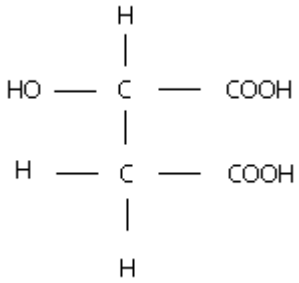
BARTEK Ingredients Inc.

A Taste for Today and Tomorrow

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℃/4℃)	1.601	
Typical Bulk Density	(lb/ft^3)	(gm/L)
Regular Granular	51	810
Coarse Granular	55	875
Powder	46	730
Melting Point (^oC)	130 - 132	
Degradation (^oC) (begins to form Fumaric Acid)	140 or above	
Flash Point (^oC) (Cleveland Open Cup)	203	

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Solubility in Water

Temp (℃)	Temp (℉)	Solubility* (%w/w)	Temp (℃)	Temp (℉)	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.

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

Heat of Solution	-4.9 Kcal/mole
Solubility of Calcium Salt	0.3 %w/v at 20℃
Solubility of Sodium Salt	41 %w/v at 20℃
Solubility in Ethanol	39.2 %w/v at 25℃
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℃/4℃)
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^{o}C referred to water at 4^{o}C.

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Dissociation Constants at 25℃ vs. Ionic Strength, *I*

	I = 0	*I* = 0.005	*I* = 0.05	*I* = 0.10
pK_{a1}:	*3.46**	*3.39***	*3.29***	*3.24**
pK_{a2}:	*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*
Malic	*0.953*	*0.273*	*0.121*	*0.076*	*0.057*	*0.045*	*0.038*
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:

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

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