STAINING AND MICROBIOLOGICAL INFESTATION OF ACRYLIC PAINTINGS ON HARDBOARD

Ulrik Runeberg

ABSTRACT — Hardboard served as a common and popular support for many modern and contemporary paintings. Some artists considered hardboard to be a stable, light and economic alternative to solid wood panels and other rigid supports, whereas others rejected the processed and compressed wood fibre boards as an inferior industrial construction material of low aesthetical value.

From the conservator's critical point of view, the many disadvantages to be found in this material, such as high acidity, hygroscope character, tendency of warping, and the flaking of certain painting materials in the case of tempered hardboard, outweigh by far the positive aspects of this material as support for paintings.

A very characteristic damage found on acrylic colour and other porous painting media on hardboard is the formation of stains, which may manifest itself in a variety of ways, including ligneous residues, bleeding extractives, and microbiological growth.

This contribution aims to describe and differentiate such characteristic stains, and provides a practical treatment proposal to reduce, neutralize and disinfect stained acrylic paintings on hardboard through the application of an alkaline absorber.

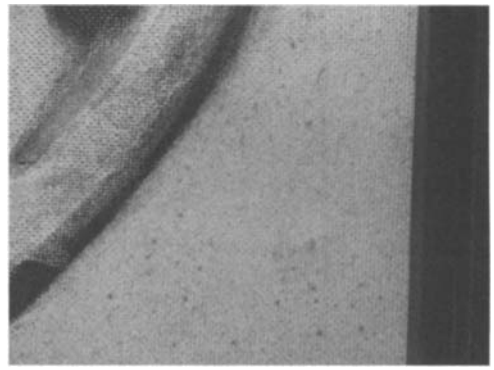

Image 1.
Detail, Support Induced Discolouration
Noemí Ruiz, 'Paisaje (árboles)' (1967), Acrylic painting on hardboard, approx. 121 cm x 92 cm (Horizontal format), MAC Cons. File # 027206, N. Ruiz.

1. INTRODUCTION

In a humid environment, the combination of acrylic paint and hardboard, and the physical and chemical properties of both materials may result relatively fast in the development of characteristic stains on the surface of a painting. Those stains are generally caused either through a phenomenon called *Support Induced Discolouration*, commonly known as 'SID', or due to a microbiological infestation of support and painting.

The term *Support Induced Discolouration* can refer to the extractive bleeding of natural components of the hardboard, and also to the off-gassing of certain artificially added coatings and impregnations. The materials concerned may include oils, resins, waxes, tannins, lignin and formaldehydes, which under certain climatic conditions tend to bleed through porous painting layers. Microbiological growth on the acrylic painting medium and hardboard can occur through fungal infestation, bacterial colonization or the development of moss and algae, if the available quantity of water is high enough ($\geq 65\%$) (Warscheid, 2003). In some cases, a combination of microbiological growth and extractive bleeding, may both exist side by side, as well as in a symbiotic-like relationship. Another source of staining that has been observed, is the extractive bleeding and efflorescence of original painting components such as Polyethylene-Oxides. As this aspect was not included in the research project, it cannot be discussed in detail here, but shall at least be mentioned.

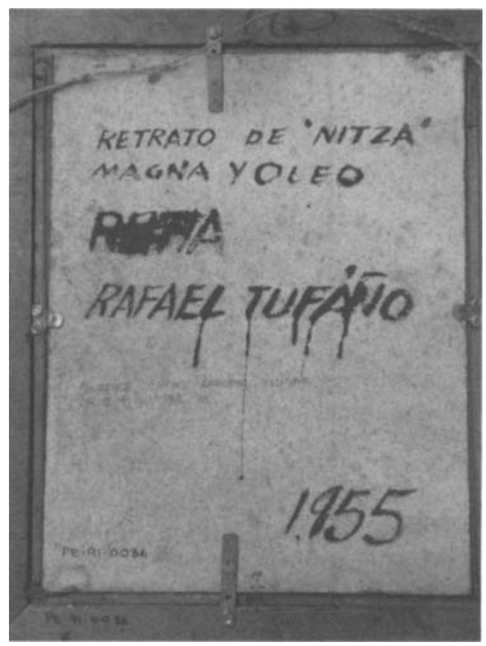

Image 2.
Reverse, Stains (Support Induced Discolouration)
Rafael Tufiño, 'Retrato de Nitza' (1955), Acrylic painting on hardboard (Reverse), MAC Cons. File #025806, Instituto de Cultura Puertorriqueña (ICP)

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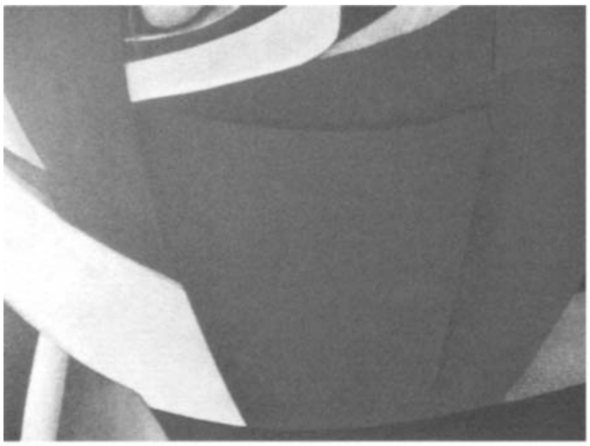

Image 3.
Metabolization of carbonic pigment contents through mold infestation
Noemí Ruiz,'Origen Antillano' (1960's), Acrylic painting on hardboard,
Approx. 91,2 cm x 122 cm (Vertical format),
MAC Cons. File #019405, N. Ruiz

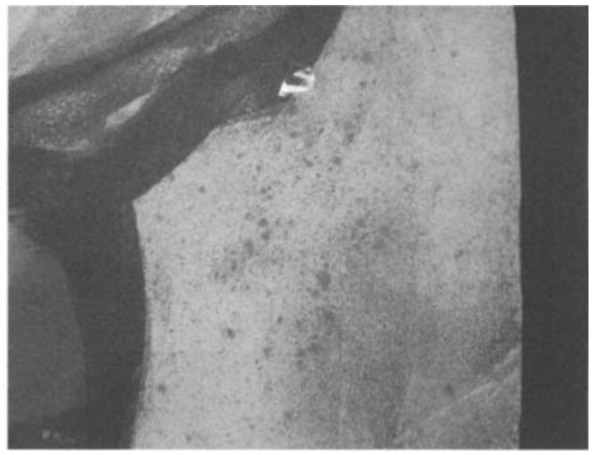

Image 4.
Combination of SID and microbiological infestation ('side by side')
Noemí Ruiz, 'Arbol', (1967), Acrylic painting on wooden composite board,
Approx. 73 cm x 202 cm (Vertical format),
MAC Cons. File # 022505, Noemi Ruiz

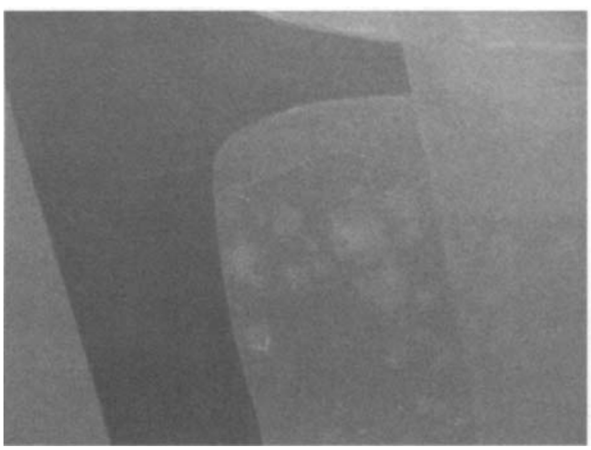

Image 5.
'Symbiotic' combination of extracts from the hardboard (SID) and mould
Noemí Ruiz, 'Trayectoria luz' (no date), Acrylic painting on hardboard,
Approx. 122 cm x 91 cm (Horizontal format),
MAC Cons. File #019505, Noemí Ruiz

