Paratene™ M390

Organic Acid for Industrial Cleaning - A Technical Comparison

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Acids are the most commonly used chemicals for the removal of scales and deposits from industrial systems. Paratene™ M390 is a strong organic acid that combines the best properties of inorganic acids with the benefits of the weaker organic acids.

Any acid used in cleaning must meet several criteria:

- ☑ **Utility** – the acid must dissolve the scale or deposit in question
- ☑ **Efficiency** – the acid must dissolve the scale by using the minimum of chemical at a rapid rate.
- ☑ **Compatibility** – the acid must not damage the equipment or process.
- ☑ **Safety** – the acid must be easy to handle, and simple to dispose.

Physical Properties Comparison

The following table shows the molecular weights and K_a values for several common acids. The hydrogen ion activity of an acid solution is related to the K_a value and the acid concentration.

Acid	K_a Value	Molecular Weight (g/mole)
Paratene™ M390	**8.30E+01**	**96.11**
Hydrochloric	**1.00E+03**	**36.5**
Sulphuric	**1.00E+03**	**98**
Phosphoric	**7.30E-03**	**97**
Sulphamic	**1.02E-01**	**97**
Formic	**1.77E-04**	**46**
Acetic	**1.75E-05**	**60**
Citric	**7.50E-04**	**210.14**

As can been seen above, the strong acids - hydrochloric, sulphuric, and M390 have substantially higher K_a values than the other acids. The hydrogen ion strength of a solution relates to each acid and its Ka value using the following formula.

