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Design, Preparation and Electrochemical Performance Regulation of Electrode Material for High Specific Capacity Lithium Ion Batteries

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In order to improve the preparation and regulation ability of high specific capacity lithium ion battery electrode material, a direct functionalization control model based on an inert C-C bond is proposed for the electrochemical performance regulation of high specific capacity lithium ion battery electrode material. The control model of a carbonyl allylation reaction of high specific capacity lithium ion battery electrode material and the electrochemical reaction control model of high specific capacity lithium ion battery electrode material are constructed. Combined with the feedback adjustment stability parameter adjustment method, the polar parameter in electrochemical regulation of battery electrode material is adjusted. Combined with the fuzzy tracking identification method, the process of battery electrode material regulation is controlled. The heteroatom functional groups are introduced to realize the steady-state regulation of the electrochemical performance of high specific capacity lithium ion battery electrode material. The asymmetric carbonyl allylation reaction is used to regulate the molecular catalytic reaction during the preparation of the lithium ion battery electrode material. The optimal controls of the design, preparation and electrochemical performance regulation of electrode material for high specific capacity lithium ion batteries are realized. The results show that this method has a good steady-state and strong catalytic ability to regulate the electrochemical performance of battery electrode material. The stability of electrochemical control is improved and the output gain of battery electrode is higher.

Keywords: high specific capacity lithium ion; battery electrode material; electrochemical performance control; preparation

1. INTRODUCTION

The preparation and electrochemical control of high specific capacity lithium ion battery electrode material are the keys to ensure the stability of battery output. The optimization design and energy collection of electrochemical regulation of high specific capacity lithium ion battery electrode material can improve the output stability of the battery, so as to improve the output dynamic gain of the battery. The researches on the electrochemical regulation method of specific capacity lithium ion battery electrode material have attracted great attention [1].

The electrode material of high specific capacity lithium ion battery is composed of the addition reaction of chiral high allyl alcohol and carbonyl allyl. Combined with the

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optimal mixture ratio design of allyl boric acid, the optimal preparation design of lithium ion battery electrode material is carried out to improve the output voltage stability of the electrode of the high specific capacity lithium-ion battery. The electrode material is derived from 1'-spirobiindane-7,7'-diol, combining the catalytic reaction of allylpalladium chloride dimer (II). Traditionally, the design and electrochemical regulation of electrode material for high specific capacity lithium ion battery mainly adopt the electrochemical regulation method based on fuzzy neural networks, and the electrochemical regulation method of lithium ion battery electrode material based on fuzzy adaptive clustering [2]. In reference [3], an electrochemical regulation method based on the second harmonic oscillation and PID neural network control is proposed to realize the electrochemical regulation optimization of high specific capacity lithium ion battery electrode material. It adopts the finite element method to carry out integrated scheduling for the electrochemical regulation of high specific capacity lithium ion battery electrode material, and adaptively adjusts the output current, power and other parameter models of the battery, so as to improve the chemical regulation ability. However, the anti-interference and self adaptability of this method are not good. In reference [4], an improved PID algorithm is proposed to optimize the electrochemical regulation of high specific capacity lithium ion battery electrode material. It first establishes a parameter model for the electrochemical regulation object of high specific capacity lithium ion battery electrode material, and then analyzes the characteristics of the control parameter of the electrochemical regulation system of high specific capacity lithium ion battery electrode material to optimize the material preparation process. However, this method has a large ambiguity, and the regulation self-adaptation is not good.

In view of the above problems, this paper proposes a direct functionalization control model based on an inert C-C bond for the electrochemical performance regulation of high specific capacity lithium ion battery electrode material. Firstly, it constructs the control model of a carbonyl allylation reaction of high specific capacity lithium ion battery electrode material and the electrochemical reaction control model of high specific capacity lithium ion battery electrode material. Then, combined with the feedback adjustment stability parameter adjustment method, it adjusts the polar parameter in the electrochemical regulation of the battery electrode material. Also, combined with the fuzzy tracking identification method, it controls the process of the battery electrode material regulation, introduces the heteroatom functional groups to realize the steady-state regulation of the electrochemical performance of the high specific capacity lithium ion battery electrode material, and adopts an asymmetric carbonyl allylation reaction to regulate the molecular catalytic reaction during the preparation of lithium ion battery electrode material, so as to realize the optimal controls of the design, preparation and electrochemical performance regulation of high specific capacity lithium ion battery electrode material. Finally, the experimental test analysis is carried out, and the validity conclusion is drawn.

