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“Mine Water & Innovative Thinking”

CAPE BRETON UNIVERSITY

HYDROMETALLURGICAL/UV PROCESS TO PRODUCE FERROUS SULFATE FROM THE PYRITE PRESENT IN COAL TAILINGS

~ IMWA 2010 ~

Sydney, Nova Scotia, Canada
September 06th, 2010.

Introduction

Brazil

South of Brazil

- The main coal mines in Brazil are located in the South States of the country.

Introduction

Coal Production

Mining → Beneficiation

Energy Production

Coal Tailing

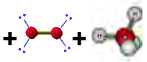
Introduction

- Resources of coal in Brazil are approximately 32 billion tons, but only 2% have been extracted.

- The beneficiation of coal in Brazil generates a great volume of tailings (from 50% to 70%).

- In the composition of coal tailings it is found pyrite (FeS_2), which is the responsible mineral for the production of the acid mine drainage (AMD).

Generation of AMD



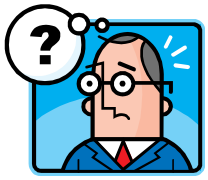
→ AMD

Acid mine drainage (AMD) is generated from the pyrite present in coal tailings that in contact with oxygen and water oxidize generating a solution with:

- low pH;
- high contents of iron;
- sulfate and other dissolved metals.

Area with generation of acid mine drainage (AMD)

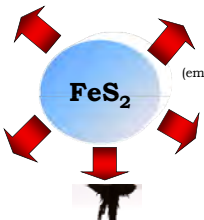
How to solve this problem ???



Possible Uses of Pyrite

Sulfuric Acid
(traditional use)

Coagulants
(emerging technology)



Pigments
(emerging technology)

Magnetite
(emerging technology)

FERROUS SULFATE
(emerging technology)

General Objective

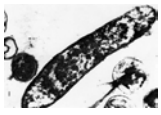
Production of ferrous sulfate by hydrometallurgical process!

Pyrite Oxidation and Bacterial Action

The bacterial action can increase the oxidation of pyrite (2) by a factor of 10^6.

$$2FeS_2(s) + 7O_2(aq) + 2H_2O \rightarrow 2Fe^{2+} + 4H^+ + 4SO_4^{2-} \quad (1)$$

$$4Fe^{2+} + O_2(aq) + 4H^+ \rightarrow 4Fe^{3+} + 2\,H_2O \quad (2)$$



These bacteria come from the genus *Acidithiobacillus* and *Leptospirillium*.

Then, it increases the amount of ferric iron in acid mine drainage (AMD)

Main Objective

▶ To develop a route for the production of ferrous sulfate n-hydrated crystals ($FeSO_4\ nH_2O$) from pyrite present in coal tailings.

CHALLENGE:
To convert ferric iron (Fe^{3+})
in ferrous iron (Fe^{2+})

Uses of Ferrous Sulfate ($FeSO_4$)

Ferrous sulfate has great use in our daily lives, in the health area, agriculture, industry, among others.

Drugs

Fertilizers

Wastewater Treatment

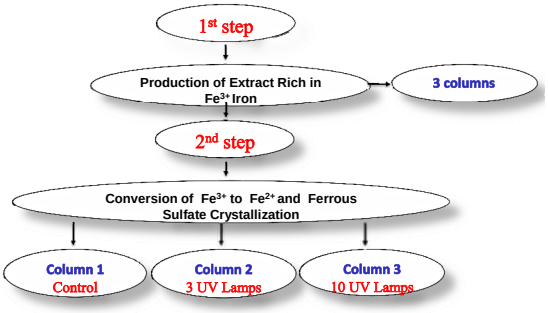
Uses of Ferrous Sulfate ($FeSO_4$)

Ferrous sulfate can be found in several states of hydration:

- FeSO4 H2O (mineral: szomolnokite)
- $FeSO_4$ $4H_2O$ (mineral: rozenite)
- $FeSO_4$ $5H_2O$ (mineral: siderotil)
- $FeSO_4$ $7H_2O$ (mineral: melanterite)

Experimental Methodology

Experimental Planning Scheme



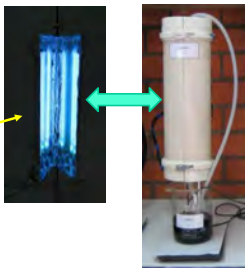
Experimental Methodology: 1st STEP

Production of the Extract Rich in Iron

Picture of the leaching reactor

Experimental Methodology: 2nd STEP

Conversion of Fe^{3+} to Fe^{2+}



Picture of Photoreactor

Experimental Methodology: 2nd STEP

Crystallization of Ferrous Sulfate

Purified with ethylic alcohol

Analysis:

- **XRD** (X-ray Diffraction)
- **SEM** (Scanning Electron Microscopy)

Results: 2nd STEP

- Studies of Conversion of Fe^{3+} to Fe^{2+}

Results: 2nd STEP

Ferrous Sulfate Crystals

COLUMN 2 – 3 UV LAMPS

COLUMN 3 – 10 UV LAMPS

Crystals of ferrous sulfate obtained in the columns 2 and 3

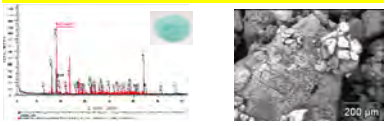
Results

• The recovery of Fe in the form of melanterite in relation to the pyritic iron existing in the columns ranged from 7.5 to 9.0%.

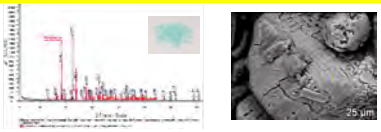
COLUMNS	RECOVERY (%)		
	Fe melanterite / Extracted Fe^{2+}	Fe melanterite / Total Extracted Fe	Fe melanterite Pyritic Fe
Column 1 Control	0.0	0.0	0.0
Column 2 UV-3 Lamps	75.0	50.0	9.0
Column 3 UV-10 Lamps	63.7	53.7	8.5

Results: XRD and SEM

Column 2



Column 3



Characterization of ferrous sulfate obtained by XRD and SEM.

The crystalline compound obtained was the **melanterite** ($FeSO_4 7H_2O$).

Conclusions

- The results showed that it is possible to produce ferrous sulfate heptahydrate from coal tailings using a leaching process under the action of ultraviolet radiation (UV).
- A new technology for commercial production of ferrous sulfate was developed using coal tailings as raw material, minimizing the environmental impact and making possible the development of a new product in coal mining in Brazil.

Acknowledgements

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REDE CARVÃO

CRICIÚMA S.A.

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Acknowledgements