

# Technology & Product Reports

## Control of Humidity in Small Controlled-environment Chambers using Glycerol-Water Solutions

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*Additional index words:* relative humidity, specific gravity

**Summary:** Solutions of glycerol and water provide a convenient and inexpensive system to control the relative humidity (RH) in small controlled-environment chambers. The relationship between the specific gravity (SG) of a glycerol-water solution and its equilibrium RH is described by the equation  $SG = [-0.189(RH) + 19.9]^{0.0001}$ . Gas can be humidified by bubbling it through jars containing solutions of glycerol-water with the desired equilibrium RH. The effects of flow rate, volume of solution, temperature, and pressure on the equilibrium RH are discussed.

Humidity is an important environmental factor that influences rates of water loss from whole plants or excised plant organs. Bates of water loss from plant cells

affect many physiological processes such as cell expansion, growth, photosynthesis, and senescence. The role of humidity on the physiology of plants often has been ignored, possibly due to a lack of convenient methods to control humidity at desired levels or because of difficulty in measuring humidity accurately (Gaffney, 1978). Equilibrium atmospheres over saturated solutions of different salts can be used to control humidity (ASTM, 1983; Solomon, 1951; Winston and Bates, 1960; Young, 1967). Disadvantages of this system are that a different salt is needed for each humidity, a salt for a specific humidity may not be available, many of the salts are corrosive, and the equilibrium relative humidity (RH) formed over many solutions varies widely with temperature. Nonsaturated solutions also can be used to produce various equilibrium RHs, depending on the concentration of the solute. This method allows for the creation of a precise and evenly graded series of RHs. Solutions of sulfuric acid (ASTM, 1983; Solomon, 1951), potassium hydroxide (Solomon, 1951), and glycerol (ASTM, 1983; Braun and Braun, 1958; Solomon, 1951) can be used in this manner to control RH.

Glycerol and water solutions have several advantages for use in RH control. Solutions of 0% to 100% glycerol can be mixed easily, and their exact composition can be determined by specific gravity (SG) (Braun and Braun, 1958) or by refractive index (ASTM, 1983) measurements. Glycerol solutions are less corrosive than salt or sulfuric acid solutions, and glycerol is relatively inexpensive. This paper discusses the use of glycerol and water solutions to control humidity in controlled-environment chambers. The

effects of temperature, pressure, flow rate, and volume of solution on maintaining constant, desired RH in chambers also are examined.

The relationship between glycerol concentration, measured as SG, and the equilibrium RH that forms at 24°C in a closed system was described by Braun and Braun (1958), and their original data are shown in Fig. 1. To aid in determining equilibrium RH from solutions not tested by Braun and Braun, we derived an equation to fit their data (Fig. 1). The equilibrium RH decreases slowly as the glycerol content increases, but changes more rapidly as glycerol content exceeds ~70%. The slower change in RH when glycerol content is < 70% allows for more accurate control of RH >60%. To aid in the determination of a solution needed to produce a desired RH, the formula in Fig. 1 can be solved for SG:

$$SG = [-0.189(RH) + 19.9]^{0.0001} \quad [1]$$

where RH is the desired percent RH and SG is the specific gravity of the glycerol-water solution needed to produce this RH. Ratios of water and glycerol needed to produce a desired SG can be estimated from Fig. 1 or calculated from Eq. [2]:

$$G_w = 383(SG) - 383 \quad [2]$$

where  $G_w$  is the percent glycerol by weight in the solution. The volumes of glycerol and water needed to prepare solutions can be calculated using Eqs. [3] and [4]:

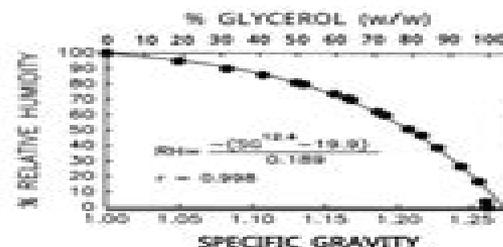


Fig. 1. The relationship of specific gravity (SG) and glycerol content of glycerol-water solutions and equilibrium relative humidity (RH) at 24°C. Points represent actual data from Braun and Braun (1958), and the line represents a model derived using these points.

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# Control Of Humidity In Small Controlled Environment

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