2. THE OBJECT MODEL AND PARAMETER DESIGN OF ELECTROCHEMICAL REGULATION FOR THE PREPARATION OF LITHIUM ION BATTERY ELECTRODE MATERIAL

2.1 The Electrode Material Preparation and Electrochemical Regulation Model of Lithium ion Battery

In order to realize the optimal design of electrochemical regulation for the preparation of lithium ion battery electrode material, firstly, the fuzzy constrained object model of electrochemical regulation for the preparation of lithium ion battery electrode material is constructed, and the modeling is extended by using the NNLI of a PID neuron adaptive control to build the predictive function and control system parameter analysis model of electrochemical regulation system for high specific capacity lithium-ion battery electrode material [5]. The structure composition of the system is then analyzed, and the principle of the remote C-H bond functionalization reaction of the electrochemical regulation system of high specific capacity lithium ion battery electrode material is shown in Figure 1.

The asymmetric conjugate amination reaction is used to suppress the power loss during the electrochemical regulation of the preparation of high specific capacity lithium ion battery electrode material [6]. The controlled object model of the electron withdrawing or electron donating substituent is as follows:

$$\rho(t) = -\Delta M\ddot{\varphi}_a - \Delta h(\varphi_a, \dot{\varphi}_a) + d(t) \tag{1}$$

Assuming that the R1 group is replaced by a variety of alkyl groups, the upper bound distribution of the fuzzy state of the process control for the preparation of the high specific capacity lithium ion battery electrode material is $\bar{\rho}(t)$, that is:

$$|\rho(t)| < \bar{\rho}(t) \tag{2}$$

The power loss of the electrode output is obtained by free radical coupling, and the relationship between the electrode loss and the electrode output power of the high specific capacity lithium ion battery is established [7]. To set:

$$\begin{cases} e_1 = \varphi_a - \varphi_{ad} \\ e_2 = \dot{\varphi}_a - \dot{\varphi}_{ad} \end{cases} \tag{3}$$

When the constraints of unsaturated alkyl substituents are not taken into account, under the common constraint and control of naphthalene formaldehyde, fatty aldehydes and methoxy groups, nickel nitrate and 2,5-dihydroxy are used as components to control the catalytic activity reaction to obtain some nickel species. The steady-state error of the

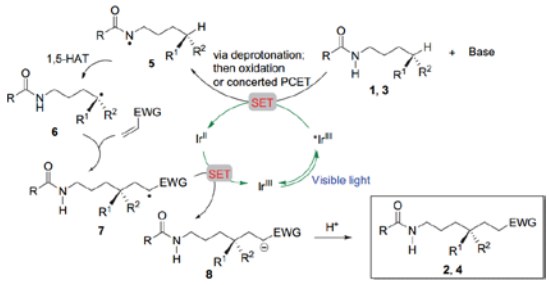


Figure 1 The Principle of the Remote C-H Bond Functionalization Reaction of the Electrode Material.

electrochemical regulation output of them under the influence of external interference is obtained as follows:

$$\begin{cases} \dot{e}_1 = e_2 \\ \dot{e}_2 = M_n^{-1}u - M_n^{-1}h_n\left(\varphi_a, \dot{\varphi}_a\right) - \ddot{\varphi}_{ad} \end{cases} \tag{4}$$

Under the constraints of the hydrogenation activity of several catalysts, the sliding surface is set by using the method of heterogeneous catalysis, which is

$$s = ce_1 + e_2 \tag{5}$$

and

$$\dot{s} = c\dot{e}_1 + \dot{e}_2 = c\dot{e}_1 + \dot{e}_2 \tag{6}$$

In the case of adding electromagnetic losses, to set:

$$\dot{s} = 0 \tag{7}$$

Thus, the control model of carbonyl allylation reaction and the electrochemical reaction control model of high specific capacity lithium ion battery electrode material are constructed.

