Transformation of the Hematite Ultramicroparticles from Red Mud into Other Forms of Iron Oxides

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The main goal of the present research was to convert the hematite form of iron oxide from red sludge to other types of iron oxides, optimally magnetite. The washed red sludge and raw red sludge were mixed with quartz microparticles originating from pyrite ore, and their pyrolysis was performed (Figure 1). The final products were further tested by different characterization methods.

Red mud represent large accumulations of the waste from the Bayer process of the bauxite processing. Bosnia and Herzegovina possess two locations with such accumulations totalling 5 million tons (in Čitluk) and 19 million tons (Zvornik). Since at the same time, Bayer process is there to stay, as the process rendering extremely important products such as zeolites, still the potential of red mud a waste material as the source of useful materials is an ever expanding subject(Milačič et al., 2012; Sahu et al., 2010; Xue et al., 2016).

Although some of the construction-related applications are proven as concept, it is at the same time meaningless to use the red mud which potentially contains some of the critical or even rare earth metals into such purposes before trying to extract or concentrate those. Present study however, focuses on the most obvious, though not critical metal-iron. According to the data from the industry, Bosnian red mud contains somewhere around 48% of hematite, some alumina and silica with traces of titanium, niobium, and other trace metals. Transforming hematite into the maghemite or magnetite would ease its separation from the red mud, while at the same time concentrating other metals and potentially enabling their exploitation.

Figure 1. Red mud powder from Karakaj accumulation (Zvornik, Bosnia and Herzegvoina), left; pyrite-originating quartz, as micronized and classified.

The red mud was studied as produced and also in various degrees of neutralization. It was mechanochemically mixed with the quartz originating from the pyrite ore covered in nanolayer of pyrite, with purpose of increasing the specific surface and supporting the transformation of the hematite into magnetic forms of iron oxides. There are ideas and some data on potential of transformation of hematite to magnetite by mixing it would the natural pyrite ore(Liu et al., 2014). Here a similar, yet different approach was taken with controlled size quartz microparticles covered by nanolayers of pyrite.

XRD data suggested that potentially better results are obtained if pre-washed red sludge is used, whose pH is lowered to an average of about 8.36. In the case of washed red sludge in magnetic parts, the magnetite peaks are of medium to strong intensity, except in the sample in which the ratio of quartz: red sludge = 1: 4 where magnetite cannot be observed, but detected peaks typical of rutile (TiO_2).

On the other hand, in the samples where raw red mud was used, the ratio of quartz: red mud = 1: 4 and the ratio of quartz: red mud = 1: 6 proved to be the best, while in the other combinations magnetite was not detected

(Figure 2). Also, it was noticed that in the samples where the washed red sludge was used, magnetites of the formula Fe3O4 appear, while in the samples where the raw red sludge was used, the compound that appears is the compound of the formula $Fe_{2.538}O_4Ti_{0.462}$.

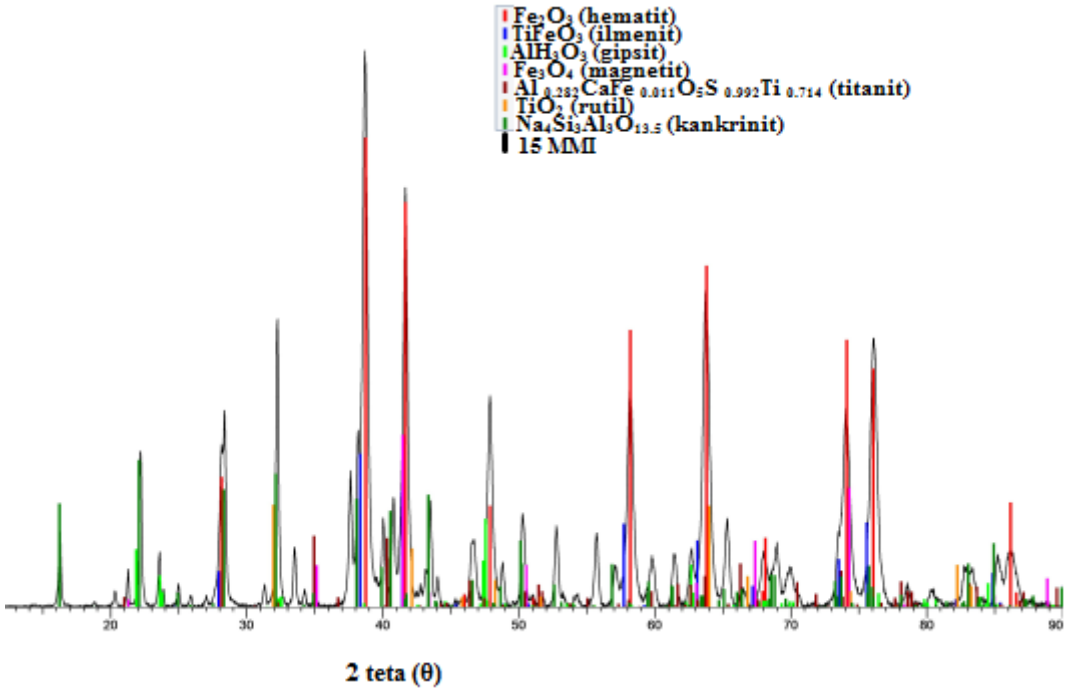

Figure 2. X-ray diffractogram of the sample treated with the 1:5 weight ratio of the pyrite-covered quartz showing appearance of the concentration of magnetite and titanium oxides

The researched method proved to be a potentially good method of converting hematite into magnetite. Also important is the fact that there is no mention of the same principle in the internationally available literature. What needs to be done further is research with changing pyrolysis conditions (time, temperature) or adding some reducing agent to red sludge for better conversion. Also, it would be important to confirm the presence of nanolayers or nanoparticles of pyrite on quartz particles of this type (method of X-ray photoelectron spectroscopy and energy dispersion X-ray spectroscopy) and determine their morphology by scanning electron microscopy.
As a final conclusion, it can be reported that the information obtained in this paper contributes to the possibility of developing methods for the recovery of iron in magnetic forms from this waste material as well as for concentrations of other useful even critical or rare metals, before conclusively eliminating the remains in the form of the construction industry filler.

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