Paints and Ecology by Neil May

The subject of paints and ecology is difficult because paints are relatively complex products, and to understand the health or environmental impact of a paint requires an understanding of chemistry, and of the relative significance of other impacts. It is also difficult because ecological paints have been misrepresented and mis-sold in recent years, and for people who have invested a lot of money or emotion in these products it is hard to accept that things may not be quite as they hoped.

The purpose of this article is to try to bring some clarity to the subject so that paints can be assessed more accurately, and so that those keen to promote ecological construction can specify paints with understanding and confidence. Unfortunately there are many areas in ecological construction where misunderstanding or wishful thinking are actually holding back the real delivery of sustainability, or even doing more harm than conventional solutions, and this in the end will be extremely unhelpful to the whole movement for sustainable construction, which is of vital and radical importance for health and the environment in the UK and elsewhere.

How then do we assess the ecological qualities of materials such as paints? At NBT we have a basic method of looking at ecological impacts by dividing them into three areas:

- The health of natural environment
- The health of people
- The health of the building fabric

Prior to any assessment of environmental impact however, there must be an assessment of performance. The least ecological product of all is one which doesn't work. This can be for a number of reasons, including bad flow, streaking, powdering, etc. For this reason, in the mainstream assessments to which I shall refer, the actual quality control and usability of a product is taken as a fundamental requirement and the coverage of a paint (particularly its opacity – which in the case of an emulsion should be 98% obliteration) is the starting point for comparison. If one paint takes 4 coats to reach 98% obliteration, while another can achieve this in one coat, then the assessment will be between the impact of 4 coats of the first and one of the second product. Coverage in coats per litre is also a vital part of the equation. In external paints the longevity of the product is also highly significant, and for this reason the report on coatings for external timber cladding looked at impacts over 100 year cycles, including cleaning and removal of paint when necessary. These criteria however are not required for internal emulsions to the same degree.

Before we try to assess paints however we need to understand clearly what paint is, and how it works.

What are Paints?

Paints are composed of 3 basic elements:

- Pigments
- Binders
- Solvents

Typically these make up about 95% of most paints.

Pigments give colour and opacity. They are held in solution by a solvent while the binder sticks the paint to the wall. In addition, paints usually have preservatives (if water based), driers and anti-skin agents (if organic solvent based), and a number of products to help flow, in-can consistency etc. Some products have more than one function, for example fillers (such as clays, micas and talcs), both act as weak pigments and can also help with film properties.

Pigments can be of many types. The most important pigment is white, both for colour but more importantly for opacity. The industry now uses Titanium Dioxide, or TiO_2 almost exclusively. Previous whites included Lead Oxide and Zinc Oxide, both of which are highly toxic and do not perform as well as TiO_2, in terms of opacity. Chalk and lime are also used as whites, although they have very poor opacity compared to TiO_2, and for this reason may require large number of coats to cover. Coloured pigments can be natural pigments (mined and processed), synthetic mineral pigments (such as ferric oxides) or organic pigments (which can have much deeper and brighter colours). Coloured pigments do not however give opacity, unless used in very large quantities.

Binders can be of many types. Basically they are all glues, except in the case of some mineral paints (such as silicate paints) where the binders react with the substrate and get their binding quality through this reaction. Primitive paints, such as distempers, used animal glues such as rabbit skin size or casein. Nowadays, most water based paints use petroleum based binders which are either vinyl or acrylic, or sometimes a combination of the two. Some of the ecological emulsions use dammar resin, linseed oil, castor oil or other natural oils.[1] Soya Alkyds and linseed oil are common binders for solvent based paints both conventional and ecological[2].

Solvents are of two types: water or organic solvents (alcohol) made from hydrocarbons (which includes natural organic materials). The most common organic solvent is White Spirit. Other common solvents include de-aromatised White Spirit, Isoparaffins, citrus oil and turpentine (which is highly restricted). It is important to note that common water

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[1] Some so called Eco paints use something called Vinegar Esther, which sounds natural but is actually a deceptive way of saying Vinyl Acetate (which is an esther of acetic acid – vinegar). It is this kind of deceit which is extremely unhelpful in taking proper ecological understanding and specification forwards.

