Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

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Enhance SCR Performance by Removing SO_3 with Trona

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Solvay Chemicals

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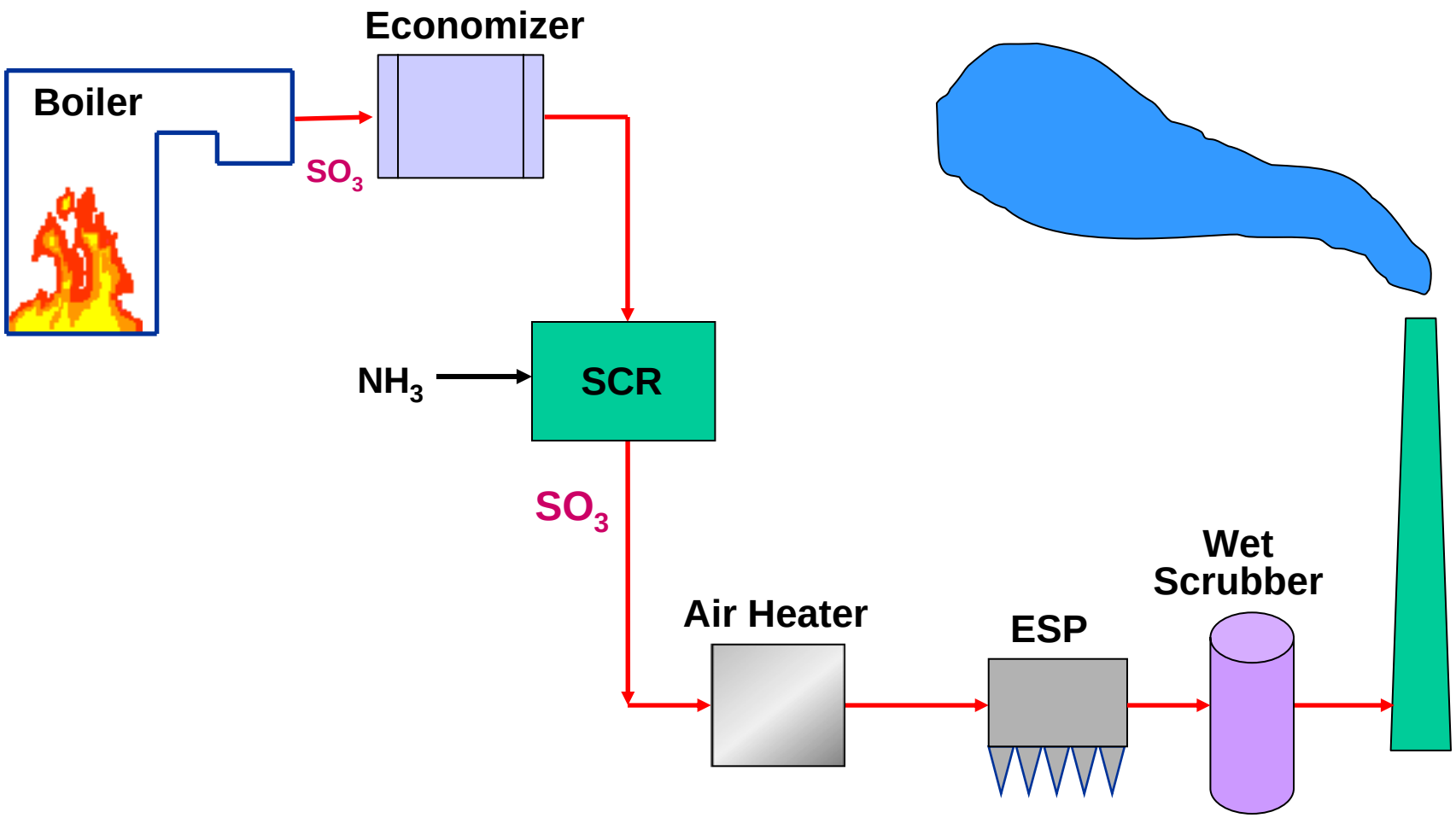
Unintended Consequence of SCR: SO_3



