$ catalysts

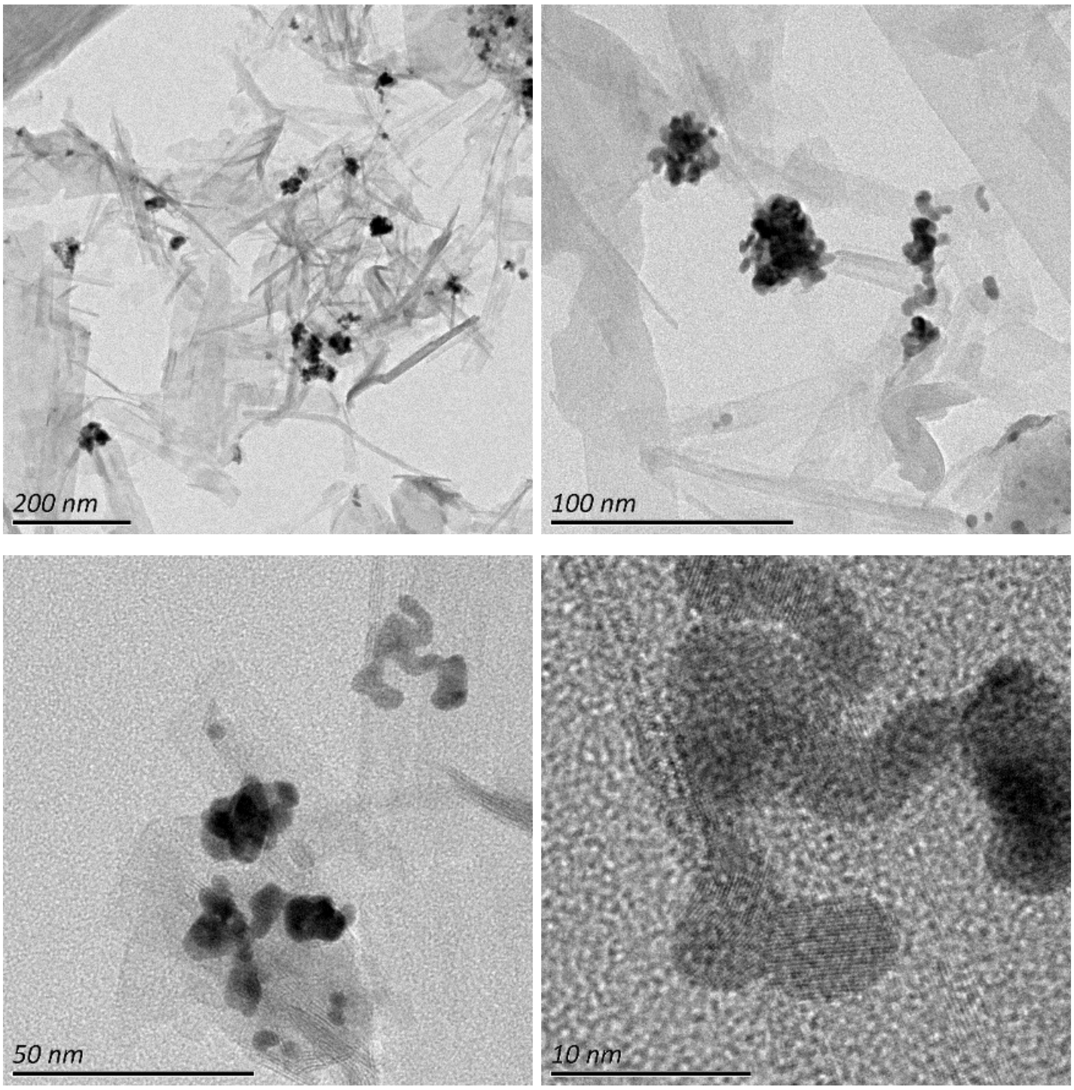

Figure s8. TEM images of $Pt_{3.0}/Ti_3Al_xC_2T_y$ catalysts

Section 7

The TEM images of **spent $Pt_{2.0}/Ti_3Al_xC_2T_y$** showed that the Pt nanostructures were mostly nanoparticles preapred by the new reduction method.