[2] It should be remembered that Alkyds (including Soya Alkyds) are synthetic resins with a large phthalate content – these are the chemicals which have been banned as plasticisers in children's toys and are currently under a high degree of scrutiny as oestrogen mimics (endocrine modulators).

based paints often contain some organic solvents (1-2%), to ensure complete paint film formation, or to accelerate drying.

When a paint is applied to a surface the solvent (whether water or organic solvent) is released into the air, leaving a dry film without solvents.

Some facts:

The paint market in the European Union is worth about $10 billion per annum. This equates to about 2.4 billion litres per annum[3]. In the UK the paint market is worth about £1 Billion, ie about 20% of the total[4].

Waterborne paints and coatings represent about 70% of the total paint market in the EU. This proportion is on the increase. However, this percentage varies hugely from country to country. Organic solvent based paints in France, for instance, constitute 46% of the market, while only 10% of the Danish market is organic solvent based, the rest being waterborne. Interestingly, of the 550,000 tonnes of organic solvent used in the paint industry, 100,000 tonnes or 20% are used for cleaning tools[5].

Ecological assessment:

The health of the environment:

What are the major environmental issues as far as paints are concerned? And how significant are paints in relation to the rest of human activity?

Detailed reports such as that by VTT in Finland on wood coatings, or the EU's research on interior paints and coatings for the paint Ecolabel, have identified a number of areas where there is an environmental impact from paint. Foremost among these are issues of:

- Energy use (particularly non-renewable energy)
- CO_2/ methane/VOC emissions (particularly in relation to global warming)
- Pollution of air (SO_2, NOx, CO_2,heavy metal particulates, VOCs)
- Pollution of land and sea (sulphate and chlorine waste, heavy metals and some other products)
- Resource use and extraction

[3] European Ecolabel for indoor paints and finishes. Final Report Sept 2002 page 4
[4] Paint Research Association Figures 1999
[5] European Ecolabel for indoor paints and finishes. Final Report Sept 2002 page 4

The impact of paints comes mainly from the manufacture of the individual components, rather than from the mixing and manufacture of the paint itself. In the VTT report it was estimated that around 10% of environmental impact came from the manufacturing process. They also estimated that transporting finished paint for a distance of 100km resulted in less than 1% of the environmental impact of most products, although for environmental impacts such as the emission of NOx and VOCs this could be as high as 5%. This is an important fact to bear in mind as many paints (both conventional and environmental) sold in the UK come from Europe.

It is difficult to judge the relevance of these emissions and the energy usage in relation to other impacts and to the whole environmental situation. The Ecolabel report estimated that only 3% of the solvent emissions in Europe come from paints (about the same as aerosols and cosmetics according to Unilever), whereas the VTT report suggests that, for Finland, as a percentage of the total of man made VOCs, coatings constitute around 12%. This includes industrial coatings and car paints. Most house paints have small amounts of VOCs by comparison. Nonetheless the proportion is significant and the VTT report concludes that "the reduction of emissions of photochemical oxidants should still be one of the primary interests of the paint industry". Similarly, although the figures are more vague, the report says that "although the environmental burdens of 1kg of paint are rather low, the adoption of eco based product development methodologies…. is nationally and economically necessary. This is critical when the total energy consumption and related emissions are to be controlled or reduced."