SO_3 Formation

- SO_3 generation in boiler: 0.1 to 1.5% of SO_2 converted into SO_3
  - Oxidation of sulfur during combustion
  - Catalytic oxidation of SO_2 by contaminants.
- SO_3 generation in SCR
  - Catalytic oxidation of SO_2 to SO_3
    - Low conversion catalyst: < 0.5% of SO_2
    - Regular conversion catalyst: up to 2% of SO_2
  - Function of inlet SO_2 concentration, type of catalyst, catalyst activity and operating temperature
- SO_3/H_2SO_4 can cause blue plume depending on atmospheric conditions, concentration, temperatures and effect can be enhanced by presence of wet scrubbers. H_2SO_4 is a condensable and can be regulated.

SO_3 on SCR Performance

- SO_3 can react with NH_3 under the catalytic conditions that exist in the SCR at temperatures in the range of 530 ºF to 630 ºF (Minimum Operating Temperature):

$$NH_3 + SO_3 + H_2O \longrightarrow NH_4HSO_4 \text{ (ABS)}$$
$$NH_4HSO_4 + NH_3 \longrightarrow (NH_4)_2SO_4 \text{ (AS)}$$
$$2NH_3 + SO_3 + H_2O \longrightarrow (NH_4)_2SO_4 \text{ (AS)}$$

- AS is dry powder that can pass through SCR catalyst.
- ABS is sticky and can plug the SCR catalyst.

Other SO_3 Caused Problems

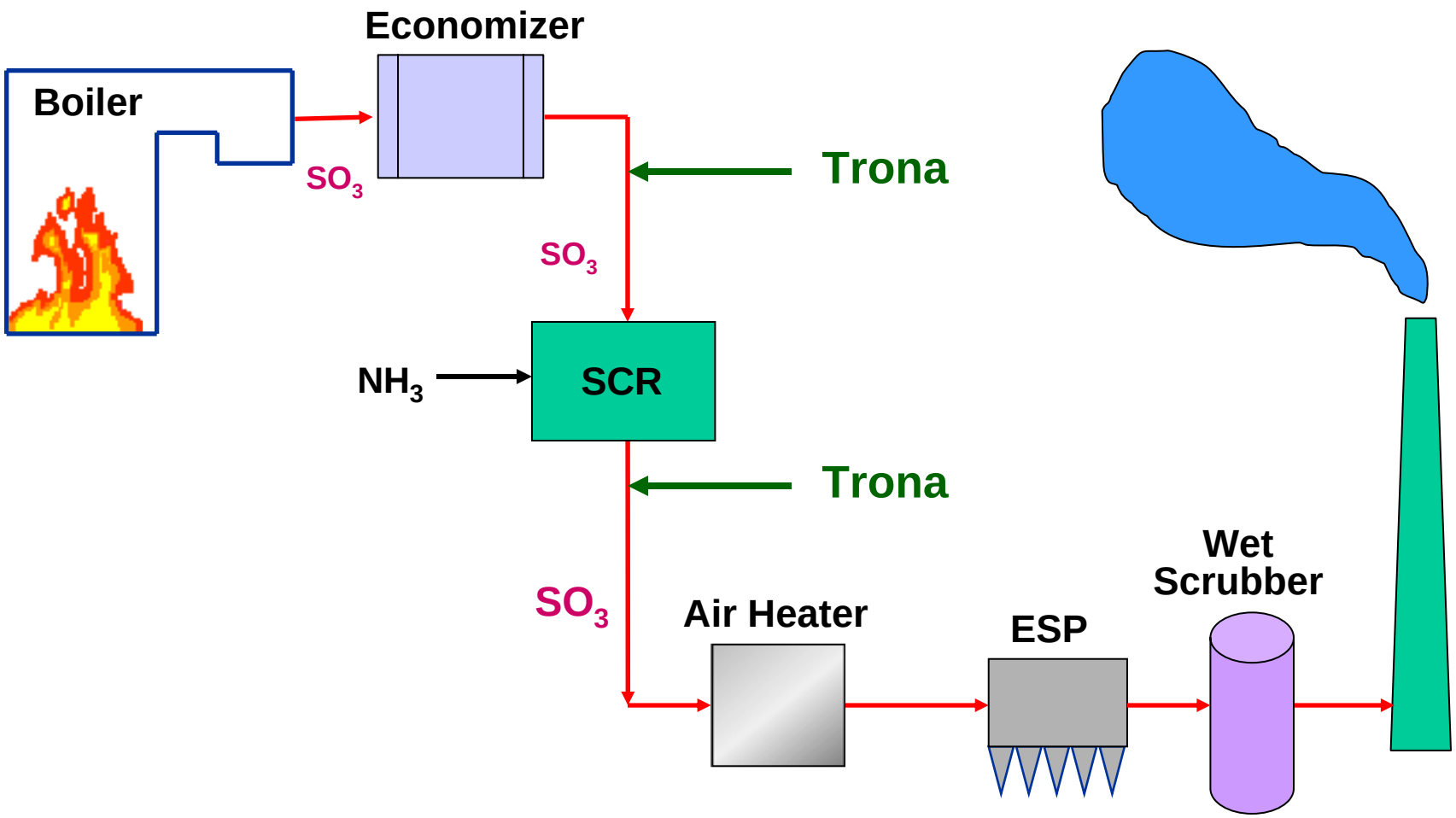
- **SO_3 and ammonia (NH_3) can react to form ammonium bisulfate (ABS) in the air heater if the flue gas temperature is between 350° F and 420° F. Sticky ABS causes fouling of air heaters**
- **Corrosion of downstream equipment**
- **Reduction of unit heat rate. Raising air heater outlet temperature by 35° F would reduce unit heat rate by 1%.**
- **Competition of SO_3 with mercury for adsorption sites on activated carbon, thus reducing the effectiveness of mercury control.**

