STUDY OF THE DESULPHURATION POWER OF THE CHAR FROM MEAT AND BONE MEAL PYROLYSIS

E. Cascarosa; M.C. Ortiz de Zarate; G. Gea; J.L. Sánchez; J. Arauzo

Thermochemical Processes Group (GPT), Aragon Institute for Engineering Research (I3A), Zaragoza (Spain)
e-mail: jlsance@unizar.es

Bioenergy III: Present and New Perspectives on Biorefineries
May 22-27, 2011; Lanzarote, Spain
OUTLINE

1. INTRODUCTION AND OBJECTIVES
2. MATERIALS AND METHODS
3. RESULTS
4. CONCLUSIONS
OUTLINE

1. INTRODUCTION AND OBJECTIVES
2. MATERIALS AND METHODS
3. RESULTS
4. CONCLUSIONS
1. Introduction and objectives

Bovine Spongiform Encephalopathy (2000)

Regulation 94/381/EC

Use of meat and bone meal (MBM) forbidden
1. Introduction and objectives

MBM valorization

Pyrolysis

Char

Gasification
1. Introduction and objectives

**Char** → High metal concentration → Hot gasification gas cleaning

Avoid: Ni catalyst deactivation → H₂S removal

**Aim:** to evaluate the desulfurization capacity of MBM char and to compare it with the capacity of a tested product for this application as calcined dolomite.
OUTLINE

1. INTRODUCTION AND OBJECTIVES

2. MATERIALS AND METHODS

3. RESULTS

4. CONCLUSIONS
2. Materials and Methods

Bioware Pyrolysis Plant
2. Materials and Methods

CHAR PRODUCTION

1. Feeding hopper
2. Pyrolysis reactor
3. Cyclone
4. Bio-oil separator
5. Aqueous phase tank
6. Fuel gas to stack
7. Char tanks
8. Bio-oil stream

MBM

Char
## 2. Materials and Methods

### CHAR PRODUCTION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor treatment capacity</td>
<td>20 kg/h</td>
</tr>
<tr>
<td>Bed temperature</td>
<td>480 °C</td>
</tr>
<tr>
<td>$V_f/V_{mf}$</td>
<td>5.1</td>
</tr>
<tr>
<td>ER</td>
<td>0.21</td>
</tr>
<tr>
<td>Ash preparation</td>
<td>UNE 32-004-84</td>
</tr>
</tbody>
</table>
## 2. Materials and Methods

### FEEDSTOCK CHARACTERIZATION

MBM and char proximate and ultimate analyses

<table>
<thead>
<tr>
<th>Proximate Analyses</th>
<th>Analytical standard</th>
<th>MBM</th>
<th>Char</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (% w/w)</td>
<td>ISO-589-1981</td>
<td>5.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Volatiles (% w/w)</td>
<td>ISO-1171-1976</td>
<td>49.5</td>
<td>16.1</td>
</tr>
<tr>
<td>Ash (%w/w)</td>
<td>ISO-5623-1974</td>
<td>38.8</td>
<td>62.9</td>
</tr>
<tr>
<td>Fixed Carbon (%w/w)</td>
<td>By difference</td>
<td>6.8</td>
<td>19.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ultimate Analysis</th>
<th>Analytical Instrument</th>
<th>MBM</th>
<th>Char</th>
</tr>
</thead>
<tbody>
<tr>
<td>C %</td>
<td>Carlo Erba 1108</td>
<td>31.1</td>
<td>28.5</td>
</tr>
<tr>
<td>H %</td>
<td>Carlo Erba 1108</td>
<td>4.7</td>
<td>1.8</td>
</tr>
<tr>
<td>S %</td>
<td>Carlo Erba 1108</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>N %</td>
<td>Carlo Erba 1108</td>
<td>8.1</td>
<td>2.8</td>
</tr>
<tr>
<td>HHV (MJ/kg)</td>
<td>ISO 1928-76</td>
<td>14.3</td>
<td>4.1 ± 0.4</td>
</tr>
</tbody>
</table>
2. Materials and Methods

