Understanding Hydrated Lime Properties In Acid Gas Control

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McIlvaine Company Hot Topic Hour
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Understanding Sorbent Properties

- Material Handling
- Chemistry
- Reactivity
- Effect on Particulate Removal
- Reaction Products
Material Handling
Material Handling Characteristics

- **Silo Design**
  - Density (25 – 35 lbs/ft³)
  - Cone Angle
  - Flowability
    - Flow Aids
    - Rotary Feeder

- **Pneumatic Conveying**
  - Air Temperature Effect
  - Moisture Level
  - Piping design
Chemistry
Chemical Composition

- Mining location can influence the chemistry of the sorbent.
- Levels of calcium and magnesium compounds are important. (90% min.)
- Higher purity – Better?
Reactivity
Sorbent Reactivity

- Normalized Stochiometric Ratio
- Fineness/Surface Area
- Temperature
- Residence Time
# Sorbent Molecular Weight Analysis

<table>
<thead>
<tr>
<th>Sorbent</th>
<th>Chemical Formula</th>
<th>Moles to Capture 1 Mole SO₂</th>
<th>Molecular Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrated Lime</td>
<td>Ca(OH)₂</td>
<td>1</td>
<td>74</td>
</tr>
<tr>
<td>Trona</td>
<td>Na₂CO₃ • NaHCO₃ • 2H₂O</td>
<td>.67</td>
<td>151</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>NaHCO₃</td>
<td>2</td>
<td>168</td>
</tr>
</tbody>
</table>

**Example: Trona Reactions**

**Primary Reaction** - \(2(\text{Na}_2\text{CO}_3\cdot\text{NaHCO}_3\cdot2\text{H}_2\text{O})(s) + \text{heat} \rightarrow 3\text{Na}_2\text{CO}_3 (s) + 5\text{H}_2\text{O} (g) + \text{CO}_2 (g)\)

**Secondary Reaction** - \(\text{Na}_2\text{CO}_3 + \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 + \text{CO}_2\)
## NSR – Ratio of Moles Not Weight

<table>
<thead>
<tr>
<th>Normalized Stoichiometric Ratio</th>
<th>Theoretical Ratio By Weight of Sorbent to SO(_2) for Complete Capture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hydrated Lime</td>
</tr>
<tr>
<td>1.0</td>
<td>1.16</td>
</tr>
<tr>
<td>1.5</td>
<td>1.73</td>
</tr>
<tr>
<td>2.0</td>
<td>2.31</td>
</tr>
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</table>
Sorbent Particle Size

<table>
<thead>
<tr>
<th>Material</th>
<th>Unmilled</th>
<th>Milled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trona</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>110</td>
<td>13</td>
</tr>
<tr>
<td>Hydrated Lime</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Sorbent Surface Area

- As surface area increases, sulfur removal increases?
- A dynamic variable
  - Temperature Effects
  - Pore plugging
Surface Area Measurement

- No standards currently exist for sample preparation.
- Begun working on standards for sample preparation in ASTM.
- Temperature and length of time for sample preparation can influence results.
- Vacuum preparation may also be a factor.

**Effect of Sample Drying Temperature on Surface Area Measurement**

![Graph showing the effect of sample drying temperature on surface area measurement. The graph plots BET surface area (m²/g) against temperature (100°C, 150°C, 200°C) for samples A, B, and C.](image-url)
Temperature Effects

- Flue gas contains multiple components that could potentially react with the sorbent.
- These components react with the sorbent in different temperature windows.
- Downstream effects of the sorbent and the reaction products must be considered.
- Trade-offs to get the targeted level of removals must be evaluated on a site by site basis.
Residence Time Impact

- Longer times of exposure benefit all sorbents.
- Temperature profile of exposure time is important.
Particulate Removal
Particulate Removal Considerations

- **Baghouse**
  - Provides greater exposure of the sorbent to flue gas which can improve removal efficiencies

- **Electrostatic Precipitator**
  - Increased solids concentration can be problematic for ESP performance
  - Lime injection can increase resistivity. Humidification can improve collection performance.
Reaction Products
Effect On Fly Ash

- Spent sorbent can be a significant portion of the fly ash collected
- Soluble salts can limit beneficial use
- Solubility of metals in ash could be impacted
Summary
Summary

- There are a wide range of characteristics that can influence the performance of sorbents.
- Differences in flue gas composition and process characteristics between boilers point to the need for testing to define performance.
- The impact of reaction products should be considered when looking at the viability of different sorbent options.
Questions?