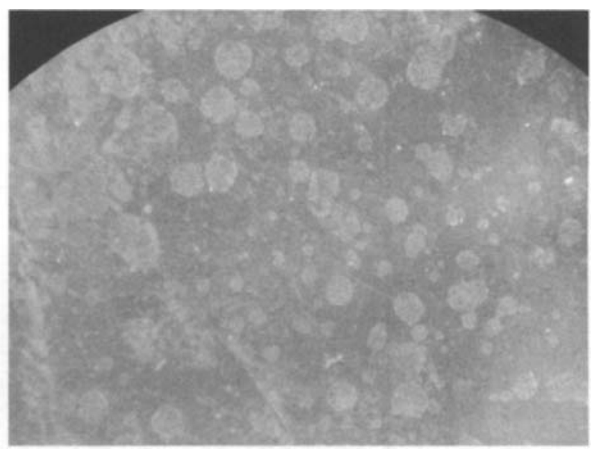

Image 6.
Detail, extractive bleeding of painting components / Poly-Ehtylene-Oxides (PEO's?)
Noemí Ruiz, 'Floral' (1960), Acrylic painting on hardboard,
Approx. 45 cm x 59 cm (Vertical format),
No Reg. #, N.Ruiz

The two characteristic kinds of stains described, develop extremely well and fast in humid tropical conditions, but may also occur to a lesser and slower degree in moderate climatic environments. Due to their visual similarity, stains often happen to be confused and described indifferently as 'fox-spots'. The lack of examination and classification, however, can easily lead to inappropriate conservation treatments, that rely on strong bleaches, leaching acids and toxic fungicides.

This article tries to establish a classification of the staining and microbiological infestation of acrylic paintings on hardboard (see 'Table Stains'), and provides case samples of stain-reduction by means of an extraction method through neutralizing poultices that contain Sodium Bicarbonate.

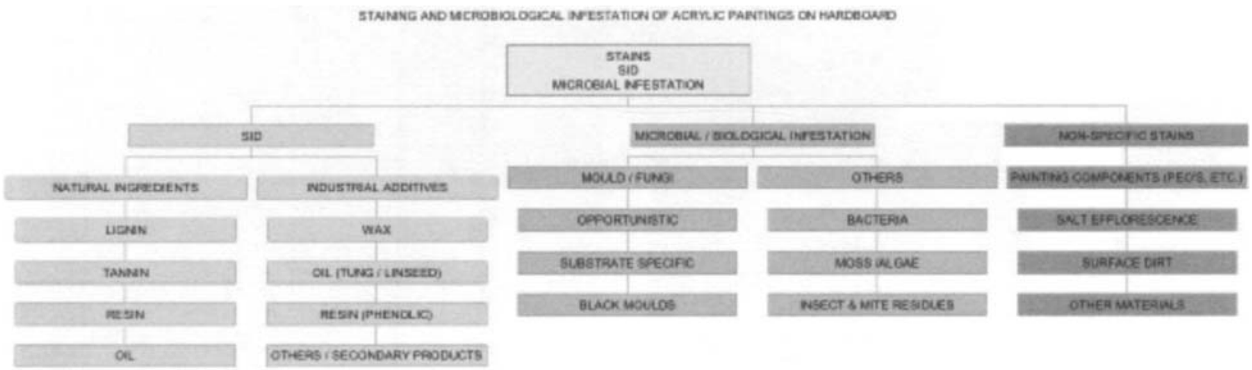

Figure I. Flow structure, Ulrik Runeberg

Most of the paintings that are included in this project, date back to the 1960's, and belong to the Puerto Rican heritage. Many had been stored in uncontrolled and excessively humid conditions above 85% relative humidity, prior to entering the Conservation Lab of the Contemporary Art Museum in San Juan, to undergo examination and conservation treatment. Usually, paintings were found to be applied on 'no name – hardboard - products', that were made in Brazil, Spain and the U.S.

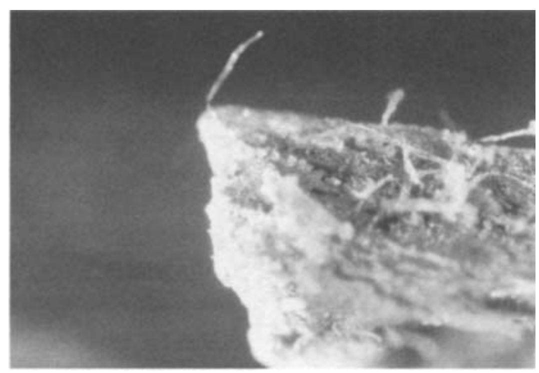

Image 7.
Fiberboard, dry-processed
Magnified through Binocular, Nikon SMZ 2 T, 4x

2. HARDBOARD

To understand the phenomenon of 'Support Induced Discoloration', which includes the two subordinated groups of 'Extractive Bleeding' and 'Off-Gassing', we will have to take a closer look on the basic properties of hardboard. At the same time, we would have to put the characteristics of acrylic colour systems into context, and take into consideration any possible interaction under certain climatic conditions.

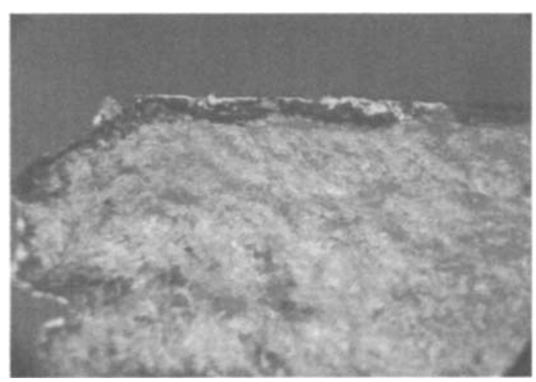

Image 8.
Fiberboard, wet-processed
Fragment, 'Astral Extravaganza' (1966), Acrylic painting on hardboard, Stereomicroscopic examination (Daniel Friedman)

Hardboard consists to over 99% of heat-compressed and inter-felted wooden fibres, which are held together through the natural polymer lignin. Hardboards are either dry- or wet-processed (*Images 7,8*). Of the many brands that exist internationally, 'Masonite' is perhaps best known. The most common boards are smooth on one side, and rugged on the other. The majority of paintings are generally executed on the smooth side. There are un-tempered hardboards, and tempered ones (*Images 9,10*). Tempered hardboards are usually impregnated or covered with a thin oil layer, a resin, or a wax coating, which tends to reject painting materials, if not prepared properly by the artist. The fibres may consist of softwood or hardwood particles, ranging from pinewood to tropical wood. Tropical wood flakes may consist of red cedar, mahogany or eucalyptus, which tend to release acidic tannins, and tend to discolour easily. The huge variety of products that are composed by different wooden blends leads to a great variety of brownish colour-

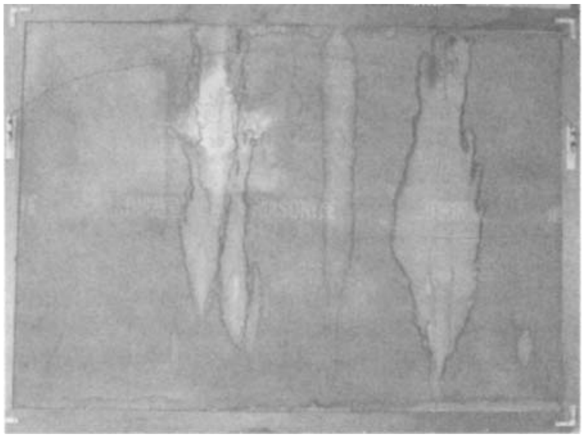

Image 9.
Reverse, Tempered Hardboard, Masonite
Fran Cervoni, 'La Masacre de Ponce' (1989), Oil on hardboard (Masonite), Approx. 177 cm x 122 cm (Horizontal format), MAC Cons. File #009003, Instituto de Cultura Puertorriqueña