**FEEDSTOCK CHARACTERIZATION**

- Ash and dolomite composition

<table>
<thead>
<tr>
<th></th>
<th>Ash</th>
<th>Dolomite</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Al}_2\text{O}_3$ (wt. % ash)</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>$\text{CaO}$ (wt. % ash)</td>
<td>32.0</td>
<td>30.3</td>
</tr>
<tr>
<td>$\text{Fe}_2\text{O}_3$ (wt. % ash)</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>$\text{K}_2\text{O}$ (wt. % ash)</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td>$\text{MgO}$ (wt. % ash)</td>
<td>0.8</td>
<td>20.6</td>
</tr>
<tr>
<td>$\text{Na}_2\text{O}$ (wt. % ash)</td>
<td>1.3</td>
<td>-</td>
</tr>
</tbody>
</table>

The B.E.T. surface area of the samples of char, ash and calcined dolomite samples were respectively: 33.91, 4.15 and 18.75 m$^2$/g.
2. Materials and Methods

Experimental Plant

- Gas flow controller and meter
- Temperature controller
- Reactor
- Furnace
- Gas chromatograph
- Bed
- Fiberglass
- N₂
- Gasification gas
2. Materials and Methods

EXPERIMENTAL PLANT

- Gasification gas
- N₂
- Gas flow controller and meter
- Bed
- Temperature controller
- Reactor
- Furnace
- Gas chromatograph

Feeding system
\[ Q_{\text{gas}} = 50 \text{ ml STP/min} \]
2. Materials and Methods

EXPERIMENTAL PLANT

- Gas flow controller and meter
- Bed
- Reactor
- Furnace
- Gasification gas
- N₂
- Temperature controller
- Gas chromatograph

[Experimental Plant Diagram]

- T = 700; 900°C
- P = 1 atm
- \( m_{\text{solid}} = 1 \text{ g} \)
- Fixed bed
- WHSV = 3.6 h\(^{-1}\)
2. Materials and Methods

**EXPERIMENTAL PLANT**

- Gas flow controller and meter
- Bed
- Furnace
- Reactor
- Gas chromatograph
- Gas detection (H₂, N₂, CH₄, CO, CO₂, C₂H₄, C₂H₆, C₂H₂ y H₂S)
OUTLINE

1. INTRODUCTION AND OBJECTIVES
2. MATERIALS AND METHODS
3. RESULTS
4. CONCLUSIONS
3. Results

SULFUR EMISSION

![Graph showing Sulfur Emission over time for different conditions at 700°C and 900°C.](image)

- Char at 700°C
- Ash at 700°C
- Dolomite at 700°C
- Blank Run at 700°C

- Char at 900°C
- Ash at 900°C
- Dolomite at 900°C
- Blank Run at 900°C

Sulphur (mg/min) vs Time (minutes) for different conditions.
3. Results

SULFUR RETENTION

\[ Me_x O_y(s) + xH_2S(g) + (y - x)H_2(g) \rightarrow xMeS(s) + yH_2O(g) \]
### SULFUR REMOVAL CAPACITY

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature (°C)</th>
<th>Removal capacity (g Sulfur/100 g of material)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Char</td>
<td>700</td>
<td>1.42</td>
</tr>
<tr>
<td>Char</td>
<td>900</td>
<td>1.99</td>
</tr>
<tr>
<td>Ash</td>
<td>700</td>
<td>1.93</td>
</tr>
<tr>
<td>Ash</td>
<td>900</td>
<td>2.42</td>
</tr>
<tr>
<td>Dolomite</td>
<td>700</td>
<td>3.25</td>
</tr>
<tr>
<td>Dolomite</td>
<td>900</td>
<td>2.81</td>
</tr>
</tbody>
</table>

3. Results
### 3. Results

#### SULFUR REMOVAL CAPACITY

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature (°C)</th>
<th>Removal capacity (g Sulfur/100 g of material)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Char</td>
<td>700</td>
<td>1.42</td>
</tr>
<tr>
<td>Char</td>
<td>900</td>
<td>1.99</td>
</tr>
<tr>
<td>Ash</td>
<td>700</td>
<td>1.93</td>
</tr>
<tr>
<td>Ash</td>
<td>900</td>
<td>2.42</td>
</tr>
<tr>
<td>Dolomite</td>
<td>700</td>
<td>3.25</td>
</tr>
<tr>
<td>Dolomite</td>
<td>900</td>
<td>2.81</td>
</tr>
</tbody>
</table>

