Supplementary Information

Carbon-Titania Composite Substrates for Fuel Cell Catalyst Application

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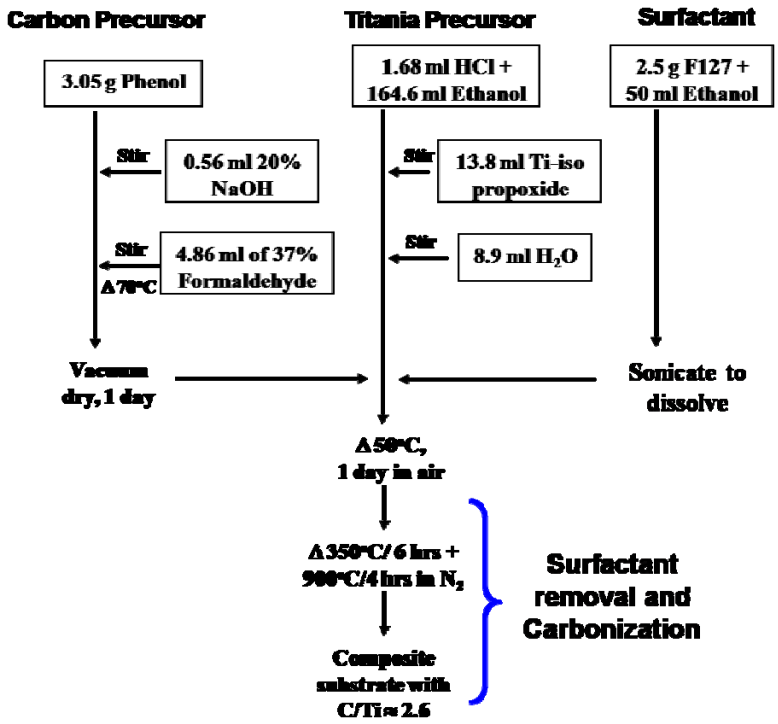
S.1. Substrate sample preparation procedure:



Flow chart for C/Ti = 2.6 composite substrate preparation starting with carbon precursor, titania precursor and surfactant solutions. The carbon precursor is made by polymerizing phenol and formaldyhyde under alkaline conditions at 70^{o}C. The titania precursor solution is prepared by hydrolyzing titanium iso-propoxide in an acidic ethanol solution. Tri-block co-polymer, F127 ($EO_{106}PO_{70}EO_{106}$, BASF), surfactant is used as a structure directing agent. The three component solutions are mixed together while stirring and then heated at 50^{o}C for 24 h to evaporate the solvent. The final product was scraped, crushed and loaded into a ceramic boat. The substrate loaded ceramic boat is heated at 350^{o}C under nitrogen for 6 h to remove the surfactant and then at 900^{o}C for 4 h to carbonize the phenol-formaldyhyde precursor. Substrates with different ratios of C/Ti are produced by fixing the ratio of titania precursor to surfactant solution while changing the amount of carbon precursor added to the mixture.

S.2. Electrical Resistivity Measurements of the platinized substrate samples:

The electrical resistivity of the substrates was determined by compressing the powdered substrates between two electrodes, to 5000 psi, in a test fixture. The resistivity was measured by applying a constant current and measuring the voltage between two points at a predetermined distance. While this procedure does not yield an absolute resistivity, it is a good measure of relative resistivity between samples. Our experience has shown that the values for a given sample are reproducible to within 10% variation.

Table 1 Normalized electrical resistivities of various composite substrates and commercial Vulcan XC-72

Substrate	Normalized resistivity
Pure Carbon	1
C/Ti = 0.65 ($TiO_xC_{0.65}$)	1.7
C/Ti = 1.3 ($TiO_xC_{1.3}$)	0.9
C/Ti = 2.6 ($TiO_xC_{2.6}$)	0.4
C/Ti = 0 (TiO_x)	3.3
Vulcan XC-72	0.03

Table 1 shows the comparative electrical resistivities of the composite substrates. The values are normalized to the pure carbon substrate (prepared without titania). The substrate resistivity decreases as the carbon content in the composite substrate is increased because carbon is more conductive than titania. The optimal substrate based on surface area analysis, $TiO_xC_{2.6}$, shows a resistivity that is within an order of magnitude of the commercial Vulcan XC-72 carbon benchmark. It was determined that a substrate resistivity within two orders of magnitude of the benchmark sample is viable for fuel cell applications. Clearly, optimal composite substrate ($TiO_xC_{2.6}$) prepared in this work falls within this range and therefore, is a potential fuel cell electrocatalyst system