SO_3 Control Locations

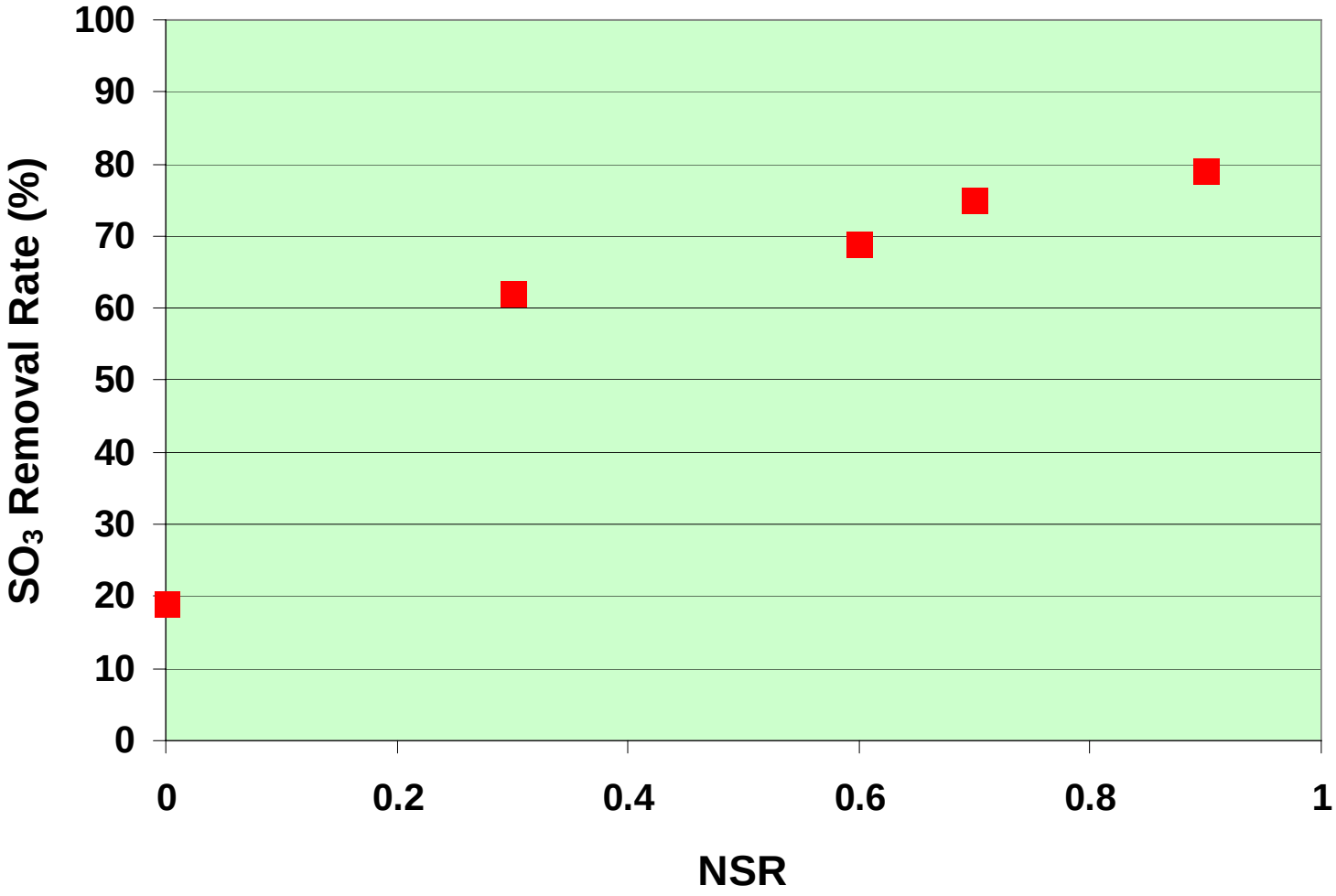
- **Upstream of SCR**
  - **Mitigate SO_3 generated from boiler to avoid SO_3-NH_3 reactions inside SCR.**

