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Nanoporous Activated Carbons for Fuel Cells and Supercapacitors

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Abstract : Nowadays energy consumption constantly increases and development of effective and cheap electrochemical sources of power, such as fuel cells and electrochemical capacitors, is topical. Due to their high specific power, charge and discharge rates, working lifetime supercapacitor based energy accumulation systems are more and more extensively being used in mobile and stationary devices. Lignocellulosic materials are widely used as precursors and account for around 45% of the total raw materials used for the manufacture of activated carbon which is the most suitable material for supercapacitors. First part of our research is devoted to study of influence of main stages of wood thermochemical activation parameters on activated carbons porous structure formation. It was found that the main factors governing the properties of carbon materials are specific surface area, volume and pore size distribution, particles dispersity, ash content and oxygen containing groups content. Influence of activated carbons attributes on capacitance and working properties of supercapacitor are demonstrated. The correlation between activated carbons porous structure indices and electrochemical specifications of supercapacitors with electrodes made from these materials has been determined. It is shown that if synthesized activated carbons are used in supercapacitors then high specific capacitances can be reached – more than 380 F/g in 4.9M sulfuric acid based electrolytes and more than 170 F/g in 1 M tetraethylammonium tetrafluoroborate in acetonitrile electrolyte. Power specifications and minimal price of H_2-O_2 fuel cells are limited by the expensive platinum-based catalysts. The main direction in development of non-platinum catalysts for the oxygen reduction is the study of cheap porous carbonaceous materials which can be obtained by the pyrolysis of polymers including renewable biomass. It is known that nitrogen atoms in carbon materials to a high degree determine properties of the doped activated carbons, such as high electrochemical stability, hardness, electric resistance, etc. The lack of sufficient knowledge on the doping of the carbon materials calls for the ongoing researches of properties and structure of modified carbon matrix. In the second part of this study, highly porous activated carbons were synthesized using alkali thermochemical activation from wood, cellulose and cellulose production residues – craft lignin and sewage sludge. Activated carbon samples were doped with dicyandiamide and melamine for the application as fuel cell cathodes. Conditions of nitrogen introduction (solvent, treatment temperature) and its content in the carbonaceous material, as well as porous structure characteristics, such as specific surface and pore size distribution, were studied. It was found that efficiency of doping reaction depends on the elemental oxygen content in the activated carbon. Relationships between nitrogen content, porous structure characteristics and electrodes electrochemical properties are demonstrated.

Keywords : activated carbons, low-temperature fuel cells, nitrogen doping, porous structure, supercapacitors
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