H_2 Sensor Series 9000

Take no risk!
Install a Hydrogen Sensor
in your Gaschromatograph

BRECHBÜHLER AG
scientific analytical solutions

Carrier Gases for GC

Probably more than 90% of the present GC instruments run with helium as carrier gas. Some people use hydrogen or nitrogen, maybe because the first ones are hidden pyromaniacs (some GC ovens actually exploded) and the second still have nitrogen mounted on the instrument from the times they worked with packed columns. These gases serve to produce wind through the column to move our solutes forward. The solute molecules evaporate from the stationary phase surface, i.e. enter the open space of the capillary column, are hit by a carrier gas molecule and start traveling down the tube. After a short distance, however, they touch the sticky surface of the stationary phase and go through another partitioning process. Does the choice of the carrier gas interfere with this? Yes, it does, through its diffusivity and viscosity. You want to know why hydrogen is the best carrier gas?

Diffusivity

Diffusivity provides a measurement for the diffusion speed of a solute vapor in a given gas. For helium and hydrogen, diffusivities are similar, but that of nitrogen is about four times lower (see Table I).

Table I: Relevant characteristics of carrier gases[1]

Carrier gas	Viscosity at 50°C [kg/s m]	Diffusivity (butane, 100°C [m2s])
Hydrogen	9.4	6 10^{-6}
Helium	20.8	5.5 10^{-6}
Nitrogen	18.8	1.5 10^{-6}

The diffusion speed of the solute in the carrier gas determines the speed of chromatography. A solute molecule evaporating from the stationary phase surface into the gas stream should be given enough time to diffuse back to the stationary phase (Figure 1) before having gone far in order to undergo another partitioning process - it is these contacts which differentiate between different substances, and a large number of contacts are needed to obtain the best separation. We get more of them if the solute diffuses more rapidly and/or when we give it more time, i.e. reduce the gas velocity. However, there is a limit: giving it more time for the diffusion towards the stationary phase (radial diffusion) also provides more time for spreading within the open bore of the column, i.e. for band broadening through longitudinal diffusion. This is why there is an optimum gas velocity: it provides a maximum number of contacts with the stationary phase with a minimum of band broadening in the gas phase.

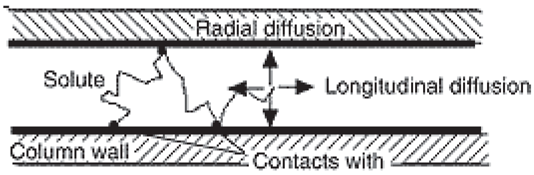
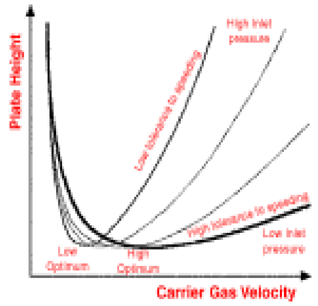
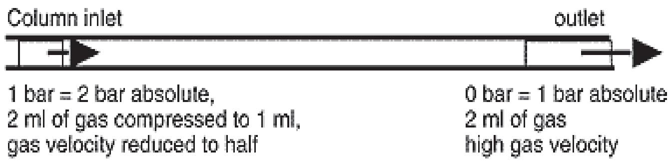


Figure 3: High inlet pressures cause the optimum gas velocity to be low and the loss in separation efficiency when exceeding this optimum to be high.



For columns of a given diameter, the optimum velocity is highest when the column is short. This is because inlet pressure is low. For hydrogen or helium, with about the same diffusivity, the optimum is almost the same, i.e. around 40-50 cm/s. Further, the losses in performance upon speeding, i.e. using excessive gas velocity, are relatively small. The longer the column, the higher is the inlet pressure required. This shifts the optimum gas speed to lower values and, as if there were a strict educator behind the chromatographer, speeding is punished more strongly when the velocity must be low anyway. Hence, using a column of doubled length requires more than twice as much run time, because the gas velocity must be lower. In this respect, helium is worse than hydrogen because its viscosity is about twice as high: the higher inlet pressure requires a lower gas velocity and if you do not obey, the punishment is harder.
What is the reason for this? If the column head pressure is, e.g., 1 bar, corresponding to 2 bar absolute pressure, the carrier gas in the inlet is compressed to half the volume compared to the column outlet (assuming the latter is at ambient pressure, 1 bar absolute, Figure 4). Hence the plug corresponding to 2 ml in the outlet is only 1 ml and is half as long. To displace 1 ml, half the velocity is required compared to displacing 2 ml at the outlet. Hence optimization must compromize between a low velocity in the inlet and a higher one at the outlet.

Figure 4: Compressibility of the carrier gas causes the gas velocity in the inlet to be lower than in the outlet.