Importantly, the significant factors in energy terms, global warming potential (not only CO_2 but also VOCs and other emissions) and pollution of the sea and land are largely to do with the 3 main constituents of paints (apart from water): TiO_2, solvents (organic) and binders. Overwhelmingly the most important and significant impact comes from TiO_2. To quote the Ecolabel report:

" ..the four environmental problems to which paints and varnishes contribute most [are]

- Non renewable resources depletion due to petroleum consumption for the production of Titanium Dioxide (TiO_2), resins and solvents
- Global warming through CO_2 and VOC (volatile organic compounds) which production results respectively from TiO_2 production and from Solvent Paints and Varnishes application
- Atmospheric acidification due to CO_2 and SOx resulting from TiO_2 process
- Discharges of waste into water essentially due to TiO_2 process"[6]

As mentioned at the beginning of this article paints are mainly pigments, binders and solvents. In a typical paint the solvent (water or spirit) can be up to 50% of the product, while the binder can be between around 12 and 25% and the basic pigment (TiO_2) also between 12 and 25%. The embodied energy of these products is quite different[7].

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[6] European Ecolabel for indoor paints and finishes. Final Report Sept 2002 page 4

[7] The figures here are compiled from manufacturer's reports, and from the logic of processes and costs. For example, solvents are simply cracked and distilled from crude oil (as are Styrenes) whereas VA monomers require a 3-4 step process from crude oil and Acrylics 6-7 steps. Each step requires an energy

Product	Typical % in paint	Typical embodied energy MJ/kg
Solvent water	50%	0
Solvent White Spirit	50%	15
Acrylic/ Vinyl Resin	12-25%	20 -25
TiO_2	12- 25%	45

It is obvious that these factors are going to have a significant impact, and that organic solvent based paints will inevitably have higher overall environmental burdens, all other things being equal, than water based paints. Natural solvents such as turpentine and citrus oil have relatively low embodied energy, but are increasingly restricted because of their high health risk. What it is important to grasp however is that, in energy terms, it is the Titanium Dioxide which is by far the most significant factor.

This is born out in the initial work for the Ecolabel project, which covered 11 different types of paint (all water based, though some had high levels of solvents), and which included an assessment of a "natural paint" (a linseed oil emulsion), that scored well in the eco-assessment (except regarding eutrophication). However, the reason for this was not due to the linseed oil or other ingredients, but due to the fact that it was a zero solvent and a relatively low TiO_2 product[8].

Similarly in the VTT study, the traditional Scandinavian timber paint had the best rating mainly because of its zero TiO_2 and zero solvent rating. Linseed oil paints also rated quite highly, mainly because they used gum turpentine as a solvent, which has very low embodied energy. The linseed oil has a relatively high embodied energy, though not as high as other binders. In the VTT report, however, the water-based alkyd stains performed better than white linseed oil paints, in embodied energy, CO_2 emissions and all other categories, mainly because they were solvent and TiO_2 free. However, not everyone wants a transparent stain for a paint[9].

Titanium Dioxide therefore is the most significant impact of paints from the perspective of impact on the natural environment. Most ecological paints do not address this issue at all because it is difficult to achieve opacity without it. In fact some ecological products may end up with higher amounts of TiO_2 than conventional products because of the other ingredients in the paint. Do not be deceived by eco paint producers saying that the TiO_2 comes from a recycling process. This does not mean that the pigment has been recycled from old paint, pills and paper, but refers to the recycling of materials in production, either by the sulphate or the chloride method. There are only two ways to make TiO_2 and

input thus increasing the amount of embodied energy. These figures contrast with those from the VTT Building Technology report on Environmental Impact of Coated Exterior Wooden Cladding 1999, which places all figures much higher but also suggests that solvents have higher embodied energy than resins. This may, however, be due to different methods of calculation which incorporate intrinsic calorific values as well as transport to Finland and a number of other variables.

8 European Ecolabel for indoor paints and finishes. Final Report Sept 2002 page 24

9 VTT Building Technology report on Environmental Impact of Coated Exterior Wooden Cladding 1999 pages 66-76

they both have equivalent environmental impacts. All manufacturers of paints, whether ecological or conventional, source their TiO_2 from the same sources.