2.2 The Analysis of Regulation and Constraint Parameters

The preparation and design of lithium ion battery electrode material are carried out by hydrothermal synthesis, and heteroatom functional groups are introduced to realize the steady-state regulation of the electrochemical performance of high specific capacity lithium ion battery electrode material [8]. Therefore:

$$\begin{aligned} ce_2 + \dot{e}_2 &= ce_2 + \ddot{\varphi}_a - \ddot{\varphi}_{ad} \\ &= ce_2 + M_n^{-1}u - M_n^{-1}h_n(\varphi_a, \dot{\varphi}_a) - \ddot{\varphi}_{ad} = 0 \end{aligned} \tag{8}$$

With the increase of pyrolysis temperature, the equivalent control law is obtained as follows:

$$u_{eq} = h_n(\varphi_a, \dot{\varphi}_a) + M_n\ddot{\varphi}_{ad} - M_n ce_2 \tag{9}$$

Considering the existence of uncertain factors in the system, the uniform dispersion performance of Ni0 catalyst in the reaction system is analyzed. Here, the current transfer control law at the far end of the electrode material under heterogeneous catalysis is selected as follows:

$$u_0 = -\mathrm{sgn}(M_n)\bar{\rho}(t)\mathrm{sgn}(s) \tag{10}$$

The electrochemical performance of DHTA is regulated. At the frequency f, the total output energy of the aromatic ring structure is obtained as follows:

$$\begin{aligned} u = u_{eq} + u_0 = h_n(\varphi_a, \dot{\varphi}_a) + M_n\ddot{\varphi}_{ad} - M_n ce_e \\ - \mathrm{sgn}(M_n)\bar{\rho}(t)\mathrm{sgn}(s) \end{aligned} \tag{11}$$

The strong diffraction peak under the constraint of the crystallinity of the material is $T = \frac{1}{2B} = \frac{1}{W}$. Through the above-mentioned parameters reconstruction of the controlled object, the specific surface area of the material before and after pyrolysis is analyzed, and the Lyapunov function characteristic of the controlled object is obtained as follows:

$$V = \frac{1}{2}s^2 \tag{12}$$

The output of the complete pyrolysis product is as follows:

$$\begin{aligned} \dot{V} =& s\dot{s} \\ =& s\left[ce_2 + M_n^{-1}u - M_n^{-1}h_n\left(\varphi_a, \dot{\varphi}_a\right)\right. \\ & \left. -\ddot{\varphi}_{ad} + M_n^{-1}\rho(t)\right] \\ =& sce_2 + sM_n^{-1}\left(h_n\left(\varphi_a, \dot{\varphi}_a\right) + M_n\ddot{\varphi}_{ad}\right. \\ & \left. -M_n ce_2 - \mathrm{sgn}(M_n)\,\bar{\rho}(t)\,\mathrm{sgn}(s)\right) \\ & - sM_n^{-1}h_n\left(\varphi_a, \dot{\varphi}_a\right) - s\ddot{\varphi}_{ad} + sM_n^{-1}\rho(t) \\ =& sM_n^{-1}\rho(t) - sM_n^{-1}\,\mathrm{sgn}\left(M_n\right)\bar{\rho}(t)\,\mathrm{sgn}(s) \\ =& sM_n^{-1}\rho(t) - \left|sM_n^{-1}\right|\bar{\rho}(t) \\ \leq& \left|sM_n^{-1}\right|\left|\rho(t)\right| - \left|sM_n^{-1}\right|\bar{\rho}(t) \\ =& \left|sM_n^{-1}\right|\left(\left|\rho(t)\right| - \bar{\rho}(t)\right) < 0 \end{aligned} \tag{13}$$

According to the above feature extraction results, the description of the process of obtaining the Ni/C nano catalyst for battery electrode material is shown in Figure 2.

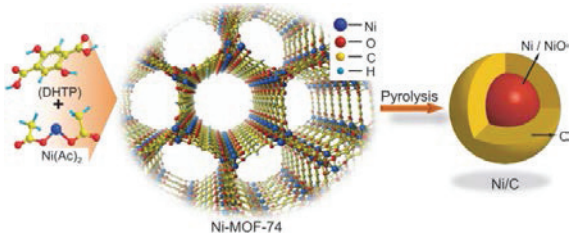


Figure 2 The Process of Obtaining Ni/C Nano Catalyst for Battery Electrode Material.

