

## ***SIMULTANEOUS DETERMINATION OF CARBON DIOXIDE AND HYDROGEN SULFIDE IN AMINE GAS SCRUBBING SOLUTIONS***



**Figure 1:** CM740 Simultaneous Carbon/Sulfur Analyzer

### **PRINCIPLES OF OPERATION AND TYPICAL USE**

This procedure is typically utilized for the analysis of amine solutions which are used to remove environmentally-controlled emissions from flue gases. This method measures the amount of carbon dioxide (CO<sub>2</sub>) and the amount of hydrogen sulfide (H<sub>2</sub>S) in the scrubbing solution. This result is used along with other analyses to determine the amine scrubbing solution's efficiency and remaining capacity.

The system is composed of an CM5016 Dual Carbon/Sulfur Coulometer and CM5330 Acidification Module. The Acidification Module is purged of atmospheric CO<sub>2</sub>, SO<sub>2</sub> and H<sub>2</sub>S with an inert carrier gas. After purging the system, an aliquot of the amine solution is injected into the sample flask. Acid is then added using the dispenser on the Acidification Module. The gases evolved from the acidification of the sample then pass into the special SO<sub>2</sub> cell of the coulometer where SO<sub>2</sub> and H<sub>2</sub>S are absorbed into the solution and titrated. CO<sub>2</sub> is not absorbed into the sulfur detector solution and provides no interference. The CO<sub>2</sub> enriched carrier gas is then routed to the CO<sub>2</sub> cell where it is absorbed and automatically titrated.

### **APARATUS**

Simultaneous Carbon/Sulfur Analyzer includes:

- CM5016 Dual Carbon/Sulfur Coulometer
- CM5330 Acidification Module
- Special, air-tight sulfur cell
- Carbon cell

Contact us for more information:

## REAGENTS

1. Pre-Scrubber Solution: 40-45% (wt/vol) potassium hydroxide (KOH)
2. Post Scrubber Solution: 3% (wt/vol) silver nitrate (AgNO<sub>3</sub>), acidified to pH 3
3. Acid: 2 to 4N Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>)
4. CM300-001 Carbon Cathode Solution
5. CM300-002 Carbon Anode Solution
6. CM300-003 Potassium Iodide (KI)
7. CM300-026 Sulfur Anode Solution
8. CM300-027 Sulfur Cathode Solution
9. External Carrier Gas (optional)

**NOTE:** An external carrier gas, such as nitrogen, helium, or CO<sub>2</sub>-free air may be used in place of the "internal" air source of the Acidification Module if desired.

## PROCEDURE

### ASSEMBLY

Assemble the Acidification Module and Carbon/Sulfur Coulometer as instructed in their respective manuals. It is especially important to ensure that the special sulfur analyzer cell is leak free and that the flow from the acidification module always passes through the SO<sub>2</sub> cell first. The solution in the CO<sub>2</sub> cell is adversely affected by sulfur compounds and passing the carrier gas through the sulfur cell first effectively removes all interfering compounds.

An optional solid silver or silver nitrate scrubber may be used in line between the sulfur cell and the carbon cell as an indicator of sulfur cell efficiency. Black precipitate in the silver nitrate solution or "graying" of the solid silver indicates that SO<sub>2</sub> or H<sub>2</sub>S is not being properly absorbed into the sulfur cell solution.

Place a stir bar in a 100-ml sample flask and attach the flask to the bottom of the condenser on the Acidification Module. Secure the flask with the red locking ring. Place the flask and assembly into the heating and stirring port of the Acidification Module. Heating is not normally required so the condenser does not need to be connected to a cooling source. If an external carrier gas is used, adjust the pressure of the system to 2-5 psi. Set the flow to 100 ml/min. using the flow meter on the front of the Acidification Module. (See Figure 2 for an example of the set-up and flow diagram).

### ANALYSIS

Determine the background rate of the system by entering "blank" as the sample name in the Sample Entry screen of CM5016 Coulometer. The coulometer will automatically determine and store the blank value according to the user selectable settings saved within the systems' memory. The instrument will use the saved blank value in calculating the final result values.

To perform an analysis, draw the sample into a syringe that is fitted with an injection needle. (See note on "sample integrity".) Usually 200 to 300 µl of sample is used depending on the sample's H<sub>2</sub>S content\*. Start the coulometer and inject the sample into the sample flask through the septum at the top of the sample column adapter. Add 5 to 10 ml of acid to flush the sample through the sample column line. The analysis endpoint will be automatically determined by the coulometer according to the user selectable settings saved within the instrument. End results are saved on a USB Flash Drive and optionally printed to attached printer.

Contact us for more information:

**\*NOTE:** Due to lower H<sub>2</sub>S solubility in the sulfur cell solution sample sizes should be adjusted to allow no more than 2500 µg S per sample at a 100 ml/minute flow rate.

The weight of the sample can be determined in either of two ways. First, the syringe can be weighed before and after injection. The weight of the sample is determined by the difference between these two measurements. Second, if the density of the sample is known, the injection volume can be noted and the weight can be calculated. This method requires a volumetric syringe. After a few samples are analyzed, the blank should be re-established and occasionally checked throughout the day. The sample flask does not need to be emptied until it is almost full.