One additional factor to take into account, which is not considered in either the Ecolabel or the VTT reports is the effect of materials on habitat destruction. Again this applies particularly to TiO_2. The reason for this is that relative to water or petroleum the raw materials for manufacturing TiO_2 are relatively scarce. The Titanium Dioxide market is worth about $8 billion per annum, which equates to 3.5 million tonnes. A significant proportion of this is for paints and coatings. There is now a global shortage of the raw material which is only found in certain geographical areas. Some of these, though by no means all, are unique habitats such as Madagascar, which are under continual pressure to open up new mines. The issue of resources and habitats as regards other paint ingredients are less significant, although it would obviously be beneficial if renewable/ sustainable resources could be used for all paint ingredients, provided that the total energy and environmental impact is kept the same or lower. The difficulty with some natural or sustainable products is that their total impact is sometimes greater than that of the synthetic alternative.

On this note, it is interesting to compare the effect of TiO_2 with other pigments, such as iron oxides, or ochres. Ochres are often sold as "natural" and as evidence of a paint being ecological. However, this is one area where the environmental facts are sometimes counter-intuitive. In the VTT report on pigments, it is noticeable that synthetic oxides including red, yellow and black, have far less environmental burden than natural red oxide (red ochre pigment mined, washed burnt and crushed), and slightly less than yellow ochre (which is not burnt). The reason for this is that the synthetic oxides are made as a by-product of another process that involves an exothermic reaction. The embodied energy is purely in transport from manufacturing plant to the paint factory. The comparison is as below. I have also included the profile of TiO2 (although not included all the other serious wastes and emissions from TiO_2 production, whether by sulphate or choride method)[10].

Impact	Synthetic ferric oxide	Natural red ochre	Natural yellow ochre	TiO_2
Non renewable energy MJ/kg	1	22	2.7	70
CO_2 g/kg	60	1100	140	5000
SO_2 g/kg	0.5	5.9	0.91	40
NOx g/kg	1	3.5	1.7	15
Particles g/kg	0.1	0.49	0.12	12
CH_4 g/kg	0.1	0.36	0.12	12
VOC g/kg	0.1	0.48	0.24	33
Heavy Metals to air g/kg	0.00001	0	0	0.001

[10] VTT Building Technology report on Environmental Impact of Coated Exterior Wooden Cladding 1999 pages 26 – 38.

I do not have an exact ecological profile of synthetic organic pigments, but understand that they are significantly worse in every area, and some particular pigments are made from highly toxic precursors such as Aniline. These are now strictly contained and monitored in the West, although there is no guarantee that this will be the case in countries such as China. The same, to some extent, goes for TiO_2, so it is important to shop locally for pigments if certainty is required reguarding environmental performance. On the plus side, synthetic organic pigments are very strong, so relatively little are required.

Nearly all paints (rather than stains), whether ecological or conventional, use large amounts of TiO_2 to give opacity. White pigment is not primarily about whiteness but about the ability of a paint to cover. It is required even in the darkest of colours, or the paint will be translucent. The proportion of TiO_2 is usually over 12% in emulsions, and can be as much as 25% in one-coat paints. In the light of this and of the table above, it is fair to say that natural pigments are not always more ecological than synthetic pigments and do not usually have a significant effect on the overall environmental profile of a paint.

The Ecolabel reports have led to the Ecolabel Product Fact Sheet for Indoor Paints and Varnishes, which divides the assessment of paint impact into 'Manufacturing and Use' and 'End of Life'. All the manufacturing impacts are related to TiO_2 and consequently limits are put on the amount of TiO_2 per m^2 of dry film as a criteria for paints having the ecolabel. This limit ($38g/m^2$) has been determined by the requirement for TiO_2 to give good opacity to the paint (a hiding power of 98% at $8m^2/l$). In order to get substantially less TiO_2 than this limit, either another white pigment (such as lithopone) would have to be substituted for some of the TiO_2, or performance would drop, more paint would be used, cancelling out the environmental benefits.

The Ecolabel criteria also put limits on VOCs, bans on toxic chemicals and restricts the use of most preservatives. Most of these are now strictly regulated or banned (for example lead in paint), but some, such as VOCs, are still the subject of voluntary codes or labels such as the Ecolabel. Most of the concern about these substances relates to human health covered in the next section.