3. THE OPTIMIZATION OF ELECTROCHEMICAL PERFORMANCE REGULATION OF ELECTRODE MATERIAL FOR HIGH SPECIFIC CAPACITY LITHIUM ION BATTERY

3.1 The Electrochemical Reaction Control

Combined with the fuzzy tracking identification method, the process control of electrode material regulation of lithium ion battery is carried out. The heteroatom functional groups are introduced to realize the steady-state regulation of the electrochemical performance of the high specific capacity lithium ion battery electrode material. The improved three-layer PID forward neural network is used to control the electrochemical reaction of the electrode of the high specific capacity lithium ion battery [9], and the control system function is obtained as follows:

$$\begin{cases} \sigma_1(\varphi_a, \dot{\varphi}_a) = \frac{1}{1+e^{-(\omega_{11}\varphi_a+\omega_{21}\dot{\varphi}_a)}} \\ \sigma_2(\varphi_a, \dot{\varphi}_a) = \frac{1}{1+e^{-\int(\omega_{21}\varphi_a+\omega_{22}\dot{\varphi}_a)dt}} \\ \sigma_3(\varphi_a, \dot{\varphi}_a) = \frac{1}{1+e^{-d(\omega_{11}\varphi_a+\omega_{21}\dot{\varphi}_a)}} \end{cases} \tag{14}$$

In the formula, $\int(\bullet)dt$ is a PID neural network integrator for electrochemical regulation of material before and after pyrolysis. Feedback modulation is performed by adjusting the pyrolysis temperature. $d(\bullet)$ is the XRD spectrum differential sign, and $\sigma(\varphi_a, \dot{\varphi}_a) = [\sigma_1(\varphi_a, \dot{\varphi}_a) \quad \sigma_2(\varphi_a, \dot{\varphi}_a) \quad \sigma_3(\varphi_a, \dot{\varphi}_a)]$ is a sequence state function for the electrochemical statistical analysis of material with the decomposition temperature between 400°C and 450°C [10]. By calculating the pore size distribution of micropores and mesopores, the variable structure control law for the electrochemical performance regulation of high specific capacity lithium ion battery electrode material is obtained as follows:

$$u = h_n(\varphi_a, \dot{\varphi}_a) + M_n\ddot{\varphi}_{ad} - M_n ce_2 - \mathrm{sgn}(M_n)\hat{\bar{\rho}}(t)\mathrm{sgn}(s) \tag{15}$$

In the formula, w_{ij} is the connection weight value from the input layer to the hidden layer for the electrochemical performance regulation of the high specific capacity lithium ion battery electrode material. The superscript "′" is the variable mark of the hidden layer. The bandwidth of the pulse control sequence $s(t)$ regulated by the electrochemical performance of high specific capacity lithium ion battery electrode material is W, and the state of the ratio element of the reactant molecule and the catalyst is as follows:

$$u_1'(k) = net_1'(k) \tag{16}$$

The output control parameter of hidden layer neurons in the electrochemical regulation PID control system of high specific capacity lithium ion battery electrode material is carried out Hilbert transform. The statistical characteristics analysis method is used to perform a steady-state adjustment of the output layer of the material electrochemical regulation system [11].

3.2 The Output of Electrochemical Performance Regulation

The heteroatom functional groups are introduced to realize the steady-state regulation of the electrochemical performance of high specific capacity lithium ion battery electrode material. The asymmetric carbonyl allylation reaction is used to regulate the molecular catalytic reaction during the preparation of the lithium ion battery electrode material. The steady-state error compensation is used to realize the parameter self-tuning qualitative treatment of the electrode material control of the high specific capacity lithium ion battery [12]. The lattice of Ni is inserted to obtain the control fitness function:

$$Y(s) = \frac{e^{-L_m s}}{(\lambda_1 s+1)}R(s) + \frac{(\lambda_2 s + L_m^s)}{(\lambda_2 s+1)}D(s) \tag{17}$$

As the output layer structure of the electrochemical regulation system of high specific capacity lithium ion battery electrode material is relatively simple, it only contains one neuron to complete the power distribution of the electrochemical regulation of high specific capacity lithium ion battery electrode material [13], and the total input is:

$$net''(k) = \sum_{j=1}^{3} w_j' x_j'(k) \tag{18}$$

The obtained feedback characteristic equation of state variable is:

$$\frac{Y(s)}{R(s)} = \frac{G_c(s)G_0(s)e^{-\tau s}}{1 + G_c(s)G_m(s) + G_c(s)(G_0(s)e^{-\tau s} - G_m(s)e^{-l_m s})} \tag{19}$$

Ni—C may exist between species and carbon, and they are fault-tolerant [14]. According to the Routh stability criterion, Ni0 can adjust temperature parameter with higher content stability to obtain the PID control output gain

