

Formic acid and oxalic acid

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The 'alchemist experiment'

As we have seen formic acid and oxalic acid represent major processes that occur both in nature and in living organisms. In both cases there are similar processes, though at different levels. In nature and in human beings there are constant transition processes between these levels and between these substances. One of these can be carried out in the laboratory. These processes were understood by the alchemists as having to do with healing processes in the human being and were therefore revered. Oxalic acid is thereby transformed into the next higher form of formic acid. If one wants to create an appropriate mood through outer factors one can use a medieval retort in which oxalic acid is slowly and moderately heated in glycerine. Formic acid forms in fluid form and carbon dioxide is given off (experiment 3).

In the lectures previously referred to, Steiner describes this chemical reaction as 'total mirroring' of that 'which can be experienced as living', not only in human beings but also 'in the life and activity of nature' (e.g. in plants and insects).

What does the term 'mirroring' tell us? In a mirror we see the external situation similar to the original, though the perspective is reversed. Every is also reduced - we can't grasp it with our hands, but rather bump into the mirror, that is, all sense impressions are reduced to the sense of sight. If one considers these aspects, then one can engage further with Steiner's suggestions that in this lab experiment we have a picture of inner processes in the human body (digestion and lungs), as everywhere in nature (decaying wood and insect life). Everywhere the emergence of these two acids is the precondition for that, which we call life and health.

Formic acid in chemical comparison

Just as we have used the comparison of oxalic acid with citric acid in order to make their appearance as clear as possible, so we can place another acid – that also arises from life transformations and that can also become perceptible outside of natural beings – alongside formic acid: acetic acid, which emerges at the end of the sweet fermentation process.

Acetic acid, like formic acid is a clear, water-like liquid that can be mixed with water but is hard to dehydrate. When cold it cannot be ignited and only burns when heated. It gives off a smell even when cold but is not as overwhelming and acrid as formic acid, being somewhat more penetratingly aromatic. Both acids taste, when diluted in water, strongly sour and eat into chalk.

Like water both acids have the possibility of quickly vaporizing and can be distilled. Likewise they lack the ability to be mixed with carbon disulfide, which is a particularly water-resistant substance. They are also similar in that both acetic acid (glacial acetic acid) and formic acid in concentrated, pure form become ice at 17 °C respectively 8°C.

Thus in both acids we have two water variants derived from life processes, however they differ from water and reveal their origin in the possibility of combustion. Thus here appear the differences between them: formic acid burns with a quiet, blue and lightly extinguishable flame, whilst acetic acid burns in a glass beaker, by boiling, with an orange coloured ring that sinks below the rim of the glass, thus demonstrating a certain weight. Formic acid is more volatile and boils at 100.5 °C, whilst acetic acid boils at 118 °C. Formic acid shows itself to be more similar to water because it doesn't mix with benzene, whereas acetic acid dilutes with benzene, but not with carbon disulfide. Acetic acid is therefore more liable to solidify and is nearer to carbon, like wax. Its lowest pH value is 2.4. Formic acid is more unstable and closer to hydrogen, is more similar to water and more acidic. That is also shown by other properties: formic acid, for example has a reducing effect on ammoniac silver nitrate, whilst acetic acid has not. Formic acid breaks down on heating its steam at 120 °C; also when combined with a concentration of sulphuric acid, only the formic acid is destroyed. It is more unstable and reacts more easily.

Acetic acid arises out of the aeration of fermentation products. The inebriating effects are overcome and sober, refreshing effects occur through the processes of oxidation. The ability to counter decay already presents acetic acid's past - that's how it arose. Thus it retains a conserving quality, as shown by foodstuffs conserved in acetic acid/vinegar. Formic acid develops an even stronger preservative force. It works above all in the landscape and into the future. Isolated, it also shows in the moment with great disinfectant effects, even 2.5‰ addition to fruit juice works in a conserving way.

Acetic acid embodies aerated, consolidating fruit forces. Formic acid embodies volatile, reactive – that is, effective in all directions – much more generalised earth forces. It bears the effects of its origins in the 'necessary' dealings of ground animals with earthy remains, as its direction of activity with it. This reveals itself in the greater density of it: 1.22 g/cm³, as opposed to 1.05 g/cm³ for acetic acid. Thus formic acid is the crowning glory of the acids in nature through its chemical force and through its density. It appears, somewhat emphatically expressed, as a peak of earthy saturation.

Thus we see in formic acid:

- A watery substance that is intensified and permeated to acidity that works broadly in nature,
- A force typical to all acids but here in strengthened form as something that protects life from decay,
- One of the imponderables¹ of life forms that express themselves in chemistry as inflammable and thus a substance that stands close to life transformations,
- An earthly concentrating force.