In conclusion to this section, the paints with the least environmental impact are water based paints with low TiO_2 content and low amounts of binders. Obviously, all toxic materials and processes should be avoided from an environmental as well as a health point of view, and in addition, renewable/sustainable resources should be used where possible. By far the largest impact, however, comes from the materials used in greatest quantities, with the most processing. TiO_2 stands out as by far the most significant ingredient, and reduction of TiO_2 should be the main aim in ecological specifications, providing that paint performance remains as good as conventional standards.

Health of People:

The main issues are:

- Organic solvents
- VOCs
- Preservatives
- APEs (hormone mimics)
- Heavy metals

In the past paints were a considerable health hazard. Lead poisoning and dangerous reactions from gum turpentine were the main risks. These products are now restricted in the ordinary market place. In spite of the marketing of some natural paint companies, it should also be clearly stated that acrylics and vinyls do not constitute a health hazard. They are virtually inert materials, which have been used in everyday applications for many decades without risk. Children's face paints are acrylic resin based, PVA white glue (wood glue) is vinyl – polyVinylAcetate and we wear synthetic polymers such as polyesters daily.

In regard to the health of people, both decorators and inhabitants of rooms, the main issues are organic solvents and the VOCs which come from organic solvents. There are also a number of other potential hazards from preservatives, hormone mimics and heavy metals.

Organic solvents are the main, though not exclusive, source of VOCs in paints. If anything smells at all then there are VOCs present, and these can come from a variety of sources. Organic solvents are dangerous both as producers of VOCs and because they can be serious irritants on skin. Toluene and Xylene for example are common organic solvents and are both dangerous irritants. As VOCs they are dangerous also for two reasons: they are volatile organic compounds (aromatic hydrocarbons derived from Benzene) which, when inhaled, can react with the human body and with Nitrogen Oxides (NOx) to create ozone at ground level. In reaction with the body they can attack the central nervous system, the liver, kidneys and the reproductive system. Natural solvents such as gum turpentine and citrus oil (de-limonene) are also extremely hazardous (because full of alkenes), and may be more dangerous in some areas of health than White Spirit. The move to de-aromatised or non-aromatic hydrocarbons is to be applauded, but there is still some risk with these products. They have a higher environmental impact in terms of embodied energy partly because of processing and also because, on the whole, more has to be used than aromatic solvents due to their poorer solvent power.

The reaction of VOCs with ozone is a cause of asthma attacks, respiratory problems and decreased lung function. Again it should be noted that VOCs from solvents in paints are probably significantly less than 10% of the man made VOCs in Europe, but may still have a considerable localised effect, particularly in an unvented room. It should also be noted that people now spend about 90% of their time indoors, and that in the case of asthma, there seems to be very little correlation between high incidence of asthma and bad outside air quality, and a very large correlation between high incidence of asthma and poor indoor air quality[11].

For these reasons, solvent and VOC levels have been reduced in paints, and there are attempts to reduce these levels further. Generally, water based paints should be used, and within water based products, those with the lowest solvent and VOC content. However, in certain external situations and in certain climates, organic solvents still provide better performance. Health and safety precautions should always be followed carefully. As pointed out above, however, deodorants and cosmetics contribute about the same amount of VOCs in Europe as paints, so be careful with that hairspray too!

Preservatives are only required in water based paints at extremely low levels (typically effective at 15ppm). This is both to stop paints going off in the tub and after opening, and also to stop contamination in paint manufacturing plants. Moulds can be extremely toxic, so there is a good point to preservatives. Once on the wall, however, most preservatives are not required, unless the room is constantly prone to damp, in which case there is a building problem. In this situation it is better to have a mineral paint than an organic paint (whether petroleum or plant based), as mineral paints are less "edible" than organic paints and are often highly alkaline, thus resisting mould and bacteria far better.

