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Attainment of Specific Levels of Relative Humidity Using Saturated Solutions of Chemicals

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ATTAINMENT OF SPECIFIC LEVELS OF RELATIVE HUMIDITY USING SATURATED SOLUTIONS OF THE FOLLOWING CHEMICALS

SOLID PHASES	°C.	% HUMIDITY
$BaCl_2 \cdot 2H_2O$	24.5	88
$CaCl_2 \cdot 6H_2O$	5.0	39.8
	10.0	38
	18.5	35
	20.0	32.3
	24.5	31
$Ca(NO_3)_2 \cdot 4H_2O$	18.5	56
	24.5	51
$CuSO_4 \cdot 5H_2O$	20.0	98
CrO_3	20.0	35
$H_2C_2O_4 \cdot 2H_2O$	20.0	76
$H_3PO_4 \cdot 1/2H_2O$	24.5	9
$KC_2H_3O_2$	20.0	20
	168.0	13
KBr	20.0	84
	100.0	69.2
$K_2CO_3 \cdot 2H_2O$	18.5	44
	24.5	43
KCNS	20.0	47
K_2CrO_4	20.0	88
KF	100.0	22.9
K_2HPO_4	20.0	92
$KHSO_4$	20.0	86
KI	100.0	56.2
KNO_2	20.0	45
$LiCl \cdot H_2O$	20.0	15
$MgCl_2 \cdot 6H_2O$	20.0	35
$Mg(C_2H_3O_2)_2 \cdot 4H_2O$	20.0	65
	30.0	60%

SOLID PHASES	°C.	% HUMIDITY
$Mg(NO_3)_2 \cdot 6H_2)$	18.5	56
	24.5	52
NH_4Cl	20.0	79.2
	25.0	79.3
	30.0	79.5
$NH_4H_2PO_4$	20.0	93.1
	25.0	93.0
	30.0	92.9
$(NH_4)_2SO_4$	20.0	81.0
	25.0	81.1
	30.0	81.1
NaBr	100.0	22.9
$NaBr \cdot 2H_2O$	20.0	58
$NaBrO_3$	20.0	92
NaCl	20.0	75
$Na_2CO_3 \cdot 10H_2O$	18.5	92
	24.5	87
$NaClO_3$	20.0	75
$NaC_2H_3O_2, 3H_2O$	20.0	76
$Na_2Cr_2O_7 \cdot 2H_2O$	20.0	52
$Na_2HPO_4 \cdot 12H_2O$	20.0	95
$NaHSO_4 \cdot H_2O$	20.0	52
$NaNO_2$	20.0	66
$Na_2SO_3 \cdot 7H_2O$	20.0	95
$Na_2S_2O_3 \cdot 5H_2O$	20.0	78
$Na_2SO_4 \cdot 10H_2O$	20.0	93
$Pb(NO_3)_2$	20.0	98
$ZnCl_2 \cdot 1\ 1/2H_2O$ *	20.0	10
$Zn(NO_3)_2 \cdot 6H_2O$	20.0	42
$ZnSO_4 \cdot 7H_2O$	5.0	94.7
	20.0	90.0

* Unstable at this temperature.

% humidity at 20°C. when an excess of the substance indicated is in contact with a saturated aqueous solution of the given solid phase. (From Handbook of Chemistry and Physics.)

Solid phase	% humidity	Solid phase	% humidity
$ZnCl_2 \cdot 1\frac{1}{2}H_2O$	10	$H_2C_2O_4 \cdot 2H_2O$	76
$LiCl \cdot H_2O$	15	$Na_2S_2O_3 \cdot 5H_2O$	78
$KC_2H_3O_2$	20.	NH_4Cl	79.5
$CaCl_2 \cdot 6H_2O$	32.3	$(NH_4)_2SO_4$	81
CrO_3	35	KBr	84
$Zn(NO_3)_2 \cdot 6H_2O$	42	$KHSO_4$	86
KNO_2	45	K_2CrO_4	88
KCNS	47	$ZnSO_4 \cdot 7H_2O$	90
$NaHSO_4 \cdot H_2O$	52	$NaBrO_3$	92
$Na_2Cr_2O_7 \cdot 2H_2O$	52	K_2HPO_4	92
$NaBr \cdot 2H_2O$	58	$Na_2SO_4 \cdot 10H_2O$	93
$Mg(C_2H_3O_2)_2 \cdot 4H_2O$	65	$NH_4H_2PO_4$	93.1
$NaNO_2$	66	$Na_2SO_3 \cdot 7H_2O$	95
NH_4Cl and KNO_3	72.6	$Na_2HPO_4 \cdot 12H_2O$	95
$NaClO_3$	75	$Pb(NO_3)_2$	98
$NaC_2H_3O_2 \cdot 3H_2O$	76	$CuSO_4 \cdot 5H_2O$	98

