TUGAS AKHIR

MODIFIKASI PERMUKAAN ANODA ALUMINIUM BERBASIS *ANODIC ALUMINIUM OXIDE* MELALUI PELAPISAN *CARBON QUANTUM DOTS* UNTUK PENGENDALIAN LAJU KOROSI DAN PERFORMA PADA BATERAI ALUMINIUM–UDARA

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ABSTRACT

Modifications to the aluminum anode through the formation of an anodic aluminum oxide (AAO) layer and the deposition of carbon quantum dots (CQDs) in a solid-state electrolyte-based aluminum–air battery were analyzed to determine their effects on the corrosion rate, ionic conductivity, and discharge capacity of the battery. The modifications were performed via an anodization process to form the AAO structure, followed by CQDs coating using the electrophoretic deposition (EPD) method. Electrochemical characterization included potentiodynamic polarization (Tafel) testing, electrochemical impedance spectroscopy (EIS), and galvanostatic charge–discharge (GCD) testing. The results showed that AAO formation reduced the corrosion rate from 0.0545 mmpy to 0.0313 mmpy; however, ionic conductivity also decreased from 5.64 × 10^{-3} S/cm to 4.46 × 10^{-3} S/cm due to the formation of an Al_2O_3 layer. Coating with CQDs further reduced the corrosion rate to 0.0157 mmpy while simultaneously increasing the ionic conductivity to 9.9 × 10^{-3} S/cm through improvements in the electrode–electrolyte interface characteristics. On the other hand, the battery discharge capacity decreased from 0.584 mAh for the aluminum anode to 0.442 mAh for the AAO anode and 0.367 mAh for the AAO/CQDs anode. This decrease in capacity indicates that the enhanced protective properties of the AAO and CQDs layers are able to control the rate of aluminum oxidation during the discharge process, but at the same time limit the utilization of aluminum as an active material. The research results show that the combination of AAO and CQDs can produce anodes with better corrosion resistance accompanied by improved ion transport characteristics, thereby providing an alternative surface modification for the development of solid-state electrolyte-based aluminum–air batteries.

Keywords: Aluminum Anode; Anodic Aluminum Oxide (AAO); Carbon Quantum Dots (CQDs); Corrosion Rate; Ionic Conductivity; Battery Capacity; Aluminum–Air Battery; Solid-state Electrolyte; Surface Modification.

ABSTRAK

Modifikasi anoda aluminium melalui pembentukan lapisan *anodic aluminum oxide* (AAO) dan pelapisan *carbon quantum dots* (CQDs) pada baterai aluminium–udara berbasis elektrolit solid-state dianalisis untuk mengetahui pengaruhnya terhadap laju korosi, konduktivitas ionik, dan kapasitas pengosongan baterai. Modifikasi dilakukan melalui proses anodisasi untuk membentuk struktur AAO, kemudian dilanjutkan pelapisan CQDs menggunakan metode *electrophoretic deposition* (EPD). Karakterisasi elektrokimia meliputi pengujian *potentiodynamic polarization* (Tafel), *electrochemical impedance spectroscopy* (EIS), dan *galvanostatic charge–discharge* (GCD). Hasil penelitian menunjukkan pembentukan AAO menurunkan laju korosi dari 0,0545 mmpy menjadi 0,0313 mmpy, namun konduktivitas ionik turut menurun dari $5{,}64 \times 10^{-3}$ S/cm menjadi $4{,}46 \times 10^{-3}$ S/cm akibat terbentuknya lapisan Al_2O_3. Pelapisan CQDs selanjutnya menurunkan laju korosi hingga 0,0157 mmpy sekaligus meningkatkan konduktivitas ionik menjadi $9{,}9 \times 10^{-3}$ S/cm melalui perbaikan karakteristik antarmuka elektroda–elektrolit. Di sisi lain, kapasitas pengosongan baterai menurun dari 0,584 mAh pada anoda aluminium menjadi 0,442 mAh pada anoda AAO dan 0,367 mAh pada anoda AAO/CQDs. Penurunan kapasitas tersebut menunjukkan peningkatan sifat protektif lapisan AAO dan CQDs mampu mengendalikan laju oksidasi aluminium selama proses *discharge* sehingga membatasi pemanfaatan aluminium sebagai material aktif. Hasil penelitian menunjukkan kombinasi AAO dan CQDs mampu menghasilkan anoda dengan ketahanan korosi lebih baik disertai peningkatan karakteristik transport ion, sehingga memberikan alternatif modifikasi permukaan untuk pengembangan baterai aluminium–udara berbasis elektrolit *solid-state*.

Kata Kunci: Anoda Aluminium; *Anodic Aluminum Oxide* (AAO*); Carbon Quantum Dots* (CQDs;, Laju Korosi; Konduktivitas Ionik; Kapasitas Baterai; Baterai Aluminium–Udara; Elektrolit *Solid-state*; Modifikasi Permukaan.