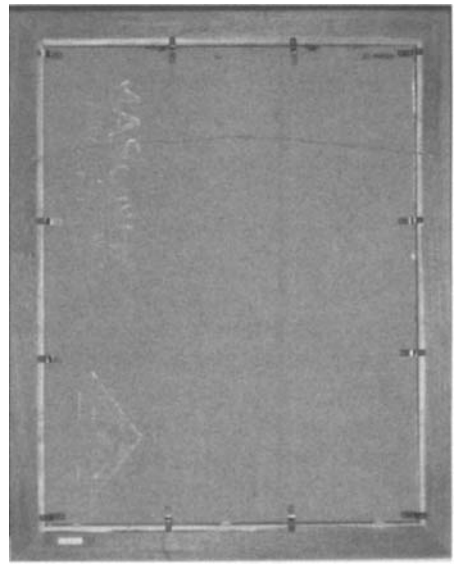

Image 10.
Reverse, untempered hardboard, Masonite
Jimmy Shine, 'El Mundo' (1963), Approx. 72 cm x 90 cm (vertical format), Acrylic painting on hardboard, MAC Cons. File #015804, Fundación Angel Ramos

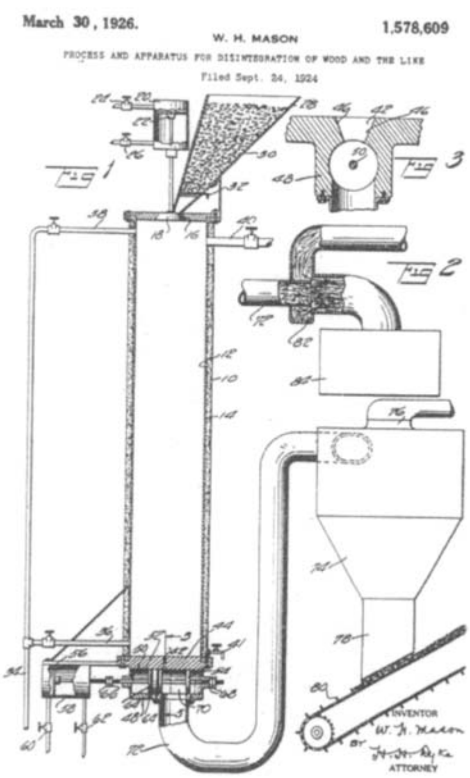

Figure 1b. Fig. Ib) Patent design, W. H. Mason (1924/1926). The copy of this patent was provided kindly by A.Katlan.

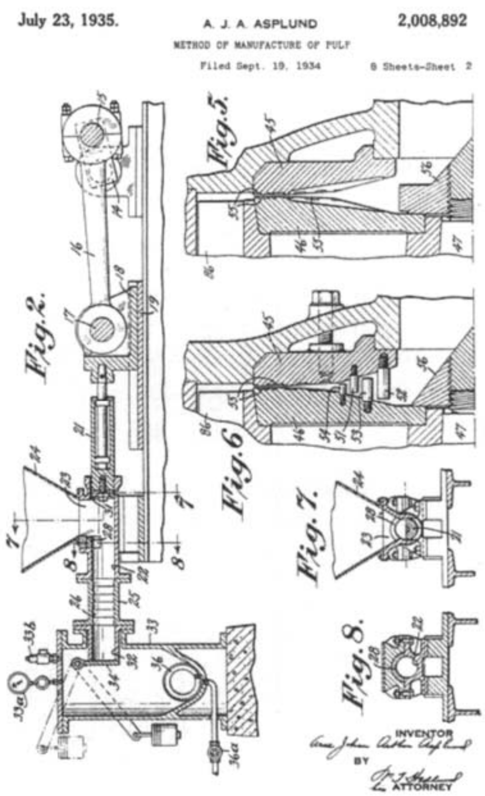

Figure 1c. Patent design, A. J. A. Asplund (1934/1935) The copy of this patent was provided kindly by A.Katlan.

tones. Any kind of hardboard has in common: high acidity of up to pH3 (*Image 11*); sensitivity towards UV-radiation and humidity; capacity to retain up to 30% of water; swelling; vulnerability of exposed edges; flaking; and even infestation through termites (*Image 12*). With the vaporization of ligneous material, the remaining cellulose structure turns fragile and can finally collapse (Hudson Highland, 2006).

Due to its tendency to absorb and retain moisture, its organic contents and high acidity, hardboard provides an ideal substrate for the development of fungus, bacteria and even algae and moss. At the same time, oils, liquids, soils and organic substances are all readily absorbed onto the fibres, and can oxidize over time, developing into coloured stains.

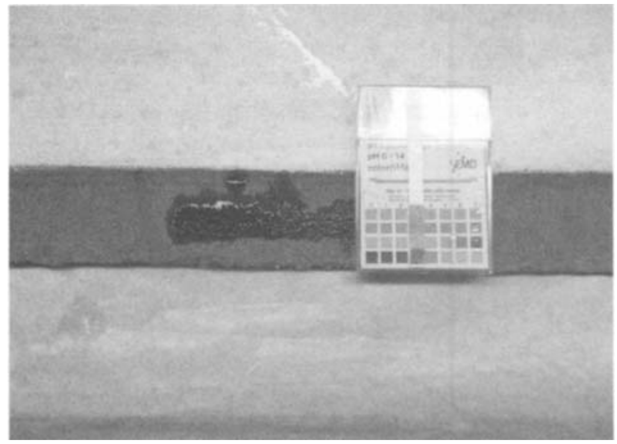

Image 11.
PH-level 3 of aged hardboard (1960s)

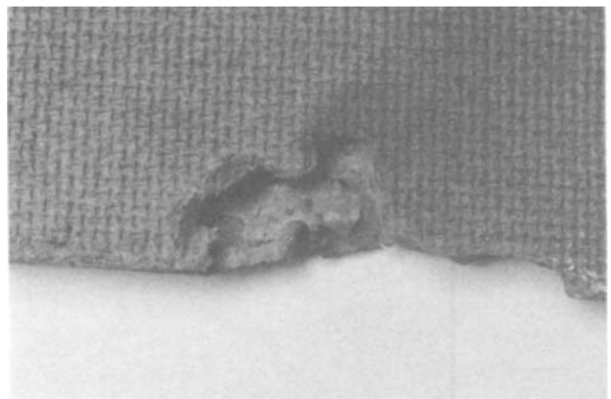

Image 12.
Termite infested and decomposed hardboard, reverse
Noemí Ruiz, 'Meditación' (1966),
Approx. 91,5 cm x 122 cm (Vertical format),
MAC Cons. File #022405, N. Ruiz

3. ACRYLIC PAINT

As we know, acrylic colour systems are prone to infestation through micro-organisms, whether on its surface, or rooting within the material. The porosity of acrylic painting layers allows hardboard contents, liquids and gases to permeate to its surface. Cavities in the painting layers tend to retain moisture and substrates, and to create a micro-climate. Voids in the painting layer may provide access for fungal structures to the substrate and moisture content of the support. Artist's acrylic painting materials are usually water-bound emulsions of Polybuthyl - Methacrylates, and may provoke the extraction and bleeding of certain wood-contents such as tannin from the support.

Acrylic colour systems are usually set to a slightly alkaline level through additives, and they are known to possess good alkali resistance as well. Extractive bleeding, however, is capable to convert the surface and painting layer easily into an acidic pH, which may lead to intense microbial infestation and further acidification through metabolism. High acidity may hydrolyse parts of the acrylic painting system, and certain pigment contents may be transformed into metallic salts. The thinner an acrylic painting layer is, the more rapid can occur any kind of support-related staining process, which might be delayed through the previous application of a thorough priming with different and less porous binders.

