INSTRUCTIONAL INFORMATION

The following module template has been developed as part of Work Package 7 of the EU-funded GoGreen project. The module is designed in a skeletal format to allow for broad adaptation to a wide range of existing curricula and professional development schemes. To enhance flexibility, the module is divided into theme blocks with suggested content, assessments, and activities. The template has been constructed to serve as foundational material for curriculum development or course integration.

INTENDED AUDIENCE

This module may be adapted for the instruction of conservation and conservation science learners at the undergraduate, postgraduate, and professional level with a focus on paintings. The activities and assessments of this module are developed for a group audience.

MODULE DELIVERY

This module is best suited for in-person, practical instruction. Recommended module delivery is through the utilization of individual case studies, either mock-ups, paintings, or previous work. Throughout the module learners will have the opportunity to:

- Conduct tests on their case study using various solvents and application methods
- Observe and record the effects of the different cleaning materials and methods by employing the Fife Solvent Star
- Utilize analytical techniques and simple assessment approaches to assess, compare, and evaluate the effectiveness of various solvents and application methods and link these with information about their environmental impact.

PRE-REQUISITE KNOWLEDGE

Prior to the module, learners should be prepped with the following skills and knowledge which may be acquired from previous coursework or through complementary GoGreen modules:

1. Knowledge of the foundational principles for paintings conservation and the effects of solvents on paint films.
2. Awareness of policies, frameworks, and methodologies within the cultural heritage sector that may be applied to the remedial conservation of paintings. Supported by the GoGreen module ***Leadership in Green Conservation***
3. Knowledge of the GoGreen definition for green conservation and green parameters, and the Green Decision-Making Model (DMM). Supported by the GoGreen module ***Leadership in Green Conservation***
4. Knowledge of green tools and frameworks that may be applied for the assessment of material sensitivity for informed decision-making in conservation and cultural heritage care. Supported by the GoGreen module ***Determining Material Sensitivities and Green Decision-making***

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MISSION STATEMENT

To empower students and professionals to make informed green(er) choices in their personal practice by integrating tools, metrics, and guidelines for selecting and evaluating green(er) cleaning materials and methods for the remedial conservation of paintings.

DESCRIPTION

Green Treatments and Their Assessment: Paintings explores the green frameworks, tools, and guidelines relevant for the selection and application of green(er) materials and methods for the conservation of paintings. The content emphasizes the cleaning stage of remedial conservation, focusing on recent advancements in green(er) solvents, solutions, and retention systems developed within the GoGreen project and broader EU-funded Green Cluster. Additionally, it covers the efficacy, safety, and ethical considerations of these materials and methods, and demonstrates how the frameworks and tools may be applied to other remedial conservation practices.

Content is delivered through practical, case study based learning, supporting student-centred development of both theoretical and practical skills. Learners are encouraged to apply green thinking to their own conservation practice or a selected case study, reflecting on the practicalities, challenges, and limitations of sustainable approaches in real-world contexts.

LEARNING GOALS AND OUTCOMES

Main Goal Provide conservation researchers and conservators with the knowledge and practical tools needed for the development, assessment and use of green(er) approaches for the cleaning of paintings

Subsidiary Goals

- Develop an understanding of the application of tools, metrics, and guidelines to support green(er) decision-making to the conservation of paintings
- Explore new solvents, solutions, and retention systems used for the remedial conservation of paintings, and assess their impact on the environment, human health and well-being, resources, and cultural heritage in comparison to commonly used materials
- Evaluate the efficacy of cleaning materials utilizing new assessment techniques from the GoGreen project
- Develop practical knowledge through the application of greener cleaning approaches and reflect on personal practice using the green conservation definition and parameters

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By the end of this module,

Learning Outcomes

1. *(**Evaluation**)* Evaluate the 'greenness' of materials used in the cleaning of paintings by applying the Green Parameters and frameworks: (1) Globally Harmonized System (GHS), (2) Life-Cycle Assessment (LCA), (3) Safe and Sustainable by Design principles, and (4) Guidelines.
2. *(**Comparison**)* Compare cleaning strategies used in the remedial conservation of paintings, considering their impact through a holistic approach aligned with the green parameters.
3. *(**Assessment**)* Gain knowledge of new analytical techniques and simple assessment approaches to assess treated surfaces to compare and evaluate different applications and materials for the cleaning of paintings.
4. *(**Reflection**)* Demonstrate theoretical and practical competency in reflecting on the selection and application of green(er) cleaning methods for painting conservation by discussing the processes, decisions, and outcomes involved in their application on a case study.

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RECOMMENDED READINGS

Visit the GoGreen Zenodo for the full module bibliography

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GREEN TREATMENTS AND THEIR ASSESSMENT: PAINTINGS				
THEME	TOPICS	DESCRIPTION	LEARNING OUTCOMES	ACTIVITIES + ASSESSMENTS
Foundation and Tools for the Green Conservation of Paintings	*Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*	Explores green conservation, the green frameworks, and practical tools for sustainable decision-making in painting conservation.	Evaluate the 'greenness' of materials used in the cleaning of paintings by applying the Green Parameters and frameworks: (1) Globally Harmonized System (GHS), (2) Life-Cycle Assessment (LCA), (3) Safe and Sustainable by Design principles, and (4) Guide-lines.	***Group Activity*:** Read the Green(er) Steps in Chapter 3: Practical Steps to ***Green(er) Solutions by Gwendoline Fife in Green(er) Solvents in Conservation: An Introductory Guide*** and complete Step 1: Studio Solvent Cupboard Assessment utilize relevant green frameworks and tools to complete activity. ***Individual Assessment*:** Using relevant green frameworks and tools, evaluate the 'greenness' of a conservation material commonly used within personal context and present findings. **Activity:** Choose and use a tool for green(er) decision-making on a provided case study for the remedial conservation of paintings. Consider the appropriateness of the treatment using a holistic approach aligned with the green parameters.
Introduction to Solvents and Solutions	*Cleaning Agents for Paintings: Solvents and Solutions*	Explores green(er) advancements in solvents and solutions for cleaning paintings, and how they compare to traditional approaches. Solvents and solutions developed within the Green Cluster are highlighted in more detail to provide a foundation for practical application.	Compare cleaning strategies used in the remedial conservation of paintings, considering their impact through a holistic approach aligned with the green parameters.	**Activity:** Investigate 2 to 3 newly identified green(er) solvents and solutions. Create a properties profile that include the physical properties, toxicity and hazard metrics, and LCA impact of chosen solvents or solutions.
	Practical Application of Cleaning Agents	Practical session focused on the application of cleaning agents highlighted in the Green Cluster and on-going innovations. Utilising suggested module delivery for instruction.		***Activity:*** *Apply* solvents and solutions identified in the previous activity, alongside commonly used solvents (including petroleum based), to a case study to expand the properties profile to include practical assessments. Exchange with fellow students and identify how they compare against commonly used approaches utilising the green frameworks. Consider effective communication strategies for presenting the full profile to broader class, for example, include star diagrams, solvent stars, etc.
Introduction to Retention Systems	*Retention Systems for the Cleaning of Paintings*	Introduces new retention systems for cleaning, highlighting materials and techniques developed in the Green Cluster projects and ongoing innovations. Green conservation parameters are applied to compare and contrast retention and free solvent systems, supporting sustainable decision-making in conservation practice.	Compare cleaning strategies used in the remedial conservation of paintings, considering their impact through a holistic approach aligned with the green parameters.	**Activity:** Investigate 2 to 3 newly identified retention systems and create a profile based on the safe and sustainable by design framework.
	Practical Application of Retention Systems	Practical session focused on the application of retention systems highlighted in the Green Cluster and on-going innovations. Utilising suggested module delivery for instruction.		**Activity:** *A*pply retention systems outlined in the previous activity on a case study to expand the properties profile to include practical assessments. Exchange with fellow students and identify how they compare against commonly used approaches utilising the green frameworks. Consider effective communication strategies for presenting the full profile to broader class, for example, include star diagrams, solvent stars, etc.

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GREEN TREATMENTS AND THEIR ASSESSMENT: PAINTINGS				
THEME	TOPICS	DESCRIPTION	LEARNING OUTCOMES	ACTIVITIES + ASSESSMENTS
Testing and Monitoring of Treated Surfaces	*Introduction to Assessment Techniques for the Evaluation of Cleaning Strategies*	Introduces new analytical techniques and simple assessment methods developed for the evaluation of cleaning efficacy in the remedial conservation of paintings. Taking into consideration risks, benefits, and limitations.	Gain knowledge of new analytical techniques and simple assessment approaches to assess treated surfaces to compare and evaluate different applications and materials for the cleaning of paintings.	**Activity/Assessment:** Present on a specific key risk, benefit, or limitation of 1-2 analytical techniques or simple assessment methods.
	Practical: Application of Assessment Techniques	Practical session focused on the application of assessment techniques highlighted in the Green Cluster and on-going research. Utilising suggested module delivery for instruction.		**Activity:** Explore when and how new analytical techniques can be applied using green parameters, and assess their added value in treatment or research. Reflect on how these techniques and methods can become part of your own conservation toolbox. **Activity:** Apply available monitoring and cleaning assessment techniques the case study to evaluate the efficacy of cleaning materials and application methods. Expand the properties profile created in earlier activities to include the efficacy of the materials and application methods. **Assessment:** Present full properties profile using visual communications strategies.
Conservation Practice	*Putting into Practice*	Provides learners with the opportunity to apply new knowledge to personal context by integrating green(er) thinking into existing conservation practice or on a case study and assessing the practicalities and limitations.	Demonstrate theoretical and practical competency in reflecting on the selection and application of green(er) cleaning methods for painting conservation by discussing the processes, decisions, and outcomes involved in their application on a case study.	**Activity/Assessment:** Present on a case study **i**dentifying strategies for integrating green(er) strategies in one's professional practice. Analyse the practicality and limitations of suggested strategies in real world contexts. **Activity/Assessment**: Create a mood board for a personal mission statement. **Activity: Group discussion** How can different stakeholders contribute to greener decision-making within the complexities of cultural heritage conservation?

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DISCLAIMER

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Horizon Europe. Neither the European Union nor the granting authority can be held responsible for them.

AUTHORS AND CONTRIBUTORS

These modules were developed as a part of Work Package 7 of the GoGreen project funded by the European Commission for Horizon Europe (grant no 101060768). We would like to thank all participating researchers in the GoGreen consortium, researchers from the Green Cluster projects MOXY and GREENART, members of the GoGreen Advisory Board, and *Green Education in Conservation* Paris Symposium attendees.

Additionally, we would like to thank the broader conservation community for collaborating in the development of the module templates through inputs and feedback via workshops, surveys, and focus groups. For more details on the list of contributors see the project deliverable 7.1 report.

1. Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation

Authors: Gwendoline Fife, Julia Wagner, Sky-Lyn Munoz

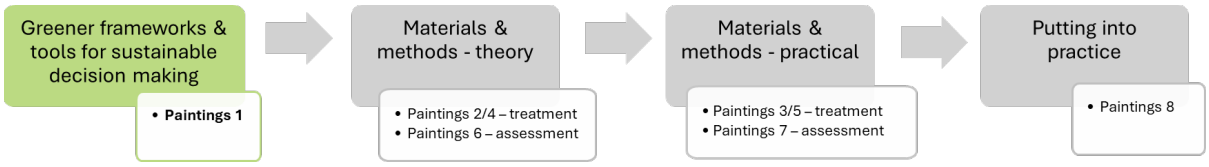
This session introduces the definition of green conservation and parameters defined by GoGreen and explores frameworks, tools, and guidelines for green decision making in the conservation of paintings.

Key Concept 1	**LCA and hazard assessments**
Key Concept 2	**Safe and sustainable by design**
Key Concept 3	**Green Conservation definition and parameters**
Key Concept 4	**Sustainable decision-making (applying parameters in practice)**

OBJECTIVES

Objective 1	Familiarity with the definition of green conservation, 14 green parameters and the decision-making model developed in GoGreen.
Objective 2	Awareness of the supporting frameworks and tools for the implementation of green conservation (according to definition, parameters and decision-making model).
Objective 3	To apply green conservation frameworks to an example of decision-making in an assessment for an interventive treatment of a painting and demonstrate an example of decision-making and assessment in the preventive conservation of painting(s).
Objective 4	To develop the technical language and general communication skills (verbal and written) to discuss the rationale behind conservation decisions.

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

Green conservation summary report. Fife, G. R., Wagner, J., Goncalves, B., Southwick, C., & Keune, K. (2025). Zenodo. https://doi.org/10.5281/zenodo.16980962)

Fife, G. R., Turrina, A., Wagner, J., Del Curto, D., Southwick, C., & Keune, K. (2025). *Defining Green in the Conservation of Cultural Heritage*. Manuscript accepted for publication in Studies in Conservation, https://doi.org/10.1080/00393630.2026.2653274

Practitioner-tested Decision Model, Taylor, J. (available on GoGreen Zenodo)

Frameworks & guidelines: Sustainability, Sustainability development goals, Globally Harmonized System (GHS), Life-Cycle Assessments (LCA),(LCC), (3) Safe and Sustainable by Design principles, green heritage science, BIZOT

Tools: GoGreen DSA, STiCH, HERiE, GCC calculator, Our Collections Matter.

SESSION OUTLINE (2 hour lecture)

Introduction (60 minutes)

- Introduce the green conservation definition and explore the 14 green parameters developed in GoGreen (from a sustainability perspective and with an LCA-based approach);
- Explore decision-making according to parameter impact categories and specific context;
- Examine metrics and frameworks for assessments: Life cycle assessments; Safe and sustainable by design (discusses circular economy, energy consumption, health and safety); Globally harmonized system (GHS); principles of green chemistry and green heritage science

Tools (60 minutes)

- Tools supporting sustainable decision-making:
    - GoGreen Digital Support App (DSA): prototype app developed within GoGreen which aims to provide metrics for conservation treatments based on the GoGreen green parameters;
    - GoGreen DMM (decision-making model);
    - GHS hazard databases (e.g. ECHA) and GHS-based approaches (e.g. Chem21);
    - STiCH: utilizes an LCA approach to provide carbon footprint data for commonly used conservation materials;
    - GCC calculator;
    - HERIe;

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  - Our Collections Matter (toolkits https://ocm.iccrom.org/);
  - Other treatment specific assessment tools aligned with parameters (safe efficacy) e.g. *Fife Solvent Star which evaluates solvent hazard, application time, swab count, for assessing and comparing solvent effect on paintings*.
- Guidelines
  - 12 principles of Green Chemistry
  - Conservation ethics guidelines (ICCROM, E.C.C.O, ICOM, ICON, AIC guidelines for conservation practices)
  - BIZOT

Activity (2-3hr session)

Individual activity (or in pairs):
Using relevant green frameworks and tools, evaluate the 'greenness' of 2 options in either an interventive conservation treatment they've recently carried out (e.g. varnish removal with ethanol and a tissue vs acetone with a swab) or a preventive approach (e.g. digital accessibility vs travelling for exhibition). Choose and use tool(s) for the green(er) decision-making. Consider the appropriateness of the treatment using a holistic approach aligned with the green parameters.

Group activity: Each individual (or group of two) presents a 10-minute summary of their specific assessment of the green parameters to compare the potential treatment/approach options holistically. They can also potentially provide a rationale for focussing on a specific impact category (i.e. hazards/energy/resources) alongside professional parameters.

Group discussion: What was found particularly challenging/what were the encountered barriers? Is there general in agreement among colleagues' choices? If not, why not (how much does the context/comparative nature/regional focus/specific or personal factors impact the decision?)

Summary / wrap-up (5–10 minutes)
Summary of main points from group discussion.

METHODOLOGY

Delivery format	Blended approach; the session will comprise an initial lecture with PowerPoint presentation, then practical exercises, followed by discussions.

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Activities / Exercises / Assessments

By the end of the activity, learners will:

- Have a basic knowledge and understanding of the frameworks and tools for assessing sustainable decision-making in the conservation of paintings.
- Apply decision-making and sustainability frameworks and tools to assess their approaches and choices in real-world conservation contexts.
- Collaborate and communicate findings effectively through discussion and analysis of comparative profiles.

Materials:

- Computer for digital documentation and sharing (if possible, using assessment tool data for displaying results),.
- Reference data (e.g. toxicity/hazard metrics, and LCA information from above tools and databases),
- Video projector.

Tasks:

- Application of decision-making tools to assess approaches and choices,
- Compile material profiles (where relevant) related to the impact categories (e.g. hazard metrics, energy, resources, cultural heritage),
- Reflection on priorities when selecting green(er) alternatives.
- Discuss findings with peers and assess practical applicability in conservation contexts.

Questions:

- What was found particularly challenging/what were the encountered barriers?
- Is there general in agreement among colleagues'' choices? If not, why not (how much does the context/comparative nature/regional focus/specific or personal factors impact the decision?)
- How do factors like accessibility, cost, material compatibility, and limitations affect the choices?

Discussion and Analysis:

- As a group discuss findings, compare comparative profiles, and reflect on the practical applicability and compromises in real-world conservation contexts.

