



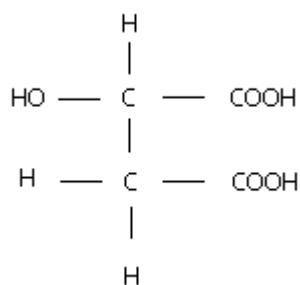
*PHYSICAL and CHEMICAL PROPERTIES:*

**MALIC ACID**

Chemical Name Hydroxybutanedioic acid

Molecular Formula  $C_4H_6O_5$

Structural Formula



Appearance White crystals

Odour None

Taste Smooth, tart

Molecular Weight 134.09

Acid Equivalent Weight 67.05

Specific Gravity (20°C/4°C) 1.601

Typical Bulk Density (lb/ft<sup>3</sup>) (gm/L)

Regular Granular 51 810

Coarse Granular 55 875

Powder 46 730

Melting Point (°C) 130 - 132

Degradation (°C) 140 or above  
(begins to form Fumaric Acid)

Flash Point (°C) 203  
(Cleveland Open Cup)

## Solubility in Water

Temp (°C)	Temp (°F)	Solubility* (%w/w)	Temp (°C)	Temp (°F)	Solubility* (%w/w)
0	32	46.8	55	131	71.3
5	41	48.9	60	140	73.4
10	50	51.0	65	149	75.4
15	59	53.2	70	158	77.3
20	68	55.5	75	167	79.1
25	77	57.8	80	176	80.8
30	86	60.1	85	185	82.4
35	95	62.4	90	194	83.9
40	104	64.7	95	203	85.4
45	113	67.0	100	212	86.7
50	122	69.2			

\*calculated using the following equation from: A. Apelblat et al. 1995. The vapour pressure of water over saturated aqueous solutions of malic, tartaric, and citric acids, at temperatures from 288 K to 232 K. *J. Chem. Thermodynamics* 27: 35-41.

$$\ln\{m_{\text{sat}} / (\text{mol} \cdot \text{kg}^{-1})\} = -113.096 + 3707.6(T/K)^{-1} + 18.075 \cdot \ln(T/K)$$

Heat of Solution	-4.9 Kcal/mole
Solubility of Calcium Salt	0.3 %w/v at 20°C
Solubility of Sodium Salt	41 %w/v at 20°C
Solubility in Ethanol	39.2 %w/v at 25°C
Log(octanol/water partition coefficient)	-1.26
Log(ether/water partition coefficient)	-1.87

## Specific Gravity of Aqueous Solutions

Acid Concentration (%w/w)	Specific Gravity* (20°C/4°C)
5	1.019
10	1.039
15	1.060
20	1.080
25	1.100
30	1.123
35	1.146
40	1.169

\*calculated using the following equations from: Lange N.A. & Sinks M.H. 1930. The solubility, specific gravity and index of refraction of aqueous solutions of fumaric, maleic and *i*-malic acids. *J. Am. Chem. Soc.* 52: 2602-2604.

$C = 244.55 (d - 0.9982)$ , for values of  $d$  less than 1.108, and  $C = 216.17 (d - 0.9839)$ , for values of  $d$  from 1.108 to 1.169, where  $C =$  %w/w acid concentration and  $d =$  specific gravity at 20°C referred to water at 4°C.

**Dissociation Constants at 25°C vs. Ionic Strength, *I***

	<i>I</i> = 0	<i>I</i> = 0.005	<i>I</i> = 0.05	<i>I</i> = 0.10
<b>pK<sub>a1</sub>:</b>	3.46*	3.39**	3.29**	3.24*
<b>pK<sub>a2</sub>:</b>	5.10*	4.97**	4.75**	4.68*

\*from Smith, W. & Martell, A.E. 1989. *Critical Stability Constants*, vol. 6, second supplement. Plenum Press, New York.

\*\*calculated using the equations of Butler, J.N. 1998. *Ionic Equilibrium: Solubility and pH Calculations*. John Wiley & Sons, Inc., New York.

**Acid Strength, (defined as the % w/v of acid required to lower the pH of 0.005N NaOH solution to a specific value\*)**

↓ Acid ↓	pH ⇒	2.5	3.0	3.5	4.0	4.5	5.0	5.5
Citric, anhydrous		0.717	0.239	0.128	0.090	0.069	0.055	0.047
Citric, monohydrate		0.784	0.262	0.140	0.098	0.075	0.060	0.051
Fumaric		0.372	0.128	0.070	0.048	0.037	0.032	0.030
Lactic, 80%		1.884	0.484	0.177	0.093	0.068	0.060	0.057
<b>Malic</b>		<b>0.953</b>	<b>0.273</b>	<b>0.121</b>	<b>0.076</b>	<b>0.057</b>	<b>0.045</b>	<b>0.038</b>
Phosphoric, 85%		0.130	0.077	0.064	0.059	0.058	0.057	0.056
Sodium Acid Sulfate, 93%		0.133	0.084	0.070	0.066	0.065	0.065	0.065
L-Tartaric		0.469	0.161	0.086	0.059	0.046	0.041	0.039
↑ Acid ↑	pH ⇒	2.5	3.0	3.5	4.0	4.5	5.0	5.5

\*for diprotic acids, calculated using the following equation:

$$\text{\%w/v of acid required to lower the pH of NaOH solution to a specific value} = \frac{([\text{Na}^+] + [\text{H}^+])(\text{mol.wt.})(0.1)}{\frac{2K_{a1}K_{a2}}{[\text{H}^+]^2 + K_{a1}[\text{H}^+] + K_{a1}K_{a2}} + \frac{K_{a1}[\text{H}^+]}{[\text{H}^+]^2 + K_{a1}[\text{H}^+] + K_{a1}K_{a2}}}$$