Modified Resin for Aluminium Carbon Anode Preparation

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Abstract

This study focuses on resins, comparing the characteristics of various types and investigating how modification methods such as doping and heat treatment affect resin performance. The results show that the coking value of modified resin significantly improves – by approximately 15 % compared to unmodified resin – but viscosity also increases. With a reasonable selection of modifier ratios and effective balance between coking value and viscosity, modified resin can be used to enhance overall anode quality. Anodes prepared with modified resin as a binder under laboratory conditions met industrial application standards, with air reactivity residue rates above 70 % and resistivity at 57.11 µΩ·m, meeting anode usage requirements.

Keywords: Anode Recipe Modification, Resin

1. Introduction

Coal tar pitch is a complex mixture composed of highly condensed polyaromatic compounds [1, 2], characterized by high carbon content, low cost, wide availability, and good binding properties, making it widely used as a binder for aluminium carbon anodes. As a binder for anodes, coal tar pitch serves two main purposes: first, to ensure the plasticity and good formability of the paste; second, during calcination, it penetrates the aggregate and carbonizes between particles to form a mechanically strong and homogeneous anode [3–5]. However, due to the high polycyclic aromatic hydrocarbon (PAH) content in coal tar pitch, its use in anode production results in significant PAH emissions, which pose health risks to workers and worsen the working environment [6, 7]. Approximately 50 % of the total coal tar pitch market is consumed as binder for aluminium electrolysis carbon anodes. With increasingly stringent environmental policies and a downturn in the upstream coal tar processing market, China's coal tar pitch production has experienced fluctuations and decline.

In recent years, the implementation of the "dual carbon" goals – carbon peak and carbon neutrality – together with the impact of new energy industries such as lithium-ion batteries on the traditional petrochemical sector, as well as improvements in both processes and products by upstream raw material enterprises, has significantly affected the production and supply of coal tar pitch for carbon anodes, further impacting the quality of carbon anodes used in aluminium electrolysis and restricting the survival and development of the aluminium industry. To address the shortage of high-quality coal tar pitch, actively seeking suitable alternative raw materials and developing environmentally friendly binders for anode production is an effective solution.

Domestic and international research has mainly focused on high-softening-point coal tar pitch, and some studies have explored using biomass tar as a substitute [8]. Studies have shown that increasing coal tar pitch softening point from 110 °C to 170 °C can reduce PAH emissions by 57.3 %, significantly lowering environmental pollution [9, 10]. In terms of biomass pitch replacing coal tar pitch, studies investigated biomass pitch characteristics and its interaction with calcined coke [11], demonstrating that biomass pitch can coat coke particle surfaces and penetrate open pores, fulfilling the same role as coal tar pitch and enabling its use in anode production.

Research on eco-friendly anode binders has mainly focused on developing new types of binders. Shandong Shengquan Group has carried out studies on using conductive phenolic resin to replace traditional coal tar pitch as a binder in carbon anode production. This enables room-temperature mixing, shortens the calcination cycle, and results in pyrolysis products that are primarily water, carbon dioxide, and other non-toxic, harmless substances. However, due to the insulating nature of resins, the electrical conductivity of the resulting anodes remains inferior to traditional ones, and storage difficulties persist. Despite this, resin has significant advantages in anode applications, enabling environmentally friendly production and room-temperature processing, reducing calcination time, and improving production efficiency.

This paper uses resin as a raw material to prepare resin-based binders for anode production through modification methods. It analyses how binder performance varies with modification conditions and evaluates the feasibility of using resin-based binders in anode manufacturing.

2. Experiment

2.1 Experimental Materials

Phenolic resin was selected as the experimental raw material. Its basic properties and microelement content were analysed. Table 1 shows the coking value, ash content, and volatile content of coal tar pitch and phenolic resin. As seen in Table 1, there are notable differences in base properties between the two: the coking value of coal tar pitch is 57.43 %, while that of phenolic resin is 51.71 %; ash content of coal tar pitch is 0.15 %, compared to 0.31 % for phenolic resin; volatile content is 54.9 % and 63.3 %, respectively. Although phenolic resin meets the ash content requirements, its coking value is lower than that of coal tar pitch. Therefore, its suitability as an anode binder may be improved through modification.

Table 1. Basic properties of phenolic resin.

Binder Type	Coking Value / %	Ash Content / %	Volatile Matter / %
Coal Tar Pitch	57.43	0.15	54.9
Phenolic Resin	51.71	0.31	63.3

Table 2 presents the microelement contents of coal tar pitch and phenolic resin. As shown, phenolic resin has overall lower microelement levels and basically meets the requirements for anode binder use. Most element concentrations in phenolic resin are lower than in coal tar pitch, except for sodium, which reaches $3350 \cdot 10^{-6}$, likely related to the production process of phenolic resin. Further experiments are needed to assess its impact on anode quality.

Table 2. Chemicals in phenolic resin.

	S/%	V/10^{-6}	Na/10^{-6}	Ca/10^{-6}	Si/10^{-6}	Fe/10^{-6}	Ni/10^{-6}
Coal Tar Pitch	0.66	0	280	220	170	210	0
Phenolic Resin	0.048	25	3350	15	15	7	6

During carbon anode mixing, binder viscosity is typically controlled between 300–600 mPa·s, ensuring good flowability and effective wetting of coke particles. This helps form high-density, low-porosity, and structurally uniform anodes. Tables 3 and 4 show the dynamic viscosity of coal

(3) Under laboratory conditions, anodes prepared using modified resin meet industrial standards. Their air reactivity residual rates exceed 70 %, and the resistivity is 57.11 μΩ·m, meeting the performance requirements for anodes.

5. References

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