Preservatives are normally chlorine based Isothiazolinones. There is now some concern about some of these products and all of them are restricted in use. The Ecolabel criteria has singled out the chlorine based preservatives as ones to be avoided if possible (As NBT has done in its paint formulations). However, all preservatives are toxic - that is their function[12].

Alkylphenolethoxylates (APEs) were previously mostly used in washing-up detergents, but are still used in some pigment dispersions. They are considered dangerous because they are hormone mimics (especially Nonyl Phenol), and when in watercourses can cause mutations in fish and water life. They have been largely phased out of paint products. However, all "ecological" paints should avoid these, as per the Ecolabel criteria.

Heavy metals should also be avoided. The Ecolabel criteria bans lead, cadmium and chromium among others, in all forms, but these have effectively been removed from paints for years[13]. There are also concerns about Cobalt in Alkyd oil paints. The problem this presents paint manufacturers is that it is the most effective paint drier for organic solvent based paints since it replaced Lead. While amounts of driers have been reduced, it is currently not possible to eliminate them altogether without having paints which are, in reality, almost non-drying![14]

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[11] See Housing and Asthma by Stirling Howieson publ. Spon press 2005

[12] Preservatives are mostly toxic to small things like bacteria since they have a toxicity limit based on body mass of organism i.e. per kg. For this reason it is argued that these amounts are unlikely to effect people.

[13] Interestingly the most toxic hexavalent Chromium --Cr(VI) is still present as the catalyst for rapid setting concretes, another example of the legislative discrepancies imposed on paints.

[14] Some people who used certain eco-paints in the early days may recognise this kind of paint!

In summary, I do not consider most water based paints to be a major risk to health, particularly in relation to other threats in our environment, especially moulds, dust mites and toxins from other materials in buildings. However, the paint industry, as all industries, needs to strive continually for less polluting and hazardous alternatives to problem ingredients. Furthermore, for those who are chemically sensitive, and for all with allergy or respiratory problems, or in any vulnerable state of life or place (such as children, old people, schools and bedrooms), zero solvent paints, with as near to zero VOCs, with minimal preservatives should, in my opinion, be used. This becomes more important the more we improve air tightness in buildings. The future has to be non-toxic and solvent free with virtually zero VOC paints.

Health and Buildings:

The main issue is:

- Water

One thing that is often forgotten by many decorators or specifiers is the effect of paints on the building fabric. This is wholly to do with the way water is dealt with in buildings, both as vapour and liquid.

What is required of a paint in a building is often very different in different circumstances. For example, on the outside of a building on a rendered wall, a paint will often be required to be resistant to water as a liquid, but open to water as a vapour, so that if there is water in the wall (whether from outside penetration or from internal vapour pressure) then it can get out and the wall can return to a dry state. This is vital for the prevention of moulds, the decay of fabric, and the loss of thermal performance (through cold bridging through the trapped water). The same does not necessarily apply to all external woodwork. Inside, the requirement for resistance to water as a liquid, and vapour openness is similar but different. In fact, the vapour openness should be higher, particularly in new constructions where there is likely to be a lot of residual construction moisture, or in "breathing constructions" where vapour is held and transmitted in and through the wall build-ups.

It should be noted that the moulds which affect building fabric also effect human health, so that although paints may not be mouldy, if they contribute to a situation where moulds appear in other parts of the fabric, then they are part of a human health problem as well as a building health problem.

The "breathability" of a paint therefore is vital. Breathability is basically about 3 factors:

- Vapour permeability
- Capillarity
- Hygroscopicity

Hygroscopicity is the ability of a material to absorb and desorb water vapour as relative humidities change. Although paints may have these qualities, they are not relevant to building or human health, because the holding capacity of paint is very small, as paints are so thin.

Vapour permeability and capillarity however are important. Here are some comparisons of the vapour permeability of different paints, as well as air and two types of plaster. What is critical is not just the resistivity to water vapour, but the common construction thickness.