Facilitator Notes

Prepare some case studies in advance in case examples are needed.

Webinar links from GoGreen: https://www.youtube.com/@GoGreenConservation

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ADDITIONAL RESOURCES

- STiCH Access Link: https://stich.culturalheritage.org/
- Starters Manual (see **Appendix 1.1**)
- Green Conservation Summary Report
- DSA APP (tutorial)
- Safety Information: Globally Harmonized System of Classification and Labelling of Chemicals, ACS: https://youtu.be/xtacgd3RXWo?feature=shared
- Safe and sustainable by design: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/chemicals-and-advanced-materials/safe-and-sustainable-design_en

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APPENDIX 1.1

Starters Guide to Using the 14 Green Parameters

Gwendoline Fife, Momoko Okuyama, Julia Wagner[1]

As a conservator, you hold a uniquely positive and powerful role: preserving human history while supporting a sustainable future. However, navigating the complexities of the climate crisis in your daily practice can feel overwhelming. The good news is that you do not need to be perfect, and you do not need to do everything at once. The green conservation framework is designed to be an encouraging, practical compass rather than an administrative burden.

To help you integrate sustainability into your work, the GoGreen project identified 14 Green Parameters for conservation grouped into four big-picture areas: Health and Environment (toxicity), Climate Change (energy), Resources (waste and water), and Cultural Heritage (professional efficacy and ethics). The parameters encourage you to weigh these environmental factors holistically alongside the safety and needs of the artwork (Parameters G9–G14), ensuring your preservation goals are never compromised[2].

For instance, the green parameters can be put into practice through two activities: **collecting comparative data and information** on the parameters e.g. for different suitable materials, equipment and treatment approaches; and **examining this information for assessing** selections, decision-making and potential advocacy from a holistic sustainability perspective.

To familiarize yourself with the parameters, you may find it easiest to begin with a comparison between two intervention options that achieve the same conservation goals.

Here is a starter's guide to using them with balance, nuance, and positivity.

1. Start Where You Are (And Start Small) You do not need to overhaul your entire studio overnight. Begin simply by pausing to reflect on a current activity. For a practicing conservator, the most direct and empowering point of leverage is often right at the bench with your material selection. Look at Parameters G1 and G2 (Toxicity and hazards). Can you swap a highly hazardous, petroleum-based solvent for a safer alternative? While the carbon footprint of conservation materials might only make up

[1] Google Notebook (off-line AI tool) helped generate this document based solely on original source material developed in the GoGreen project.
[2] A full description of these parameters can be found on the GoGreen website, on GoGreen's Zenodo page and in Fife, G. R., Turrina, A., Wagner, J., Del Curto, D., Southwick, C., & Keune, K. (2025). *Defining Green in the Conservation of Cultural Heritage*. [Manuscript accepted for publication by Studies in Conservation]. https://doi.org/10.1080/00393630.2026.2653274

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1% of an activity's total impact, choosing less toxic materials drastically improves your immediate health and local environment, turning climate anxiety into positive, tangible action.

2. Embrace Nuance and Balance A crucial secret to green conservation is acknowledging that "100% green" simply does not exist. Sustainability is always a comparative, consultative process full of trade-offs. You might find a bio-based material that is great for reducing impacts on the environment, but it might take a relatively excessive amount to achieve the preservation goals. Because this is a cyclical process, if a greener option isn't viable today due to budget or time constraints (Parameter G13), simply note the barrier and try again on the next project.

3. Look Up From the Bench to the Bigger Picture While your bench work is vital, the parameters also help you map your influence onto larger systems. Energy consumption for indoor climate control (Parameter G3) is one of the sector's biggest impacts. You can leverage your specialized knowledge to advocate for greener institutional policies. For example, by using your understanding of material stability, you can confidently advise curators or registrars to widen evidence-based relative humidity tolerances for museum loans, or advocate for microclimate boxes instead of room/building-level climate control. This shifts your influence from the operational level (the bench) to the strategic level, massively reducing your institution's HVAC energy burden.

Ultimately, using the 14 parameters aligns with a scientific attitude—a willingness to ask questions, test new empirical evidence, and openly communicate with your peers. By integrating these nuanced reflections into your daily routine, you actively drive the conservation profession toward a resilient and greener future.

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2. Cleaning Agents for Paintings: Solvents and Solutions

Authors: Beatrice Menegaldo, Maartje Stols-Witlox, Gwendoline Fife

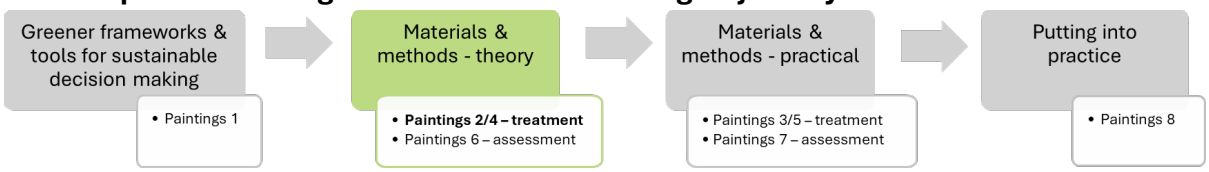
This theoretical session introduces recent developments in greener solvents and solutions for cleaning of paintings, with a particular focus on varnish/coatings removal, and prepares participants for their practical use. Participants will compare them with traditional solvents and critically assess their safety, health, and environmental impacts through the frameworks, tools, and guidelines presented in *Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*.

Key Concept 1	**Varnish removal**
Key Concept 2	**Greener solvents**
Key Concept 3	**Greenness assessment**

OBJECTIVES

Objective 1	Recognise the health and environmental impacts of some traditional solvents used for cleaning paintings.
Objective 2	Identify and describe greener solvents and solutions as alternatives for traditional solvents with negative health and environmental impact used in the cleaning of paintings including those developed within the Green Cluster.
Objective 3	Gain knowledge of methods to compare the performance, safety, environmental, and health impacts of traditional and greener solvents and solutions.
Objective 4	Justify the importance of greener solvents and solutions for practical application in the cleaning of paintings.

Module placement in green treatments learning trajectory



PREPARATORY MATERIALS

The facilitator of the module is requested to prepare the following teaching materials/ set-up beforehand:

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- PowerPoint presentation containing the information discussed during the lesson
- Materials for the activity "Theoretical evaluation of greener cleaning agents". The facilitator must prepare the form or an online template (e.g., Padlet) in advance.

SESSION OUTLINE (total 2 hours)

Introduction (10 minutes)

- This section introduces key issues and risks associated with the use of free organic solvents in the cleaning of paintings, with particular attention to the environmental, health, and safety implications of traditional cleaning agents.
- Rationale for adopting greener cleaning agents, emphasising their potential to reduce risks while maintaining effectiveness.
- Link to previous learning by reinforcing how this session builds on the module *Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*.

Traditional solvents (25 minutes)

- This section gives an overview of traditional organic solvents used in painting conservation and examines their safety, health, and environmental implications using the frameworks, tools, and guidelines presented in *Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*.
- Identification of solvents that may require replacement and emphasise that some traditional solvents are already greener options.

Potentially greener cleaning agents (25 minutes)

- This section introduces the definition of "greener solvents" to emphasise the relative nature of solvent assessment, referring to solvents that may offer reduced human toxicity and environmental impact compared with currently employed alternatives.
- It presents the latest greener cleaning agents and explores their evaluation through sustainability frameworks. The cleaning agents that have recently been introduced by the Green Cluster will be discussed (A list of greener cleaning agents is available in the *Additional Resources* section of this document).
- It examines the transparency and availability of chemical and physical data, as well as sustainability assessment information, including potential longer-term impacts on humans and the environment.

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- It considers the potential interactions between greener cleaning agents and underlying paint layers, highlighting that materials effective at removing coatings may still pose risks to original components; where evidence on long-term effects — including impacts on human health and the environment — is limited or unavailable, this is explicitly identified as a critical factor in the assessment process.
- Case studies demonstrating greener cleaning agents are presented.

Break (5 minutes)

Applied Learning Activity: Theoretical evaluation of greener cleaning agents (45 minutes)

Learners will work individually or in small groups to critically evaluate potentially greener agents as alternatives to a more hazardous solvent, recognising that no agent can be considered truly "greener" until it has been adequately assessed, including for artwork safety. Learners will compare properties, sustainability, and practical applicability using the frameworks, tools, and guidelines presented in *Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*. Potential interactions with underlying paint layers are also critically considered, emphasising potential risks to original components and gaps in longer-term effects, including impacts on human health, particularly in the case of new or insufficiently tested solvents (full activity detailed **in Activities / Exercises / Assessments**).

Case study

Presentation of case study where greener agents have been applied in the cleaning of paintings, demonstrating reduced hazards and increased efficiency (e.g., achieving multiple treatment objectives in a single step).

Wrap-up/Key takeaways (5–10 minutes)

Recap of key points:

- Criteria and frameworks for selection and evaluation of greener cleaning agents.
- The importance of balancing safety, sustainability and performance, while critically considering potential interactions with underlying paint layers and uncertainties in long-term effects.

Discussion prompts:

- What barriers exist to wider adoption of greener cleaning agents?
- If a hazardous solvent is necessary, how can its health and environmental impacts be minimised?

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- If no greener alternatives are practically feasible for a given cleaning task, should no treatment be considered as a valid and responsible conservation strategy?
- Considering all the potential stakeholders involved in such a decision – can the 14 green conservation parameters help you document and communicate your findings and perspective?

Preparation for the practical session: linking theoretical understanding to hands-on experimentation and evaluation.

METHODOLOGY

Delivery Format The session will be delivered using a blended approach, combining contents presented through slides, case study analysis, interactive discussions, and practical activity to engage participants and reinforce learning.

Activity **Theoretical evaluation of greener cleaning agents**
(total 45 minutes)

Description:

Participants work individually or in small groups to investigate 2–3 greener cleaning agents as potential replacement for a less green alternative, creating a properties profile that includes hazard/toxicity metrics, environmental impact (LCA), chemical and physical properties. Profiles are then discussed together, allowing participants to compare findings, and reflect on practical applicability. The suggested template for this activity is reported in the *Additional Resources* section.

By the end of the activity, learners will:

- Critically evaluate greener cleaning agents by comparing their chemical and physical properties, toxicity, and environmental impacts relative to traditional solvents.
- Apply decision-making and sustainability frameworks to assess the practical suitability of cleaning agents in real-world conservation contexts.
- Collaborate and communicate findings effectively through discussion and analysis of comparative profiles.

Materials:

- Worksheets or digital templates (Padlet).
- Reference data (A list of tools and guidelines supporting sustainable decision-making is available in the *Additional Resources* section of this document).

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- Whiteboard or interactive whiteboard/projector.
- Access to a teaching space suitable for lectures and group discussion.

Tasks:

- Select 2–3 greener cleaning agents as alternatives to a more hazardous solvent.
- Compile a comparative properties profile for each, using the decision-making and sustainability frameworks.
- Discuss findings with peers and reflect on priorities when selecting greener alternatives.

Questions:

- What factors most influence the choice of cleaning agents (e.g., personal safety, environmental impact, unknown or potential effects on painting materials, effectiveness of greener alternatives to obtain cleaning objectives)?
- How do factors like accessibility, cost, material compatibility, and limitations affect the choice of cleaning agents?

Discussion and analysis:

- As a group discuss findings, compare comparative profiles, and reflect on the practical applicability and compromises of different greener cleaning agents in real-world conservation contexts.

Facilitator Notes

General guidance:

- Keep the session interactive, encouraging questions and discussions.
- Emphasise the connection with green conservation frameworks presented in the module "*Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*".
- Remind participants that "green does not necessarily mean new"—some greener alternatives build on established methods.

Recommended discussion points:

The discussion prompts listed in the Summary / Wrap-Up section above can be used to guide group reflection. When facilitating:

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- For the question on barriers to adoption, invite participants to draw on their own professional experience.
- For the question on hazardous solvents, guide the discussion towards practical mitigation strategies (e.g., PPE, ventilation, reduced quantities, retention systems).
- For the question on 'no treatment', emphasise that this represents a significant shift in conservation thinking and encourage participants to consider it as a genuinely valid option, not a last resort.

Resources required:

- Slides with key concepts and visual examples.
- Worksheets or digital templates (Padlet) for the activity.
- Reference data (You can refer to the list of tools and guidelines supporting sustainable decision-making in the *Additional Resources* of this document).
- Reference bibliography for participants to consult.
- Whiteboard or interactive whiteboard/projector for group discussion notes.

Tips for Facilitator:

- Use real examples where possible to make concepts concrete.
- Tailor the concepts to participants' backgrounds (e.g., conservators, heritage scientists) and experience levels (e.g., students, instructors, professionals).

ADDITIONAL RESOURCES

1. List of potentially greener cleaning agents to test (note: not a recommendation list)

Bio-based solvents

- Dimethyl carbonate (DMC)
  - Prati, S., Sciutto, G., Volpi, F., Rehorn, C., Vurro, R., Blümich, B., Mazzocchetti, L., Giorgini, L., Samorì, C., Galletti, P., Tagliavini, E., & Mazzeo, R. (2019). Cleaning oil paintings: NMR relaxometry and SPME to evaluate the effects of green solvents and innovative green gels. New Journal of Chemistry, 43(21), 8229–8238. https://doi.org/10.1039/C9NJ00186G
  - Ramacciotti, F., Sciutto, G., Cazals, L., Biagini, D., Reale, S., Degano, I., et al. (2024). Microporous electrospun nonwovens combined with green solvents for the selective peel-off of thin coatings from painting surfaces. Journal Of Colloid And Interface Science, 663, 869-879. https://dx.doi.org/10.1016/j.jcis.2024.03.006

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- Ethyl lactate (EL)
  - Prati, S., Sciutto, G., Volpi, F., Rehorn, C., Vurro, R., Blümich, B., Mazzocchetti, L., Giorgini, L., Samorì, C., Galletti, P., Tagliavini, E., & Mazzeo, R. (2019). Cleaning oil paintings: NMR relaxometry and SPME to evaluate the
  - effects of green solvents and innovative green gels. New Journal of Chemistry, 43(21), 8229–8238. https://doi.org/10.1039/C9NJ00186G
  - Kampasakali, E.; Fardi, T.; Pavlidou, E.; Christofilos, D. Towards Sustainable Museum Conservation Practices: A Study on the Surface Cleaning of Contemporary Art and Design Objects with the Use of Biodegradable Agents. Heritage 2021, 4, 2023-2043. https://doi.org/10.3390/heritage4030115

- Gammavalerolactone (GVL)
  - Samorì, C., Galletti, P., Giorgini, L., Mazzeo, R., Mazzocchetti, L., Prati, S., Sciutto, G., Volpi, F., Tagliavini, E. (2016). The Green Attitude in Art Conservation: Polyhydroxybutyrate–based Gels for the Cleaning of Oil Paintings. ChemistrySelect, 1(15), 4502–4508. https://doi.org/10.1002/slct.201601180
  - Prati, S., Volpi, F., Fontana, R., Galletti, P., Giorgini, L., Mazzeo, R., Mazzocchetti, L., Samorì, C., Sciutto, G., & Tagliavini, E. (2018). Sustainability in art conservation: a novel bio-based organogel for the cleaning of water sensitive works of art. Pure and Applied Chemistry, 90(2), 239–251. https://doi.org/10.1515/pac-2017-0507
  - Melchiorre, C., Melchiorre, M., Marra, M., Rizzo, E., Fatigati, G., Rossi, P., Cerruti, P., Improta, I., Amoresano, A., Marino, G., Ruffo, F., & Carpentieri, A. (2023). Green solvents and restoration: Application of biomass-derived solvents in cleaning procedures. Journal of Cultural Heritage, 62, 3–12. https://doi.org/10.1016/j.culher.2023.05.013

- d-limonene
  - Kampasakali, E.; Fardi, T.; Pavlidou, E.; Christofilos, D. Towards Sustainable Museum Conservation Practices: A Study on the Surface Cleaning of Contemporary Art and Design Objects with the Use of Biodegradable Agents. Heritage 2021, 4, 2023-2043. https://doi.org/10.3390/heritage4030115

- Deep eutectic solvents (DES)
  - Biribicchi, C, A. Macchia, G. Favero, R. Strangis, B. Gabriele, R. Mancuso and M. F. La Russa. “Sustainable Solutions for Removing Aged Wax-Based Coatings from Cultural Heritage: Exploiting Hydrophobic Deep Eutectic Solvents (DESs).” *New J. Chem.*, vol. 47, no. 12 (March 2023): 5991–6000. doi.org/10.1039/D3NJ00228D.