$g$ S/100 g ash
OUTLINE

1. INTRODUCTION AND OBJECTIVES
2. MATERIALS AND METHODS
3. RESULTS

4. CONCLUSIONS
CONCLUSIONS

• Char and ash from MBM can retain $\text{H}_2\text{S}$ from a synthetic gas mixture.

• Apart from its composition, BET surface of the char can help to Ca availability for its reaction with $\text{H}_2\text{S}$

• Ash obtained from the solid residue produced in the MBM pyrolysis could be a substitute of the dolomite used as sulfur removal in gas cleaning gasification processes.
STUDY OF THE DESULPHURATION POWER OF THE CHAR FROM MEAT AND BONE MEAL PYROLYSIS

E. Cascarosa; M.C. Ortiz de Zarate; G. Gea; J.L. Sánchez; J. Arauzo

Thermochemical Processes Group (GPT), Aragon Institute for Engineering Research (I3A), Zaragoza (Spain)
e-mail: jlsance@unizar.es

Bioenergy III: Present and New Perspectives on Biorefineries
May 22-27, 2011; Lanzarote, Spain
### 3. Results

#### Sulfur Removal Capacity

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature (°C)</th>
<th>Removal capacity (g Sulfur/100 g of material)</th>
<th>up to rupture point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Char</td>
<td>700</td>
<td>1.42</td>
<td>0.42 (22 min)</td>
</tr>
<tr>
<td>Char</td>
<td>900</td>
<td>1.99</td>
<td>1.03 (52 min)</td>
</tr>
<tr>
<td>Ash</td>
<td>700</td>
<td>1.93</td>
<td>0.75 (35 min)</td>
</tr>
<tr>
<td>Ash</td>
<td>900</td>
<td>2.42</td>
<td>1.17 (60 min)</td>
</tr>
<tr>
<td>Dolomite</td>
<td>700</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Dolomite</td>
<td>900</td>
<td>2.81</td>
<td></td>
</tr>
</tbody>
</table>
### Sulfur Removal Capacity

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature (°C)</th>
<th>Removal capacity (g Sulfur/100 g of material)</th>
<th>up to rupture point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Char</td>
<td>700</td>
<td>1.42</td>
<td>0.67 (22 min)</td>
</tr>
<tr>
<td>Char</td>
<td>900</td>
<td>1.99</td>
<td>1.63 (52 min)</td>
</tr>
<tr>
<td>Ash</td>
<td>700</td>
<td>1.93</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>900</td>
<td>2.42</td>
<td></td>
</tr>
<tr>
<td>Dolomite</td>
<td>700</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Dolomite</td>
<td>900</td>
<td>2.81</td>
<td></td>
</tr>
</tbody>
</table>

3. Results
BIBLIOGRAPHY


Cortez LAB, Mesa-Pérez JM, Rocha JD, Jordan RA, Marin-Mesa HR, Felfli FEF. Research and development in biomass fast pyrolysis technology in Brazil. Biomass & Bioenergy. (Manuscript pending of acceptance).


Cascarosa E., Gasco L., Gea G., Sánchez J.L., Arauzo J.
Co-gasification of Meat and Bone Meal with Coal in a Fluidised Bed Reactor. Fuel, DOI: 10.1016/j.fuel.2011.04.005
STUDY OF THE DESULPHURATION POWER OF THE CHAR FROM MEAT AND BONE MEAL PYROLYSIS

E. Cascarosa; M.C. Ortiz de Zarate; G. Gea; J.L. Sánchez; J. Arauzo

Thermochemical Processes Group (GPT), Aragon Institute for Engineering Research (I3A), Zaragoza (Spain)
e-mail: jlsance@unizar.es

Bioenergy III: Present and New Perspectives on Biorefineries
May 22-27, 2011; Lanzarote, Spain