Material	Range of resistivity r MNs/gm	Typical resistivity r MNs/gm	Thickness of the layer mm	Construction resistance (at typical resistivity) G MNs/g
air	5	5	1000	5
cement plaster	75 -200	100	20	2
lime plaster	45-200	75	20	1.5
emulsion paints for indoor use	1000-7500	1,500	100 µm	0.15
emulsion paints for outdoor use	10,000-25,000	15,000	120 µm	1.8
silicate paints	250-350	300	100 µm	0.03
5 coatings with pure limewash	250	250	100 µm	0.025
solvent based glosses	15,000-25,000	20,000	120 µm	2.4
alkyd varnishes	60,000-100,000	80,000	120 µm	9.6
coatings, based on epoxy resins	175,000-250000	200,000	120 µm	24
coatings, based on chlorinated rubber	350,000	350,000	120 µm	42

It is important to note is that while an indoor emulsion may have 5 times the vapour resistivity of a limewash, in terms of construction resistance it is still very small compared with a plaster, because the plaster is so much thicker. If, however, a gloss paint is applied to the inside of a wall then the vapour resistance is considerably higher, and a real effect is felt. This effect is to limit the amount of water vapour passing into or out of the wall (if wet or acting hygroscopically). This is not normally critical until buildings are airtight and inadequately ventilated, as most moisture transmission at present in buildings is through ventilation and air leakage into the structure. It is also not really relevant to moisture control unless the walls/ceilings are either vapour open as a whole, or have hygroscopic qualities. This situation occurs almost always in traditional construction (for example in the 25% of the UK building stock that is solid wall) and will increasingly occur in modern constructions when the full importance of breathable construction is realised[15].

Minke has done some interesting work comparing the effects of different paints and finishes on the moisture vapour absorbance of a clay wall, and has also found that until

[15] See my article on "Breathability: the key to building performance"

you reach a very high resistivity, as in double boiled linseed oil (probably similar to epoxy resin resistance) the finishes on the walls make relatively little difference to the wall performance[16]. It is my opinion that where it is beneficial to maximise breathability, and ensure vapour openness over a long period (when walls may be painted several times), the most vapour-open products should be used. Internally this means silicate paints or very vapour-open matt emulsions.

Vapour-open paints should not be confused with paints with high capillarity, which means that they also absorb water as a liquid. Capillarity is often confused for vapour permeability. For example a paint like a limewash, or a casein paint, changes colour when liquid water goes onto it. This indicates that it is capillary open, and in the case of emulsions this usually indicates that the paint is underbound (ie has a low amount of binder compared to pigment). The consequence is that these products will come off if rubbed down with a wet cloth, and will absorb dirt more easily. In some situations this capillary openness is desirable, as on infill panels on the outside of an exposed traditional timber frame building, or inside a cold church prone to condensation. In these circumstances the building fabric can be protected by this capillary draw (thus reducing condensation in the case of the church, and reducing run off in the case of the timber frame). In most circumstances it is desirable that paints are more capillary closed. It is perfectly possible to have a paint which is as vapour open as limewash, and as capillary closed as a standard masonry paint. Indeed this is the quality that most external silicate paints have.

Having the wrong vapour permeability in a paint can cause buildings to rot and fall down. This is commonly seen in the conservation world, where gloss, alkyd or worse, epoxy or rubberised finishes are applied to the outside (and sometimes to the inside) of timber frame houses or historic buildings with timber such as joist ends embedded in walls. The lack of vapour permeability means that residual moisture, rain penetration through hairline building cracks, or other moisture sources can cause moulds and insect infestations in timbers resulting, eventually, in structural failure.

