Effect of Wood Type on Biocoke Wettability by Coal Tar Pitch

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Abstract

One of the major challenges for the aluminum industry is the greenhouse gas (GHG) emissions generated both during the manufacture of carbon anodes and during the electrolysis. The aluminum industry is actively pursuing sustainable production practices and reducing greenhouse gas (GHG) emissions. Carbon anodes used in aluminum electrolysis are composed of petroleum coke, coal tar pitch, recycled anodes and butts. In order to reduce GHG emissions, several solutions have been proposed, including the partial replacement of petroleum coke by biocoke in carbon anodes. Biocoke is obtained by pyrolysis of wood chips around 1 100 ºC, similar to the maximum temperature reached during anode baking. Our research group succeeded in replacing part of the petroleum coke with biocoke modified with additives without affecting the anode properties. However, only one source of wood chips was used in the biocoke production.

The objective of this study was to investigate how the choice of wood type for biocoke production and the modification of the produced biocoke influence its wettability by coal tar pitch. In this work, five different wood species were used to produce biocokes which were then modified using an additive. The type of wood species was the only difference among the five unmodified biocoke samples. They were all produced under the similar conditions. The wettabilities of unmodified and modified biocokes by the pitch were measured using the sessile-drop method. The wettability plays a major role in the penetration of pitch into the pores of biocoke particles as well as the biocoke bed, a critical factor in producing high-quality anodes. The best wood species among the ones studied were identified for use in future anode production.

Keywords: Anode, Wood species, Biocoke, Wettability, Additive

1. Introduction

Aluminum is one of the most used metals in various fields such as aeronautics, construction or even in everyday life. It is electrolytically produced from alumina (Al_2O_3) in the presence of a carbon source (anode) using electrical energy [1]. During this process, about 0.44 tonne of carbon is consumed and about 2 tonnes of CO_2 equivalent per tonne of aluminum is produced [2, 3]. Thus, even if the Canada produces the greenest aluminum in the world [3], there is still GHG emissions. Aluminum industry is aiming to further reduce these emissions to achieve more sustainable aluminum production.

Carbon anodes are composed of petroleum coke, butts, rejected anodes (baked and green) used as dry aggregate and coal tar pitch used as binder. Among these, the coke is the raw material, which is used in high quantities compared to the other raw materials [1]. It is important that the pitch penetrates into the pores of the coke particles and empty spaces between the particles. During baking, pitch carbonizes forming pitch-coke which binds the aggregate particles together resulting in good quality anodes. The anode quality has the outmost importance for overcoming many challenges the aluminum industry is facing with respect to issues related to carbon loss, energy use, cell performance, and production cost, especially for high amperage cells.

To reduce the GHG emissions using different raw materials and maintaining the anode quality at the same time is very challenging [7-16]. Utilization of biocoke to partially replace the petroleum coke as an alternative raw material has not been successful, because it results in deterioration of anode quality [7, 8, 11-16]. This decline is due to the highly porous nature of biocoke and its weak interactions with pitch. Researchers have been working on improving the properties of coke and pitch by chemical modification making use of additives and surfactants [5, 6]. The researchers of the Research Chair on Industrial Materials (CHIMI) modified the biocoke and successfully replaced 3 % of the coke with this raw material without affecting the anode quality [7-16]. Biocoke is a carbon material produced from biomass (wood chips, sawmill dust, etc.). It is inexpensive, renewable, and available [18]. The partial replacement of petroleum coke by biocoke, produced from wood residue, has the potential of reducing the production cost and the GHG emissions.

In 2018, a study carried out by the researchers of CHIMI recommended the utilization of small biocoke particles (45 µm) to reduce the effect of biocoke porosity on the anode quality [11]. It was found that the replacement of 3 % of o petroleum coke by the biocoke did not lead to degradation of the anode properties for the given raw materials. In another study, they tested the effect of the biocoke percentage on the anode quality. This time, the size reduction of biocoke particles was not enough to maintain the anode quality. The difference between this study and the previous one was the type of petroleum coke used. As it is well-known, the coke quality changes from one supplier to another as well as the coke blending. To enhance the wettability of biocoke by pitch so that it can be used with different types of cokes, the surface of the biocoke was chemically modified using an additive [12]. It was found that anodes manufactured with 3 % biocoke modified with 3 % additive, in general, had better properties than those manufactured with unmodified biocoke for different types of coke [14]. In order to determine additive to be used for the modification of biocoke, an investigation was carried out using different additives. The results showed that not all selected additives improved the biocoke-pitch interactions [15]. In addition, other studies were carried out to improve the quality of the biocoke used in anode production. The effect of heating rate used during biocoke production [16] and the final pyrolysis temperature [13] on the quality of the anodes were studied.

In all of the above studies, only one type of wood was used to produce biocoke. This article focuses on the utilization of various types of species for the production of biocoke in order to investigate the impact of wood type used on the biocoke-pitch interactions, and effect of its eventual utilization on the anode quality were investigated. For this purpose, the modification of five different biocokes with an additive and the measurement of the wettability of unmodified and modified biocokes by pitch were carried out. Additive chosen as the best additive during the previous study [15] was used. In general, the correlation between the wettability of biocoke/coke by the pitch and the quality of green anode is very good [19]. Thus, the wettability test is a useful tool for preselecting the suitable species for the biocoke production. If the best type of wood is determined to produce biocoke, it might be possible to increase the percentage of petroleum coke replaced in the anode which would decrease the GHG emissions further.

The wettability test is used to assess the level of interactions between coke and pitch. The measure of the wettability is the contact angle, which is the angle formed between the solid (biocoke) and liquid (pitch) phases when a pitch drop is placed on biocoke bed (see Figure 1). It is affected by several parameters such as the porosity of the solid (both particle and bed porosity), the compatibility of surface functional groups present on the biocoke and pitch surfaces. A contact angle greater than 90° indicates that the liquid/solid system is non-wetting. If the contact angle is

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6. References

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