

Sintesis dan aplikasi TiO₂ nanotube sebagai kapasitor dan pendukung kapasitor TiO₂- RuO₂ = Synthesis and application of TiO₂ nanotube as capacitor and Co-Capacitor TiO₂-RuO₂

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Abstrak

[ABSTRAK

Kapasitor elektrokimia merupakan piranti yang dapat menyimpan energi listrik pada kedua sisi elektrodanya. Pada penelitian ini elektroda kapasitor elektrokimia dibuat dari TiO₂ Nanotube (TiO₂-NT) dan komposit TiO₂-RuO₂. TiO₂-NT disintesis dengan metode anodisasi logam Ti menggunakan elektrolit NH₄F dalam gliserol dan air sedangkan komposit TiO₂-RuO₂ didapatkan dengan mengendapkan RuO₂ pada TiO₂-NT melalui metode elektrodeposisi. TiO₂-NT dikalsinasi pada suhu 300oC, 400oC dan 500oC, dan dilakukan pengamatan pengaruh perubahan suhu kalsinasi terhadap morfologi, fasa kristal dan besar nilai kapasitansi titania. TiO₂-NT dengan kondisi optimum dan nilai kapasitansi tertinggi dibentuk menjadi komposit dengan RuO₂. Karakterisasi dilakukan dengan peralatan SEM, XRD, FTIR, dan UV-VIS DRS, sedangkan sifat elektrokimia dan unjuk kerja elektroda diuji dengan metode linier sweep voltametry (LSV), voltametri siklik dan pengisian-pengosongan galvanostatik (PPG). Hasil karakterisasi menunjukkan bahwa kalsinasi tidak mengubah morfologi nanotube, tetapi mempengaruhi ukuran diameter dan ketebalan dinding tube TiO₂, ukuran diameter yang relatif seragam, yaitu $50,15 \pm 1,30$ nm diperoleh pada suhu kalsinasi 400oC. Analisa difraktogram menunjukkan bahwa TiO₂-NT hasil sintesis berbentuk amorf, sedangkan kalsinasi pada suhu 400oC dan 500oC menghasilkan kristal anatase TiO₂ dengan nilai band gap 3,2eV. TiO₂-NT diketahui bersifat aktif dengan menunjukkan respon arus cahaya saat dikenai sinar UV dengan nilai yang meningkat seiring kenaikan suhu kalsinasi. Karakterisasi komposit TiO₂-RuO₂ menunjukkan kandungan Ru yang relatif kecil (4,8%) dibandingkan massa Ti. RuO₂ yang terdeposit berbentuk amorf dan mengandung air. Nilai kapasitansi elektroda kapasitor TiO₂-NT dan TiO₂-RuO₂ dengan metode voltametri siklik didapatkan masing-masing 565,09F/cm² dan 979,5F/cm², sedangkan nilai kapasitansi dengan uji PPG pada TiO₂-NT didapatkan kapasitansi 31,86 F/cm² dan TiO₂-RuO₂ 580,36 F/cm². Nilai kapasitansi menunjukkan bahwa TiO₂-NT dapat digunakan sebagai elektroda kapasitor dan pendukung elektroda kapasitor dalam bentuk komposit TiO₂-RuO₂.

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ABSTRACT

Electrochemical capacitors are energy storage devices which store electrical energy in two series electrodes. In this work, the capacitor electrodes made of TiO₂ nanotube and TiO₂-RuO₂ composite. TiO₂-NT were synthesized by anodization method in NH₄F electrolyte with glycerol and water. The composite electrode were obtained by electrodeposition of RuO₂ from RuCl₃ solution on TiO₂-NT which has optimum condition and high capacitances. The anodized TiO₂-NT was calcined in a range of temperatures between 300oC to 500oC and the influences of temperature to morphology, crystal phase and capacitance values of TiO₂-NT were observed. The characterizations were performed by SEM, XRD, FTIR and UV-VIS DRS instruments and the electrochemical behaviour and the electrode performance were conducted with linier sweep voltametry, cyclic voltametry and galvanostatics charge-discharge test. The temperature calcinations