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- FAMEs (fatty acid methyl esters)

  Zaratti, C., Marinelli, L., Colasanti, I. A., Barbaccia, F. I., Aureli, H., Prestileo, F., De Caro, T., La Russa, M. F., & Macchia, A. (2024). Evaluation of Fatty Acid Methyl Esters (FAME) as a Green Alternative to Common Solvents in Conservation Treatments. Applied Sciences, 14(5), 1970 https://doi.org/10.3390/app14051970

2. Tools and guidelines supporting decision-making

- Green parameters, Access Link: https://gogreenconservation.eu/defining-green-conservation/
- GoGreen DSA and tutorials
- STiCH Carbon Calculator, Access Link: https://stich.culturalheritage.org/carbon-calculator/
- Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Access Link: https://youtu.be/xtacgd3RXWo?feature=shared

  GHS hazard databases (e.g. ECHA) and GHS-based approaches (e.g. Chem21)
- Material Safety Data Sheets (MSDS)

3. Appendix 2.1: Template for the activity – Greener Solvent Assessment Worksheet
(worksheet template below)

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Appendix 2.1 Greener Solvent Assessment Worksheet

The 14 green conservation parameters developed by GoGreen form a logical starting point for assessing the toxicity and environmental impact of the methods being tested for conservation treatments. In these 14 parameters, general environmental impacts (G1-G8 covering hazard impacts on human health and environment, impact on climate change, impact on resource depletion) are connected to considerations central to the professional context of conservation (G9-14).

> Go through these parameters, and decide which ones are most relevant to the treatment choice you have to make. The details of this choice depend on your conservation goal and the methods you have access to.

Depending on your selection/ranking of parameters, you will need various resources and will need to collect data about the methods you want to consider (e.g. amounts used, tools needed, etc.)

Data on all conservation materials may be incomplete. This means dealing with uncertainties. This uncertainty is increased by updates in data, changes in circumstances, and by the introduction of new chemicals and methods. However, by working with what is known we can lower our environmental impact and our risk of exposure to hazardous materials. Every step counts.

The GoGreen Digital Support app (DSA), currently being tested, aims to provide direct access to certain data for the parameters. This information is sourced from various recognized frameworks (e.g. GHS) and existing reliable resources (e.g. STiCH) and thus acts as a portal as well as a tool that allows for easy and detailed comparison between different chemicals and tools. STiCH - Sustainability Tools in Cultural Heritage - already offers a carbon calculator and provides information sheets on LCA – Lifecycle Assessment. SDS – Material Safety Datasheets for material-specific information on toxicity and environmental concerns - must always be checked and the appropriate guidelines followed. Consider local waste separation/recycling strategies in assessing recyclability. Always check the SDS for appropriate waste disposal.

> Use the above resources to gather information about the materials you intend to use, and assemble these in the worksheet below

> How to approach comparing them?

The choice of solvent and approach depends on the parameters and the demands related to your specific circumstances and requirements. Because these vary, it is not possible to provide a standard ranking between the criteria or between the materials. It is not possible to standardly weight the parameters. Therefore, the step of choosing solvents is one of subjective decision making, although certain parameters could be prioritised. The decision process can be helped by going through the worksheet, considering broader implications, specific concerns, circumstances, and choosing on that basis.

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Resources

www.gogreenconservation.org : general project page and information about GoGreen; DEFINING GREEN CONSERVATION - GoGreen: Green definition and parameters; For fuller details see Fife, G., Turrina, A., Wagner, J., Curto, D. D., Southwick, C., & Keune, K. (2026). Defining Green in the Conservation of Cultural Heritage. Studies in Conservation, 1–23. https://doi.org/10.1080/00393630.2026.2653274

GoGreen Zenodo repository (https://zenodo.org/communities/gogreen/)

www.stich.culturalheritage.org : carbon calculator, LCA, The Red List - Living Future: the red list.

Worksheet for comparing solvents according to the 14 Green Conservation Parameters

This worksheet helps conservators go through the GoGreen categories and parameters systematically and indicates in bullet points which resources can be consulted for each parameter.

Tips:

- Fill in parameters as specifically as possible;
- For solvent mixtures fill in the worksheet for each individual solvent,
- Use colour coding to rank the materials (green/orange/red) when sufficient information has been obtained for the particular parameter.

Greener Solvent Assessment Worksheet (a digital version is available via Padlet)

Category	Parameter • information source	Material 1	Material 2
Hazard impacts on human and environment (G1-2)	G1 Toxicity and hazard metrics for the natural environment (Ecotoxicity - aquatic & terrestrial) • GHS Hazard statement • GHS Hazard pictograms • MSDS		
	G2 Toxicity and hazard metrics for humans Exposure risks (inhalation, skin contact): • GHS Hazard statements • GHS Hazard pictograms • MSDS - Required PPE - Storage & handling risks		

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Impact on climate change (G3-G5)	G5 Energy – Conservation approach / treatment-associated materials / products to be used Carbon Footprint Resource origin (e.g. fossil vs renewable) • STiCH Calculator		
Impacts on resources (G6-G8)	G7 Availability – Biodiversity impacts • Red list		
	G8 Waste • MSDS		
Artwork, cultural heritage object specific / professional parameters (G9-14)	G9 Material / product selection and application method • Intended use (e.g., varnish removal) • Interaction with paint layers • Hansen / Teas parameters • Boiling point • Volatility (VOC contribution) • Potential to adapt application method to reduce impacts (e.g., gels, electrospun nonwovens)		
	G10 Efficiency - Number of applications/consumption/quantities of materials/products used • Treatment tests		
	G11 Longevity of result • Personal assessment		
	G12 Accessibility – Cost / availability of approach / used materials / products • Supplier (can also be qualitatively assessed by user) • Transport impacts		
	G13 Accessibility – Ease of use and time • Personal assessment (Is it innovative with potential professional / long-term benefits?)		

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	G14 Quality / value impacts of result in meeting preservation goals • Long-term effects on substrate • Personal assessment		
Assessment summary:	*Briefly describe your general 'verdict' on the solvent/approach*		

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3. Practical Application of Cleaning Agents: Solvents and Solutions

Author: Maartje Stols-Witlox

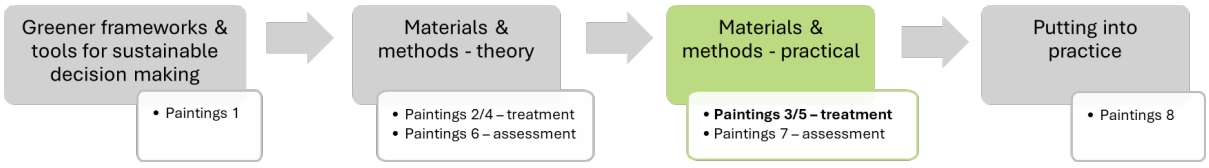
This practical session is directly connected to Session 2 “Cleaning Agents for Paintings: Solvents and Solutions”. In this practical application session, participants practice selecting greener solvents and solvent mixtures for varnish removal from paintings by applying the principles and knowledge gained in the session “Cleaning Agents for Paintings”, using them on prepared experimental sample materials and selected test paintings before proceeding to the complexity of the treatment of real heritage objects, which is the topic of the session “From Theory to Practice”. The current module focuses on the use of liquid solvents and solvent mixtures. Selection of greener retention systems is the topic of parallel sessions “Retention Systems” and “Practical Application of Retention systems”.

Key Concept 1	**Varnish removal**
Key Concept 2	**Greener solvents**
Key Concept 3	**Solvent star**
Key Concept 4	**Paintings conservation**

OBJECTIVES

Objective 1	**Assess** the greenness of the methods to be tested for varnish removal using free solvents and solvent mixtures.
Objective 2	**Compare** the efficacy of liquid traditional and greener solvents and solvent mixtures for varnish removal from paintings
Objective 3	**Select and apply** assessment methods to test the practical performance of traditional and alternative greener solvents and solvent mixtures for varnish removal from paintings

Module placement in green treatments learning trajectory



PREPARATORY MATERIALS / STEPS

1. Preparation of artificially aged test boards and/or purchasing/identification of naturally aged test paintings (‘sacrificial objects’).

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2. Selection of cleaning agents to be tested.

Steps 1 and 2 are interconnected, as the number and nature of materials to be tested depend on as well as influence the number and nature of test board to be prepared or sacrificial paintings to be used for testing.

Selecting and preparing test surfaces should be done well ahead of time, especially if it involves artificial ageing of the board and/or the coatings to be tested. As the exact details of this selection depend entirely on local circumstances, no specific instructions are provided. Instead, instructors are advised to consult the Modules bibliography, section “Green Treatments and their Assessment: Paintings", in particular those within theme blocks 2 and 4. For broad testing and general comparison of properties, test boards with larger uniform surfaces are advised. Consider combinations of smooth and impastoed paints, and select the binder of the paint and the varnish based on the specific workshop goals. If available, naturally-aged student reconstructions can be very useful as a surface for the application of varnishes that can be tested after artificial ageing.

In selecting cleaning agents, consider the green parameters. For this thematic session, particularly applicable are:

- Hazard impacts on human and environment (especially G1, G2, G5)

- Impact on resources (G6-G8)

Other parameters become relevant in the steps that follow preliminary selection, and will influence choice of method. The exact choice of methods to be tested will depend on the local circumstances/facilities and availability (G12). The additional resources of session 02, cleaning agents for paintings, provides a list of greener cleaning agents that are considered interesting replacements around the time of publication of these education modules. Mark that the selection will change with the identification/formulation of other alternatives, so consider updating them based on new insights.

3. Preparation of diagrams with a schematic for tests.

A model diagram is prepared by the workshop instructor, to be handed out/shown on a screen to participants, so that they can transfer the design onto the test systems they will be using. Simplest is using a grid with letters or numbers as labels for each cell in the grid. (Participants may also be invited to develop their own testing diagram, but this step will add an additional 30 minutes to the workshop schedule, and may result in individual testing protocols that are difficult to compare between participants.)

4. Selecting and preparing the classroom/laboratory/tools/solvents/documentation material.

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Decide between printing documentation sheets or using digital documentation sheets depending on the local situation. Both have environmental impact (paper and ink vs electricity), and the choice will also be influenced by local circumstances (table space, power socket availability, preventing loose cables, etc.). But ease of use and time (G13) must also be considered.

5. Selecting preparatory reading for the class from the literature list.

If applicable, check the GoGreen Modules bibliography, section "Green Treatments and their Assessment: Paintings", for preparatory reading for participants. This session assumes that participants have completed the "Module Cleaning Agents for Paintings". If this is not the case, the session moderator needs to study this module and prepare reading material that covers the main theory and systems introduced in this session, related to the education level of the students.

SESSION OUTLINE (2.5 hours, plus cleaning up)

Introduction: aims, methods and assessment (25 minutes)

General introduction (5 minutes)

- This session has the aim of taking the insights gained during the session "Cleaning Agents for Paintings: Solvents and Solutions" and applying it in practice.
- Link to previous learning by summarizing main outcomes insights of that session.
- Introducing the goals of the session and the general set-up

The cleaning agents that will be tested and compared (10 minutes)

- Describe the test objects that will be used
- Introduce the choice of solvents for the workshop
- Only free solvents used, application using traditional method of cotton wool swabs
- For each solvent, use the properties profile developed in Module 2 to compare solvents. If a solvent is tested that has not been the topic of Module 2, develop a properties profile using the template "Greener Solvent Assessment Worksheet", provided in Module 2.
- Include links/background data/literature for the cleaning agents and their application to paintings or painted surfaces.

The assessment methods that will be used (15 minutes)

- Reminder of the 14 green conservation parameters
- Introduction comparison tool for volatile organic solvents: Fife Solvent Star

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- Low-tech methods: visual observation, UV illumination, raking light – if relevant, magnification with head loupe or (USB) microscope
- Provide links/background data/literature about assessment methods

Setting up for the practical part of the session (5 minutes)

- Explain documentation sheets
- Divide into groups that together perform the same tests on their test boards
- Explain how groups move from work station to work station if more work stations are used.

Practical (70 minutes)

Practical testing (60 minutes, including note-taking)

- Safety / logistics instructions by facilitator
- Transfer the testing plan for the pre-selected solvents to the test boards
- Execute tests. Each person performs their own tests and fills in their own assessment sheet, with solvent star for every test (see Template "Practical Assessment Worksheet" below).
- Each group shares observations informally while doing tests.
  - What are your observations?
  - What do you like/dislike about the methods tested?
  - How are your experiences with the testing protocol/solvent star?

Write down ideas for personal action plan (10 minutes)

- Write down 4-5 action points for yourself, things you would like to learn/do/change after having participated in this session, and decide the timeline for each action point.

General discussion and wrap-up (45 minutes)

- Each group reports on observations (5-10 minutes per group)
- General discussion on the methods tested, focused on the critical evaluation of the solvents, key considerations for the choice of solvents and evaluation of the risks involved (to operator and environment). *See for more detailed suggestions for the general discussion the box facilitator notes below*

Finalise personal action plan (10 minutes)

- Update action plan based on the general discussion

Cleaning up (15 minutes)

- Dedicated attention for waste management, using the opportunity to discuss and demonstrate environmentally sustainable waste management practice

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Case Study / Example

This workshop uses pre-made and artificially aged test boards, to which varnishes have been applied, as well as naturally aged test paintings. It focuses on developing the testing methodology through practical application in small areas. The application of the solvents explored in this session, upscaling and finetuning to actual paintings undergoing treatment in the conservation studio, is the topic of the session "Putting into Practice," which provides the broader perspective needed for decision making and the safe application of the methods developed to actual cultural heritage objects.

METHODOLOGY

Delivery Format

The session will start with an introduction/instruction that is best delivered as a presentation. It continues with a practical for which different workstations are set up, and for which a laboratory setting is required (solvent cabinet, fume hood, laboratory waste disposal system). The session finishes with a discussion and reflection. Depending on the facilities, educators may choose to host the introduction/discussion in a separate classroom, or set up a beamer in the laboratory environment.

Activities / Exercises / Assessments

1. **Design a testing plan for the pre-selected solvents** (activity, 10 minutes)

   Materials/tools: test boards, pencil to mark test areas on test boards, paper to draw schematic of test areas

   Description: Depending on the number of participants, number and nature of objects available for testing and the number of experimental variables included in the workshop, the exact division of a test board or painting into different testing areas will differ. The workshop instructor will therefore design templates, which the workshop participants will follow. Test board may be divided into sections using pencil and a ruler, for sacrificial paintings, a Melinex/Mylar overlay may be considered, divided into sections with a water-resistant pen. Participants make sure always to change only a single variable, and consider the minimum area needed for a representative result.

2. **Practical testing of solvents** (activity, 60 minutes)

   Materials/tools: solvent bottles with selected solvents, cotton wool, toothpicks, practical assessment sheet with solvent stars (see below, appendix), pencil, paper towels, jar for used solvents/cotton swabs, gloves, solvent mask, UV torch, stereo microscope if available.

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Description:
Participants test the selected solvents according to their testing plan. They fill in the assessment sheet while working and preserve the cotton swabs they have used for comparison.

3. **Workshop report** (assessment, started during testing finished afterwards at home, 30-45 minutes)

   Materials/tools: computer/laptop, documentation sheets from practical testing, photo camera, course literature, including GoGreen definition and parameters.

   Description: The assessment sheets filled in during the workshop stand at the basis of a workshop report that at least contains the following elements:
   - Table describing the basic properties of the solvents tested (chemical formulas, safety, health impact, personal protection measures needed)
   - Documentation sheets of all the solvents tests (appendix)
   - Text discussing the performance of the solvents tested, based on the solvent star results.
   - Reflection on the applicability of green solvents for the cleaning of paintings, and the requirements for integration into practice.

4. **Follow-up action plan** (documentation and/or assessment tool) - 10 minutes
   Materials/tools: computer/laptop, course literature, GoGreen definition and parameters.

   Description: Before the general discussion takes place, each participant writes down 4-5 action points they would like to pursue after the workshop, and include the timeline they consider feasible for each action point. During the general discussion, action points are shared and discussed. After the end of the general discussion, each participant reassesses their action points, adjusting/adding/removing elements/timing based on the general discussion. (The action plan may be added to the workshop report for assessment, or may serve as a reminder to take home, without being part of an assessment.)

Facilitator Notes

Resources required:
- PowerPoint slides with key concepts and visual examples.
- Worksheets or digital templates for the activity.
- Reference data (e.g., physical properties, toxicity/hazard metrics, and LCA information).
- Reference bibliography for participants to consult.
- Laboratory environment with tools/supplies as indicated above.

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Preparation:

- When selecting systems to be tested, link selection of methods to be tested to the local aims of the workshop. For instance, choose between having all participants test all options and dividing the systems to be tested between groups, and have group inform each other on their observations.
- Adapt benchmark methods to local customs and practices.
- The practical has been described so that each participant does their own tests. If better for local environment, teams of 2 students can be an alternative, with the added benefit of constant exchange. Groups of 4-6 people can still simultaneously perform the same tests.

General guidance:

- Make sure that everything is always labelled.
- Encourage questions and discussions but also ensure that participants focus on finishing their own test boards.
- Emphasise the connection between green conservation frameworks (Module 1).
- Remind participants that "green does not necessarily mean new"—some green(er) alternatives build on established methods.
- Tailor the concepts to participants' backgrounds (e.g., conservators, heritage scientists) and experience levels (e.g., students, instructors, professionals).
- If your schedule allows, together go through the supporting literature list, highlighting titles that you find particularly interesting.