Poly-Ethylene-Oxides (PEO's) and other bleeding painting components and additives that may appear on the surface of aged acrylic colours, certainly can also have a significant influence on microbiological growth.

4. '*SUPPORT INDUCED DISCOLOURATION*' ('SID')

Now, what exactly is *Support Induced Discoloration*? SID is a generalizing term that tries to describe any kind of extractive bleeding or off-gassing from the support material. SID can have its origin in the natural components of the wooden fibres that compose hardboard, such as tannin, lignin, resin, and oil, and/or in industrial additives such as waxes, oils and resins that were applied artificially for impregnation.

Image 13.
Close-up, SID
Noemí Ruiz, 'Paisaje (árboles)' (1967) Acrylic painting on hardboard,
Aprox. 121 cm x 92 cm (Horizontal format),
MAC Cons. File # 027206, N. Ruiz

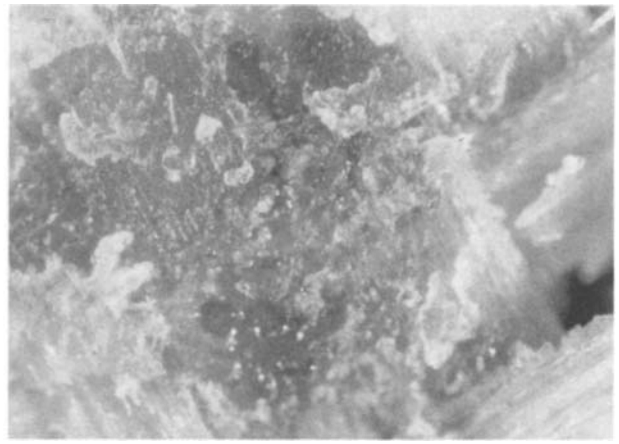

Image 14.
SID / Resinous residues
Resinous extractive on unpainted hardboard fragment.
Magnified Binocular, Nikon SMZ 2 T, 6,3x

Humidity, heat, UV-radiation, air-pollution and microbial infestation are all factors that help to crack down the natural and artificial components which constitute hardboard. Ligneous material, tannins, resins, and oils may become hydrolysed and oxidized, and in consequence bleed-out or gas-off in the form of discoloured residues. The impact of high humidity helps to accelerate this process (*Images 13,14*).

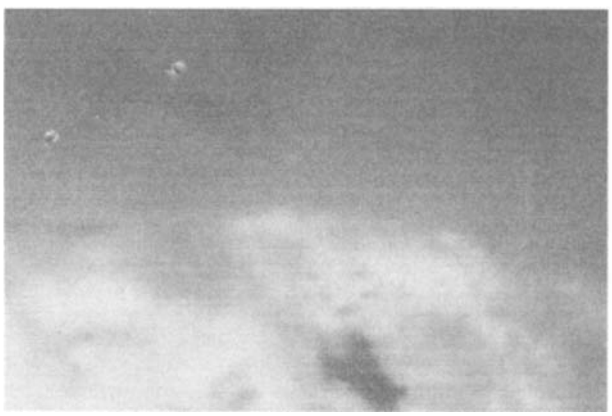

Image 15.
SID / Hardboard - Fiber
Noemí Ruiz, 'En Aire' (1981), No Reg. #
Bulk – typical stain on the surface. Lab photo (300x, reflected light) edge view of section of this sample shows pigment surrounding a fiber which had been sticking up from the surface at the time of application.
(Daniel Friedman)

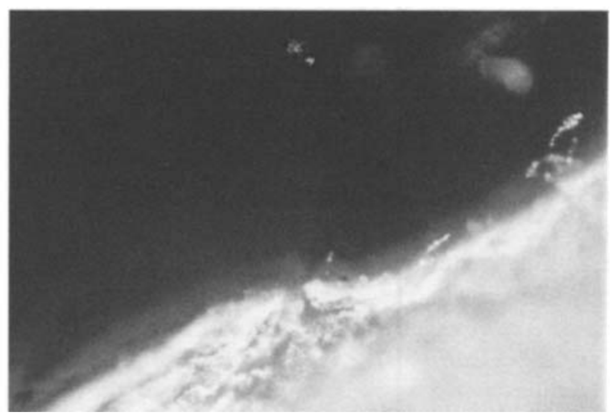

Image 16.
SID / Void in painting layer
Painting sample, 'En Aire' , 360x, reflected light
(Daniel Friedman)

Image 15 shows us extractive bleeding through fibres that stick up, trespass the painting layer, and transport semi-transparent, resinous residues to the surface through osmosis. Extractives also can gas out through porosities, as we can see on Image 16: The decay of ligneous components occurs, since lignin is slowly volatile. It is easily broken down by oxygen and other components of the air, and transported through the porous painting to its surface, where it may accumulate as brownish transparent residues. Ligneous components may be identified and distinguished from other components by colour staining and counter-staining with chemical solutions, such as phloroglucinol, zinc-chlor-iodine, safranine and astral blue (Wülfert, 1999). (*Images 17, 18, 19, 20).*

Similar processes of Support Induced Discoloration may occur when oils, resins and waxes oxidize and gas-off or bleed-out. Occasionally, augmented 'Support Induced Discoloration' of resinous character can be detected, where wooden supports are glued or nailed onto the reverse of the hardboard - panel.

Occasionally, and despite its acidic characteristics, hardboard can even be found as 'conservation-material', for instance as backing support for paintings on canvas. There is, however, a high risk that such measures can lead to fatal discoloration of the original painting, due to the interaction between excessive humidity and bleeding ingredients of the hardboard.

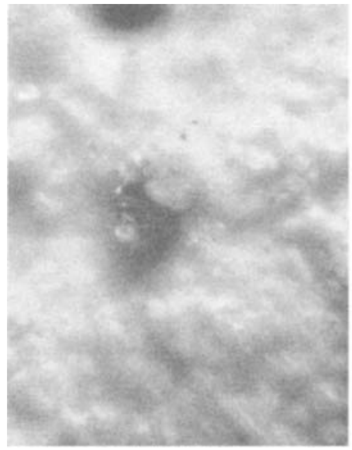

Image 17. Sample, surface closeup (300x). Brown material, apparent bleedthrough of resinous material from the wood substrate (Lab015, 5 Dez 2006 Daniel Friedman).

Image 18. Oxidized extractive on tip of fiber. (Lab018, 5 Dez 2006, Daniel Friedman).

5. FUNGAL INFESTATION

In general, macro- and microscopic examinations are sufficient to distinguish safely between SID and fungal infestation. We have to bear in mind, however, that the paintings under treatment usually have a long history of microbial infestation, and that we usually only detect recent or present growth. Biological infestation can be divided into *opportunistic* and *substrate specific growth*, and may include filamentous species, black mould, bacteria, and even algae.

Image 19. Void in painting layer. (Lab019, 5 Dez 2006, Daniel Friedman).

Image 20. Closeup of extruded resinous material on surface in area of spotting. Suggestive of paint component separation and bleed-through to surface. (Lab021, 5 Dez 2006, Daniel Friedman).

In many cases, fungal growth is not substrate-specific, and the most important factors are the level of humidity, pH and temperature (Mary Lou E. Florian, 2002). In the case of test-dummies, Aspergillus and Penicillium spore chains and active conidiophores, and also Cladosporium [sp. (sphaerospermum)] could be detected after 3 weeks under humid conditions above 95% (*Image 21*). The encountered species are ubiquitous, and predominant in tropical and sub-tropical regions, and develop predominantly on acidic substrates. With the passing of time, and due to the shift towards an acidic pH-level, both acrylic paint and hardboard in combination may provide favourable conditions for fungal growth in a humid environment. Water is regarded as the determinant environmental factor for mould growing, and every single fungal species has its preferred individual range of available water content (Art, Biology & Conservation, 2003). The reduction of humidity below 50% over two weeks, stopped fungal growth, and left behind hyphal structures, inactive spores and metabolic residues, many of which consequently dried out. (*Image 22*).

