Microwave and Gliding Arc Plasma Pyrolysis of Methane: Carbon Characterization

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Abstract

CO_x-free production of hydrogen can be achieved by plasma-mediated methane pyrolysis, not only yielding hydrogen but also solid carbon as a coupled product. Carbon samples produced by two different plasma sources (microwave plasma and gliding arc plasmatron) under variation of synthesis parameters were collected and characterized using thermogravimetric analysis, nitrogen physisorption, elemental analysis, electron microscopy and X-ray diffraction to determine the physical and chemical properties. The obtained results were compared to the properties of commercial carbon black products to assess whether the resulting carbon is suitable for substitution of conventional carbon blacks in applications such as batteries. When comparing the carbon materials obtained from the two different sources operated at similar methane concentration and specific energy input, significant differences in surface area and thermal oxidation stability were observed. The carbon sample produced by the microwave plasma showed a high stability against oxidation similar to a commercial acetylene black and also had a similar surface area, whereas the carbon obtained with the gliding arc plasmatron source showed much lower oxidation stability, even lower than commercial gas blacks combined with three times the specific surface area compared with the sample from the microwave source. For the microwave plasma it was also observed that with increasing specific energy input the surface area of the resulting carbon material increased. Carbon samples from both sources showed very high phase purity and a high chemical purity in general with ~98 % of carbon content. Based on the electron microscopy results a carbon black-like morphology is present in both samples.

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