In the case of external joinery it is often argued that paints should be vapour open. This is a debatable point, and depends on the condition of the joinery, the detailing and position of the joinery, the level of exposure etc. One of the disadvantages of using more vapour open paints on timber is that the wood is more prone to swelling and shrinkage as relative humidity changes. This can then cause windows and doors to stick or become loose in their frames, it can open up cracks in timber, particularly on cills, which then may let in rain. Most of the damage to timber joinery is done by water getting into timber. It takes a very short time for liquid water to get in and a very long time for it to come out as vapour, even with vapour-open finishes. In my opinion the critical thing about external joinery is that it should use high quality timber (durable and stable), and timber cills should be avoided at all times as these are vulnerable to both rain and UV in a way that vertical timber is not. The joinery should be set back as far as possible to protect it from rain and wet masonry, and if new, the joinery should be factory glazed and coated when the timber is dry. If these rules are followed there will be no problems with timber

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[16] Earth Construction Handbook by Gernot Minke WIT press 2000 pages 16 – 18

joinery for the life of the building and more. The actual paint in these situations is less important, so long as it keeps the rain and the UV out.

In summary, understanding the vapour permeability and capillary qualities of a paint are highly important to the health of the building and consequently to the health of the building's occupants. The appropriate breathable qualities in a paint will vary between different applications. It is also not even necessarily good that a paint is vapour-open, although in most wall situations this is often true. (Please refer to my article on Breathability for a fuller treatment of this subject.) However, unless the breathability of a paint and the demands of the structure are taken into account when paints are specified, then building performance can be adversely affected, sometimes with serious consequences for people, buildings and, ultimately, the environment.

Conclusion:

I hope that this article has helped to explain, in lay terms, the issues surrounding paint and ecology. As I made clear at the beginning, there is an awful lot of confusion and mis-representation in this field, which is not helpful and ultimately undermines the good-hearted attempts of people to do something positive for the environment.

It is important to distinguish on what basis paints are being assessed. The NBT method of assessment takes account of three different criteria, the health of the environment, the health of people and the health of the building fabric, to ensure that the paints that are traded or recommended are ecological in all ways. This is not always possible, however, as some demands and applications are more urgent than others, and sometimes these conflict. In our opinion, functionality or performance is the essential starting criteria, and environmental impact, human health and building fabric health are then given different values according to the application. For example, a paint on the outside of a building which has excellent performance (durability, breathability etc) would justify higher embodied energy and health risks than an ordinary emulsion for use inside a house. In bedrooms, schools or hospitals, the health factor may be the most significant, whereas in old houses the resistance to mould and breathability are often the most important.

Ecological paints have come a long way in the past ten years. Conventional domestic paints, however, have probably moved further due to legislation and the market awareness of environmental and health impact. Nonetheless there remain considerable concerns, and ecological paints need to continue to force the market to move forward, and to make the point clearly and scientifically for more environmental sound and healthy products.

The manufacturers and promoters of ecological paints need to be focussed first on issues of greatest impact and concern, and to set paints within the context of overall building health, performance and impact. The judgement of what is of most concern needs to be based on sound and objective science, not on emotion or ambiguous marketing. It also needs to be put in the greater context of total environmental impact, and effort needs to be proportionate to these. Understanding the science and the facts of both paints and more general environmental and health issues, is the first step towards a more rational and progressive attitude to paints, their use and development.

NM 11/05/05

Note:

NBT Paints have been selected and developed on the basis of the above assessment

NBT Trade Emulsion: Zero Solvent, Virtually zero VOC (about 0.01%), 25% less TiO2 and resin than standard comparable emulsions for the same performance. APE and Chlorine free. Very vapour permeable. Made in the UK

NBT Trade gloss and eggshell: Very low VOC, water based products, made in the UK.

NBT Timber Paints: Scandinavian Timber Paints (as classified by the VTT report as by far the most ecological timber cladding product with high long term performance), made from linseed oil, cellulose, iron oxide and iron vitriol. In 4 colours.

Black Timber paint: made with natural VOC free asphalt and using isoparaffin as a solvent. Very durable, resistant black paint for sawn timber, such as cladding for barns.

NBT Beeck Silicate paints: Zero solvent, high durability, silicate paints, which being alkaline and mineral are mould, pollution and fire resistant, as well as highly vapour permeable