- **Downstream of SCR**
  - **Mitigate SO_3 generated in SCR to avoid ABS formation, corrosion to downstream equipment and blue plume.**

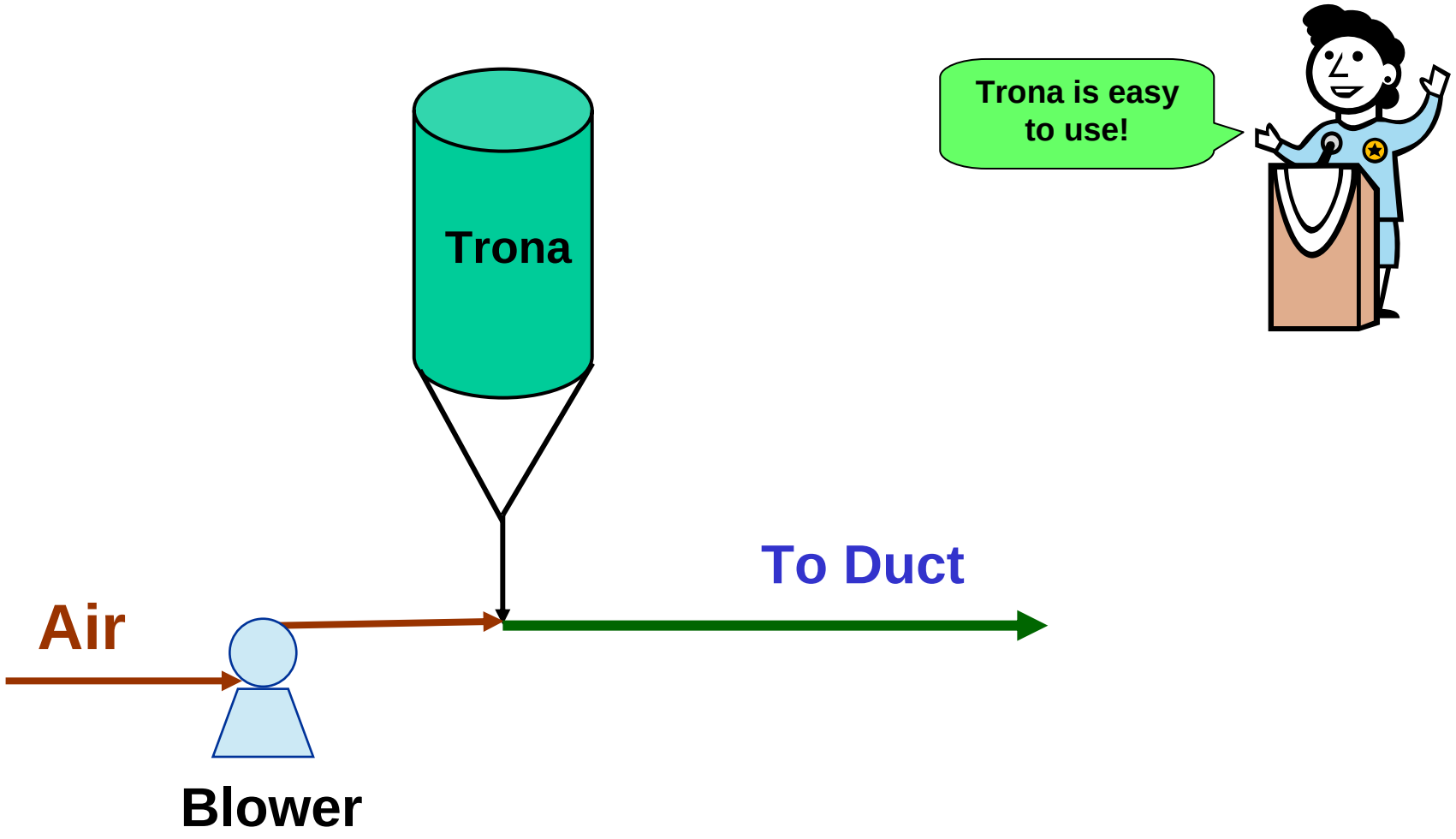
Trona Injection to Mitigate SO_3



SO_3 Removal Performance with Trona