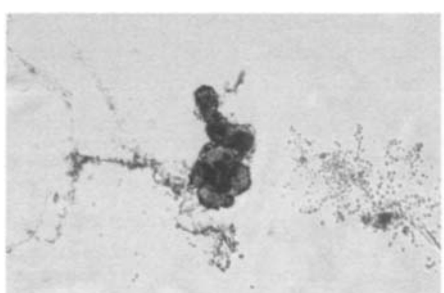

Image 21. Mould
Microscopic image (UPR); taken from test dummie. Penicillium sp. conidiophore fragments and complete conidiophores (active fungal growth). This fungus was dense in this sample.

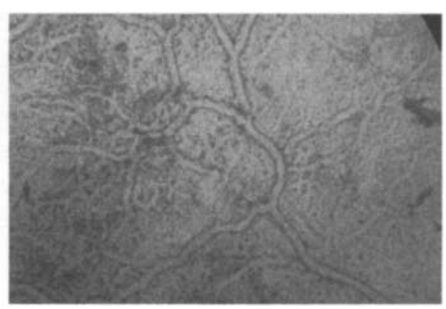

Image 22. Dried Hyphal structure
Test dummie, acrylic painting on hardboard; after 4 weeks exposure to humidity above 95%, and consequent drying of about two weeks below 40% relative humidity.

On a porous and extremely dry (oil) painting on paper and hardboard, which was executed by the Puerto Rican artist Francisco Rodon during the 1960's, both opportunistic growth such as Curvularia Lunata, Chaetomium sp. and Basidiomycetes could be determined. Also, on the reverse-side, substrate specific species, which are known to digest woody and cellulosic material, such as Alternaria sp., Cladosporium sp. and Basidiomycetes, were found. This painting was exposed for several decades in an open garden house to the environment. The presence of micro-organisms was respectively diverse and manifold.

A substrate-specific metabolization of black, carbonic pigment is also commonly observed (*Images 23&23B*). The degradation and metabolization of black pigments through fungus is a widely observed phenomenon in all kinds of paintings that contain elemental carbon. In addition, carbonic pigments seem to have the tendency to absorb an elevated level of humidity.

In some stages of their development, certain moulds, such as Memnoniella, may look like resinous extracts, and could be confused easily with SID. In such cases, the breeding of samples could help to identify fungal growth, and to distinguish them from SID.

Another important and ubiquitous group of fungi are the dark pigmented and black moulds, such as the melanin pigmented stains of Cladosporium, which are notorious for their irreversibility from delicate and porous paintings. The development of black mould occurs predominantly on water-damaged objects. The characteristic dark pigmented stains contain melanin.

In a few cases, melanin ghosts caused by some species of Memnoniella, Cladosporium, Aureobasidium and Alternarium, may remain disturbingly visible, and may require a touch-up locally. Enzyme treatments may be partially successful in specialized laboratory conditions, and may provide a promising tool with regard to the removal of specific fungal or oily stains (Wolbers, 2000). Several years ago, some promising trials were also carried out in an effort to establish enzymatic treatment methods for the removal of Chaetomium sp. and Cladosporium sp. and their by-products of metabolism (Baldwin; Art, Biology & Conservation, 2003).

6. BACTERIAL INFESTATION / YEAST

On some occasions, no fungal activity was detected, no fungal residues were found, no accumulation of resinous extractives was present, and no salt efflorescence was detected. The painted and unpainted reverses of several hardboards, however, were affected by heavy staining (*Image 24*). The examination of samples revealed a possible bacterial infestation, and assumes in another case yeast-cells as the stain-causing micro-organism (*Image 24B*). We also may find Zygomycetes (Bread moulds), Ascomycetes (Sac Fungi) and Saccharomycetes (Yeasts), linked to painting materials and the environment (Szczepanowska, Cavaliere, 2003). It is also quite likely that at times, acrylic colour and painting tools are already infested during the painting act, and cause an infestation right from the very beginning. Bacteria may affect the hardboard through erosion, tunnelling and cavitation.

Image 23. Metabolization of carbonic pigment contents through mold infestation. Noemí Ruiz,'Homenaje' (1967), Acrylic painting on plexiglass, Approx. 90 cm x 122 cm (Vertical format), MAC Cons. File #027306, N. Ruiz

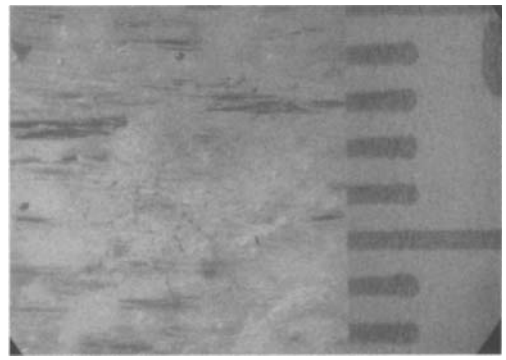

Image 23 b. Fungal Stain with hyphae and conidiae
Noemí Ruiz, 'Homenaje' (1967), Acrylic painting on plexiglass, Approx. 90 cm x 122 cm (Vertical format), Magnified Binocular, Nikon SMZ 2 T, 6,3x

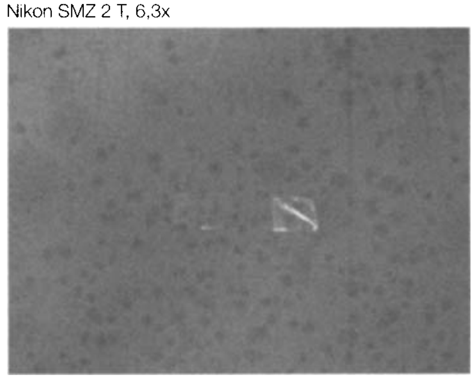

Image 24. Stains, Bacterial infestation, reverse
Noemí Ruiz, 'Presencia' (1967), Hardboard (Reverse). Approx. 91,5 cm x 122 cm (Vertical format). MAC Cons. File #022305, N. Ruiz

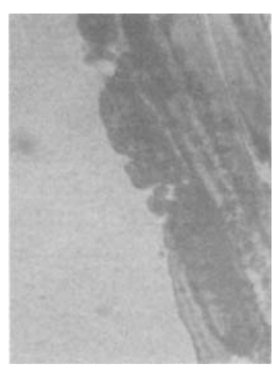

Image 24 b. Fabric fibers, possibly with bacterial activity.
No fungal material was detected in the sample. (Lab Prep: Lacto phenol cotton blue: Lab #028, 02 January 2006, Daniel Friedman)

Research carried out in the 1970s that investigated the 'Progression of Micro-organisms on painted panels in Puerto Rico', suggests that bacteria are more compatible with freshly painted surfaces than moulds or yeasts. It also implies that some of the moulds and yeasts have an adaptation period during which time the paint surface is conditioned by other micro-organisms or weathering before they can predominate (O'Neill & Drisko, 1978).

7. COMBINATION OF 'SID' AND MICROBIAL INFESTATION / SYMBIOTIC RELATION

Quite often, diverse stains exist side by side, and SID and bacterial infestation may provide an ideal acidic environment and appropriate substrates for subsequent fungal infestation. Ligneous residues, tannins, oils and resins that settle due to off-gassing or extractive bleeding on the surface of a porous acrylic painting medium, adhere dust and moisture, and as a consequence, allow fungal and bacterial structures to settle and develop. Resulting metabolization products lead to further acidification of the painting layer, and to further hydrolization and destruction.