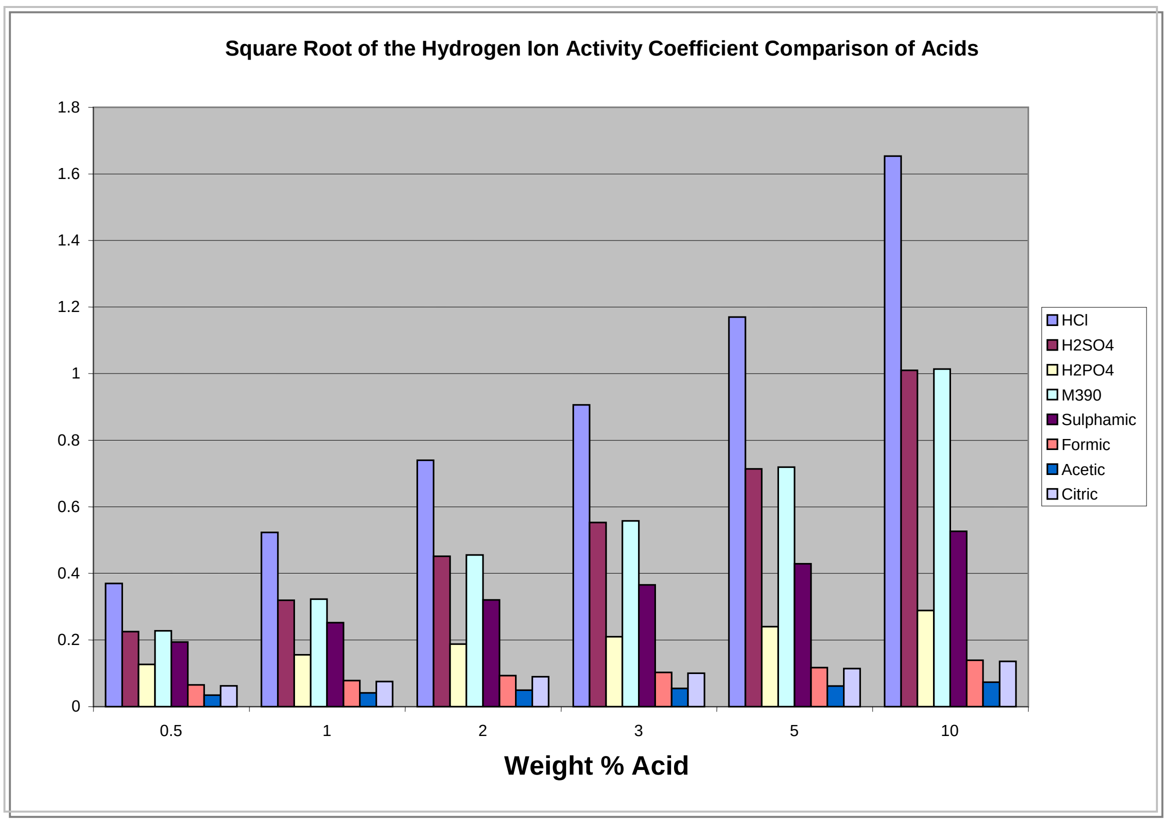
$$(1)\ K_a = [H^+][A^-]/[HA]$$

The above formula gives the relationship between the hydrogen ions available in solution and the acid concentration. The hydrogen ion activity is then proportional to the reaction rate of the acid. There fore more hydrogen ions in solution the quicker the acid will dissolve many scales.

A second consideration is that cleaning acids are typically applied on a percentage weight basis, but the actual activity of each acid is dependant on the molar concentration. The table below represents the molar concentrations for each of the acids considered.

	Molarity							
Weight %	HCl	H_2SO_4	H_2PO_4	M390	Sulphamic	Formic	Acetic	Citric
0.5	0.14	0.05	0.05	0.05	0.051	0.11	0.083	0.024
1	0.27	0.10	0.10	0.10	0.10	0.22	0.17	0.048
2	0.55	0.20	0.21	0.21	0.21	0.43	0.33	0.095
3	0.82	0.31	0.31	0.31	0.31	0.65	0.5	0.14
5	1.37	0.51	0.51	0.52	0.51	1.09	0.83	0.24
10	2.7	1.02	1.03	1.04	1.03	2.17	1.67	0.48

By considering the information represented in both tables, we can produce the following graph to compare the relative performance of different acids.



The graph clearly shows that Paratene™ M390 provides more available acid strength for all of the acids considered with the exception being hydrochloric.

A third consideration in determining the ability of an acid to dissolve a particular scale or deposit also depends on the solubility of the resulting ions in the spent acid solution. The table below shows some common cation solubility's.

Cation	Solubility g/100g of water		
	M390	Sulphuric	Hydrochloric
Calcium	**94.2**	**0.209**	**59.3**
Barium	**68**	**0**	**31**
Magnesium	**35**	**26**	**54.2**
Copper	**60**	**14**	**6.9**

The increased solubility of some cations – particularly Calcium and Magnesium make M390 superior at dissolving water scales.

Materials Compatibility, Corrosion and Temperature Limits

Acids are corrosive to most metals. Corrosion Inhibitors may be added to reduce the corrosion rates, but in some cases the inhibitors cannot prevent secondary problems such as stress cracking.

	Concentration	Inhibitor	Temperature °C	Carbon Steel	Cast Iron	300 Series Stainless	400 Series Stainless	Copper	Copper Alloys	Monel	Cupro Nickel	Chromalloy	Zinc	Aluminum	Titanium
M390	1-20		max 90	A	B	A	A	A	A	A	A	A	X	X	A
HCl	3 - 15		max 80	A	B	X	X	A	A	A	A	A	X	X	A
HCl/Thiourea	5 -15/0.5 -2		55-75	A	B	X	X	X	X	X	X	X	X	X	X
HCl/ABF	3 - 15/0.5 - 3		max 80	A	B	X	X	A	A	A	B	B	X	X	X
HCl/Boric	5/2		65-80	A	B	X	X	A	B	A	B	B	X	X	C
H2SO4	5 - 10		max 80	A	B	B	B	B	B	A	B	B	X	X	X
H2SO4/ABF	2.5/0.5		max 80	A	B	B	B	B	B	A	B	B	X	X	X
Sulphamic	max 10		20-85	A	B	A	A	X	X	X	X	B	X	X	X
Phosphoric	1 -21		Max 80	A	B	A	A	A	A	B	X	X	X	X	X
CrO3	max 10		120	A	B	X	X	A	X	X	B	B	A	A	B
NaBromate			40-70	A	A	X	X	X	A	X	X	B	A	X	X
Citrosolve	5		65-150	A	A	A	A	X	X	X	X	B	A	X	X
Citric	3-5		50-100	A	A	A	A	A	X	A	X	B	X	X	X
Formic	3 -10		50 - 150	A	A	A	A	A	X	A	X	B	X	X	X
Glycolic	3-5		51 - 150	A	A	A	A	A	X	A	X	B	X	X	X
Formic/Glycolic	2/1		52 - 150	A	A	A	A	A	A	A	A	B	X	X	X
Formic/Citric	2/1		53 - 150	A	A	A	A	A	A	A	A	B	X	X	X
Nitric	1-10		80	X	X	A	A	X	X	A	A	X	X	B	A
H2O2	<5		40 -60	A	X	A	A	X	X	B	B	X	X	B	A
SHP	5		50	A	X	A	A	X	X	B	B	X	X	X	A

