The Solvent Star: Assessing and documenting solvent selection.

When selecting solvents safest for treating a specific artwork the most critical data is that which we conservators collect during our own testing. Yet until now we have lacked a straightforward way to quantify, easily document and potentially share these test results. In this short white paper Gwendoline R. Fife describes the methodology and use of the simple star diagram she teaches at the Stichting Restauratie Atelier Limburg (SRAL) and distributes at her workshops for this purpose.

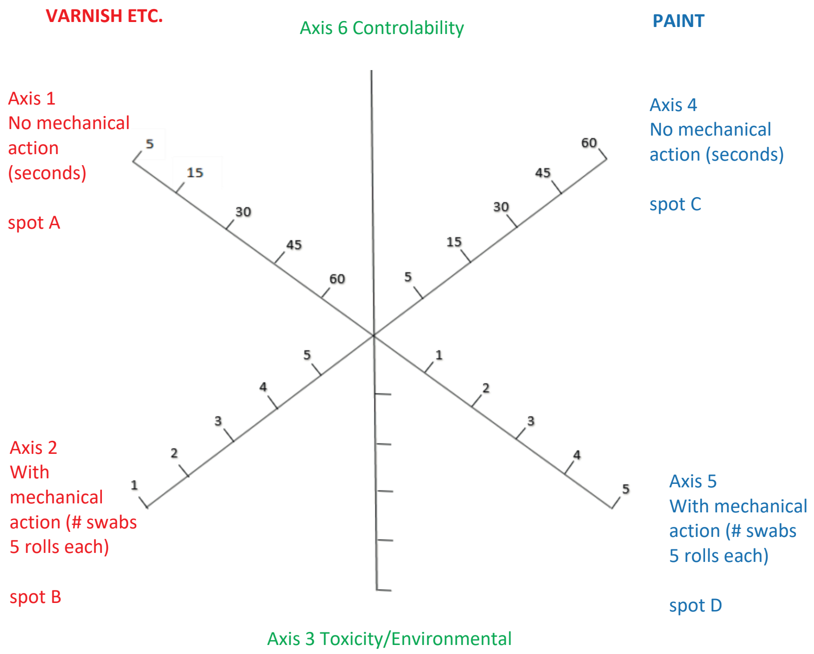
INTRODUCTION

Research published over the last seventy years on modelling the effects of solvents on paint films has been invaluable in developing our profession's understanding of paint films and in helping us fine-tune our solvent-based treatment approaches, (including varnish removal, varnish application and consolidation). However, we have always been limited in applying these models for solubility prediction to our practice. For instance, whilst the ubiquitous, yet fundamentally flawed, TEAS chart may be sufficiently reliable for preparing straightforward varnish preparations, it has proven inept for describing solvent interactions with paint films (Phenix 2013). Happily, solvent modelling continues to evolve and exquisitely refine, from incorporating cavitation energy considerations to quantum chemistry-based equilibrium thermodynamics, giving hope for more direct conservation applications (Ormsby 2018; Zumbühl 2014).

But the complexity of our real-life situations means that a most invaluable data source will likely remain the small solvent tests we are obliged to carry out on the individual work prior to embarking on solvent-related treatments. These observations help us reduce risk and develop our *heuristic* model of the behaviour of the individual art work, with the added

Fife Solvent Star

Painting Description (medium & support, size):
Title:
Artist:
Date:



Solvent(s)	Ratio (if mixture)	Colour Legend	Quantity solvent (ml) spot A	spot B

Date of testing:
Notes/comments:

Selected Solvent/Approach:

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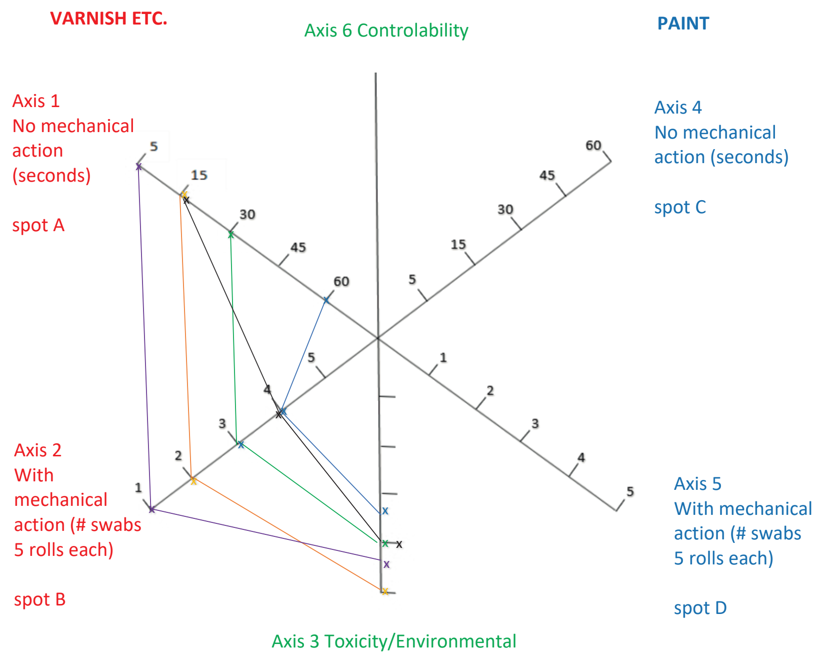
Figure 1

Fife Solvent Star

Painting Description (medium & support): oil on canvas, 120cm x 210cm
Title: Annunciation scene
Artist: Unknown
Date: 19th century



Solvent(s)	Ratio (if mixture)	Colour Legend	Quantity solvent (ml) spot A	spot B
Ethanol			0.5	1
Isopropanol			0.5	2
Acetone			0.5	0.5
Ethyl acetate			1	1.5
Isooctane : ethanol	3:1		2	2

Date of testing:
Notes/comments:

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Figure 2

advantage that with every new situation we add to our data set, thereby enhancing our conceptualised modelling (what we could equally term our 'experience') of paint film behaviour in general. Since the more accurate the testing, the more dependable the data, some years ago I started quantifying solubility and safety margin tests. As well as providing unexpected insights I found that simply measuring solvent quantities and timing swab contact gave me added confidence in both my observations and the selection of the final approach for treatment. Incorporation of this simple method within the solvent workshops provided for experienced practitioners has been similarly met with enthusiastic responses.[1]

As research findings continue to emerge that corroborate not only the general importance of limiting solvent quantity and contact, but also how this can critically influence the potential effects of a treatment adaptation such as gel or tissue applications it seems that more accurate and efficient testing approaches could be generally useful to our practising community (Baij *et al* 2019). Such tests could also underpin and facilitate further important practical developments within our field such as, for instance, our assessment and application of new sustainable solvents. In this endeavour, and inspired by similar test diagrams,[2] the solvent star described below aims to provide an easy, and efficient way to quantify and plot solvent tests, clarify risk assessment and approach selection, and enable further sharing of results within the community (figure 1).

THE SOLVENT STAR

Six axes are used in the star. To better quantify solvent interaction with the materials (both original and non-original) responses are measured with and without the effect of mechanical action (timed contact with, and without, swab rolling respectively).

A primary consideration is to determine the relative rate of dissolution of the material one wants to dissolve (spots A and B) versus the potential swelling of / effect on the original art material (spots C and D). So, axes one and two describe the response of the varnish (or coating) and axes four and five describe the / any response of the original (paint). The central axes three and six are for respectively denoting environmental / toxic considerations and describing the 'feel' / controllability of the action, an important aspect of our work. Up to five solvents (selected from experience, a pre-testing method, or following a specific order) can be feasibly depicted per star.

HOW IT WORKS

Axis 1. Test spot A

Select a spot representative of an area to be cleaned.

- A small amount of the selected solvent for testing is poured into a small measuring cylinder and the volume noted.

- A small cotton swab is moistened in the cylinder, lifted out (noting volume change in cylinder) and then directly held (without rolling / rubbing) to the surface at this spot A. A timer is started from the moment the cotton swab makes contact.