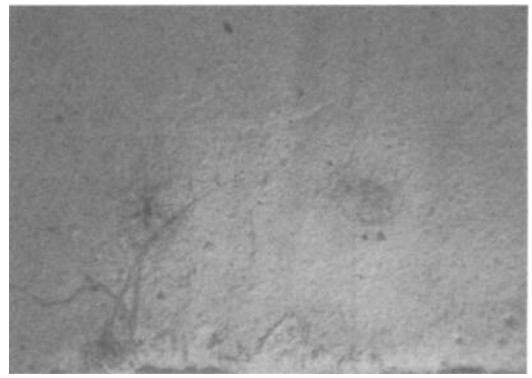

Image 25. SID & Fungal Infestation, side by side
Test Dummie, Acrylic paint (liquitex) on hardboard: SID (right) and Mould (left)

The test dummy on Image 25 shows a fungal stain (Penicillium?) next to a 'Support Induced Discoloration' on an un-tempered hardboard support (*Image 25*). The differences are, though, not always that clear. In the case of a deteriorated painting from the 1960's (detail, *Image 29*), the deterioration is a much more complex matter: Extractive bleeding from the support and fungal stains of Basidiomycetes appear often at first sight to be similar in both form and colour. Only some tear-shaped residues in this specific case immediately indicate the presence of ligneous extractives. The Brazil-made support of this painting, for instance, is rich in tannins, and partially decomposed by Basidiomycetes. Whitish growth within the ochre colour field was determined as Chaetomium [Sp.], which is known to settle on wooden and synthetic material alike, and is commonly observed on paintings.

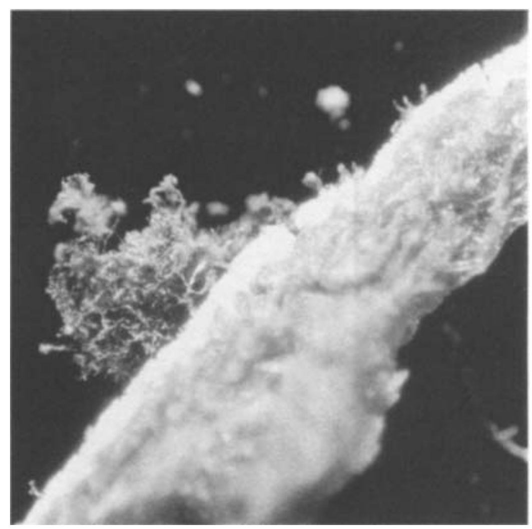

Image 26. Fungal growth on hardboard / through void in painting layer. Test dummie, Magnified Binocular, Nikon SMZ 2 T, 6,3x (Daniel Friedman)

The coexistence of SID and fungal infestation seems at times to undergo a symbiotic-like relationship between extractives from the support that may provide nutrition, moisture, an acidic environment, and mould, which in the right conditions may settle easily on and around voids in porous acrylic painting layers (*Image 26*), and on extracts and woody residues (Compare *Image 5*).

8. TREATMENT / REMOVAL OF THE STAINS

The cleaning, disinfection and neutralization of stained acrylic paintings on hardboard requires the development of a safe and effective cleaning method. Bleaching agents, acidic cleaning solutions and fungicides can do a lot of harm to the original substance (Bishop Museum, 1994), and to our health, and should generally be substituted by more appropriate conservation materials. A widely practised approach seems in general, to bleach fox spots through the application of peroxides, chloride containing bleaches and reductive chemicals, which are known to have a destructive long-term-effect to acrylic polymers and wood fibre-containing supports. The often superfluous impregnation of treated paintings with toxic and reactive fungicides seems also widespread practice. Resulting damages and leached painting areas are then usually covered up through the application of solvent-based varnishes, which - in addition to changing the

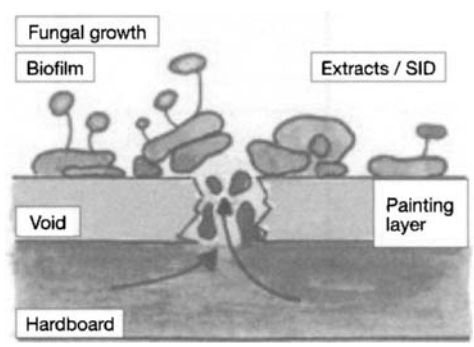

Figure II. Scheme/Sketch, off-gassing and microbiological growth/Ulrik Runeberg.

appearance of an originally unvarnished artwork – are almost impossible to remove afterwards without impacting the original acrylic painting layers. As these coatings usually remain semi-permeable, and tend to retain moisture within the hardboard, this effect may worsen the problem of fungal growth and Support Induced Discolouration.

The search for a safe and effective cleaning alternative for stains on unvarnished acrylic paintings on hardboard led to the evaluation of a range of absorbents and deacidifiers. Neutralizing agents that are commonly applied in paper conservation, such as Calcium Hydroxide, Natrium Hydroxide or Magnesium Hydroxide, hardly extracted any stains, whereas 'Sodium Bicarbonate' (Arm & Hammer) worked very efficiently on these paintings as chemisorbtion material. Ideally, it is applied in the form of dry powder on slightly wet paper, which resembles the structure and principle of a poultice (*Images 27&28*). The paper may consist of Japanese paper, e.g. Kozo Kashmir, Tengujo fine, or Green's Mending Tissue, which is soaked with distilled water, to neutralize and extract the stains and any excess of humidity in combination with the dry absorbent medium. Sodium Bicarbonate also acts as scavenger material and pH buffer on the surface of the painting, and neutralizes acidic deposits, oxidized oils and resins, wooden extractives and biofilms (*Image 29*). Sodium Bicarbonate is also known to have fungistatic properties, and may be described as 'contact fungicide'. With this method, most stains that originate in SID and fungal infestation could successfully be neutralized and extracted from the painting concerned (Compare Image 30 with Image 4 – 'Before&After'). (*Image 30*).

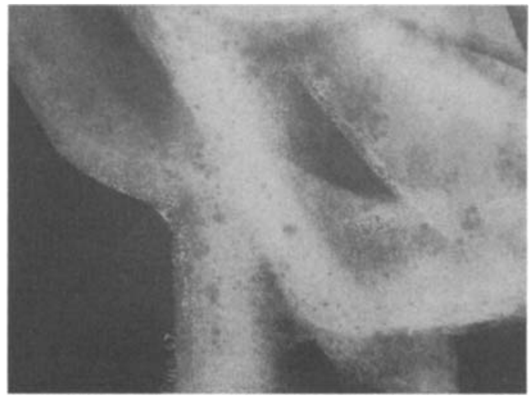

Image 27. Stain, before removal
Removal through poultices with Sodium Bicarbonate (Arm&Hammer), Noemí Ruiz, 'Presencia' (1967), Approx. 122 cm x 91,5 cm (Vertical format). MAC Cons. File #022305, N. Ruiz

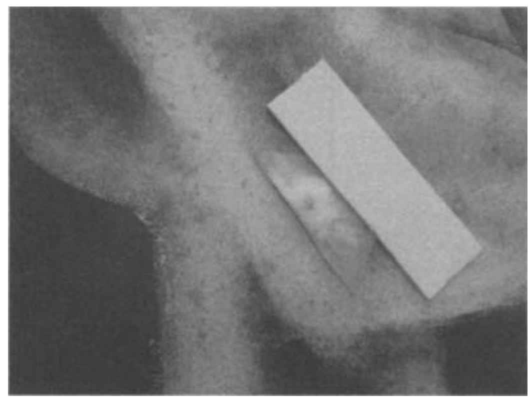

Image 28. Stain, after removal
Removal through poultices with Sodium Bicarbonate (Arm&Hammer), Noemí Ruiz, 'Presencia' (1967), Approx. 122 cm x 91,5 cm (Vertical format). MAC Cons. File #022305, N. Ruiz