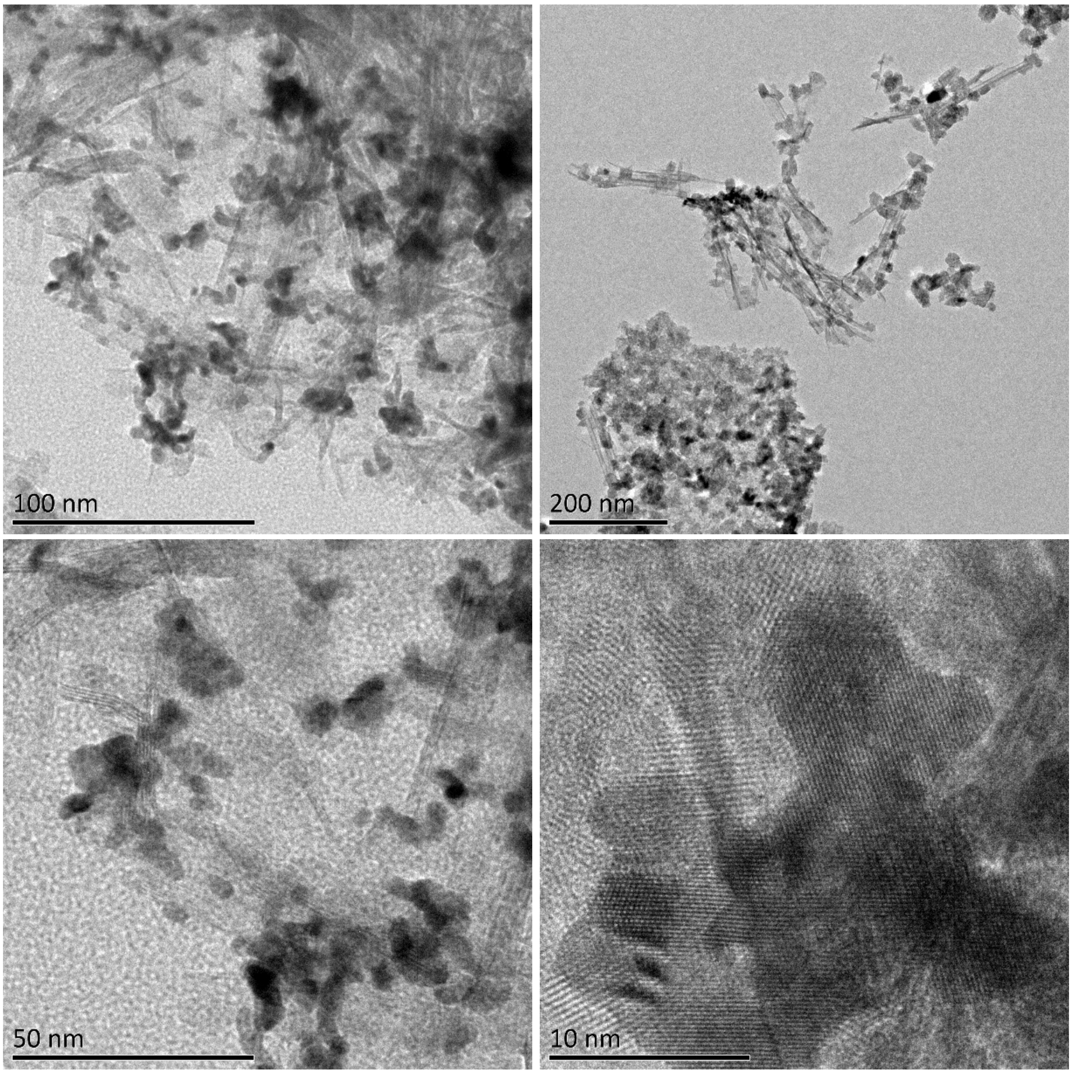

Figure s9. TEM images of spent $Pt_{2.0}/Ti_3Al_xC_2T_y$

The TEM images of **spent 3%Pt/$Ti_3Al_xC_2T_y$** showed that the Pt nanostructures were mostly nanoclusters preapred by the chemical reduction (CR) method.