Let us now put two acids – formic acid and oxalic acid –, that could be easily transformed into each other in the lab, alongside each other, then the differences are raised to the level of polarity: Here a strongly smelling liquid - there a firm substance that even in crystal form in water only dissolves to an extent, that tends to sublime rather than melt. Here rapid inflammability - there slow to burn only at higher

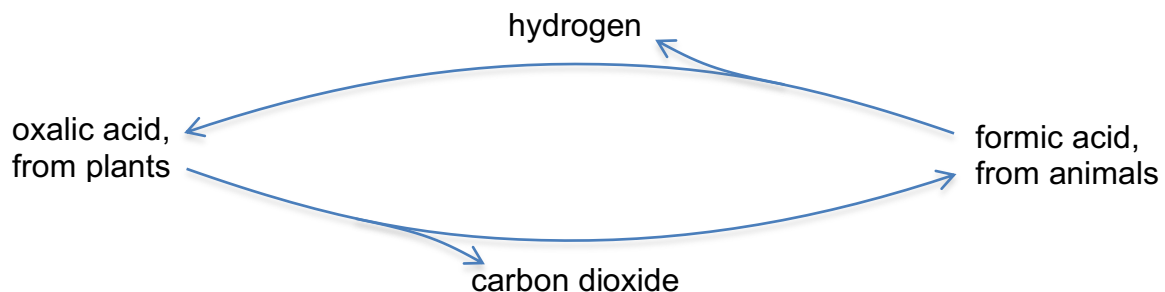
¹ See v Mackensen (2001, p. 9ff) 'Prozesschemie' for a description of imponderables as mobile forces derived ultimately from the cosmos.

temperatures. In oxalic acid we see an expression of solidifying plant life, bound to a particular location out of which it arose. The extreme insolubility of its calcium salt is well known and frequently used, whilst formic acid is used as a lime-dissolver. On the other hand, when the resilience of oxalic acid is overcome through watery solution it develops a stronger acidic effect than formic acid (pH down to 0.7).

In the transforming of formate into oxalate hydrogen escapes, in the transformation of oxalic acid into formic acid carbon dioxide is produced. Something is expressed in the character of these two gases that reveals the difference between their original substances: warmth that streams towards the cosmos on the one hand and earth-bound isolating consolidation forces on the other. Formic acid appears to us as something dissolving, mobile, setting things in motion. These movement-generating imponderables appear in many aspects of formic acid, above all in the capacity to reduce (silver experiment), in the capacity to burn and in the etheric solubility; but slightly also in the fruity smells of its esters and in their stability.

As acid, formic acid has power and aggression, but in the realm of the salts it is not consolidating and mineralizing. As substance against rheumatism it shows a dissolving effect that mobilizes sediments in life processes. Formic acid brings what has halted, into motion. The ant that can transport heavy objects on the forest floor is an image of such a process. A force coming tirelessly from within becomes active and begins to move that which has become a solid and physical object.

Overview of relationships:



Experiment 1: Sulphuric acid drives formic acid out of its salts

Experiment lasts about 3 minutes.

As stronger and less volatile acid, sulphuric acid can attack formic acid salts and free formic acid.

Procedure: fill a test tube with about 2 cm³ natriumformiate (= sodiumformiate) and cover with diluted sulphuric acid. On heating one can identify the typical formic acid smell.

Experiment 2: Esterification of formic acid

Experiment lasts about 7 minutes.

As in experiment 1, natriumformiate (= sodiumformiate) can also be used as starting material for combining formic acid and ethanol.

Procedure: The salt and the alcohol, each about 2 cm³, are put into a test tube. About 1 ml of concentrated sulphuric acid is added and the tube well shaken. The formation of ester is soon apparent through the fine smell of arrack. On warming (about 1 minute at 50 °C) the smell grows stronger. After pouring into another glass half full of water and ensuring that the salt is dissolved completely by shaking, the ester forms as an oily film on the surface.

Experiment 3: The alchemist experiment

The transformation of oxalic acid into formic acid and carbon dioxide occurs through heating in glycerine.

Procedure: Into a retort or round-bottomed flask 50 g of oxalic acid dihydrate crystals are filled, then 50 g glycerine are added. The thermometer should reach into the mixture. A suction flask is attached gas-tight to the retort. From the suction flask a rubber tube passes to a beaker with about 5 cm depth of calcium hydroxide solution. The retort is placed on a tripod with a mesh and fixed there. The neck of the retort can be cooled with a wet cloth. The mixture is quickly heated until the thermometer shows 110 °C. By then all the crystals should have dissolved and gas bubbles are rising through the calcium hydroxide solution. Now the temperature is raised slowly to 140 °C. Then a clear distillate should drop into the suction flask, and the calcium hydroxide solution should become cloudy through the gas and then later maybe clear up again. After about 5 - 7 minutes the burner is extinguished and all connections are disconnected. Then the distillate can be tested regarding smell, taste, pH value and ability to reduce using an ammoniac silver nitrate solution.