Development of nanomaterials for formate electrochemical oxidation aiming sustainable energy generation

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The world energy system is highly depended of fossil fuels, which is not sustainable [1]. Thus, the use of alternative energy is crucial and fuel cells are being considered good options. In this context, this work aimed to develop electrocatalysts based on palladium nanoparticles (PdNPs) supported on the physical mixtures of carbon (Vulcan XC72) and titanium dioxide (P25) toward formate oxidation in alkaline medium and its application in formate fuel cells. The materials were synthesized by the borohydride reduction method [2] with 20% (m/m) of metal loading and in two batches. In the first batch, the PdNPs were reduced in the physical mixture of carbon (C) and titanium dioxide (TiO_2), in different proportions of C and TiO_2, identified as Pd/(C+TiO_2), while in the second one, the PdNPs were reduced only in TiO_2 with later incorporation of C which were identifies as Pd/TiO_2-C. On both batches, the ratios between C and TiO_2 used were 75:25, 50:50 and 25:75 (m/m). A reference material, complied of PdNPs supported just on C (Pd/C) was also prepared. All materials were characterized by X-ray diffraction, showing peaks of the face-centered-cubic (fcc) structure of the Pd, as well as TiO_2 peaks of anatase and rutile phases. Transmission Electron Microscopy (TEM) were also evaluated showing an average particle size between 3 and 8 nm. Electrochemical experiments considering voltammetry and chronoamperometry showed that the materials with PdNPs reduced in the TiO_2 (Pd/TiO_2-C) were more promising when compared to Pd/(C+TiO_2), and among them Pd/TiO_2-C 75:25 presented the highest current observed in chronoamperometry. Comparing the Pd/(C+TiO_2) materials, the Pd/(C+TiO_2) 50:50 presented the highest current. Taking into account single cell experiments, although the electrochemical results evidenced the improvement toward formate with PdNPs deposited firstly in the TiO_2, the fuel cell tests showed the opposite, presenting the best cell efficiencies with Pd/(C+TiO_2) materials, where Pd/(C+TiO_2) 75:25 (ratio between C and TiO_2) was the best material with the highest power density obtained. This fact can be explained by the higher conductivity of C, in a higher proportion, coupled with the small amounts of TiO_2, which provides oxygenated species that facilitate the formate oxidation.

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References:
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