- Lift the swab to check surface at the noted time intervals and mark this axis with a small coloured cross **as soon as** any dissolution is noted (if none occurs after 60 seconds place cross at the origin).

Axis 2. Test spot B

Select a new spot (but also representative of an area to be cleaned).

- Repeat the above process for axis one but instead of just holding the swab on the surface, introduce a gentle mechanical action with five very small rolls. If dissolution has not occurred change swab and repeat this (up to five swabs) stopping **as soon as** any dissolution is noted.

- Mark a similar cross on this axis referring to the number of the swab at which dissolution occurs (if none occurs after five swabs place cross at the origin).

Axis 3. Mark toxicity of solvent and / or environmental considerations

Both axes three and six have been left qualitative, although toxicity can be indicated quantitatively via comparable MSDS exposure guidelines or LC50 values (bearing in mind exposure method and species).[3]

- Join the crosses you have generated, then repeat and similarly document these tests for the five solvents you have selected. After doing so you will have a partially completed diagram like the example shown in figure 2.

If any of the five show sufficient promise (*ie.* fast action) move on to testing of the paint (axes four and five). At this point you may also want to make some slightly larger cleaning windows with your leading solvent. If none have proven satisfactory consider new solvent types and repeat axis one to three.

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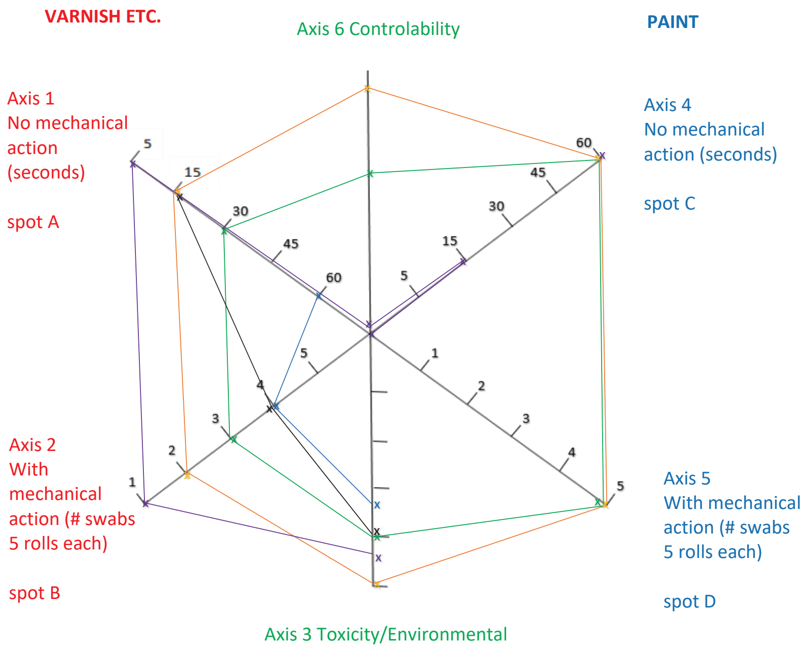

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Isooctane : ethanol	3:1		2	2

Date of testing: 23/10/2019 (for intended varnish removal treatment)
Notes/comments: acetone, ethanol and ethyl acetate selected for testing on axes 4 & 5. Sensitivity to acetone noted in red glaze regions so further testing with acetone aborted.
Selected Solvent/Approach: ethanol selected for further testing.
Chosen approach: Evolon tissue with ethanol (25seconds contact with measured solvent loading)

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Figure 3

Axis 4. Testing spot(s) C

Select your most promising solvent and carry out similar steps as for axis one but on a spot representative of the original paint surface. If using a small cleaning window from previous testing, allow sufficient evaporation time (at least 30 minutes) beforehand.

- Repeat in as various and many spots as felt required to account for different paint types / colour.

- Check the swab at the noted time intervals. If at any moment during the 60 seconds, there is any indication of swelling / solubility / pigment loss *etc.* abort test and note time. If only a specific colour / type shows sensitivity this can be noted in the comments section.