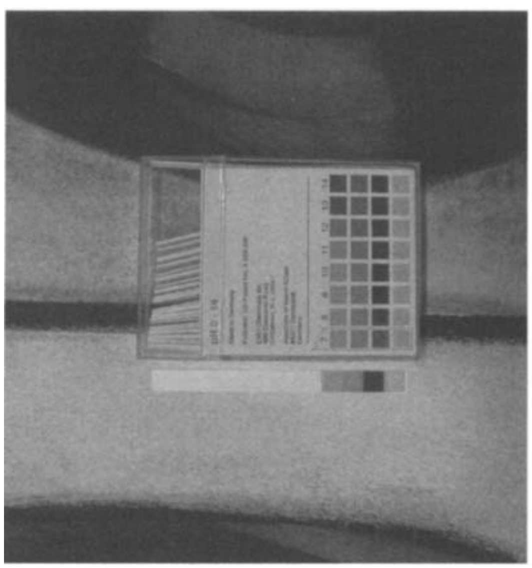

Image 29. PH 9 - 10 after treatment with alkaline poultices
Noemí Ruiz, 'Instrumentos', Acrylic paint on hardboard, Approx. 61 cm x 121,5 cm (Vertical format)
MAC Cons. File #021405, N. Ruiz

Image 30. Detail, after reduction of stains (compare to Image 4 – before treatment). Noemí Ruiz, 'Arbol', (1967), Acrylic painting on wooden composite board, Approx. 73 cm x 202 cm (Vertical format), MAC Cons. File # 022505, Noemí Ruiz

The extraction method presented intends to stimulate cleaning trials and experiments with Sodium Bicarbonate, which may be combined with other neutralizing agents, to adjust the pH-level, if required. It is not the intention of the author to provide an 'all-round' recipe of general validity. The reactivity of the Sodium Bicarbonate is believed to root in the alkaline character, and its interaction with acidic materials such as metabolic residues from mould, or ligneous extractives from the hardboard support.

Wax stains may in addition need to be solved locally with mineral spirits. However, precaution always has to be the highest priority: "Although acrylic paint is mentioned in the literature as being insoluble in mineral spirits or water, many of the additives in emulsion products – [and Poly-Ethylene Oxides (PEO's), which may aggregate as surfactants on the surface of an acrylic painting film] – might be dissolved in some cases by these liquids" (Learner, 2004, p.5).

However, in general no negative effect should be expected from the poultices when applied temporarily as absorbant on acrylic paintings. In this context, it is noteworthy, that colour makers set acrylic emulsion paint alkaline, usually by adding Ammonia, to establish a pH of about 9.5 (!). Sodium Bicarbonate occasionally is found to have been used by artists as an additive to acrylic paint, to increase the impasto and texture, and in the field of Conservation it was successfully applied on many occasions as neutralizer of acetic acid deposits on tempera paint during the early 20th century. With the passing of time, though, this technique became forgotten.[1]

In some cases of stain-extraction, however, precaution is required: certain sensitive pigments and coloured areas might have suffered severely from fungal infestation and may easily be extracted through any kind of poultice or any other contact. Oil colour should under no circumstance be cleaned with Sodium Bicarbonate, as a leached painting surface could be the result.

Sodium Bicarbonate has comparatively weak temporal fungistatic properties, which in long-term effectiveness may be compared to low concentrations of Thymol. In combination with controlled drying and an appropriate storage of the painting after treatment, however, fungal re-infestation is very unlikely. Several paintings that were monitored one-and-a-half year after treatment with Sodium Bicarbonate, reversal fumigation with Thymol, and storage in controlled climatic conditions, showed no re-infestation. Drastic climatic changes, however, and an increased level of humidity, may cause repeated staining and microbiological infestation.

In the case of black mould removal from a polychrome surface, the literature also mentions poultices of (Kalium) perganmanate (KMnO4) and sepiolite (Meerschaum) as an efficient alternative treatment method (Graf, Burgstaller, 2004). Another source, which focuses on the removal of oxidized adhesives on cellulose supports, refers to clay, siliceous components and cellulose powders as possible absorption materials (Saéz, Gimeno, 2004).

9. COATINGS & VARNISHES

A quite common reaction towards the conservation of porous or sensitive paintings is the application of a 'protective' varnish. Although in many cases, the sealing or coating with acrylic varnishes can have beneficial aspects for the conservation of a painting layer (*Image 31*), some considerable drawbacks may be experienced: any coating on solvent base with higher polarity than Mineral Spirits, bears a high risk of severely harming an acrylic painting, and would also be irreversible from the original acrylic painting in the future. Reversible, water-based varnishes which contain aquazol or cellulosic derivates stay sensitive against high humidity, they are optically inappropriate, get sticky, and aquazol even may provide an additional substrate for certain fungal organisms. A mayor disadvantage in this context is, however, that multiple coating layers tend to retain moisture, and hence could increase microbial growth – especially when hardboards have already been infested by hyphae and dormant spores before the application of any coating, and which are continuously kept in extreme humid conditions.

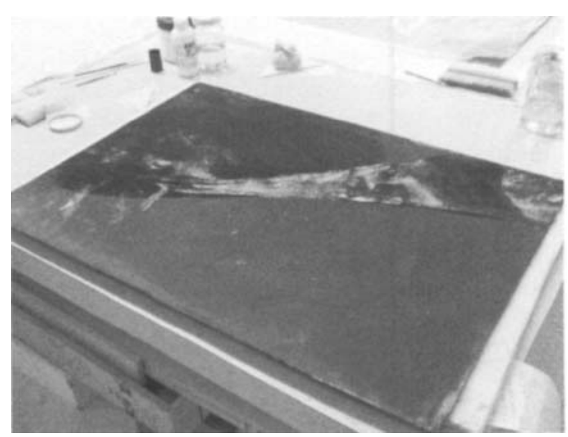

Image 31. Varnish on aged acrylic Painting on hardboard (from 1966) – Preventive medium, or cause for accelerated decay? Noemí Ruiz, 'Camino Sideral' (1966), Approx. 86 cm x 61cm (Horizontal format), MAC Cons. File #024006, N. Ruiz

Research on moisture transport properties of paint coatings on wood, that were carried out and described by R. S. Williams (Williams, 1991) showed that most paints are fairly porous and that it is possible for moisture to diffuse readily into and out of painted wood. The author wishes to emphasize that paint coatings inhibit the loss of moisture more than they do to the absorption of moisture and that, under cyclic exposure to high and low relative humidity, paint traps moisture. This type of cyclic exposure is seldom a problem under most circumstances because sufficient drying time usually passes between periods of high humidity. If, however, wood is subjected to continuous high humidity from either the inside or the outside, loss of adhesion, Support Induced Discolouration and microbiological growth is likely.

The development of an appropriate and reversible varnish especially for acrylic paintings, which is not based on organic solvents, is a concern, that recently has brought on the way major research projects, such as the Tate AXA Art Modern Paints Project, which commenced in 2006, and investigates among other aspects the varnishing of acrylic emulsion paints and cleaning treatments. To make things even more complex, the ideal varnish for acrylic paintings in a humid, tropical environment would need to be water resistant, to avoid its dissolution.

10. CONCLUSIONS & OUTLOOK

The difference between stains caused through SID and microbiological growth is of prime importance, since it allows the conservator to adjust the method of treatment. A stain-infested painting with no fungal diagnosis obviously would not require the application of any fungicide, whereas a mouldy board would need to be kept separately, and require drying, cleaning, disinfection, and in some cases further treatment with stronger fungicides, anorexic environments, enzymes and oxygen scavengers.