Table 1. Glycerine-distilled water solution used to obtain various relative humidity levels at 20° C.

Relative Humidity %	Glycerin %	Water %
20	96	4
42	84	16
48	81	19
52	78	22
60	71	29
70	62	38
75	55	45
78	50	50
88	35	65
96	20	80

The following values were selected from the literature referenced with some values adjusted by interpolation to the temperatures listed.

EQUILIBRIUM RELATIVE HUMIDITIES
FOR SATURATED SALT SOLUTIONS

Saturated Salt Solution	Formula	Percent Relative Humidity at Stated Temperatures		
		68°F(20°C)	77°F(25°C)	86°F(30°C)
Lithium Chloride	$LiCl \cdot H_2O$	12.4	12.0	11.8
Potassium Acetate	$KC_2H_3O_2$	23.3	22.7	22.0
Magnesium Chloride	$MgCl_2 \cdot 6H_2O$	33.6	33.2	32.8
Potassium Carbonate	$K_2CO_3 \cdot 2H_2O$	44.0	43.8	43.5
Potassium Nitrite	KNO_2	49.0	48.1	47.2
Magnesium Nitrate	$Mg(NO_3)_2 \cdot 6H_2O$	54.9	53.4	52.0
Sodium Nitrite	$NaNO_2$	65.3	64.3	63.3
Sodium Chloride	$NaCl$	75.5	75.8	75.6
Ammonium Sulfate	$(NH_4)_2SO_4$	80.6	80.3	80.0
Potassium Nitrate	KNO_3	93.2	92.0	90.7
Potassium Sulfate	K_2SO_4	97.2	96.9	96.6

CONCLUSION

Saturated salt solution generation of humidity is only a secondary method of obtaining an approximate humidity condition. Disagreement among references as to the humidities created indicates a need to qualify this method by independent measurements and to note the salt and reference source used.

To obtain stable humidity values it is essential that the following conditions be met:

1. Chemically pure salt.
2. Distilled water.
3. Large solution surface area and small vapor space.
4. Adequate air circulation.
5. Elimination of hygroscopic construction materials.
6. Solution and vapor at same temperature or in balance.
7. Time allowed for vapor equilibration.

Most of the above requirements (1 thru 5) can be met inexpensively and without elaborate techniques except for the temperature and diffusion rate requirements (6 and 7).

While a difference in the temperatures of the solution and vapor will produce a humidity other than the literature value, a stable humidity condition can be created and maintained without the expense of precise temperature regulation. As long as the temperature relationship between solvent and vapor is kept constant the resultant humidity is also constant. Normally, in a properly designed small chamber the temperatures will be within relatively close agreement so that a stable humidity, within several percent relative humidity of the literature value, will be maintained. However, it is recommended that an independent humidity measuring device, such as Hygrodynamics' Hygrosensor, be used to determine the actual humidity condition created and to monitor its stability (4).

The introduction of the hygroscopic material to be tested or conditioned can greatly affect the time required to approach the true equilibrium relative humidity. The mass and hygroscopic nature of the material may be such that fairly stable humidity conditions considerably different from the literature values are created. Therefore, when conditioning or testing a hygroscopic material it is essential that a humidity measuring instrument be used to verify the existing humidity condition.

Saturated salt solution generation of humidity is not as simple as generally believed, but it need not be complex. As noted, the properly designed humidity chamber has adequate air circulation, it minimizes use of hygroscopic materials and temperature unbalance and uses a reliable independent humidity measuring device. For information on chambers meeting these requirements, or if only the humidity measuring equipment is desired, contact Hygrodynamics, Inc.