did not change the morphology of TiO₂-NT, but influence diameter size and tubes thickness, in which the uniform diameter $50,15 \pm 1,30$ nm was obtained from 400°C of TiO₂-NT. The as anodized TiO₂-NT were in amorphous phase, on the other hand, 400°C and 500°C of TiO₂-NT were anatase crystal structure with 3.2eV band gap. TiO₂-NT showed photocurrent responses with UV light and the values rised as the temperature increased. SEM-EDX showed the composite composition, Ru have smaller mass percentage (4,8%) than Ti. The phase of RuO₂ was amorphous and contained water molecules or in hidrates form. TiO₂-NT prepared at 400°C yielded the largest capacitances of 565,09F/cm² and TiO₂-RuO₂ composites of 979,5F/cm² at a scan rate of 10 mVs⁻¹. GCD test, give the capacitance 31,86 F/cm² of TiO₂-NT and 580,36 F/cm² of TiO₂-RuO₂ composites. These findings of capacitance could open new opportunities of TiO₂-NT materials in constructing high performance capacitors and supporting capacitors in the form of TiO₂-RuO₂ composite; Electrochemical capacitors are energy storage devices which store electrical energy in two series electrodes. In this work, the capacitor electrodes made of TiO₂ nanotube and TiO₂-RuO₂ composite. TiO₂-NT were synthesized by anodization method in NH₄F electrolyte with glycerol and water. The composite electrode were obtained by electrodeposition of RuO₂ from RuCl₃ solution on TiO₂-NT which has optimum condition and high capacitances. The anodized TiO₂-NT was calcined in a range of temperatures between 300°C to 500°C and the influences of temperature to morphology, crystal phase and capacitance values of TiO₂-NT were observed. The characterizations were performed by SEM, XRD, FTIR and UV-VIS DRS instruments and the electrochemical behaviour and the electrode performance were conducted with linier sweep voltametry, cyclic voltametry and galvanostatics charge-discharge test. The temperature calcinations didnot change the morphology of TiO₂-NT, but influence diameter size and tubes thickness, in which the uniform diameter $50,15 \pm 1,30$ nm was obtained from 400°C of TiO₂-NT. The as anodized TiO₂-NT were in amorphous phase, on the other hand, 400°C and 500°C of TiO₂-NT were anatase crystal structure with 3.2eV band gap. TiO₂-NT showed photocurrent responses with UV light and the values rised as the temperature increased. SEM-EDX showed the composite composition, Ru have smaller mass percentage (4,8%) than Ti. The phase of RuO₂ was amorphous and contained water molecules or in hidrates form. TiO₂-NT prepared at 400°C yielded the largest capacitances of 565,09F/cm² and TiO₂-RuO₂ composites of 979,5F/cm² at a scan rate of 10 mVs⁻¹. GCD test, give the capacitance 31,86 F/cm² of TiO₂-NT and 580,36 F/cm² of TiO₂-RuO₂ composites. These findings of capacitance could open new opportunities of TiO₂-NT materials in constructing high performance capacitors and supporting capacitors in the form of TiO₂-RuO₂ composite, Electrochemical capacitors are energy storage devices which store electrical energy in two series electrodes. In this work, the capacitor electrodes made of TiO₂ nanotube and TiO₂-RuO₂ composite. TiO₂-NT were synthesized by anodization method in NH₄F electrolyte with glycerol and water. The composite electrode were obtained by electrodeposition of RuO₂ from RuCl₃ solution on TiO₂-NT which has optimum condition and high capacitances. The anodized TiO₂-NT was calcined in a range of temperatures between 300°C to 500°C and the influences of temperature to morphology, crystal phase and capacitance values of TiO₂-NT were observed. The characterizations were performed by SEM, XRD, FTIR and UV-VIS DRS instruments and the electrochemical behaviour and the electrode performance were conducted with linier sweep voltametry, cyclic voltametry and galvanostatics charge-discharge test. The temperature calcinations didnot change the morphology of TiO₂-NT, but influence diameter size and tubes thickness, in which the uniform diameter $50,15 \pm 1,30$ nm was obtained from 400°C of TiO₂-NT. The as anodized TiO₂-NT were in amorphous phase, on the other hand, 400°C and 500°C of TiO₂-NT were anatase crystal structure with 3.2eV band gap. TiO₂-NT showed photocurrent

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