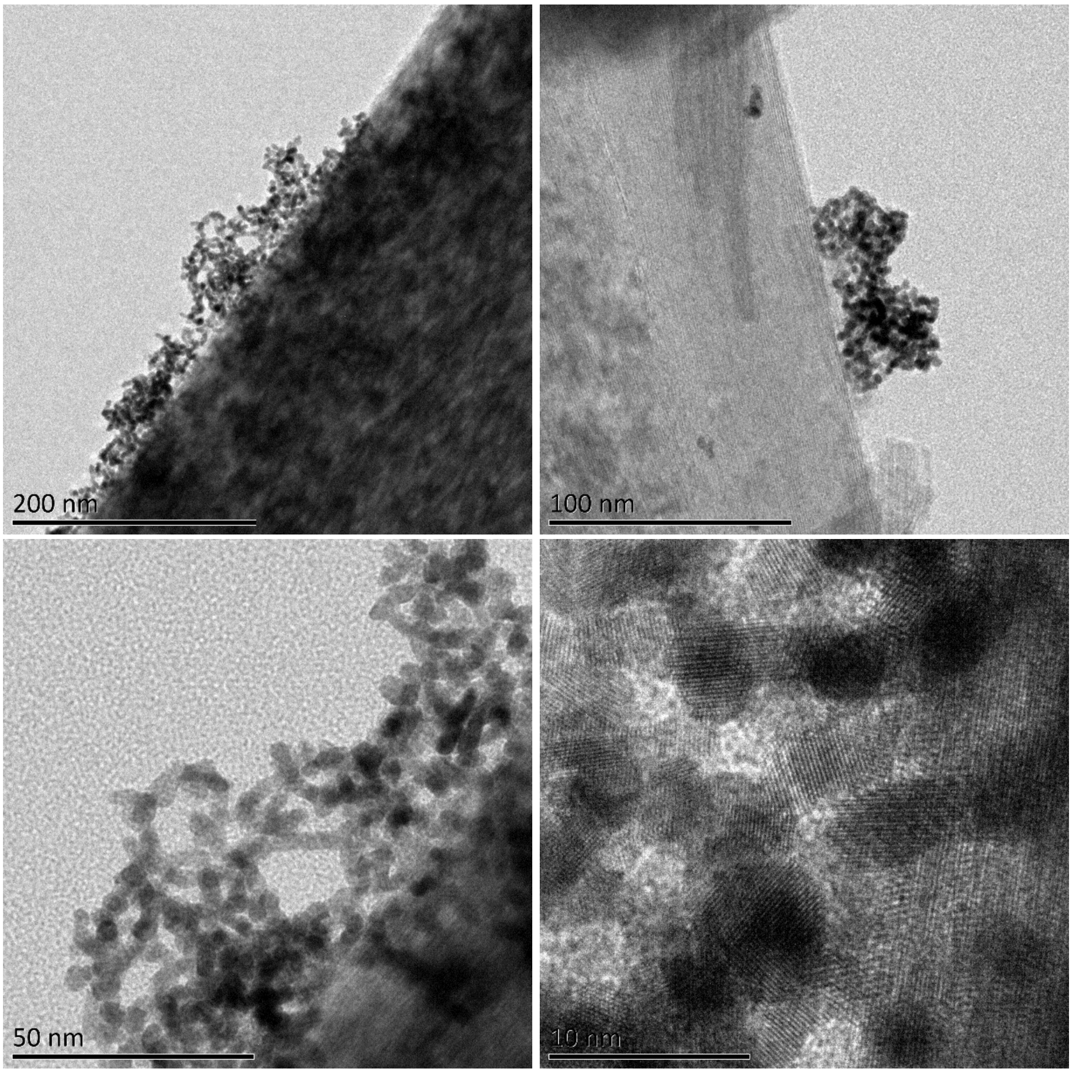

Figure s10. TEM images of spent 3%Pt/$Ti_3Al_xC_2T_y$