Typical Trona Injection System



What is Trona?

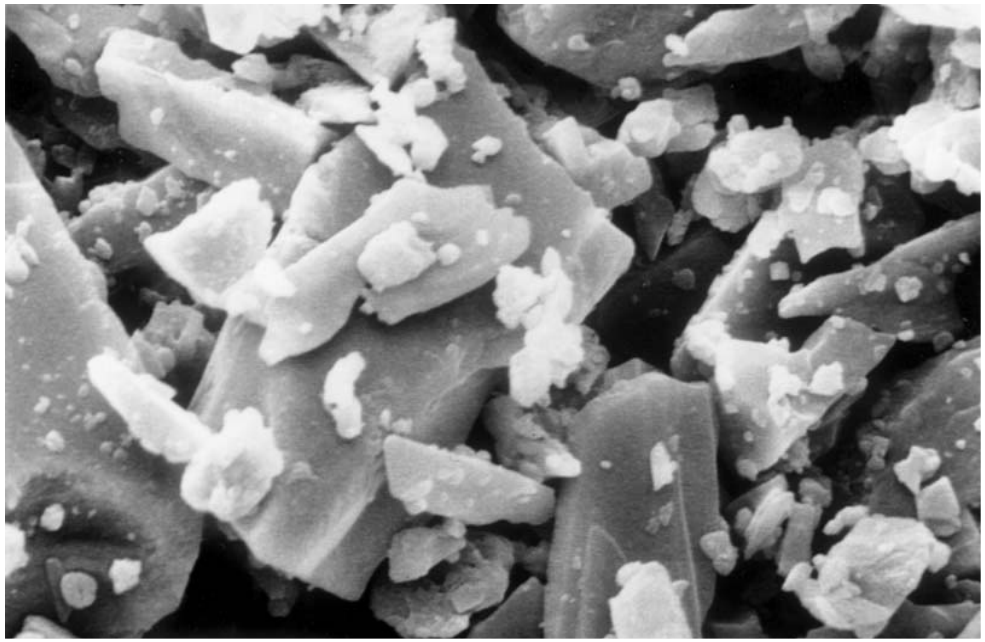
- Trona is an ore mined underground
- Trona is naturally formed sodium sesquicarbonate (Na_2CO_3• $NaHCO_3$•$2H_2O$)
- Green River, Wyoming, has billions of tons of Trona