Recommended discussion points general discussion:

- What factors most influence the choice of cleaning agents (e.g., safety, environmental impact, painting material and build-up, expected short- and long-term effects on the painting)?
- What barriers exist to wider adoption of green(er) cleaning agents?
- Are there cases where green(er) solutions may not be applicable? Why? (e.g., lack of availability of nonpolar green(er) solvents)
- If a hazardous solvent is unavoidable, how can its health and environmental impacts be minimised? Is treatment unavoidable in such cases?

ADDITIONAL RESOURCES

- Appendix 3.1: Worksheet for solvent assessment and comparison
- Appendix 3.2: Instructions for assessing toxicity and environmental impact

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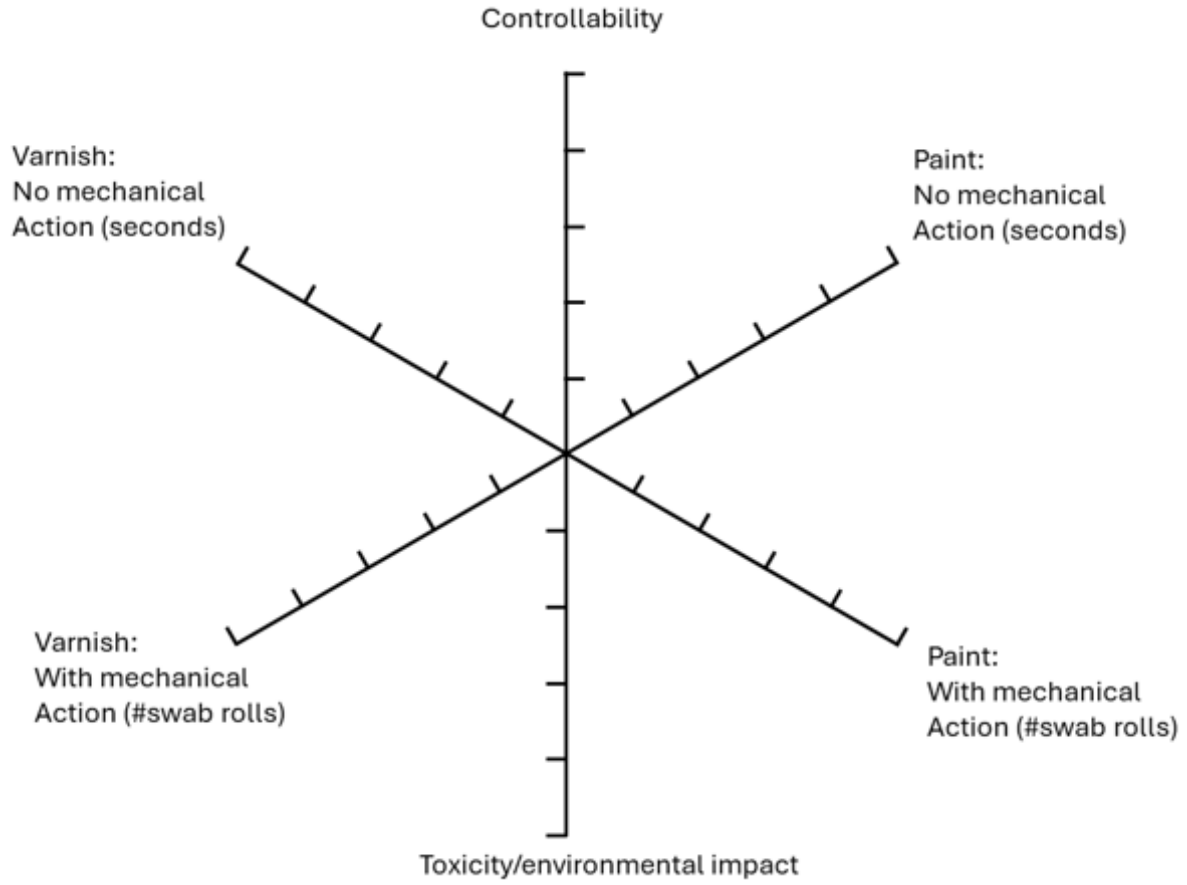
Appendix 3.1: Greener Solvent Assessment Worksheet

Name: _____

Date: _____

Painting : _____

Colour on star	Solvent(s)	Ratio (if mixture)	Notes



Notes:

**Worksheet and solvent star modified from Fife 2020*

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Appendix 3.2: Instructions for assessing toxicity and environmental impact

The 14 green conservation parameters developed by GoGreen form a logical starting point for assessing the toxicity and environmental impact of the methods being tested for conservation treatments. In these 14 parameters, general environmental impacts (G1-G8 covering hazard impacts on human health and environment, impact on climate change, impact on resource depletion) are connected to considerations central to the professional context of conservation (G9-14).

> Go through these parameters, and decide which ones are most relevant to the treatment choice you have to make. The details of this choice depend on your conservation goal and the methods you have access to.

Depending on your selection/ranking of parameters, you will need various resources and will need to collect data about the methods you want to consider (e.g. amounts used, tools needed, etc.)

Data on all conservation materials may be incomplete. This means dealing with uncertainties. This uncertainty is increased by updates in data, changes in circumstances, and by the introduction of new chemicals and methods. However, by working with what is known we can lower our environmental impact and our risk of exposure to hazardous materials. Every step counts.

The GoGreen Digital Support app (DSA), currently being tested, aims to provide direct access to certain data for the parameters. This information is sourced from various recognized frameworks (e.g. GHS) and existing reliable resources (e.g. STiCH) and thus acts as a portal as well as a tool that allows for easy and detailed comparison between different chemicals and tools. STiCH - Sustainability Tools in Cultural Heritage - already offers a carbon calculator and provides information sheets on LCA – Lifecycle Assessment. SDS – Material Safety Datasheets for material-specific information on toxicity and environmental concerns - must always be checked and the appropriate guidelines followed. Consider local waste separation/recycling strategies in assessing recyclability. Always check the SDS for appropriate waste disposal.

> Use the above resources to gather information about the materials you intend to use, and assemble these in the worksheet below

> How to approach comparing them?

The choice of solvent and approach depends on the parameters and the demands related to your specific circumstances and requirements. Because these vary, it is not possible to provide a standard ranking between the criteria or between the materials. It is not possible to standardly weight the parameters. Therefore, the step of choosing solvents is one of subjective decision making, although certain parameters could be prioritised. The decision process can be helped by going through the worksheet, considering broader implications, specific concerns, circumstances, and choosing on that basis.

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Resources

www.gogreenconservation.org : general project page and information about GoGreen; DEFINING GREEN CONSERVATION - GoGreen: Green definition and parameters; For fuller details see Fife, G., Turrina, A., Wagner, J., Curto, D. D., Southwick, C., & Keune, K. (2026). Defining Green in the Conservation of Cultural Heritage. Studies in Conservation, 1–23. https://doi.org/10.1080/00393630.2026.2653274

GoGreen Zenodo repository (https://zenodo.org/communities/gogreen/)

www.stich.culturalheritage.org : carbon calculator, LCA, The Red List - Living Future: the red list.

Worksheet for comparing solvents according to the 14 Green Conservation Parameters

This worksheet helps conservators go through the GoGreen categories and parameters systematically and indicates in bullet points which resources can be consulted for each parameter.

Tips:

- Fill in parameters as specifically as possible;
- For solvent mixtures fill in the worksheet for each individual solvent,
- Use colour coding to rank the materials (green/orange/red) when sufficient information has been obtained for the particular parameter.

Greener Solvent Assessment Worksheet (a digital version is available via Padlet)

Category	Parameter • information source	Material 1	Material 2
Hazard impacts on human and environment (G1-2)	G1 Toxicity and hazard metrics for the natural environment (Ecotoxicity - aquatic & terrestrial) • GHS Hazard statement • GHS Hazard pictograms • MSDS		
	G2 Toxicity and hazard metrics for humans Exposure risks (inhalation, skin contact): • GHS Hazard statements • GHS Hazard pictograms • MSDS - Required PPE - Storage & handling risks		

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Impact on climate change (G3-G5)	G5 Energy – Conservation approach / treatment-associated materials / products to be used Carbon Footprint Resource origin (e.g. fossil vs renewable) • STiCH Calculator		
Impacts on resources (G6-G8)	G7 Availability – Biodiversity impacts • Red list		
	G8 Waste • MSDS		
Artwork, cultural heritage object specific / professional parameters (G9-14)	G9 Material / product selection and application method • Intended use (e.g., varnish removal) • Interaction with paint layers • Hansen / Teas parameters • Boiling point • Volatility (VOC contribution) • Potential to adapt application method to reduce impacts (e.g., gels, electrospun nonwovens)		
	G10 Efficiency - Number of applications/consumption/quantities of materials/products used • Treatment tests		
	G11 Longevity of result • Personal assessment		
	G12 Accessibility – Cost / availability of approach / used materials / products • Supplier (can also be qualitatively assessed by user) • Transport impacts		
	G13 Accessibility – Ease of use and time • Personal assessment (Is it innovative with potential professional / long-term benefits?)		

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	G14 Quality / value impacts of result in meeting preservation goals • Long-term effects on substrate • Personal assessment		
Assessment summary:	*Briefly describe your general 'verdict' on the solvent/approach*		

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4. Retention Systems for the Cleaning of Paintings

Authors: Beatrice Menegaldo, Maartje Stols-Witlox

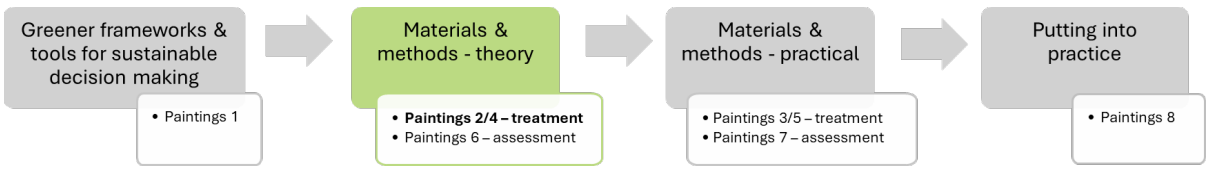
This theoretical session introduces recent developments in greener retention systems for cleaning of paintings, with a particular focus on dirt and varnish/coatings removal and prepares participants for their practical use. Participants will compare them with traditional retention systems and assess their safety, health, and environmental impacts through the frameworks, tools, and guidelines presented in "*Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*".

Key Concept 1	**Varnish removal**
Key Concept 2	**Greener solvents**
Key Concept 3	**Retention systems**
Key Concept 4	**Greenness assessment**

OBJECTIVES

Objective 1	Recognise the challenges associated with the use of free solvents as a rationale for the use of retention systems.
Objective 2	Gain knowledge of greener retention systems.
Objective 3	Compare greener retention systems with traditional cleaning application methods and free solvents using green conservation parameters.
Objective 4	Evaluate performance, safety, and health impacts of different cleaning approaches.

Module placement in green treatments learning trajectory



PREPARATORY MATERIALS

The facilitator of the module is requested to prepare the following teaching materials / set-up beforehand:

- PowerPoint presentation containing the information discussed during the lesson.

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- Materials for the activity "Theoretical evaluation of greener retention systems". The facilitator must prepare the form or an online template (e.g., Padlet) in advance.

SESSION OUTLINE (total 2 hours)

Introduction (10 minutes)
This session addresses the challenges associated with the use of free cleaning agents in the cleaning of paintings (dirt and varnish/coatings removal) and introduces retention systems as a more controlled and environmentally sustainable alternative.

- Advantages:
  - Reduced solvent consumption
  - Reduced solvent exposure for the user
  - More controlled and even removal of coatings

Reduced solvent penetration into paint layers

Overview of currently available retention systems (25 minutes)
This section provides an overview of established retention systems, outlining their properties, limitations, and typical applications in conservation practice.

- Gels
  - Natural polymers (e.g., agar, gellan gum, PHB)
  - Synthetic polymers (e.g., PVA, PVAc, PVP, PAM, pHEMA)
- Nonwovens (e.g., Evolon)

Overview of greener advancements in retention systems (25 minutes)
This section presents newly developed greener retention systems produced within Cluster 2, «Green technologies and materials for cultural heritage» and their potential applications in the cleaning of paintings. (A list of greener retention systems is available in the *Additional Resources* section of this document).

Break (5 minutes)

Activity (45 minutes)
Learners will work individually or in small groups to critically evaluate newly identified retention systems and create a comparative profile, assessing their properties, sustainability, and practical applicability using the frameworks, tools, and guidelines presented in *Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation* (full activity detailed in **Activities / Exercises / Assessments**).

Case Study / Example
Presentation of examples in which newly developed greener retention systems have been applied in the cleaning of paintings, demonstrating reduced hazards not only to human health and the environment, but also to the painting itself.

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Summary / Wrap-Up (5–10 minutes)
Include prompts for discussion, questions, or reflection points.

Recap of key points:

- Criteria and frameworks for the evaluation and selection of greener cleaning agents and retention systems.
- Advantages and limitations of traditional versus newly developed greener retention systems.

Discussion prompts:

- What are the disadvantages of using retention systems? (e.g., limited visibility of the surface during treatment, gels residues)
- What challenges might conservators face when adopting new greener retention systems in daily practice?

Preparation for the practical session: linking theoretical understanding to hands-on experimentation and evaluation.

METHODOLOGY

Delivery Format The session will be delivered using a blended approach, combining contents presented through slides, case study analysis, interactive discussions, and practical activity to engage participants and reinforce learning.

Activities / Exercises / Assessments

Activity Title: Theoretical evaluation of greener retention systems
Time: 45 minutes

Description: participants work individually or in small groups to investigate 2–3 greener retention systems and create a profile that includes chemical and physical properties, hazard/toxicity metrics and environmental impact (EHS & LCA). Profiles are then discussed together, allowing participants to compare findings, evaluate sustainability, and reflect on practical applicability. The suggested template for this activity is reported in the *Additional Resources* section.

By the end of the activity, learners will:

- Be able to assess different greener retention systems using a structured safe and sustainable by design framework.
- Reflect on the advantages and limitations of each system and make informed choices for conservation practice.

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- Gain insights from different perspectives and approaches by discussing and comparing profiles with peers.

Materials:

- Worksheets or digital templates (Padlet),
- Reference data (A list of tools and guidelines supporting sustainable decision-making is available in the *Additional Resources* section of this document).
- Whiteboard or interactive whiteboard/projector.
- Access to a teaching space suitable for lectures and group discussion.

Tasks:

- Work individually or in small groups to select 2–3 greener retention systems for evaluation.
- Apply decision-making and sustainability frameworks to select and compare retention systems.
- Compile a properties profile for each retention system, including environmental and health impact, safety, sustainability, accessibility and material compatibility.
- Present and discuss findings with the group, highlighting similarities, differences, and trade-offs.
- Reflect on which systems to choose for specific examples and justify the decisions.

Questions:

- What factors most influence the choice of the retention system (e.g., personal safety, environmental impact, type of material to be removed, unknown or potential effects on painting materials)?
- What compromises arise when selecting a greener retention system?
- How do factors like accessibility, cost, material compatibility, and limitations affect the choice of retention systems?
- Are there any limitations or challenges in using these systems in real conservation practice?

Discussion and Analysis:

- As a group discuss findings, compare comparative profiles, and reflect on the practical applicability and compromises of different retention systems in real-world conservation contexts.

Facilitator Notes

General Guidance:

- Keep the session interactive, encouraging questions and discussions.

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- Emphasise the connection with green conservation frameworks presented in the module "*Green Frameworks and Tools for Sustainable Decision-Making in Painting Conservation*".

Recommended Discussion Points:

- For the question on factors influencing the choice of retention system, invite participants to draw on their own professional experience and consider how context-specific constraints shape decision-making (e.g., personal safety, environmental impact, type of material to be removed, unknown or potential effects on painting materials).
- For the question on compromises, encourage participants to reflect on trade-offs between greenness, performance, and artwork safety.
- For the question on accessibility and cost, guide the discussion towards practical barriers that may limit the wider adoption of greener retention systems, including availability, affordability, and ease of sourcing.
- For the question on a conservator's commitment to intervention, emphasise that choosing not to intervene can be a valid and responsible conservation strategy, and encourage participants to consider this genuinely.

Resources Required:

- Slides with key concepts and visual examples.
- Worksheets or digital templates (Padlet) for the activity.
- Reference data (A list of tools and guidelines supporting sustainable decision-making is available in the *Additional Resources* section of this document).
- Reference bibliography for participants to consult.
- Whiteboard or interactive whiteboard/projector for group discussion notes.

Tips for Facilitator:

- Use real examples where possible to make concepts concrete.

Tailor the concepts to participants' backgrounds (e.g., conservators, heritage scientists) and experience levels (e.g., students, instructors, professionals).