Conclusions are against intuition. From short columns we know that 40-50 cm/s are best. In the last, e.g., 15 m of a long column, pressure conditions are the same as in a short column, i.e. the optimum gas velocity and tolerance to speeding must be the same. The problem resulting from the compressibility of the gas is obviously in the inlet of the long column. We are tempted to assume that it is related to the fact that the gas velocity is 20-25 cm/s only and would conclude that a compromize should be chosen between maybe 30 cm/s in the inlet and 70 cm/s in the outlet in order to result in some 50 cm/s as an average. Experiments show that this is wrong: the best average velocity is only 20-25 cm/s. Hence the system wants an even lower velocity in the inlet: about 10 cm/s. And it insists in that: it forces to choose a velocity at the outlet lower than found to be optimum, and if you do not obey to the 10 cm/s in the inlet, punishment is hard. A rapid glance into the above h/u curve shows that 10 cm/s would provide extremely poor performance at the column outlet. Thus the correct conclusion is that optimum velocities are far lower in a compressed gas. This is not really new: GC with vacuum at the outlet, e.g. with GC-MS, is even faster.
Nitrogen has only drawbacks and is not suitable for capillary GC. Helium is as good as hydrogen if inlet pressures are below about 50 kPa, but requires slower GC at higher inlet pressures (for longer columns), the difference being roughly a factor of two when 150-200 kPa must be applied for helium.

H_2-Sensor for your GC

Get all the benefits of hydrogen as carrier gas....
without taking the risk.

If you want to take full advantage of the power of High Resolution Gaschromatography for your analytical results, then hydrogen will be in most cases the carrier gas of choice. Its low viscosity and excellent mass transfer capabilities results in shorter run times and better separation performances.

Beside this hydrogen costs about 75% less then helium of comparable quality.

The only drawback is the danger of explosion in case of a leak in the column oven.

Take no risk! Install a H_2 -Sensor in your gaschromatograph!

The H_2-Sensor will continuously monitor the atmosphere in the GC-oven. If the present threshold level is exceeded, an audible alarm is alerted and the alarm starts blinking. The oven is immediately shut off and the cooling flap opens. In addition the system can switch to nitrogen if a gas switching valve is provided.
This will also happens in a event of power failure.
In case of malfunction of the unit, the operator will be alerted by an external alarm (optional)

H_2-Sensor - Principle of operation

A thermostated flow-through semiconductor-type sensor continuously monitors the hydrogen concentration in the GC-oven. The lowest detection limit is 0.5% H_2 by volume and the alarm threshold can be freely set between 0.5% and the lower explosion limit of hydrogen (4% H_2 by volume). If the threshold level is exceeded, an audible alarm will sound and the flashing light on the unit will indicate the presence of hazardous conditions. The sensor allows for a reset only when the concentration of H_2 falls below about 0.8% by volume.

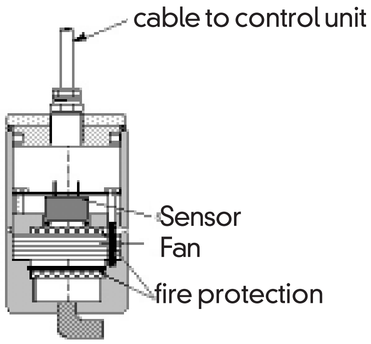
	Specifications		
Detection Limit:	0.5% hydrogen by volume		
Alarm threshold:	Continuously adjustable from 0.5% to 4% by volume (recommended value: 0.8-1.2% by volume)		
Stability of threshold level:	Better than 500 PPM of set value (within one year)		
Sensor lifetime:	At least 5 years (in a non-corrosive environment)		
Instrument readings:	Power on/off LED (green bargraph) Display for H_2 concentration Bar graph LED for H_2-level display Blinking alarm display Audible alarm on/off safety switch (rear side)		
Outputs:	**Gasalarm:**	**GA1:**	**4 pol connector rear side** line voltage 230/115 VAC/1A
		GA2:	**D-Sub 15 pol connector rear side** 1 potential free contact (contact closure) 50V/1A 1 TTL output 5V
	Technical alarm:	**GA2:**	**D-Sub 15 pol connector rear side** 1 potential free contact (contact closure) 50V/1A 1 TTL output 5V
	Others:	**GA2:**	**D-Sub 15 pol connector rear side** Sensor analog output 0-1 V linearized
Operating temperature:	Electronics		-5 to +55° C
	Sensorhead	SC:	-10 to +80°C
		EC:	-10 to +40° C
Power:	90 - 260 VAC - 50/60 Hz		
Calibration:	Should be checked once a year with a test gas (1.0% by volume) in a corrosive environment this procedure must be repeated more often.		

Available systems

Passive system: **principle:** The most of the GC's available on the market have a slight overpressure. This overpressure is used to assure the gas flow trough the sensor head.

Active system: **principle:** If no overpressure is available in the GC the active system is available. A small fan is installed in the sensor head to assure the gas flow trough the sensor head.

H2 Sensor Active system



Ordering Information

Part Number	Description
	Passive System SC
9 1000900	H_2-Sensor Series 9000 SC/PS
	Active System SC
9 1000920	H_2-Sensor Series 9000 SC/AS
9 1000801	H_2/N_2 autom. switching valve with 6MB fitting for 1/16″ or 2mm tubings
9 1000810	H_2/N_2 autom. switching valve with 1/8″ fitting for 1/8″ tubings
9 1000811	H_2/N_2 autom./manual switching valve with 6MB fitting for 1/16″ or 2mm tubings
9 1000812	H_2/N_2 autom./manual switching valve with 1/8″ fitting for 1/8″ tubings
9 1000841	Shut down valve 115V
9 1000842	Shut down valve 220V
9 1000850	Calibration Gas 1 bottle
9 1000851	Calibration Gas 1 pack (6 bottles)
9 1000852	Calibration Gas 10 pack (60 bottles)
9 1000860	Adapter Kit for calibration gas
9 1000925	Active system fan replacement kit

Manufactured by:

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