Iron Recovery from Mining Waste and Production of Fe/C Composites using Acid Aqueous Fraction from Bio-oil

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Introduction

Fast pyrolysis of biomass gives high yields of a dark-brown liquid, besides a byproduct char and gas.[1] The liquid is composed of an organic phase, known as bio-oil, which can be used as a fuel, and an aqueous phase, the acid extract. The production of this extract is seen as a disadvantage in the pyrolytic process.[2]
Mining activity is one of the most important sectors in Brazil, especially in the case of iron ore. However, mining companies have problems with the destination of their wastes: iron rich, but not suitable to be used in the industry. Laterite is one of these wastes, with iron highly dispersed and extremely hard to separate.
An innovative and cheap method of iron recovery from mining wastes is proposed in this work. The iron present in laterite is extracted by the acid aqueous fraction from bio-oil and, after a thermal treatment, the composite obtained can be directly used in steelmaking process. Besides, an upgraded fuel can be obtained from the acid fraction (Equations 1 and 2).

$$Fe^{3+}_{Laterita} + \text{Acid Fraction} \rightarrow \text{Acid}/Fe^{3+}_{extracted} \quad (1)$$
$$\text{Acid}/Fe^{3+}_{extracted} \rightarrow Fe^{0}/\text{Carbon} + \text{Fuel} \quad (2)$$

Results and Discussion

The experiments of iron extraction were done with 5 mL of acid extract and 500 mg of natural laterite ore at 100ºC, varying the time of reaction: 8, 24, 48 and 72 hours. Acid extract is capable to perform the iron extraction in a very good extension in 48 hours of reaction, presenting an extraction of 37% of the iron present in laterite.
After extraction, the mixture of acid fraction and Fe^{3+} extracted from laterite was dried and thermally treated under N_2 atmosphere at 500, 650 and 800ºC. In order to study the effect of the different temperatures of treatment, a mixture was done with acid fraction and $Fe(NO_3)_3.9H_2O$. The composites obtained were named according to the temperature of treatment, EAFe500, EAFe650 and EAFe800, besides the material without treatment, named EAFe.

Mössbauer and X-ray diffraction results showed that the material obtained at 800ºC presented phases of Fe^0, besides Fe^{3+}. For the materials EAFe500 and EAFe650, only Fe^{3+} phase was observed. Elemental and thermal analysis showed that the carbon contents of the materials were higher for the materials treated at higher temperatures. In SEM images it was possible to observe that the materials were heterogeneous, with particles of different sizes. Figure 1 shows SEM images obtained for the material EAFe800. In the images obtained with BSE detector it is possible to observe clear points referring to the presence of Fe^0 in this material.

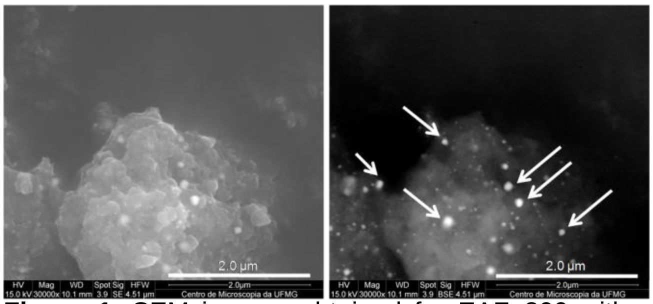

Figure 1. SEM images obtained for EAFe800 with SE (left) and BSE (right) detectors.

Conclusions

Acid aqueous fraction from bio-oil, considered a disadvantage in the pyrolytic process, was effective in iron extraction from laterite, a mining waste. The mixture obtained after the extraction was thermally treated in three different temperatures, in order to obtain Fe/C composites. The composite produced at 800ºC showed the presence of Fe^0 particles, and it can be directly used in the steelmaking industry.

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