ADDITIONAL RESOURCES

1. List of potentially greener retention systems developed by the Green Cluster for testing (note, not a recommendation list)

- Electrospun nonwovens
    - Self-standing (e.g., pullulan, PA6)
    - Supported (e.g., viscose+PA6, bamboo+PA6)
- GREENART hydrogels (e.g., PVA-starch hydrogels, Improved Nanorestore Peggy gels, PVA-modified cryogels (PVA-X))
- GREENART organogels (Polyester-enriched castor oil polyurethanes)

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2. Tools and guidelines supporting sustainable decision-making

- Green parameters, Access Link: https://gogreenconservation.eu/defining-green-conservation/
- GoGreen DSA and tutorials
- STiCH Carbon Calculator, Access Link: https://stich.culturalheritage.org/carbon-calculator/
- Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Access Link: https://youtu.be/xtacgd3RXWo?feature=shared
  GHS hazard databases (e.g. ECHA)
- Material Safety Data Sheets (MSDS)

3. Appendix 4.1: Template for activity – Greener Retention Systems Assessment Worksheet (below)

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Appendix 4.1: Greener Retention Systems Assessment Worksheet

The 14 green conservation parameters developed by GoGreen form a logical starting point for assessing the toxicity and environmental impact of the methods being tested for conservation treatments. In these 14 parameters, general environmental impacts (G1-G8 covering hazard impacts on human health and environment, impact on climate change, impact on resource depletion) are connected to considerations central to the professional context of conservation (G9-14).

> Go through these parameters, and decide which ones are most relevant to the treatment choice you have to make. The details of this choice depend on your conservation goal and the methods you have access to.

Depending on your selection/ranking of parameters, you will need various resources and will need to collect data about the methods you want to consider (e.g. amounts used, tools needed, etc.)

Data on all conservation materials may be incomplete. This means dealing with uncertainties. This uncertainty is increased by updates in data, changes in circumstances, and by the introduction of new chemicals and methods. However, by working with what is known we can lower our environmental impact and our risk of exposure to hazardous materials. Every step counts.

The GoGreen Digital Support app (DSA), currently being tested, aims to provide direct access to certain data for the parameters. This information is sourced from various recognized frameworks (e.g. GHS) and existing reliable resources (e.g. STiCH) and thus acts as a portal as well as a tool that allows for easy and detailed comparison between different chemicals and tools. STiCH - Sustainability Tools in Cultural Heritage - already offers a carbon calculator and provides information sheets on LCA – Lifecycle Assessment. SDS – Material Safety Datasheets for material-specific information on toxicity and environmental concerns - must always be checked and the appropriate guidelines followed. Consider local waste separation/recycling strategies in assessing recyclability. Always check the SDS for appropriate waste disposal.

> Use the above resources to gather information about the materials you intend to use, and assemble these in the worksheet below

> How to approach comparing them?

The choice of retention system and approach depends on the parameters and the demands related to your specific circumstances and requirements. Because these vary, it is not possible to provide a standard ranking between the criteria or between the materials. It is not possible to standardly weight the parameters. Therefore, the step of choosing retention systems is one of subjective decision making, although certain parameters could be prioritised. The decision process can be helped by going through the worksheet, considering broader implications, specific concerns, circumstances, and choosing on that basis.

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Resources

www.gogreenconservation.org : general project page and information about GoGreen; DEFINING GREEN CONSERVATION - GoGreen: Green definition and parameters; For fuller details see Fife, G., Turrina, A., Wagner, J., Curto, D. D., Southwick, C., & Keune, K. (2026). Defining Green in the Conservation of Cultural Heritage. Studies in Conservation, 1–23. https://doi.org/10.1080/00393630.2026.2653274

GoGreen Zenodo repository (https://zenodo.org/communities/gogreen/)

www.stich.culturalheritage.org : carbon calculator, LCA, The Red List - Living Future: the red list.

Worksheet for comparing retention systems according to the 14 Green Conservation Parameters

This worksheet helps conservators go through the GoGreen categories and parameters systematically and indicates in bullet points which resources can be consulted for each parameter. Tips:

- Fill in parameters as specifically as possible;.
- For systems with more than one material, fill in the worksheet for each individual component.
- Use colour coding to rank the materials (green/orange/red) when sufficient information has been obtained for the particular parameter.

Greener Retention Systems Assessment Worksheet

Category	Parameter • information source	Material 1	Material 2
Hazard impacts on human and environment (G1-2)	G1 Toxicity and hazard metrics for the natural environment (Ecotoxicity - aquatic & terrestrial) • GHS Hazard statement • GHS Hazard pictograms • MSDS		
	G2 Toxicity and hazard metrics for humans Exposure risks (inhalation, skin contact): • GHS Hazard statements • GHS Hazard pictograms • MSDS - Required PPE - Storage & handling risks		

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Impact on climate change (G3-G5)	G5 Energy – Conservation approach / treatment-associated materials / products to be used Carbon Footprint Resource origin (e.g. fossil vs renewable) • STiCH Calculator		
Impacts on resources (G6-G8)	G7 Availability – Biodiversity impacts • Red list		
	G8 Waste • MSDS		
Artwork, cultural heritage object specific / professional parameters (G9-14)	G9 Material / product selection and application method • Intended use (e.g., varnish removal) • Compatibility with selected solvent systems • Residues presence		
	G10 Efficiency - Number of applications/consumption/quantities of materials/products used • Treatment tests • Reusability		
	G11 Longevity of result • Personal assessment		
	G12 Accessibility – Cost / availability of approach / used materials / products • Supplier (can also be qualitatively assessed by user) • Transport impacts		
	G13 Accessibility – Ease of use and time • Personal assessment (Is it innovative with potential professional / long-term benefits?)		
	G14 Quality / value impacts of result in meeting preservation goals • Long-term effects on substrate • Personal assessment		
Assessment summary:	*Briefly describe your general 'verdict' on the retention system/approach*		

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5. Practical Application of Retention Systems for Varnish Removal from Paintings

Author: Maartje Stols-Witlox

This practical session is directly connected to Session 4 'Retention Systems for the Cleaning of Paintings.' In this practical application session, participants practice comparing cleaning strategies used in the remedial conservation of paintings, focusing specifically on retention systems, and how they can support greener practice. They apply the principles and knowledge gained in the session 'Retention Systems for the Cleaning of Paintings,' using them on mock-ups or sacrificial objects before proceeding to the treatment of heritage objects, which is the topic of the session 'From Theory to Practice'.

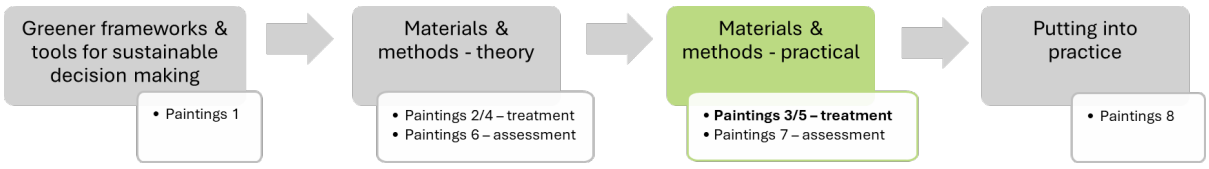
The practical description consists of two parts, part 1: gel preparation, and part 2: method testing and assessment. Part 2 covers new gels developed within the Green Cluster and the use of innovative tissues developed within GoGreen. Part 1 may be excluded if dictated by time/resources, in which case all gels need to be prepared by the facilitator of the workshop. The current session focuses on the selection of greener retention systems. Selection of greener liquid solvents is the topic of parallel sessions "Cleaning Agents for Paintings" and "Practical Application of Cleaning Agents."

Key Concept 1	**Varnish removal**
Key Concept 2	**Greener solvents**
Key Concept 3	**Solvent star**
Key Concept 4	**Retention systems**

OBJECTIVES

Objective 1	Assess the impact of different retention systems (gels, tissues) on the greenness of treatments for the cleaning of paintings
Objective 2	Select and apply assessment methods to test the practical performance of different retention systems
Objective 3	Compare the efficacy of different retention systems, including innovative greener retention systems, for the cleaning of paintings
Objective 4	Learn to prepare innovative greener gels

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS / STEPS

1. Preparation of test boards and/or purchasing/identification of sacrificial paintings that can be used for testing.

2. Selection of cleaning agents and retention systems to be tested.

Steps 1 and 2 are interconnected, as the number and nature of systems to be tested depend on as well as influence the number and nature of test board to be prepared or sacrificial paintings to be used for testing.

Selecting and preparing test surfaces should be done well ahead of time, especially if it involves artificial ageing of the board and/or the coatings to be tested. As the exact details of this selection depend entirely on local circumstances, no specific instructions are provided. Instead, instructors are advised to consult the Modules bibliography, section “Green Treatments and their Assessment: Paintings", in particular those within theme blocks 2 and 4. For broad testing and general comparison of properties, test boards with larger uniform surfaces are advised. Consider combinations of smooth and impastoed paints, and select the binder of the paint and the varnish based on the specific workshop goals. If available, naturally-aged student reconstructions can be very useful as a surface for the application of varnishes that can be tested after artificial ageing.

In selecting retention systems and cleaning agents, consider the green parameters. For this session, particularly applicable are:

- Hazard impacts on human and environment (especially G1, G2, G5)

- Impact on resources (G6-G8)

Other parameters become relevant in the steps that follow preliminary selection and will influence choice of method. The exact choice of methods to be tested will depend on the local circumstances/facilities and availability (G12).

3. Preparation of diagrams with a schematic for tests.

A model diagram is prepared by the workshop instructor to be handed out/shown on a screen to participants, so that they can transfer the design onto the test systems they will be using. Simplest is using a grid with letters or numbers as labels for each cell in the grid. (Participants may also be invited to develop their own testing diagram, but this step will add an additional 30 minutes to the workshop schedule, and may result in individual testing protocols that are difficult to compare between participants.)

4. Selecting and preparing the classroom/laboratory/tools/solvents/documentation material.

Decide between printing documentation sheets or using digital documentation sheets depending on the local situation. Both have environmental impact (paper and ink vs electricity), and the choice will also be influenced by local circumstances (table space,

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power socket availability, preventing loose cables, etc.) But ease of use and time (G13) must also be considered.

5. Preparing gels to be tested during the workshop

Prepare gels that need resting time the day(s) before the workshop. In case only part 2 of the practical is included in the workshop, prepare *all* gels to be tested.

6. Selecting preparatory reading for the class from the literature list.

If applicable, check the GoGreen Modules bibliography, section “Green Treatments and their Assessment: Paintings," for preparatory reading for participants. This session assumes that participants have completed the Module ‘Cleaning Agents for Paintings’ and ‘Retention Systems for Paintings.’ If this is not the case, the session moderator needs to study these modules and prepare reading material that covers the main theory and systems introduced in this session, related to the education level of the students.

SESSION OUTLINE (2.5 or 3 hours – choosing part 2 or parts 1 & 2 – in total)

Introduction: aims, methods and assessment (30 minutes)

General introduction (5 minutes)

- This session has the aim of taking the insights gained during the session “Cleaning Agents for Paintings: Retention Systems” and applying it in practice.
- Link to previous learning by summarising main outcomes insights of that session. (If the workshop does not have to fit within the schedule, this might be done interactively, with students sharing their main conclusions from prior experience)
- Introducing the goals of the session and the general set-up

The retention systems that will be tested and compared (10 minutes)

- Describe the test objects (mock-ups and/or sacrificial paintings) and test systems that will be used
- Introduce the choice of solvents and retention systems for the workshop
- 2-3 innovative retention systems will be compared with traditional retention systems, and with application as liquid solvent with a cotton swab.
- Provide descriptions for each retention system, include conservation-relevant properties, safety data, LCA data, requirements regarding waste management and personal protection
- Provide information on the solvents that will be tested based on the contents of the practical session on cleaning with liquid solvents.
- Include links/background data/literature for the systems discussed.

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The assessment methods that will be used (10 minutes)

- Reminder of the 14 parameters
- Introduction comparison tool: star diagram Betelu for retention systems (see additional material below)
- Low-tech methods: visual observation, UV illumination, raking light – if relevant, magnification with head loupe or (USB) microscope
- Provide links/background data/literature about assessment methods

Setting up for the practical part of the session (5 minutes)

- Explain documentation sheets
- Divide into teams– team size depending on the choice of practical format (1 or 1&2)
- Explain how participants move from work station to work station if more work stations are used

Practical (75 minutes, or 120 minutes including gel preparation)

Two version of the practical are proposed, one including gel preparations, one working with pre-made gels only. The workshop organiser can choose between both practicals.

Practical part 1: gel preparation (45 minutes)

- Safety / logistics instructions by facilitator
- Handing out written preparation instructions/recipes for 2-3 gels
- Instructions by facilitator
- Division into teams of maximum 2 people
    - Each team follows the preparation instructions and prepares 1 gel.
    - Facilitator walks around and provides tips/advice.
- Facilitator calls teams together, and teams visit each work station, team representative reporting on preparation steps taken and results.
- If gels require resting time, they are set aside, work stations cleaned up/solvents stored, for part 2 of the practical.

Practical part 2: application and assessment

Practical testing (60 minutes)

- Safety / logistics instructions by facilitator – *if only part 2 is taught*
- Transfer the testing plan for the pre-selected systems to the test boards

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- Execute tests. Each person performs their own tests and fills in their own assessment sheet, with assessment star for every test.
- Each team shares observations informally while doing tests.
  - What are your observations?
  - What do you like/dislike about the methods tested?
  - How are your experiences with the testing protocol/assessment star?

Write down ideas for personal action plan (10 minutes)

- Write down 4-5 action points for yourself, things you would like to learn/do/change after having participated in this session, and decide the timeline for each action point.

General discussion and wrap-up (45 minutes)

- If practical part 1 was included, the prepared gels are inspected
- Each team reports on observations during part 2 (5-10 minutes per team)
- General discussion on the methods tested and lessons learned

Finalise personal action plan (10 minutes)

- Update action plan based on the general discussion

Cleaning up (20 minutes)

- Dedicated attention for waste management, using the opportunity to discuss and demonstrate environmentally sustainable waste management practice

Case Study / Example

This workshop uses pre-made and artificially aged test boards, to which varnishes have been applied, as well as sacrificial objects/flea market objects. It focuses on developing the testing methodology through practical application in small areas. The application of the retention systems explored in this session, upscaling and finetuning to actual paintings undergoing treatment in the conservation studio, is the topic of the session "Putting into Practice," which provides the broader perspective needed for decision making and the safe application of the methods developed to actual cultural heritage objects.

METHODOLOGY

Delivery Format

The session will start with an introduction/instruction that is best delivered as a presentation. It continues with a practical for which different workstations are set up,

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and for which a laboratory setting is required (solvent cabinet, fume hood, laboratory waste disposal system). The session finishes with a discussion and reflection.

Depending on the facilities, educators may choose to host the introduction/discussion in a separate classroom, or set up a projector in the laboratory environment.

Activities / Exercises / Assessments

1. **Prepare an innovative gel** (activity, 45 minutes plus waiting time)

Materials/tools: Gel ingredients, glassware, precision scales, automatic stirrer & bean, stirring rods, spatula or spoon, plus what is indicated in the gel recipe.

Description: Depending on the number of participants, number and nature of objects available for testing and the number of experimental variables included in the workshop, the exact division of who prepares which gel, and whether duplicates are prepared will be established. The workshop instructor prepares detailed preparation instructions – if non-existent, discusses them with the team, and discusses health-safety considerations. Teams split up to prepare gels, the instructor walks around. Gel systems are then prepared per team, participants are asked to critically assess the written-out recipe and suggest additions/clarifications to be shared with the team during the evaluation session. Waiting time during preparation can be used for note taking, preparing labels and cleaning up, or for activity 2.

2. **Design a testing plan for testing 2-3 pre-selected retention systems** (activity, 10 minutes)

Materials/tools: test boards, pencil to mark test areas on test boards, paper to draw schematic of test areas

Description: Depending on the number of participants, number and nature of objects available for testing and the number of experimental variables included in the workshop, the exact division of a test board or painting into different testing areas will differ. The workshop instructor will therefore design templates, which the workshop participants will follow. Test board may be divided into sections using pencil and a ruler, for sacrificial paintings, a melinex/mylar overlay may be considered, divided into sections with a water-resistant pen. Participants make sure always to change only a single variable, and consider the minimum area needed for a representative result.

3. **Practical testing of retention systems** (activity, 60 minutes)

Materials/tools: solvent bottles with selected solvents, cotton wool, toothpicks,

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retention systems to be tested (2-3 innovative ones, 2 tradition ones, liquid solvents), assessment sheet with star diagram Betelu, pencil, paper towels, jar for used solvents/cotton swabs/tissues, gloves, solvent mask, UV torch.

Description: Participants test the selected solvents according to their testing plan. They fill in the assessment sheet while working, and preserve used tissues or swabs they have used for comparison.

4. **Workshop report** (assessment, started during testing finished afterwards at home, 30-45 minutes)

Materials/tools: computer/laptop, documentation sheets from practical testing, photo camera, course literature, including GoGreen definition and parameters.

Description: The documentation prepared during the workshop is developed into a workshop report with at least the following elements:

- Diagram of the systems tested, and their basic properties (chemical, safety, health impact, personal protection measures needed)

- Documentation sheets of all the systems tests

- Comparison of the performance of the solvents tested, based on the solvent star results, with special attention to handling.