Axis 5. Testing spot(s) D

Similar steps as for axis two are now repeated on a spot representative of the original paint surface. Again, if using a small cleaning window from previous testing, allow sufficient evaporation time (at least 30 minutes) beforehand, and repeat in as various and many spots as felt required to account for different paint types / colour. Check the swab(s) continuously. If at any moment, there is any indication of swelling / solubility / pigment loss *etc*. abort test and note swab number. If only a specific colour / type shows sensitivity this can be noted in the comments section.

Axis 6. Mark controllability

On this axis you can express your feeling / comfort with the cleaning action. The better your feeling, the further from the origin you place a small cross. You can also use this axis, for example, to note (dis)satisfaction with the appearance of the revealed surface after testing.

Join the crosses you have generated, see example illustrated in figure 3. Generally, the broader the star for an individual solvent, the more successful the result, whilst normally any paint sensitivity noted during testing spots C and D would negate the use of that solvent. Once the relative rates of dissolution have been thus illuminated, and potential solvent(s) selected, ways to minimise solvent contact (through adapted applications with thickened solvents / chemical gels / micro-emulsions / tissues etc.) can be considered and further tested. It is advised not to simply extrapolate the behaviour indicated by the free solvent to its adapted form. The star diagram can then be completed noting the finally selected method for treatment (free solvent and swab / solvent gelled with... / tissue type etc.).

PRACTICAL NOTES

Try to keep swabs and test areas as small and uniform as possible. If feasible, carry out preliminary solubility testing of extracted micro-sample material to describe the coating solubility then test and plot the most promising solvents in the Solvent Star (Zumbühl 2019). If a fast evaporating solvent is being tested it may prove necessary to re-dip the swab. In this case note on the diagram the total amount of solvent used for the one spot accordingly.

For even more volume-measurement accuracy a graduated pipette can be used to deliver solvent to the swab.

COLLECTION AND SHARING

The Solvent Star is available on SRAL's website.[4] It is hoped that completed stars will be incorporated into the treatment documentation of the artwork and shared on SRAL's data base (work in progress) to enable future reference, research and developments. For further information please contact g.fife@sral.nl or info@sral.nl

ACKNOWLEDGEMENTS

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Gwendoline R. Fife

ENDNOTES

1. See, Fife, G.R. 2015 and 2017. *Modelling Solvent Behaviour, Solvent Effects on Paint Films, and the Practical Ramifications*, Estonian Academy of Arts/Art museum of Estonia, Tallinn, Estonia; National Museum, Stockholm, Sweden; and Fife, G.R. 2018 & 2019. *Solvents and Paint Films: Practical Solutions*, SRAL, Maastricht, Netherlands.

2. Rachel Barker and Bronwyn Ormsby described the star diagrams they employed during the treatment of *Whaam!* by Roy Lichenstein, as part of the Nanorestart project, in an evening talk held during the *Gels in Conservation* conference, London 2017.

3. MSDS - Material Safety Data Sheets, for exposure guidelines; LC50 - concentration of a compound that is lethal for 50% of exposed population.

4. See http://www.sral.nl/en

REFERENCES

Baij, L., Astefanei, A., Hermans, J. *et al.* 2019. 'Solvent-mediated extraction of fatty acids in bilayer oil paint models: a comparative analysis of solvent application methods'. *Heritage Science* 7 (31).

Ormsby, B. 2018. 'Dow-Tate Hansen Parameters fatty acids in modern oil' paper presented at the *CMOP Cleaning Modern Oil Paints* conference, Amsterdam, 23-25th May 2018.

Phenix, A. 2013. 'Effects of organic solvents on artists' oil paints.' In *Proceedings of Symposium New Insights into the Cleaning of Paintings* (Cleaning 2010), Smithsonian Institution Scholarly Publications/ Polytechnic University of Valencia: 69-76.

Zumbühl, S. 2014. 'Parametrization of the solvent action on modern artists' paint systems'. *Studies in Conservation,* 59(1): 24-37.

Zumbühl, S. 2019. *Solvents, Solvation, Solubilization, Solution: The solubility of materials - An introduction for conservators, including solubility data of selected conservation materials.* Bern: HDW publications.