A-Good	B-Fair	C-Poor	X-Unsatifactory

The chart above illustrates that Paratene™ M390 has a greater range of compatibility with more metals than any of the other acid solutions.

When applied with the correct corrosion inhibitor, the rate of corrosion for most acids can be controlled.

Acid	Wt%	Molarity Moles/liter	Temperature (°C)	Inhibitor	Rate (mpy) without inhibitor	Rate mpy 0.2% Inhibitor
Hydrochloric	**5**	**1.36**	**60**	**I201**	**859**	**25**
M390	**10**	**1.04**	**60**	**I205**	**859**	**16**
Sulphuric	**10**	**1.02**	**60**	**I205**	**6311**	**12**
Sulphamic	**10**	**1.03**	**70**	**I205**	**3972**	**35**

The above table compares corrosion results under similar temperatures and molarity, and shows that Inhibited M390 has comparable corrosion rates to comparatively inhibited HCl solutions.

Environmental and Disposal Problems

The direct disposal of strong acids is not practical. Acid solutions are corrosive and can cause damage to the equipment as well as the environment, and must be neutralized prior to their disposal. In addition the system being cleaned will contribute other ions into the acid solution that may increase the toxicity of the spent solution and increase the considerations for proper disposal.

The neutralized solutions salts such as sodium, iron, and calcium salts of sulphate, phosphate or nitrate are typically not considered to be an environmental problem except where they act as eutrifecation agents, where they encourage the growth of algae. In the case of the salts of hydrochloric acid – calcium, sodium or iron chloride can cause serious negative problems on non-salt water plants and animals, which limits the options for disposing hydrochloric solutions. In Western Canada, and particularly Alberta, the disposal of salt water solutions is common place due the availability of injection wells.

The relative toxicity for various acid solutions is provided in the table below.

	EC50 mg/L			
Acid	Dapnia Magna	Algae	Activated Sludge	Biodegradable
M390	**260**	**72**	**530**	**Yes**
Citric acid	**>100**	**>100**	**>100**	**Yes**
Sulfuric	**43**	**No data**	**No data**	**No**
Hydrochloric	**560**	**800**	**1000**	**No**
Acetic	**100**	**75**	**No effect**	**Yes**

When dealing with the safe handling of acids several issues are frequently causes of concern. One concern is the relative vapour pressure of the acids – acids that generate a lot of vapour are both inhalation hazards and environmental risks. Additionally acids like sulfuric also have serious problems in the heat of reaction both in mixing the acid with water and with neutralizing the acid for disposal.

Acid	Vapour Pressure mmHg at 25°C
M390	**0.0267**
Hydrochloric	**25**
Sulphuric	**0.3**
Acetic	**11**
Formic	**44**

***Paratene*™ *M390* *is an excellent choice in cleaning applications to dissolve scale and deposits from a variety of process systems constructed of common or uncommon metallurgy.* ***Paratene*™ *M390* *provides rapid and efficient removal of deposits while remaining both safer in handling and disposal than many other acids.*

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