- Reflection on the applicability of green retention systems for the cleaning of paintings, and the requirements for integration into practice.

5. **Follow-up action plan** (documentation and/or assessment tool) - 10 minutes

Materials/tools: computer/laptop, course literature, GoGreen definition and parameters.

Description: Before the general discussion takes place, each participant writes down 4-5 action points they would like to pursue after the workshop and includes the timeline they consider feasible for each action point. During the general discussion, action points are shared and discussed. After the end of the general discussion, each participant reassesses their action points, adjusting/adding/removing elements/timing based on the general discussion.

(The action plan may be added to the workshop report for assessment, or may serve as a reminder to take home, without being part of an assessment.)

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Facilitator Notes

Resources required:

- PowerPoint slides with key concepts and visual examples.
- Worksheets or digital templates for the activity.
- Reference data (e.g., physical properties, toxicity/hazard metrics, and LCA information).
- Reference bibliography for participants to consult.
- Laboratory environment with tools/supplies as indicated above.

Preparation:

- When selecting systems to be tested, link selection of methods to be tested to the local aims of the workshop. For instance, choose between having all participants test all options and dividing the systems to be tested between teams, and have team inform each other on their observations.
- Adapt benchmark methods to local customs and practices.
- The practical has been described so that each participant does their own tests. If better for local environment, teams of 2 students can be an alternative, with the added benefit of constant exchange.
- Carefully consider the amount of gel required in relation to the number of participants and test boards to prevent waste. Gels with a long shelf-life may be used in practice after the workshop.

General guidance:

- Make sure that everything is always labelled.
- Encourage questions and discussions but also ensure that participants focus on finishing their own test boards.
- Emphasise the connection between green conservation frameworks (Module 1).
- Remind participants that “green does not necessarily mean new”—some green(er) alternatives build on established methods.
- Tailor the concepts to participants’ backgrounds (e.g., conservators, heritage scientists) and experience levels (e.g., students, instructors, professionals).
- If your schedule allows, together go through the supporting literature list, highlighting titles that you find particularly interesting.

Recommended discussion points general discussion:

- What factors most influence the choice of cleaning agents (e.g., safety, environmental impact, painting material and build-up, expected short- and long-term effects on the painting)?
- What barriers exist to wider adoption of green(er) cleaning agents?
- Are there cases where green(er) solutions may not be applicable? Why? (e.g., lack of availability of nonpolar green(er) solvents)

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- If a hazardous solvent is unavoidable, how can its health and environmental impacts be minimised? Is treatment unavoidable in such cases?

ADDITIONAL RESOURCES

- **Appendix 5.1:** Worksheets for retention system assessment and comparison
- **Appendix 5.2:** Instructions for assessing toxicity and environmental impact

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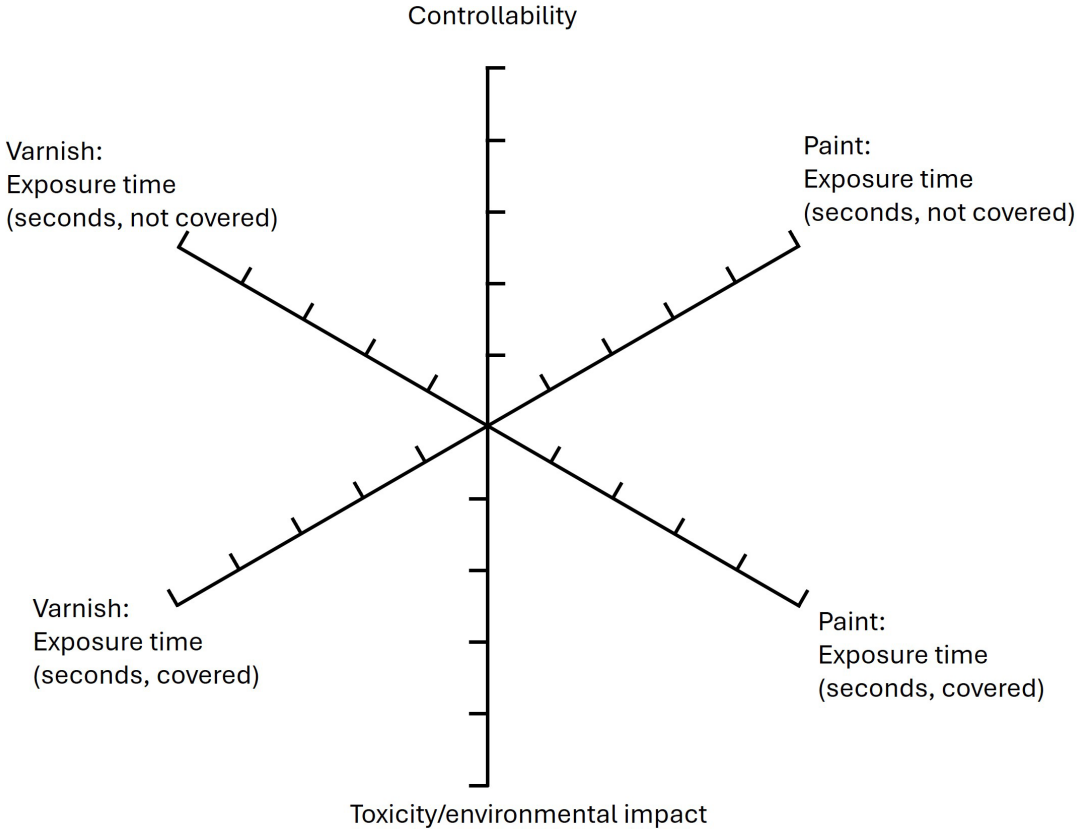
Appendix 5.1.1 Greener Retention System Assessment Worksheet - Gels

Name: _____
Date: _____
Painting : _____

Colour on star	System(s)	Solvent ratio (if mixture)	Amounts used	Notes



Notes:

**Worksheet modified from Fife 2020*

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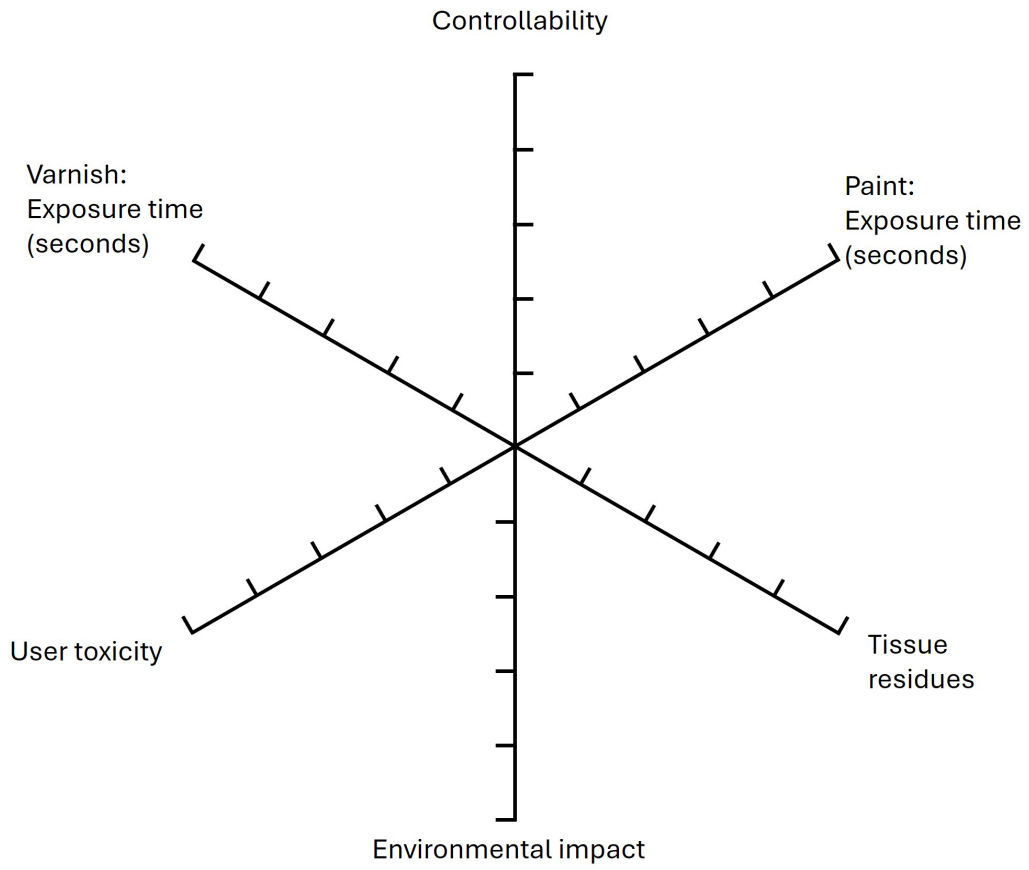
Appendix 5.1.2 Greener Retention System Assessment Worksheet - Tissues

Name: _____
Date: _____
Painting : _____

Colour on star	System(s)	Solvent ratio (if mixture)	Amounts used	Notes



Notes:

**Worksheet modified from Fife 2020*

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Appendix 5.2: Instructions for assessing toxicity and environmental impact

The 14 green conservation parameters developed by GoGreen form a logical starting point for assessing the toxicity and environmental impact of the methods being tested for conservation treatments. In these 14 parameters, general environmental impacts (G1-G8 covering hazard impacts on human health and environment, impact on climate change, impact on resource depletion) are connected to considerations central to the professional context of conservation (G9-14).

> Go through these parameters, and decide which ones are most relevant to the treatment choice you have to make. The details of this choice depend on your conservation goal and the methods you have access to.

Depending on your selection/ranking of parameters, you will need various resources and will need to collect data about the methods you want to consider (e.g. amounts used, tools needed, etc.)

Data on all conservation materials may be incomplete. This means dealing with uncertainties. This uncertainty is increased by updates in data, changes in circumstances, and by the introduction of new chemicals and methods. However, by working with what is known we can lower our environmental impact and our risk of exposure to hazardous materials. Every step counts.

The GoGreen Digital Support app (DSA), currently being tested, aims to provide direct access to certain data for the parameters. This information is sourced from various recognized frameworks (e.g. GHS) and existing reliable resources (e.g. STiCH) and thus acts as a portal as well as a tool that allows for easy and detailed comparison between different chemicals and tools. STiCH - Sustainability Tools in Cultural Heritage - already offers a carbon calculator and provides information sheets on LCA – Lifecycle Assessment. SDS – Material Safety Datasheets for material-specific information on toxicity and environmental concerns - must always be checked and the appropriate guidelines followed. Consider local waste separation/recycling strategies in assessing recyclability. Always check the SDS for appropriate waste disposal.

> Use the above resources to gather information about the materials you intend to use, and assemble these in the worksheet below

> How to approach comparing them?

The choice of retention system and approach depends on the parameters and the demands related to your specific circumstances and requirements. Because these vary, it is not possible to provide a standard ranking between the criteria or between the materials. It is not possible to standardly weight the parameters. Therefore, the step of choosing retention systems is one of subjective decision making, although certain parameters could be prioritised. The decision process can be helped by going through the worksheet, considering broader implications, specific concerns, circumstances, and choosing on that basis.

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Resources

www.gogreenconservation.org : general project page and information about GoGreen; DEFINING GREEN CONSERVATION - GoGreen: Green definition and parameters; For fuller details see Fife, G., Turrina, A., Wagner, J., Curto, D. D., Southwick, C., & Keune, K. (2026). Defining Green in the Conservation of Cultural Heritage. Studies in Conservation, 1–23. https://doi.org/10.1080/00393630.2026.2653274

GoGreen Zenodo repository (https://zenodo.org/communities/gogreen/)

www.stich.culturalheritage.org : carbon calculator, LCA, The Red List - Living Future: the red list.

Worksheet for comparing retention systems according to the 14 Green Conservation Parameters

This worksheet helps conservators go through the GoGreen categories and parameters systematically and indicates in bullet points which resources can be consulted for each parameter. Tips:

- Fill in parameters as specifically as possible;.
- For systems with more than one material, fill in the worksheet for each individual component.
- Use colour coding to rank the materials (green/orange/red) when sufficient information has been obtained for the particular parameter.

Greener Retention Systems Assessment Worksheet

Category	Parameter • information source	Material 1	Material 2
Hazard impacts on human and environment (G1-2)	G1 Toxicity and hazard metrics for the natural environment (Ecotoxicity - aquatic & terrestrial) • GHS Hazard statement • GHS Hazard pictograms • MSDS		
	G2 Toxicity and hazard metrics for humans Exposure risks (inhalation, skin contact): • GHS Hazard statements • GHS Hazard pictograms • MSDS - Required PPE - Storage & handling risks		

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Impact on climate change (G3-G5)	G5 Energy – Conservation approach / treatment-associated materials / products to be used Carbon Footprint Resource origin (e.g. fossil vs renewable) • STiCH Calculator		
Impacts on resources (G6-G8)	G7 Availability – Biodiversity impacts • Red list		
	G8 Waste • MSDS		
Artwork, cultural heritage object specific / professional parameters (G9-14)	G9 Material / product selection and application method • Intended use (e.g., varnish removal) • Compatibility with selected solvent systems • Residues presence		
	G10 Efficiency - Number of applications/consumption/quantities of materials/products used • Treatment tests • Reusability		
	G11 Longevity of result • Personal assessment		
	G12 Accessibility – Cost / availability of approach / used materials / products • Supplier (can also be qualitatively assessed by user) • Transport impacts		
	G13 Accessibility – Ease of use and time • Personal assessment (Is it innovative with potential professional / long-term benefits?)		
	G14 Quality / value impacts of result in meeting preservation goals • Long-term effects on substrate • Personal assessment		
Assessment summary:	*Briefly describe your general 'verdict' on the retention system/approach*		

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6. Introduction to Assessment Techniques for the Evaluation of Cleaning Strategies

Authors: Francesca Ramacciotti, Momoko Okuyama.

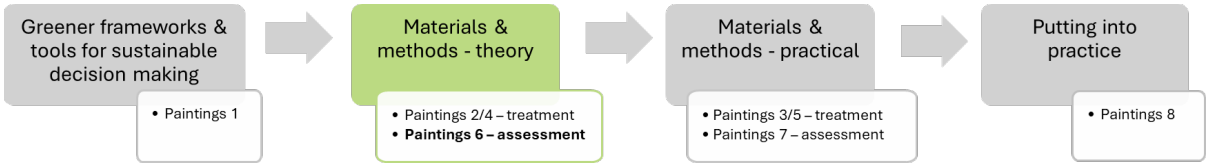
This session introduces the analytical techniques used to study cleaning processes and results. We will assess the advantages and disadvantages of the most widely used analytical techniques and demonstrate how to integrate results from different techniques.

Key Concept 1	**Analytical question**
Key Concept 2	**Low- and high-tech approaches**
Key Concept 3	**(Non) invasive / (non) destructive**
Key Concept 4	**Quantitative / qualitative**

OBJECTIVES

Objective 1	Learn how to define the analytical question and possible constraints.
Objective 2	Gain knowledge of the different analytical techniques with their advantages and limitations.
Objective 3	Understand how to combine different techniques to expand knowledge.

Module placement in learning trajectory



PREPARATORY MATERIALS

1. PowerPoint presentation containing the information discussed during the lessons, Introduction, and Analytical techniques
2. Materials for the activity "Match the analysis to the question". The facilitator must prepare the cards or an online template (e.g., Flippity) in advance.

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SESSION OUTLINE (total 2 hours)

Introduction (30 minutes)
This session introduces key concepts to bear in mind when evaluating a cleaning process and selecting the most appropriate analytical techniques.

- Overview of the parameters for the assessment of the cleaning process and efficacy
- Definition of the analytical question with the key aspects for its identification
- Definition of qualitative, semi-quantitative, and quantitative results
- Definition of acquisition mode (e.g., bulk, single point, map)
- Classifications of the analytical techniques (low-tech/high-tech; destructive/non-destructive, invasive/non-invasive; portable/bench)
- Discussion of the advantages and disadvantages of each category and identification of the most suitable for post-cleaning assessment

Break (5 minutes)

Analytical techniques (50 minutes)
This session introduces analytical techniques for assessing cleaning procedures based on the classifications outlined earlier. For each analytical technique presented, outline the goal and the results that can be obtained, highlighting the advantages and drawbacks. **You can refer to the list of techniques in Module Practical Application of Assessment Techniques, also reported in the Additional resources of this document*.

- Low-tech approaches (e.g., visual inspection, photography (Vis and UV))
- High-tech approaches
    - Invasive and destructive (e.g., chromatographies)
    - Invasive and non-destructive (e.g., optical microscopy on paintings' cross-sections)
    - Non-invasive and non-destructive (e.g., multi/hyper-spectral imaging)
    - Bench vs portable (e.g., Infrared spectroscopies)
- Latest discoveries: here you can discuss the analytical techniques/ processes that have recently been developed, including the one recently studied by the Green cluster

Break (5 minutes)

Applied Learning Activity: Match the analysis to the question
This session is a role-play in which participants will be divided into two groups to work on a case study and an analytical tool. Participants will have the opportunity to put what they have learned in the theory session into practice in a fun and engaging way. (activity detailed **below**).