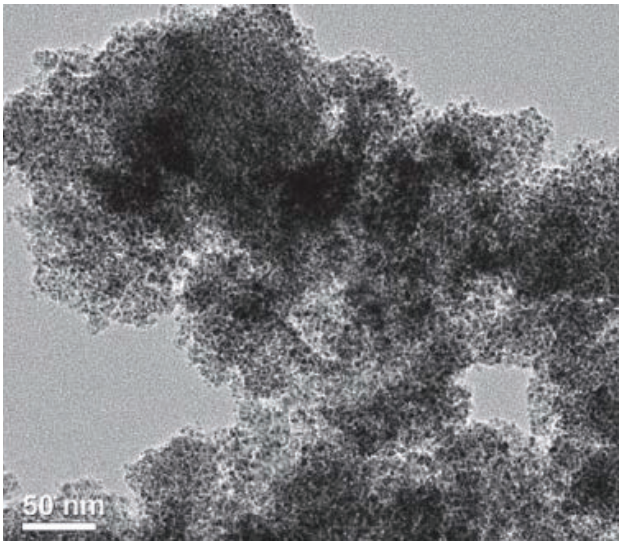


Figure 3 The Prepared Crystal of Lithium Ion Battery Electrode Material.

of electrochemical performance regulation of high specific capacity lithium ion battery electrode material, which is:

$$\begin{cases} \Delta K > 0 \\ \Delta K < 1 + \frac{\lambda_2}{L_m} \end{cases} \tag{20}$$

The elements at different depths of the particles are determined, and the first-order Taylor expansion is used to approximate $e^{-L_m s} = 1 - L_m s$. The relationship between the sensitivity of the fault-tolerant setting of the high specific capacity lithium ion battery electrode material and A_m and φ_m can be obtained as follows:

$$\begin{cases} A_m > \frac{M_s}{M_s - 1} \\ \varphi_m > 2 \arcsin \frac{1}{2M_s} \end{cases} \tag{21}$$

Among them, the variable r and variable l are positive integers. With the increase of the sputtering time, the output asymmetric carbonyl allylation reactions are $d_1(t)$ and $d_2(t)$, respectively. In the self-tuning measurement process, the interaction load characteristics between the carbon layers on the surface meet the following requirements:

$$0 \le d_1(t) \le h_1 \le \infty, \qquad 0 \le d_2(t) \le h_2 \le \infty \tag{22}$$

Through the above analysis, the compensation state function of the electrochemical performance regulation of the battery electrode material is obtained as follows:

$$\frac{Y(s)}{R(s)} = \frac{G_c(s)G_0(s)e^{-\tau s}}{1 + G_c(s)G_m(s) + G_c(s)(G_0(s)e^{-\tau s} - G_m(s)e^{-t_m s})} \tag{23}$$

Under the control of steady-state error compensation, the asymmetric carbonyl allylation reaction is used to adjust the molecular catalytic reaction during the preparation of lithium ion battery electrode materials, so as to realize the optimal controls of design, preparation and electrochemical performance regulation of high specific capacity lithium ion battery electrode material. The proportional element, integral element and differential element of the control system are constructed to perform PID control, so as to improve the electrochemical performance regulation [15].

4. THE PERFORMANCE TEST ANALYSIS

In order to test the application performance of the method proposed in this paper, in the electrochemical performance regulation of electrode material for high specific capacity lithium ion battery, the experimental test analysis is carried out. The consumption peak of the electrode material is set as ($T3$, max = 643 ∼ 745°C); the temperature is 55°C; the hydrogen pressure is 1.4 MPa; the catalytic performance of the Ni/C catalyst is (0.833mmol • $\min^{-1}$ • g^{-1}). The 0.2 g of Ni-MOF-74 is taken into the reaction reagent of the high specific capacity lithium ion battery electrode material for catalytic reaction, and the obtained prepared crystal of lithium ion battery electrode material is shown in Figure 3.

In the setting of the cycle stability number of the electrode material of the high specific capacity lithium ion battery, taking $c_1 = \frac{1}{mV}(57.3 c_y^{\alpha} q S_M + P)$, $[S^{-1}] = 0.13$, $c_y^{\alpha} = 1.24$, $c_3 = \frac{P}{mV}$, $c''_3 = \frac{m_R l_R}{mV} = 3.45$, and $b_1 = \frac{57.3}{J_{z1}V} m_{dz} q S_M l_k^2$, the obtained electrochemical performance regulation output of the electrode material of the high specific capacity lithium ion battery is shown in Figure 4.

The parameter control performance of the electrochemical performance regulation of the high specific capacity lithium ion battery electrode material is tested, and the obtained stability output of the electrochemical regulation is shown in Figure 5.