Most of the some fifty (50) stain-infested acrylic paintings on hardboard, which entered during the past few years the conservation laboratory at the Museo de Arte Contemporáneo [Museum of Contemporary Art] in Puerto Rico, suffered from a combination of SID and microbial infestation. Both, symbiotic as well as isolated fungal growth, bacterial infestation and SID could be examined, while salt efflorescence through a maritime environment was only a minor factor. In general, SID and microbial growth could be differentiated from each other by means of microscopic examination and chemical staining. To determine the exact type of SID and extractive bleeding, however, GC and other analytical procedures would be helpful and necessary tools to undertake more specific investigations. DNA analysis might provide exact results, and GC might help to analyze and differentiate wax from oil and resin.

The majority of stains presented, that were caused whether through microbiological infestation or Support Induced Discolouration, were extracted and disinfected successfully through poultices of Sodium Bicarbonate, and could be kept stable through the reduction of environmental humidity and monitoring of the climatic conditions.

Further research in the staining processes involved is currently under way and may be presented alongside comparative cleaning trials and the assessment of the effectiveness of sealing techniques in a following publication.

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REFERENCES

Art Conservation Handout 1996. *To Bleach or Not To Bleach...*Hawaii: Bishop Museum.

Baldwin, A. M. 2003. An introduction to Tiffany Studies; (pp. 83-93); in: *Art, Biology, and Conservation: Biodeterioration of Works of Art*. New York: The Metropolitan Museum of Art.

Florian, Mary-Lou E. 2002. *Fungal Facts – Solving fungal problems in heritage collections*. London: Archetype Publications Ltd.

Graf, V., and Burgstaller, D. 2004. Bleichen als Methode zur Behandlung von schwarzem Schimmel an einem gefassten Barockaltar; (pp. 143-148) in: *Schimmel – Gefahr für Mensch und Kulturgut durch Mikroorganismen*. Stuttgart: Konrad Theiss Verlag.

Hudsonhighland: *http://www.hudsonhighland.com/deteriorationofwoodpanels.com* (Entered 2006).

Koestler, R., V. Koestler, A.E. Charola and F. E. Nieto-Fernandez [Editors]. 2003. *Art, Biology, and Conservation: Biodeterioration of Works of Art*. New York: The Metropolitan Museum of Art.

Learner, Thomas J. S. 2004. *Analysis of Modern Paints*. Los Angeles: Getty Publications.

O'Neill, T. B., and R. W. Drisko. 1978. Progression of Microorganisms on Painted Panels in Puerto Rico; in: *Journal of Coatings Technology*, Vol. 50, No. 641, June 1978 (pp. 31-32).

Rauch, A., S. Miklin-Kniefacz and A. Harmssen. 2004. *Schimmel – Gefahr für Mensch und Kulturgut durch Mikroorganismen*. Stuttgart: Konrad Theiss Verlag.

Saéz, J. A., and Gimeno, E. 2004. Utilización de papetas para la eliminación de manchas provocadas por la oxidación de cintas adhesivas sobre soporte celulosico; in: Reunión Grupo Arte contemporáneo IIC (Grupo Español), abril 2004. ISBN 84-609-5636-9 (CD).

Szczepanowska, H. M., A. R. Cavaliere. 2003. Artworks, Drawings, Prints, and Documents – Fungi eat them all!; (pp. 129-151) in: *Art, Biology, and Conservation: Biodeterioration of Works of Art*. New York: The Metropolitan Museum of Art.

Warscheid, T. 2003. *The Evaluation of Biodeterioration Processes on Cultural Objects and Approaches for their Effective Control*; (pp. 15-27) in: *Art, Biology, and Conservation: Biodeterioration of Works of Art*. New York: The Metropolitan Museum of Art.

Williams, R. S. 1991. Effects of Acidic Deposition on Painted Wood: A Review; in: Journal of Coatings Technology, Vol. 63, No. 800, September 1991.

Wolbers, R. 2000. *Cleaning Painted Surfaces – Aqueous Methods*. London: Archetype Publications, Ltd.

Wülfert, S. 1999. *Der Blick ins Bild – Lichtmikroskopische Methoden zur Untersuchung von Bildaufbau, Fasern und Pigmenten*. Ravensburg: Ravensburger Buchverlag.

FURTHER READING

Carll, C. G. 1996. Review of Thickness Swell in Hardboard Siding – Effect of Processing variables; in: USDA General Technical Report FPL-GTR-96.

Digney-Peer, S., A. Burnstock, T. Learner, H. Khanjian, F. Hoogland and J. Boon. 2004. The migration of surfactants in acrylic emulsion paint films; in: *IIC – Contributions to the Bilbao Congress 13-17 September 2004, Modern Art New Museums* (pp. 202-207).

Drewello, U., and R. Drewello. 2005. Die Schläfer im Depot – Schimmelpilze warten auf das Wasser; in: *Restauro – Forum für Restauratoren, Konservatoren und Denkmalpfleger* (pp. 440-448), Vol. 6/2005. München: Callwey Verlag..

English, B., J. Youngquist, A. Krzysik. 1994. Lignocellulosic Composites; in: *Cellulosic Polymers, Blends and Composites*, (pp. 115-130, chapter 6), Richard D. Gilbert (Ed.), (1994).

Feist, W. C. Wood Surface Treatments to prevent Extractive Staining of Paints; in: *Forest Products Journal*; Vol. 27, No. 5.

Gatenby, S. 1990. An investigation into cleaning procedures for mould stained Australian aboriginal objects painted with modern media (pp. 157-162); in: *Preprints, ICOM Committee for conservation 9th triennial meeting: Dresden, German Democratic Republic, 26-31 August 1990.*

Hoadley, R. B. 1994. Wood as a Physical Surface for Paint Application; in: *Painted wood: History and Conservation.* Los Angeles: The Getty Conservation Institute.

Hons, S., J. von Stockhausen, S. Zumbuehl. 2005. Migrationsprozesse freier Fettsäuren in Malmittelfilmen – Untesuchungen zur Entfernung von Ausblühungen und Überlegungen zur präventiven Konservierung; in: *Zeitschrift für Kunsttechnologie und Konservierung (ZKK)*, 19. Jahrgang 2005, Heft 1 (pp. 32-38).

Katlan, A. W. 1994. Early Wood – Fiber Panels: Masonite, Hardboard, and Lower Density Boards; in: Journal of the American Institute for Conservation (JAIC), 1994, Volume 33, Number 3, Article 5 (pp. 301-306)]

Laundrie, J.F., G. C. Myers, L. R. Gjovik, H. J. Hell, R. O. Gertjejansen. 1979. Evaluation of particleboards and hardboards from mixed Ghanaian hardwoods after a one-year exposure in the Caribbean National Forest of Puerto Rico. Report to: *Office of Science and Technology, Development Support Bureau, Agency for International Development, U.S. department of State.*

McCrady, E. 1991. The nature of lignin; in: *Alkaline Paper Advocate*, Vol. 4, Number 4 (Nov. 1991)

Muehl, J. H., A. M. Krzysik. 1997. Effect of resin and wax on mechanical and Physical Properties of Hardboard from Air-Laid Mats (pp.3-9); in: *DRVNA Industriaq 48 (1) 3-9 (1997).*

Williams, R. S. Effects of Acidic Deposition on Painted Wood: A Review; in: *Journal of Coatings Technology*, Vol. 63, No. 800, (September 1991)

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ENDNOTES

1. *Current Issues in Restoration – the splitting of Easel Paintings and Murals*; Scientific Conference; Academy of Fine Arts in Cracow, faculty of Art Conservation and Restoration; Cracow, June 2006: "Splitting methods abroad: The beginnings of splitting treatment on wooden panels abroad date back to the 1920s, when Russian restorers made their first attempts o split paint layers on icons. In the first experiments, they used acetic acid to soften tempera paint (neutralized with sodium bicarbonate) and cigarette paper glued with sturgeon adhesive as facing. The method devised was one of the great achievements of these times."