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Case Study / Example
Presentation of case studies where the analytical techniques presented have been employed for the assessment of cleaning procedures. It is recommended to select case studies that employ greener cleaning methods or approaches. If not, make references to the green parameters discussed in the other modules.

Summary / wrap-up (5–10 minutes)
Recap of key points:

- The importance of the analytical question
- Which kind of information can you get from each analytical technique
- Criteria and frameworks for the selection of the analytical techniques

Preparation for the practical session:

- Which criteria would you use to select an analytical technique?
- Do you think the same question can be answered with different techniques and vice versa?

METHODOLOGY

Delivery Format The session will be delivered using a blended approach, combining PowerPoint slides, case study analysis, interactive discussions, and practical activities to engage participants and reinforce learning.

Activities / Exercises / Assessments

Match the analysis to the question (45 minutes)

Activity Preparation
Participants are divided into two groups: *Question* and *Analysis*.

- Each *Question* participant receives a card with a case study description and a related question.
- Each *Analysis* participant receives an instrument card with its description (based on the previously introduced classification) and the type of result it produces.

Procedure
Question participants move around and interview *Analysis* participants. When both agree they have found a match — that is, the instrument fits the case study question — they approach the facilitator together. Note that the same analytical technique may answer multiple questions and that the same question may find an answer with different analytical techniques.

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Is it a match?
When the instrument can answer the question, it is a match! Then the matched cards can receive a result card. This will include a graphic showing the kind of result that can be obtained with this instrument, along with an answer to the question the instrument has produced. Note that this answer is not always useful.

By the end of the activity, the learner will be able to:

- Understand the importance of the analytical question
- Understand that the same question can find a similar, but different, answer with different techniques
- Understand that the same analytical technique may answer different questions
- Collaborate and communicate strategies through discussion

Materials

- Case studies related to cleaning procedures with an analytical question to be answered
- Cards for the Question group (see suggested template in Additional resources)
- Cards for the Analysis group (see suggested template in Additional resources
- Cards for the results (see suggested template in Additional resources)

The cards can be printed, or the activity can be organized on digital tools.

Questions:

- Could the analytical question be answered with one analytical technique or more? Why?
- How did you select the analytical technique?

Facilitator Notes

General Guidance:

- Keep the session interactive by encouraging questions and discussion.
- Remind participants that more analysis doesn't mean better answers, but that the protocol should be tailored to the analytical question and the practical constraints.

Recommended Discussion Points:

- How do the analytical question and the eventual constraints influence the choice of the protocol of analysis?
- Which kind of information is possible to obtain from each analytical technique?
- How do the analytical question and constraints shape the selection for the protocol?
- Which constraints can influence the choice behind the analytical protocol?

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Resources required:

- PowerPoint slides with key concepts and visual examples
- Bibliography for participants to consult
- Whiteboard or interactive whiteboard/projector for group discussion notes
- Materials for the activity, following the template or taking inspiration from it

Tips for Facilitator:

- Use real examples where possible to make concepts concrete.
- Tailor the concepts to participants' backgrounds (e.g., conservators, heritage scientists) and experience levels (e.g., students, instructors, professionals).

Guide to using the template for the activity.

- The case study may be taken from the literature or created specifically for the course. And the facilitator may select one or more case studies.
- The analytical questions are at the facilitator's discretion.
- For every match, there should be a result card.
- The facilitator must prepare the cards in advance.
- All the combinations that are not a match can be used to discuss the reasons why and to expand understanding of the importance of the analytical question. For example, a missed match can be due to constraints on the possibility of sampling; thus, a technique that, in theory, can provide results that answer the question cannot be applied because the case study does not foresee sampling.

ADDITIONAL RESOURCES

1. Suggested list of analytical techniques discussed in the module *Practical Application of Assessment Techniques*

Widely Available Techniques used for the assessment of cleaning methods on paintings:

- Macro-imaging techniques (Digital Photography, Hyperspectral and Multispectral Imaging, UV-Excited Fluorescence Imaging, FLIM)
- Micro-imaging techniques (Light Microscopy, Digital Microscopy, Secondary Electron Imaging, and Confocal Laser Fluorescence Microscopy)
- Spectroscopic Methods (UV-Vis, FTIR, Raman, Spectrocolorimetry)
- Mass spectrometry
- Chromatographic Techniques

Assessment Methods developed within the GoGreen project:

- Monochromatic filters for assessing UV-induced photoluminescence in varnishes

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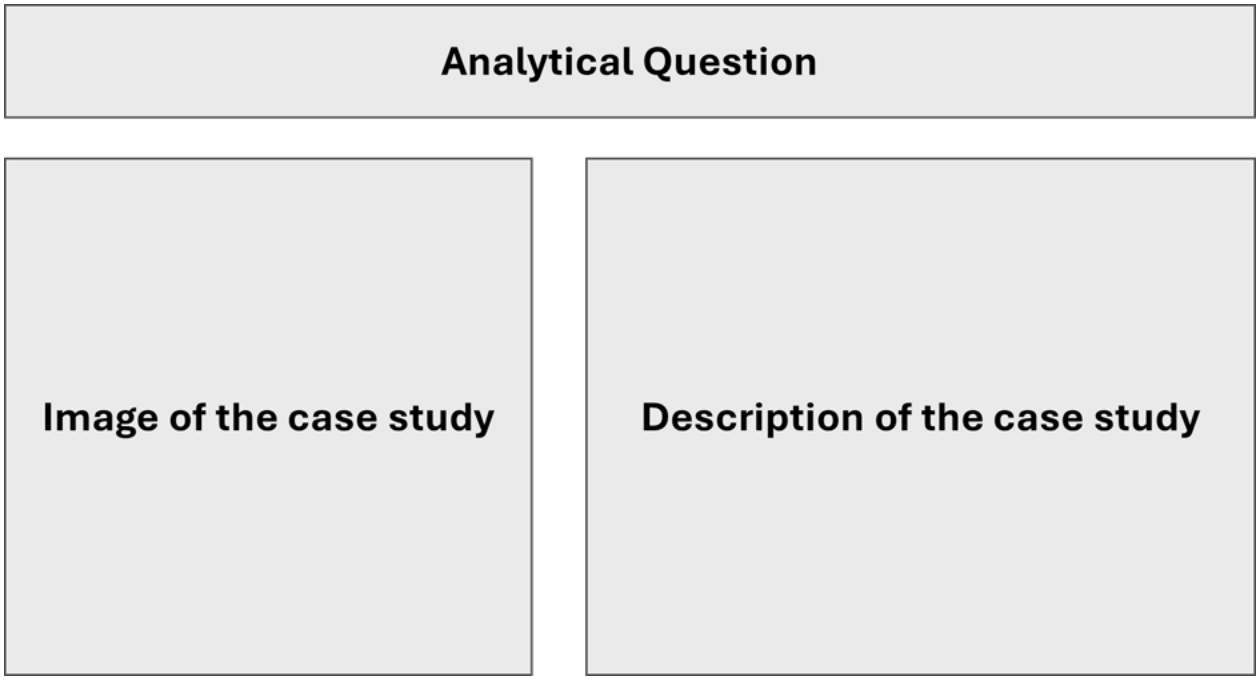
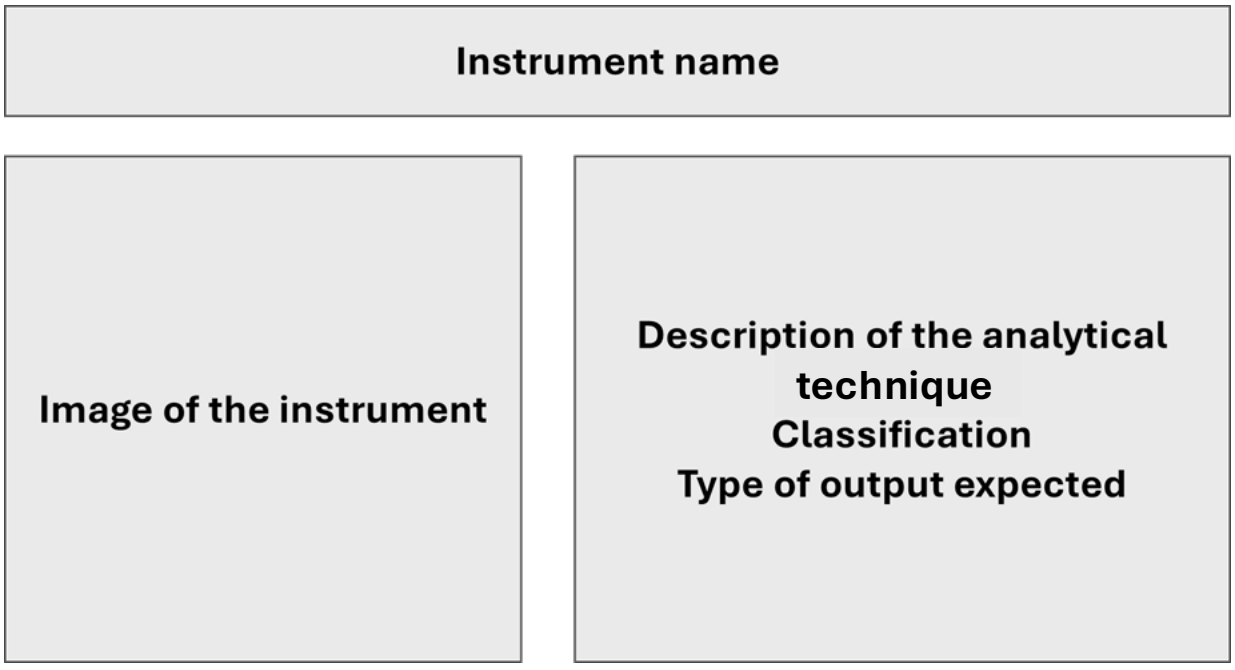
- FT-LSI for evaluating solvent dynamics for painting conservation
- Photoluminescence Multispectral Macro Imaging (PL-MSMI)
- Hyperspectral Vis-NIR imaging
- NMR relaxometry

2. Appendix 6.1: Templates for the activity – *Match the Analysis to the Question*

Card template for the *Question* group



Card template for the *Analysis* group



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Card template for the R*esults*

Results	
Image of the result (spectrum/a, image, table with data)	Description of the main results and discussion

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7. Practical Application of Evaluation Techniques

Lead author: Momoko Okuyama

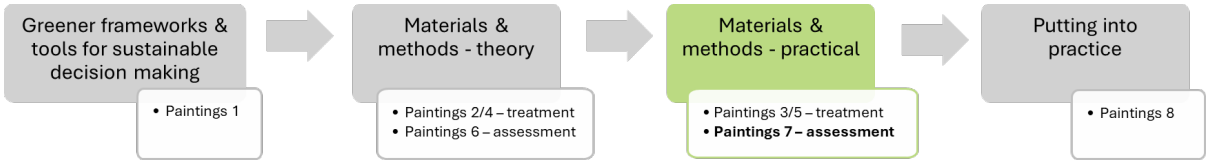
This session is about the practical application of the evaluation techniques introduced in the module, "Introduction to Assessment Techniques for the Evaluation of Cleaning Methods" (*Paintings Session 6*). Learners will learn about the practical implications of applying methods for evaluating varnish removal from painted surfaces through group activities based on literature and hypothetical scenarios. As an optional addition to the session the technique(s) are applied, hands-on, on test boards or case studies to familiarize with the assessment technique. This is subject to the availability of assessment techniques for use by the learners.

Key Concept 1	**Varnish removal**
Key Concept 2	**Green conservation science**
Key Concept 3	**Assessment techniques**
Key Concept 4	**Paintings conservation**

OBJECTIVES

Objective 1	Compare the evaluation techniques in relation to guidelines for green parameters
Objective 2	Develop a protocol for applying the most appropriate assessment methods to evaluate a cleaning treatment
Objective 3	Identify the most suitable approach according to the analytical question and constraints.
Bonus objective	In the case an assessment technique is locally available, apply an assessment technique to a test board or case study

Module placement in green treatments learning trajectory



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PREPARATORY MATERIALS

The facilitator of the module is requested to prepare the following teaching materials / set-up beforehand:

- Classroom with whiteboard
- Fill in the facilitator's sections in the template for Activity 2
- Print out worksheets listed in the Activities section

The facilitator is recommended to take the following preparatory steps:

- Familiarize themselves with the green parameters

For the Bonus activity (optional):

- Ensure access to analytical technique(s)
- Source pre-prepared test board or case study

CONTENT OUTLINE (total 2 hours)
Introduction (10 minutes)

- This session is about the practicalities of applying the assessment techniques covered in the "Introduction to Assessment Techniques for the Evaluation of Cleaning Strategies" (referred to as *Paintings Session 6* hereafter)
- Mention the goals of the session and the agenda
- Brainstorm key questions related to efficacy of varnish removal and impact on the original paint that can be answered using evaluation techniques
- Connect to the previous learning by summarizing key takeaways from that session
- Describe link between greenness and assessment
    - Assessment techniques can inform the conservator whether/ to what extent treatment goals are met during their greenness evaluation of their treatment. For example, Assessing the condition of the paint before and after a treatment is necessary to evaluate if a safe and effective treatment has been achieved. This relates to parameters G11 and G14.
    - An assessment technique can also be evaluated and compared using the green parameters. For example, energy and resource use due to the assessment technique is covered by G4-G8
    - Usability of the assessment technique such as required level of expertise or time (i.e. professional parameters) can be evaluated using G9-G14.
    - Ultimately, assessment methods help evaluate the safety and efficacy of a treatment, at the expense of energy use, resource use, time, labour and/or physical integrity of the object (sampling). It is important to evaluate how the different objectives balance out.

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Applied Learning Activity 1: Examples in literature (35 minutes)
In this activity, the learners work individually to conduct an online search, apply the Green parameters, and share findings with a small group.

Break (10 minutes)

Applied Learning Activity 2: Designing a protocol (55 minutes)
In this activity, the learners will work individually or in small groups to develop an analytical protocol in response to an analytical question.

Wrap-up (10 minutes)

- Recap of the objectives and key concepts
- Interactive discussion sharing new lessons learned, and any that can be brought back to the learners' daily practice.

METHODOLOGY

Delivery Format The session will be delivered using activities and interactive discussions, with some use of a whiteboard to document findings.

Activities / Exercises / Assessments
/
Applied Learning Activity 1 (35 minutes)**: Examples in literature**
In this activity, the learners work individually to read examples in literature, and share findings with a small group.

Divide into groups of 5 or less. Each person in the group is assigned a different analytical technique. Instruct the learners to find out information for this technique using information available online. They should find one example where the technique was applied to a painting that received a cleaning treatment and at least one piece of information that the technique helped obtain. Then, instruct the learners to evaluate how the assessment technique performs for a number of green parameters. A suggested worksheet template is in **Appendix 7.1**.

Afterwards, learners share any surprises or interesting findings among their groups.

Allocated time for online search and writing down notes: 30 minutes
Allocated time for discussion in groups: 5 minutes

By the end of the activity, learners will be able to:

- Describe their assigned technique from multiple perspectives including types of information obtained, their greenness and added value

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Tasks:

- Identify an example where an assessment technique was applied
- Identify the finding that was obtained by using the assessment technique
- Evaluate the assessment technique using the green parameters

Materials:

- Writing utensils
- Laptops or tablets and internet access to conduct online searches
- List of green parameters and their descriptions (available, for example, on the GoGreen website)
- Optional: print outs of a worksheet in which learners can include the required information, such as name of case study, analytical technique, information obtained, and the green parameters. This should be prepared by the facilitator.

Discussion prompts:

- What are the added value of using the analytical technique?
- Did the green parameters assessment impact on whether they would choose to use this analytical technique?

Break (10 minutes)

Applied Learning Activity 2 (55 minutes)**: Designing an assessment protocol**

In this activity, the learners will work individually or in small groups to develop an analytical protocol in response to an analytical question.

Learners will work individually or in pairs to develop an assessment protocol for a case study and research question that are assigned to them. The assessment protocol should combine 2-4 assessment techniques. Additionally, they will be provided with one or more constraints (e.g., time, budget, accessibility of instrumentation, sampling feasibility) to consider.

Afterwards, learners discuss the rationale with a peer or a pair of peers for the proposed protocol and how each assessment technique provides, or part of, the answer to the starting question. Protocols will be discussed together, allowing learners to compare and highlight the pros and cons of their approaches.

Allocated time for coming up with the protocol: 40 minutes
Allocated time for discussion: 15 minutes

By the end of the activity, learners will be able to:

- Critically understand an analytical question and practical constraints, and their importance in the decision-making process of an analytical protocol

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- Develop an analytical protocol tailored to a case study, understanding its limitations and advantages
- Collaborate and communicate strategies through discussion of different approaches

Tasks:

- Select 2-3 analytical techniques most suited to answer the question, including at least one low-tech method
- Associate with each analysis the expected output and justify its selection
- Reflection on priorities and limitations when selecting the protocol
- Discuss findings with peers

Materials:

- Case studies related to cleaning procedures with a research question to be answered and its constraints. Refer to *Paintings Session 6* for common constraints. Suggestions for research questions are available in **Appendix 7.2** of this session.
- Worksheets (suggested template in **Appendix 7.1**)
- Whiteboard or interactive whiteboard/projector.