By analyzing Figure 5, it can be determined that the output stability of the electrochemical performance regulation of the high specific capacity lithium ion battery electrode material is better using the method proposed in this paper. The voltage of electrode output terminal is tested, and the test results are shown in Figure 6.

By analyzing Figure 6, it can be determined that the output voltage gain is higher and the catalytic ability is stronger using the method proposed in this paper to carry out the electrochemical performance regulation of the high specific capacity lithium ion battery electrode material, which also improves the stability of the electrochemical control.

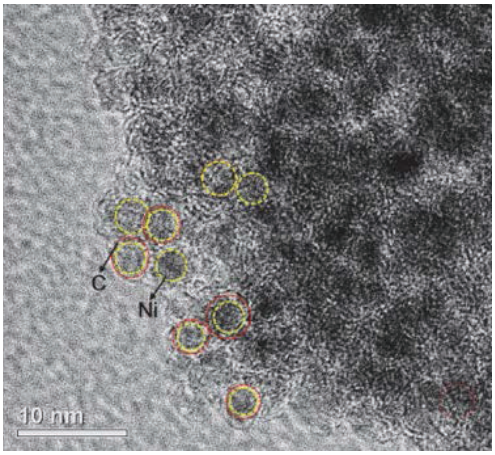


Figure 4 The Electrochemical Performance Regulation Output of the Electrode Material of the High Specific Capacity Lithium Ion Battery.

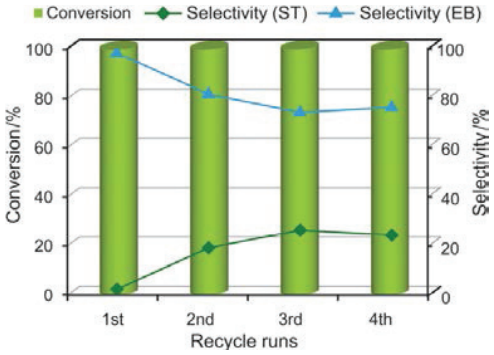
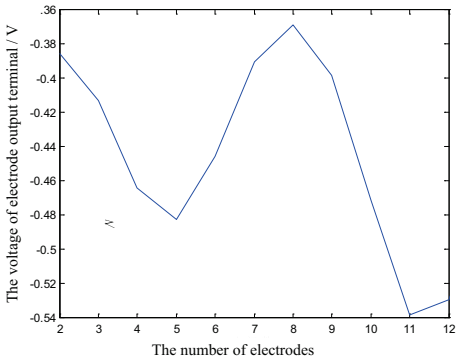
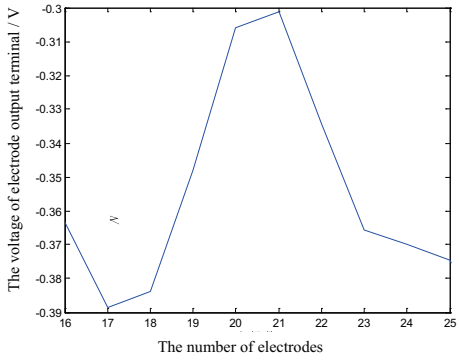


Figure 5 The Stability Output of the Electrochemical Regulation.



(a) The method proposed in this paper



(b) The traditional method.

Figure 6 The Voltage of Output Terminal of the Electrochemical Performance Regulation of High Specific Capacity Lithium Ion Battery Electrode Material.

5. CONCLUSION

In order to strengthen the electrochemical regulation of high specific capacity lithium ion battery electrode material, improve the output stability of the battery, and improve the output dynamic gain of the battery, this paper proposes a direct functionalization control model based on an inert C–C bond for the electrochemical performance regulation of high specific capacity lithium ion battery electrode material. It constructs the control model of a carbonyl allylation reaction of high specific capacity lithium ion battery electrode material. Combined with the feedback adjustment stability parameter adjustment method, it adjusts the polar parameter in the electrochemical regulation of the battery electrode material. It also adopts an asymmetric carbonyl allylation reaction to regulate the molecular catalytic reaction during the preparation of lithium ion battery electrode material. The optimal controls of the design, preparation and electrochemical performance regulation of electrode material for high specific capacity lithium ion batteries are realized. The results show that the method proposed in this paper has a good steady-state and strong catalytic ability to regulate the electrochemical performance of battery electrode material. The stability of electrochemical control is improved. The battery electrode also has a large output gain and good performance.

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