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How to Measure "Total CO_2" for EDI

The Problem:

The load on an EDI module includes the "Total CO_2" in the feed. "Total CO_2" is the sum of dissolved CO_2 gas (or H_2CO_3) and bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}) ions. The pH determines the balance between these 3 species.

However, a normal "CO_2 Test Kit" only measures 1 of the 3 species, so often underestimates the load on an EDI system.

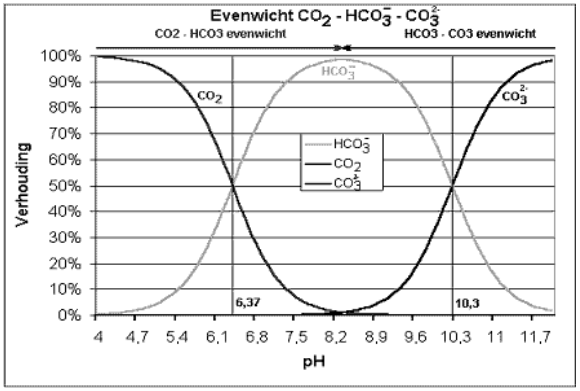
The Science:

For CO_2 in water, there are 3 important equilibria:

$H_2O <-> H^+ + OH^-$ $([H^+][OH^-] = 10^{-14})$
$H_2CO_3 <-> H^+ + HCO_3^-$ $([H^+][HCO_3^-]/[H_2CO_3] = 4.16 \times 10^{-7})$
$HCO_3^- <-> H^+ + CO_3^{-2}$ $([H^+][CO_3^{-2}]/[HCO_3^-] = 4.84 \times 10^{-11})$

pKa is the pH at which there is a 50:50 equilibrium in a chemical equation.

$H_2CO_3 <-> H^+ + HCO_3^-$ pKa = 6.4
$HCO_3^- <-> H^+ + CO_3^{-2}$ pKa = 10.3



Most RO permeate has a pH in the range of 5 – 8, so generally there is no need to worry about carbonate ion (CO_3^{-2}). Therefore we need only measure dissolved CO_2 gas and bicarbonate ion (HCO_3^-).

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The Measurements:

- If the pH of your water is below 5.4, you can measure CO_2 only.
- If the pH of your water is above 7.4, you can measure HCO_3^- only.
- If the pH of your water is between 5.4 - 7.4, you must measure both CO_2 and HCO_3^- to get "Total CO_2". Most RO permeate is in this pH range.

Measuring CO_2

CO_2 test kits have an indicator that turns pink[1] as the pH rises above 8.2, and has a dropper with dilute NaOH, so you titrate up from low pH. The NaOH converts all CO_2 to HCO_3^- and is a measure of dissolved CO_2 itself, not CO_2+ HCO_3^-. This measurement is 95% accurate if the starting pH is below 5.4.

Measuring HCO_3^-

HCO_3^- is measured using an M-alkalinity (Total Alkalinity) test kit. This test uses an indicator[2] that starts to turn from yellow to orange as the pH lowers below 4.4. It has a dropper with dilute acid, so you titrate down from whatever the pH. The acid converts all HCO_3^- to CO_2, and is only a measure of HCO_3^- not CO_2+ HCO_3^-. This measurement is 95% accurate if the starting pH is above 7.4.

The Recommendation:

SnowPure recommends testing both CO_2+ HCO_3^- in most situations to determine the total CO_2 for diagnosing or predicting EDI performance.

SnowPure has both test kits for sale.

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[1] Phenolphthalein , pKa=9.2

[2] Methyl Orange, pKa=3.5