Although calibration is not required, the instrument's performance can be checked using calcium carbonate (CaCO<sub>3</sub>) and Sodium Sulfite (Na<sub>2</sub>SO<sub>3</sub>). This is done by weighing 10 to 15 mg of CaCO<sub>3</sub> and 5 to 10 mg of Na<sub>2</sub>SO<sub>3</sub> into a small teflon cup and placing it in a 10-ml sample flask. The sample flask is connected to the bottom of the condenser, purged, and then acidified. Alternatively, the user may use a liquid standard to verify the instrument's performance. To prepare a 10,000 mg C-S/L solution, weigh 3.237 g of sodium bicarbonate, 4.428 g of sodium carbonate and 3.931 g of sodium sulfite and transfer all to the same 100 ml volumetric flask. Bring to volume with reagent water. This solution should yield 2000 µg C and 2000 µg S when using a 200 µl injection. The user should establish acceptance criteria for whichever type of performance check is used.

**NOTE:** Sample Integrity ... Because of the ability of amine solutions to absorb CO<sub>2</sub>, sample handling is extremely important. The collection should be done so that the sample has as little contact with the air as possible. Ideally, the samples should be collected into bottles with septum tops. The septum top allows the sample to be drawn into the injection syringe without opening the sample bottle.

## RESULTS

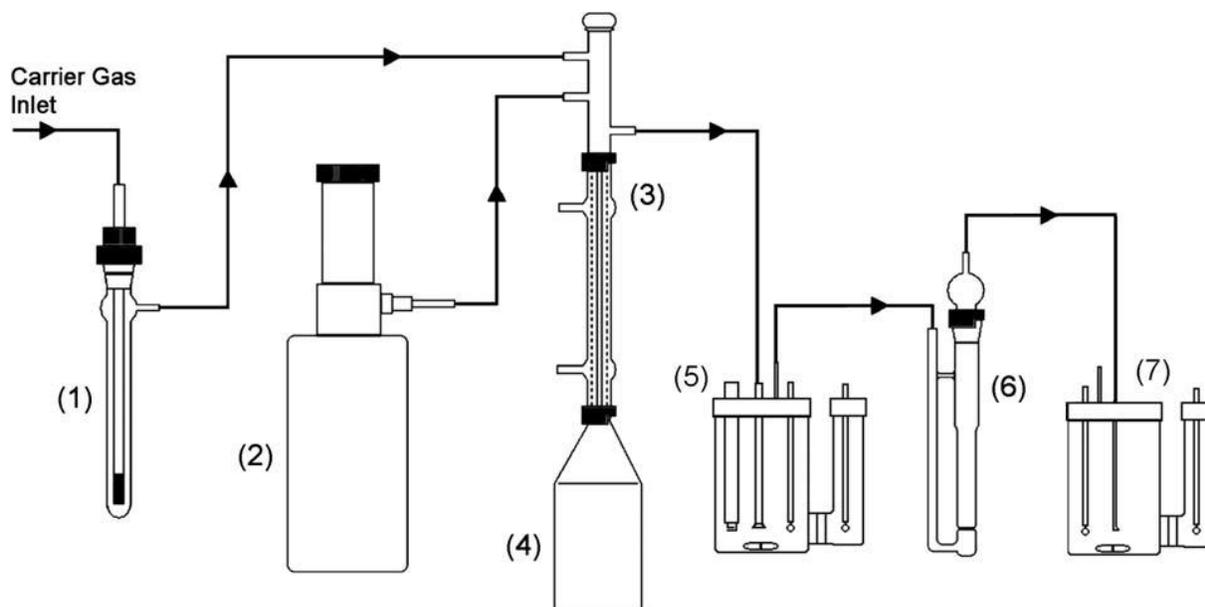
### Actual Results Using This System

Sample	Wt. Range	# of Runs	Theory %H <sub>2</sub> S	Found %H <sub>2</sub> S	Std. Dev.	RSD	Theory %CO <sub>2</sub>	Found %CO <sub>2</sub>	Std. Dev.	RSD
CaCO <sub>3</sub> / Na <sub>2</sub> SO <sub>3</sub>	5-15mg	7	26.74	26.54	0.089	0.36%	44.01	43.82	0.014	0.12%
Amine 1	400- 1200mg	6	----	0.35	0.003	0.73%	----	0.63	0.006	0.96%
Amine 2	200- 400mg	6	----	1.21	0.004	0.34%	----	2.30	0.005	0.22%
Amine 3	200- 400mg	6	----	0.24	0.005	2.23%	----	1.28	0.010	0.82%

The analysis accuracy is normally limited to the precision of the sample volume measurement. The relative standard deviation for standard materials is better than 0.5 %.

Assuming that the system is clean, and that high purity water and acid are used, blank rates as low as 1 to 2 µg of carbon in 10 minutes are typical. Normally, blanks lower than 1 µg of carbon per minute are accepted.

Contact us for more information:



Item	Part Number	Description
1	CM210-011	Pre-Scrubber Assembly
2	CM101-115	Acid Dispenser
3	CM210-010	Sample Column Assembly
4	CM200-045	100ml Sample Flask
5	CM210-026	Sulfur Cell Assembly
6	CM210-012	Post-Scrubber Assembly
7	CM210-015	Carbon Cell Assembly

**FIGURE 2:** Flow diagram of the Acidification Module including the SO<sub>2</sub> and CO<sub>2</sub> cell assemblies.

## ADDITIONAL INFORMATION

For information about the instrument's capabilities for specific types of samples, or to have a sample analysis completed, contact the UIC, Inc. or UIC Europe.

Contact us for more information: