Health & Safety

Health and Safety Considerations for Menthol: A Case Study in Evaluating Risk for Household Products

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Introduction

Conservators often borrow tools and materials designed for other purposes and use them in ways unintended by manufacturers. It is tempting to assume that chemicals found in common household products, such as cosmetics, medicines, or food, have already been vetted for safety and can therefore be used without additional precautions. However, the use of these products in conservation often varies significantly from the commercially intended use. Frequently, conservators use chemicals at higher concentrations or for longer durations than those found in over-the-counter applications. In addition, the exposure scenario is entirely different; where a commercial product may be intended for acute skin application or even ingestion, in a conservation context the route of exposure may be entirely through inhalation. Because published safety data is based upon common usage, it may not be applicable to the ways materials are applied in conservation contexts. One example is the use of menthol as a temporary consolidant. Menthol is found in over-the-counter medicines and food, but is it safe to use in a conservation context as well?

Menthol in Conservation

Menthol has been suggested as an alternative to cyclododecane for use as a volatile binding medium or temporary consolidant (Rozeik 2018, 1; Rowe 2018, 13). With many of the same characteristics as cyclododecane, it offers additional advantageous working properties; it has a faster sublimation rate, a lower melting point, does not solidify as quickly when molten, and forms a solid, dense film rather than an open structure with needle-like crystals. Following reduced accessibility of cyclododecane due to increased cost in importing hazardous materials, menthol has been suggested as a "non-toxic" and more widely available option. For example, Kremer lists it as "non-toxic" in their technical data sheet ("87108 Menthol" N.d.).

Menthol has been used primarily in small amounts (<10 grams) but also in large scale applications, such as for archeological fieldwork (Hamilton 2021). One source describes using it as a protective barrier for mold making (Chock 2020). Application methods typically involve dropper and brush; menthol's lower melting point makes brush application significantly easier than with cyclododecane (Rowe 2018, 16). After application, menthol is typically allowed to sublimate off for a period of days or weeks.

Is Menthol a Safer Alternative to Cyclododecane?

Many conservators perceive menthol to be safe because it is found in many household goods. But is it?

Although many conservation users believe that cyclododecane is safe or not safe based on their interpretations of available health and safety information, in reality there is very little toxicological information available specifically about inhalation exposure to support either view due to its limited industrial or commercial use (Koss Schrager et al. 2017). Unlike cyclododecane, menthol is a familiar commercial product found in products such as topical ointments, cough drops, gum, and liqueurs, and is classified as "generally recognized as safe" (GRAS) by the FDA. The commercial usage of menthol in these ways has been cited in several publications as validation of its safety in conservation contexts. Among five articles in English referring to menthol in AATA, three make brief reference to menthol's "well-established safety profile" (Han et al. 2016, 271; Han et al. 2018, 1334; Han et al. 2014, 1043) and one references the compound's "very long history of being used in food and medical-related products" and "pharmaceutical applications" (Yu et al. 2019, 104).

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However, these papers do not discuss that in these commercial applications, menthol is present in very low concentrations; for example, 15mg in Halls Super Menthol Cough Drops and 2.6% in Vick's Vapo Rub versus kilograms of undiluted menthol that could be potentially used as a consolidant for large sculpture or in archeological situations. As a medicine or food additive, menthol exposure is limited to minutes or hours, while conservators are potentially exposed to the material at full concentration for long periods of time. One paper provides a more extensive discussion of safety concerns; the authors cite a lack of information available on the toxicity of volatile binding media, and they recommend caution and adequate PPE until further studies are conducted (Sadek et al. 2018, 201).

The toxicological literature further demonstrates a lack of clarity concerning hazards associated with menthol use. For its use as a fragrance, menthol receives a yellow triangle from the EPA's Safer Chemical Ingredients List, indicating it "has met Safer Choice Criteria for its functional ingredient-class, but has some hazard profile issues" and it "is not associated with a low level of hazard concern for all human health and environmental endpoints... While it is a best-in-class chemical and among the safest available for a particular function, the function fulfilled by the chemical should be considered an area for safer chemistry innovation" (EPA 2022).

Toxicological Parameter	Results	Source
Occupational Exposure Limits	None available	PEL, REL, TLV, MAK
Acute Inhalation Toxicity: Gases/Vapors (LC50)	None available	
Acute Inhalation Toxicity: Dusts & Mists (LC50)	Rat 5.2ppm (Category 4, Low)	European Chemicals Agency (ECHA)
Acute Oral Toxicity (LD50)	Rat 3300 mg/kg (Slightly Toxic)	NCBI 2022
Acute Dermal Toxicity (LD50)	Rabbit > 5000 mg/kg (Practically Non-Toxic)	NCBI 2022
Irritant	Skin, eye, respiratory tract, mucous membrane	NCBI 2022
Carcinogenicity	Not classified	ACGIH, IARC, NTP, or CA Prop 65
Embryotoxicity	Hatching rate for zebrafish embryos decreased with exposure to menthol. All died when the concentration exceeded 0.01 mg/mL. Surviving embryos exposed to menthol showed a significant increase in malformation rate.	Zhang et al. 2018
Teratogenicity	None available	
Reproductive toxicity	None available	
Neurotoxicity	None available	
Other reported health effects	Hypersensitivity reactions (contact dermatitis), flushing, headache, insomnia, unsteady gait, thick speech, tremor of the hands, mental confusion, depression, vomiting, cramp in the legs and bradycardia, painless blanching or erythema, possible corrosion, profuse sweating, intense thirst, nausea, diarrhea, cyanosis from methemoglobinemia, hyperactivity, stupor, blood pressure fall, hyperpnea, abdominal pain, hemolysis, convulsions, coma, and pulmonary edema followed by pneumonia.	NCBI 2022

Table 1. Summary of Available Toxicological Information on Menthol.

Similar to cyclododecane, menthol SDSs vary among different suppliers and manufacturers (ex: Kremer, Sigma, Fischer, Flinn) and by isomer (Menthol CAS 89-78-1; L-menthol CAS 2216-51-5, D/L-menthol CAS 1490-04-6). The relevant toxicological information for L-menthol is presented in Table 1. Notably, no occupational exposure limits have been established. Menthol is a documented skin, eye, and respiratory irritant in both human and animal studies (effects not established for cyclododecane). The remaining acute and chronic data is limited. Note that lack of classifications or data should not necessarily be interpreted as an indicator of safety.

There are no human studies related to chronic, high-level, or undiluted exposures to menthol or data related to inhalation as would be relevant for a conservation setting. However, two cases of extreme menthol exposure have been published:

- One individual suffered coma, skin lesions, and gastrointestinal and neurological symptoms following ingestion of large amounts of menthol in the form of two bags of 10 mg menthol cough drops consumed daily (Baibars et al. 2012)
- A second case involved fatal intoxication resulting from occupational exposure (inhalation of vapor) at a peppermint factory (Kumar et al. 2016).

Remarkably, one publication evaluates the toxicity of menthol with regards to its specific use as a temporary consolidant. In this study, zebrafish embryos were incubated with four temporary consolidants (cyclododecane, menthol, coumarin, and ethyl maltol) to determine their biological effects on embryos. The authors concluded that these materials "resulted in an increased mortality and malformation rate, and a decreased hatching rate." The order of embryotoxicity was determined as menthol > coumarin > ethyl maltol > cyclododecane (Zhang et al. 2018, 50).

Health Effects

Side effects of exposure to menthol in large amounts (menthol poisoning) include palpitations, rapid heartbeat, convulsions, dizziness, tremors, losing consciousness, unsteadiness, blood in the urine or no urine output, rapid or shallow breathing, abdominal pain, diarrhea, nausea, and vomiting (Mount Sinai 2022). Additional reported health effects are included in Table 1 listed above. As conservators we should be equally concerned about acute health effects as well as chronic effects (i.e., cancer and reproductive effects); even minimally altered physical or mental states can have serious effects on safe working practices especially when working at heights or in confined spaces, which can lead to more serious injuries.

Safety Perceptions and Survey Results

Surveys conducted by members of the AIC Health & Safety Network in 2017 and 2021 (AIC 2017, 2021) revealed that the majority of respondents care about the health and safety implications of their treatments. In both 2017 and 2021, over 90% of conservators said that they considered health and safety concerns "very important" or "somewhat important" in formulating their treatments. Yet, less than 25% of respondents in both surveys reported that they were frequently successful at finding health and safety information if Safety Data Sheets were incomplete, as is the case for both menthol and cyclododecane.

In the 2021 survey, only 32 of 190 respondents had heard of menthol as a replacement for cyclododecane, indicating that it is still a new material to the field of conservation. Responses were inconsistent regarding how conservators viewed the safety of menthol. While 7% of respondents thought menthol was not hazardous, 33% thought it was hazardous, and 61% did not know. When asked directly whether household products should automatically be considered safe to use in conservation contexts, 92% of respondents indicated that they should not. However, 27% of respondents who indicated that menthol was not hazardous stated this was because it is a common household ingredient.

The survey also reflected some confusion about available safety information; 18% of respondents indicated that they would consider menthol safe because of SDS information, while 22% of respondents indicated that they would consider it unsafe because of SDS information. When compared to cyclododecane, 47% thought menthol was safer than cyclododecane and 42% thought it was comparable to cyclododecane. Responses on the hazardous nature of each chemical individually were consistent with this impression (Figure 1).

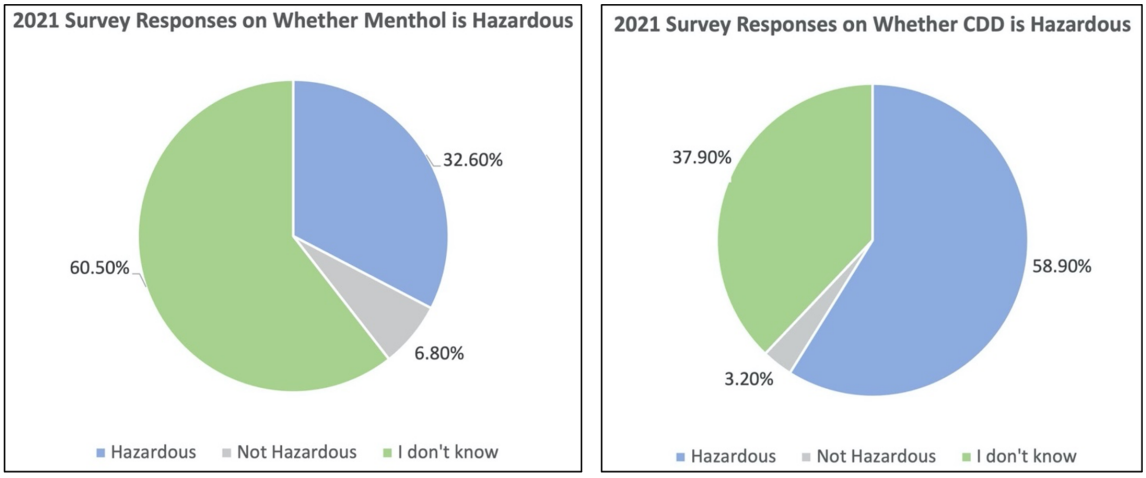

Figure 1. Pie charts showing 2021 survey responses on whether menthol is hazardous (left) and whether cyclododecane is hazardous (right).

Notably, there was a change between 2017 and 2021 on respondent opinions of the safety of cyclododecane. In 2021, 59% considered it hazardous (compared to 49% in 2017), 3.2% considered it not hazardous (compared to 18.4% in 2017), and 38% did not know (compared to 33% in 2017). This is an interesting result considering there has been no new health and safety information on cyclododecane between the two surveys. However, the commercial availability of cyclododecane did change, suggesting accessibility and familiarity do play a role in health and safety perceptions. In addition, some conservation-related talks, papers, and conferences may have also raised concern over cyclododecane in the conservation community (Koss Schrager 2017; Roseik 2018).

Final Thoughts

Menthol may at first glance seem like a low-risk replacement for cyclododecane due to its familiarity from household products. However, familiarity in everyday use does not necessarily mean materials are safe for use in a conservation context. The occupational exposure scenario experienced by conservators using menthol as a temporary consolidant has not been evaluated; thus, conservators should not assume that it is low risk.

Like many potentially hazardous chemicals used in conservation, menthol can be safely applied with proper precautions.

- Because the primary route of exposure is inhalation, proper ventilation and respiratory protection should be used in all stages of treatment from application through complete sublimation.
- Consider that the menthol will be sublimating for a period of days or weeks after application, creating long-term opportunities for exposure.
- Small-scale objects should ideally be kept in a running fume hood until the menthol is fully sublimated.
- Conservators should minimize the amount of heat used for melting (a cup warmer is ideal for melting small amounts at low temperatures) due to the combustibility of menthol solutions and because it can decompose into carbon monoxide and carbon dioxide at high temperatures.
- Although there is no published information on glove compatibility for menthol, conservators should exercise caution and use synthetic gloves while working with this material.

Choosing the Right Gloves for Working with Menthol

As you may have guessed from the lack of other safety information related to menthol, safe glove choice is also not straightforward. Glove materials must be selected for the specific chemical.

For assistance in choosing the correct gloves for some common conservation chemicals see the Health & Safety Network's "PPE Chemical Protective Material Selection Guide" (AIC, 2014).

Information about testing of various glove materials for their resistance to menthol breakthrough is not available through glove manufacturers; therefore, conservators must rely on available literature and their specific use to assess the type of hazard and the possible risk. Performance of glove materials with structurally similar chemicals may provide some guidance.

For example, nitrile may be the glove of choice for most conservation tasks, but a study on the chemical breakthrough of Kimberly Clark nitrile gloves for limonene, which is a monoterpene (menthol is a monoterpanoid), recommends: "The lavender, sterling, and purple gloves should not be used as personal protective equipment for exposure to limonene, even for short period exposures. Although the blue gloves provided the best performance compared to the other gloves, they can only be used for no more than 20 minutes."

It is important to remember that despite similarities, all chemicals react differently; therefore, users should avoid prolonged contact with menthol even with gloved hands.

Most importantly, the 2017 survey revealed that most conservators respect their colleagues' work and regularly rely on the opinions and reported practices of their peers to determine their own level of precaution when using novel materials and techniques. Therefore, it is paramount to use more protective health and safety protocols to ensure that best practices are maintained when conclusive toxicological information is missing.

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