SOLVAir® Select 200 - Typical Analysis

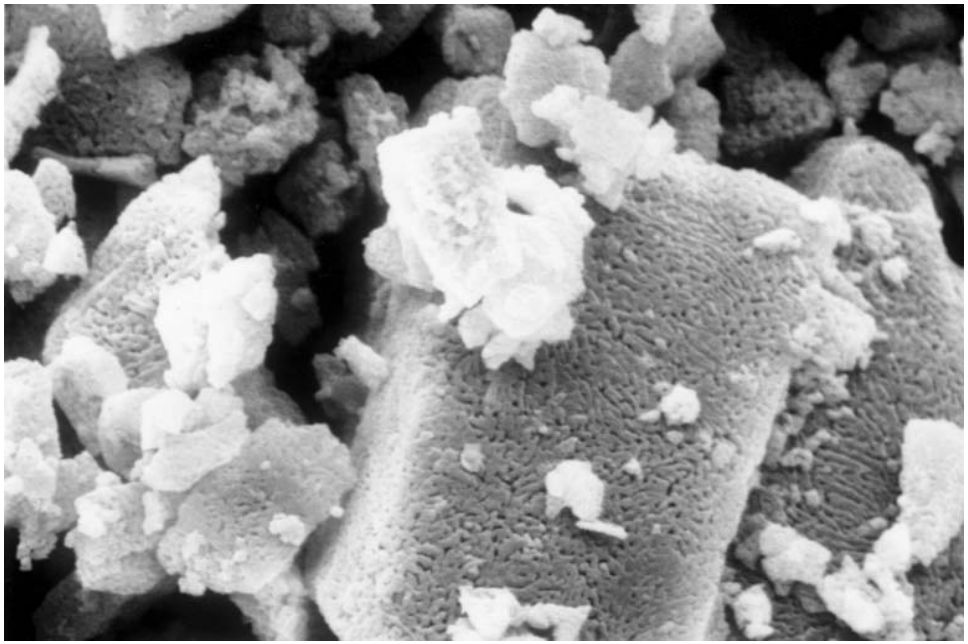
- **Purity** 97.5%
- **Free Moisture** 0.02%
- **NaCl** 0.2%
- **H_2O Insoluble** 2.3%
- **Free Flowing Bulk Density** 49 lb/ft^3
- **Mean Diameter - (d_{50})** 30 µm

Trona After Injection

Raw Ground Trona



Trona Heated at > 275 °F



$$2(Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O)(s) + \text{heat} \rightarrow 3Na_2CO_3(s) + 5H_2O(g) + CO_2(g)$$

Parameters Affecting Performance

- Sorbent injection rate /Normalized Stoichiometric Ratio (NSR)
- Sorbent particle size
  - Mill or no mill?
- Sorbent residence time in flue gas stream
- Sorbent penetration and mixing with flue gas
- Particulate control device (ESP or Baghouse)
- Flue gas temperature
  - Minimum 275 ^{o}F
  - The higher, the better up to 1500 ^{o}F

Guidelines of Trona System

- Distribute trona evenly in flue gas so that trona and acid gases are well mixed.
- Residence time: > 1 second
- Flue gas temperature: 275 ~ 1500 ºF
- Conveying air: < 140 ºF

Summary

- SO_3 generated from boiler can react with NH_3 in SCR catalyst to form sticky ABS which degrades SCR performance.
- SO_3 generated in SCR catalyst can react with NH_3 slip to form ABS in air preheater which can cause plugging.
- Inject trona upstream and downstream of SCR to mitigate SO_3 in both situations
  - Both locations provide right temperatures for trona.
- Trona handling system is simple – low capital and maintenance costs, but still requires sound engineering to maximize its effectiveness.

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