Discussion prompts:

- Could the research question be answered with one assessment technique or more? Why?
- Are the resolution and detection limits of the chosen assessment techniques suitable for the research question?
- If the question is answered with one assessment technique, is it necessary to employ more?
- Which constraints most influenced the selection of the assessment protocol?
- What compromises arose when setting up a protocol?

Bonus activity (Additional >3.5 hours, not included in Session Outline as optional)
In this activity, learners apply an analytical technique that is locally available to case studies or test boards. Choose a specific research question, and choose the location(s) on which the analytical technique should be applied.

Allocated time for selection of research question and establishing an analytical protocol: >1 hour
Allocated time for analysis: >1.5 hours
Allocated time for data interpretation: Not included within the activity, estimated to be 2-4 hours
Allocated time for discussion: >30 minutes

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Materials:

- Access to analytical technique(s)
- Pre-prepared test boards tied to a specific research question related to varnish removal (see ideas for research questions in **Appendix I**) that is suitable to the analytical technique available. The test boards already have windows where varnish has been removed using 3 different methods.

Tasks:

- Select a research question
- Establish an analytical protocol
- The analysis can be conducted by the learners themselves, or by experts where necessary
- Data interpretation with assistance from an expert or facilitator
- After the results are obtained, reflect in a group discussion

Discussion prompts:

- How useful was the technique in answering the research question?
- What are other techniques that complement or replace the technique used?
- What were some advantages and disadvantages of applying the technique?
- How green is the assessment?
- In what scenarios do you envision using the technique?

Facilitator Notes

General:

- The session requires the facilitator to prepare their own materials for both activities 1 and 2 before the session
- Keep the session interactive, encouraging questions and discussions
- Remind learners that good quality assessment can be achieved without high-tech assessment techniques
- Ask stimulating questions about why assessment is necessary and how it can help answer the learners' research question
- This session focuses on varnish removal, but it can be adapted to other types of cleaning treatments for paintings.

Specifically for Activity 1:

- It is possible to steer the discussion to focus on specific techniques by assigning them, or keep the choice open. The instructor may refer to the techniques introduced in *Paintings Session 6*.

Specifically for Activity 2:

Guide on the use of the template for the activity

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- The case studies assigned to the learners have ideally been researched using a multi-analytical protocol. This case study should be new to the learner, so that they can come up with their own protocol and later compare with the actual protocol.
- It is recommended to vary the case study per group, to enrich the discussion later. (3 groups of 2 people = 3 unique case studies)
- The analytical question, the level of assessment, additional information, items 'out of scope' and constraints (Section 1 on the template) are at the facilitator's discretion. It is encouraged to vary these from case study to case study to enrich the final discussion.
- The facilitator must compile the list of analytical techniques (Section 2), and it is at their discretion which ones to include. It is recommended to include a wide variety of techniques, including those not available at the facility where the course is delivered. The 'availability' column should be completed at the facilitator's discretion, as with the other constraints of Section 1, to stimulate learners' critical thinking.

The learners will fill only section 3 of the template

Specifically for Activity 3:

- For the Bonus activity, it may be necessary to divide the activity between two separate days, so that there is time for the analysis to be conducted and the data to be processed.

Appendix 7.1: Suggested templates

The templates cam be edited to suit the needs of the specific audience and facilitator.

Template for Activity 1

Name:

Date:

Assigned analytical technique:

Chosen case study:

Information obtained:

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Evaluation of greenness of assessment technique*

**The green parameters to include in the evaluation are suggestions only, and should be tailored to the context of use.*

Chosen green parameter and (short description of parameter)	**Evaluation (poor, good, excellent, inconclusive) and reasoning**
G4 Energy - Consumption in approach / application	
G5 Energy – Products used	
G6 Water & resource use	
G12 Accessibility – Availability of approach	
G13 Accessibility – Ease of use and time	
Additional green parameter G__ of choice	

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Template for Activity 2

Group members:

Date:

1. Case study

Brief description of the case study: Bibliographic reference (if available/needed):
Analytical question: for example, “Which cleaning method leaves the least amount of varnish residues on the surface after treatment?”
Level of assessment: qualitative, semi-quantitative, quantitative
Additional information of interest: example, presence of solvent residues
Out of scope: any information that is beyond the scope of the analysis
Constraints: e.g. low budget, not possible to collect samples/transport the object

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2. List of analytical techniques available with specifics associated with general constraints (first lines as example)

Technique	Specifics						Budget		
	1.High/Low tech	2.Portable/ Bench	3. invasive/non-invasive	4. Destructive/non-destructive	5. Acquisition mode	6. Main output	7. Cost	8. Time of analysis	9. Availability
Vis photography	Low	Portable	Non-invasive	Non-destructive	Superficial	Photographic documentation	low	low	Yes
ATR-FTIR	High	Bench	Can be performed directly on small objects or on samples	Non-destructive	Superficial, Single points or mapping	Molecular composition	Medium-high, depending on parameters 3 and 5	Medium-high, depending on parameters 3 and 5	Yes

3. Multi-analytical approach

Selected techniques:

Details

Technique 1:	
Which location(s) will be analysed or sampled?	Expected outcome of analysis and format (spectra, technical image, numerical data…)

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Technique 2:	
Which location(s) will be analysed or sampled?	Expected outcome of analysis
Technique 3:	
Which location(s) will be analysed or sampled?	Expected outcome of analysis and format
Technique 4:	
Which location(s) will be analysed or sampled?	Expected outcome of analysis and format

Appendix 7.2: Cleaning questions

In no specific order:

Efficacy of treatment

- Are there residues?
- How even is the cleaning?

Impact on paint surface/ paint chemistry

- Is the cleaning method causing visible changes in the original paint (pigment pick-up, abrasion, topography change)?
- Is the cleaning method causing chemical changes in the original paint, such as leaching or swelling?
- Are specific paints or passages presenting more swelling, pigment pick-up, or cracking?
- Is the blanching of the surface due to the optical effect of the varnish or damage to the original paint?
- Is the solvent penetrating too deep into the underlying layers or staying within the paint layer for prolonged periods?

Have new cracks formed due to cleaning?

The above list is not an exhaustive list and is meant to serve as a starting point.

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8. Putting into practice

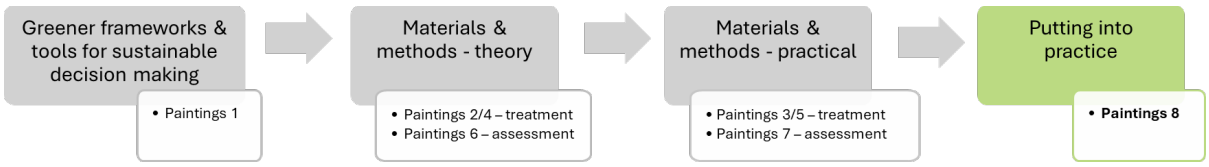
Author: Claire Betelu

The aim of this session is to apply the knowledge gained in previous sessions to a practical case study of painting treatment. The objective is to compare the various cleaning methods employed during the test session and evaluate the effectiveness of green treatments in the treatment formulation. This session builds on the knowledge acquired in the Green Practice module, applying the methodological principles of conservation to cleaning practices and their physical and aesthetic consequences.

OBJECTIVES

Objective 1	Be able to draw on and apply the knowledge and tools acquired in previous sessions effectively.
Objective 2	Be able to identify the most suitable cleaning solution based on criteria such as solubility, efficiency, quality of finish and environmental considerations.
Objective 3	Be able to present arguments that justify their choice of action, considering environmentally responsible criteria while being aware of the advantages and limitations of the methods.
Objective 4	

Module placement in green treatments learning trajectory



PREPARATORY MATERIALS / STEPS

1.Selection of paintings

The number of paintings should be determined according to the available resources. As the focus is on formulating their choices rather than handling the materials, we suggest that participants work in pairs or groups of three.

Step1: to compare methods on a homogeneous oxidised varnish layer on a well-preserved painting. This enables the effectiveness of the methods to be assessed in relation to the defined objective.

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Step 2: to determine the suitability of different cleaning methods depending on the situation, paintings may exhibit different surface textures (flat or textured), varying states of preservation (e.g. good condition or open craquelure) and different degrees of varnish oxidation.

2. Selection of cleaning agents and retention systems to be tested

Based on Modules 2 and 4, select two to three retention systems (at least one gel and one tissue) and a group of solvents to be tested.

In selecting cleaning agents, consider the green parameters. For this thematic session, particularly applicable are:

- Hazard impacts on human and environment (especially G1, G2, G5)

- Impact on resources (G6-G8)

Other parameters become relevant in the steps that follow preliminary selection, and will influence choice of method. The exact choice of methods to be tested will depend on the local circumstances/facilities and availability (G12). The additional resources of session 02, cleaning agents for paintings, provides a list of greener cleaning agents that are considered interesting replacements around the time of publication of these education modules. Mark that the selection will change with the identification/formulation of other alternatives, so consider updating them based on new insights.

3. Preparation of diagrams with a schematic for tests

Create or reuse a diagram for conducting the tests. If they wish participants to take specific criteria into account, the teacher may provide a pre-filled template, or they may encourage participants to agree on the criteria to be used. You can use the diagram from the previous module here, or adapt it as necessary

4. Selecting and preparing the classroom/laboratory/tools/solvents/ documentation material

Decide between printing documentation sheets or using digital documentation sheets depending on the local situation. Both have environmental impact (paper and ink vs electricity), and the choice will also be influenced by local circumstances (table space, power socket availability, preventing loose cables, etc.) But ease of use and time (G13) must also be considered.

5. Preparing gels to be tested during the workshop

Prepare gels that need resting time the day(s) before the workshop. In case only part 2 of the practical is included in the workshop, prepare all gels to be tested.

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CONTENT OUTLINE

The session is scheduled to last 3 hours (provided the cleaning materials are ready) including general wrap up conclusion.

General introduction : (10 minutes)

This session has the aim of taking the insights gained during the previous session "Cleaning Agents for Paintings: Solvents & Retention Systems" and applying it in a real case. Quick summary of previous sessions.

Allocation of participants to teams

Session 1 : Defining level of varnish removal (30 minutes).

Observation of the paintings, determining the desired level of varnish removal, and identifying the risks to be taken into account. Presentation of the conclusion

Session 2 : An overview of the cleaning solutions available_ interactive session (15 minutes)

The parameters to be considered and the testing protocol definition are discussed with the whole group. The participants then outline the available greener options, as well as the advantages and limitations of each. Participants reflect here on previous practical modules. Only greener solutions that provide the necessary perspective are being tested at this stage.

Session 3 : Practical (60 minutes)

The participants carry out tests to measure the effects of various cleaning solutions. They then record their observations using decision-making tools, enabling the findings to be shared.

The participant assesses the effectiveness of the treatment based on the expected result on the paintwork, the practitioner's comfort and the ease of application.

The initial test sections may measure 1 x 1 cm. With the supervisor's approval, the participant will then create larger sections to assess the method's suitability and anticipate potential difficulties with application, removal and consistency of results. He assesses the effectiveness of cleaning agents with the naked eye, under UV light and under a microscope, and reports back to the star.

Session 3b : A theoretical session on the removal of repaint could be developed here. Since this process requires solvents considered toxic, an exercise could be designed to explore the use of substitutes or consider other options. (+30 min)

Session 4 : General discussion (30 minutes)

Participants share their test results. This provides an opportunity to discuss the concept of effectiveness when it comes to cleaning a painting. Should practitioners set limits on their choice of methods to protect themselves? Can a result that appears satisfactory at the time of application be considered sufficient? This session encourages participants

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to weigh up the pros and cons of the different options and reflect on the role of the practitioner in the testing protocol and decision-making process.

Session 5: Finalise personal action plan (10 minutes)

Update action plan based on the general discussion

Session 6: Wrap up (10 minutes)

Session 7: Cleaning up (15 minutes)

Dedicated attention for waste management, using the opportunity to discuss and demonstrate environmentally sustainable waste management practice

Summary / Wrap-Up (5–10 minutes)
At the end of this session, we can reflect on the benefits and limitations. This provides an opportunity to review all the modules relating to cleaning practices from a more environmentally friendly perspective. What positive aspects did the participants highlight? Which limitations were clearly identified? In which areas do they think improvements could be made? On what scale?

METHODOLOGY

Delivery Format This session alternates between practical activities and group discussions.

The session will start with a short introduction/instruction, which is best delivered as a presentation. This will be followed by the first practical session, during which the participants will examine the painting they have been assigned and define the desired level of cleaning. Then, working in groups, they will define the cleaning solution to be used, taking into account the parameters observed in the previous modules. Then, in a practical session, they will apply the cleaning method and evaluate its efficacy in terms of the expected results, its effect on the practitioner and its long-term effects. A general discussion will allow the results to be shared and different points of view to be exchanged.

To engage participants on a regular basis and draw on real-life examples, educators may choose to host the introduction/discussion in front of the paintings.

Activities / Exercises / Assessments

1. Defining level of varnish removal (activity, 30 minutes)

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Materials/tools : paintings, light, UV light

Description : Depending on the number of participants, number and nature of objects available for testing and the number of experimental variables included in the workshop, each participant or a group of participant examine the painting in order to define the level of varnish removal considering the condition of the painting, aesthetic and methodological aspect. He identifies the areas that would be most relevant for testing

2. An overview of the cleaning solutions available (activity, 15 minutes)

Materials/tools : computer/laptop, documentation sheets from practical testing, photo camera, course literature, including GoGreen definition and parameters

Description : The parameters to be considered and the testing protocol are discussed with the whole group. The participants then outline the available green options and the pros and cons of each. Participants then reflect on previous practical modules. At this stage, only greener solutions that provide the necessary perspective are tested. The workshop instructor summarises the options that could be considered and limits the options that will be used in practice. It highlights solutions that are considered 'green' and asks participants to list the advantages and limitations of each one. The decision-making tool is reintroduced in the same activity and will be used in section 3.

3. Testing (activity 60 minutes)

Materials/tools : solvent bottles with selected solvents, cotton wool, toothpicks, practical assessment sheet with solvent stars (see below, appendix), retention system (2-3 innovative ones, 2 traditional ones), pencil, paper towels, jar for used solvents/cotton swabs, gloves, solvent mask, UV torch, stereo microscope if available.

Description : Participants test the selected solvents according to their testing plan. They fill in the assessment sheet while working and preserve the cotton swabs they have used for comparison. On that first test, they select the more appropriate solvent on the base of solvent star. Then, they compare the effects of this free solvent to the zones where the solvent is used in retention systems. At this point they collect the information on the star diagram Betelu or a redesign version. The participants then discuss how to proceed with the clean-up. Which solution should they choose? Is it the most environmentally friendly option? Would this approach be effective for a large-scale clean-up? The participants discuss these questions in small groups.

4. General discussion (activity, 30 minutes)

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Materials/tools : computer/laptop, documentation sheets from practical testing, photo camera, course literature, including GoGreen definition and parameters

Description : Participants share their test results. They have ten minutes to prepare a clear presentation outlining the benefits and limitations of the tested solutions, and justifying their choice of treatment protocol. The presentation should take into account the condition of the paintwork, how well the desired objective has been achieved, environmental considerations and any known long-term effects. When assessing the risks to the paint film and the use of free solvents, participants must take any rinsing steps into account.

This provides an opportunity to discuss the concept of effectiveness when it comes to cleaning a painting. Should practitioners set limits on their choice of methods to protect themselves? Can a result that appears satisfactory at the time of application be considered sufficient? This session encourages participants to weigh up the pros and cons of the different options and reflect on the role of the practitioner in the testing protocol and decision-making process.

Facilitator Notes

Preparation:

- When selecting systems to be tested, link selection of methods to be tested to the local aims of the workshop. For instance, choose between having all participants test all options and dividing the systems to be tested between groups, and have group inform each other on their observations.
- Adapt benchmark methods to local customs and practices.
- The practical has been described so that each participant does their own tests. If better for local environment, teams of 2 students can be an alternative, with the added benefit of constant exchange. Groups of 4-6 people can still simultaneously perform the same tests.

General guidance:

- Make sure that everything is always labelled.
- Encourage questions and discussions but also ensure that participants focus on finishing their own test boards.
- Emphasise the connection between green conservation frameworks (Module 1).
- Remind participants that “green does not necessarily mean new”—some green(er) alternatives build on established methods.
- Tailor the concepts to participants’ backgrounds (e.g., conservators, heritage scientists) and experience levels (e.g., students, instructors, professionals).

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If your schedule allows, together go through the supporting literature list, highlighting titles that you find particularly interesting.

ADDITIONAL RESOURCES

See, in previous Session 5 (Practical Application of Retention Systems):

- **Appendix 5.1**: Worksheets for retention system assessment and comparison
- **Appendix 5.2**: Instructions for assessing toxicity and environmental impact

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