

Tapping into Industry Knowledge – Establishing new guidelines for evidence environmental considerations

Marcela Najarro
Evidence Management Conference
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Preservation

- Preserve¹:
1. To maintain (something) in its original or existing state
 2. To keep intact or free from decay
 3. To keep safe from harm or destruction

Maximize Preservation

Why Preserve Evidence?

- **Complying with Evidence Retention Laws:** Retention laws vary from state to state, "case status" (open, charges filed, adjudicated, no further investigation) crime category (homicide offenses, sexual offenses, assault, etc.)
- **Reanalysis:** Defense expert, court ordered, training aids, audits/tampering, etc.
- **Advancements in Technology:** safeguarding the evidence of the future
 - Testing may not be available at the time of the original trial
 - Technology has advanced to a level that provides a more accurate test than the one used previously

Preserving evidence can help solve cases and exonerate the innocent

Literature Review Goal

Goal: Establish storage guidelines that maximize the preservation of forensic evidence based on **peer-reviewed data**

- First, determine best practices independent of resources
- Then, as a community close the gap between ideal vs. practical

Storage Conditions Matrix

Type of Evidence	Frozen	Refrigerated	Temperature Controlled	Room Temperature
X	Never	Best	Less than 24 hours	
Y	Best	Less than 24 hours		
Z			Best	Acceptable

- Identify data gaps/needs for the forensics research community

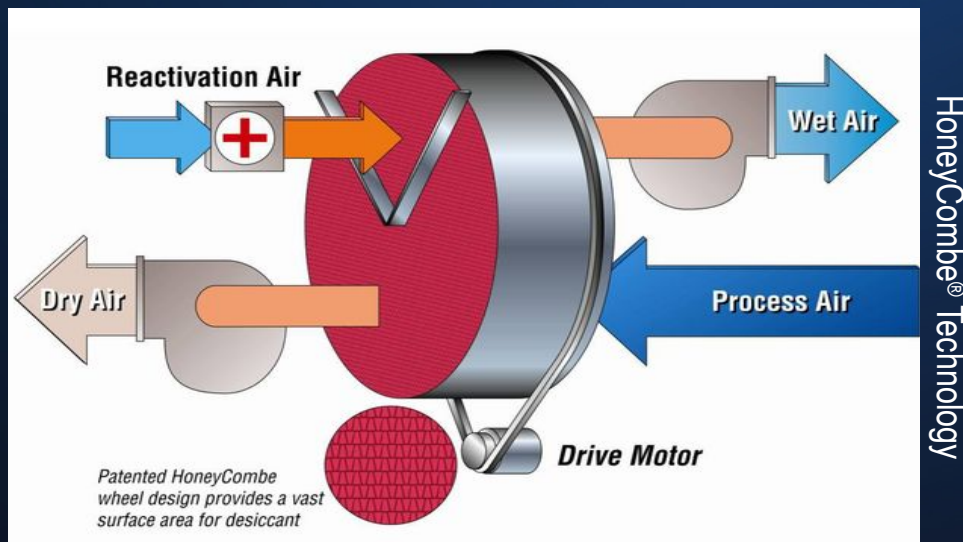
Storage Conditions Terminology

Standardizing terminology ensures that the community of practice (including hospitals and courts) have a common understanding of the recommended parameters for environmental storage conditions

Frozen	Thermostatically at or below -10°C (14°F)
Refrigerator	Thermostatically between 2°C and 8°C (36°F and 46°F) with less than 25% humidity
Temperature Controlled	Between 15.5°C and 24°C (60°F to 75°F) with less than 60% humidity
Room Temperature	Temperature is equal to the ambient temperature of its surroundings, storage area may lack temperature and humidity control methods

Environmental Conditions at Storage Facilities

- Temperature-controlled facilities manage temperature
- Climate-controlled facilities may **manage both temperature and humidity**
- Both humidity and temperature work together to control moisture levels in storage space.
 - As humidity in the air increases, air's ability to hold heat increases
 - When humidity decreases, it also helps keep temperatures low



NWS Heat Index

Temperature (°F)

	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

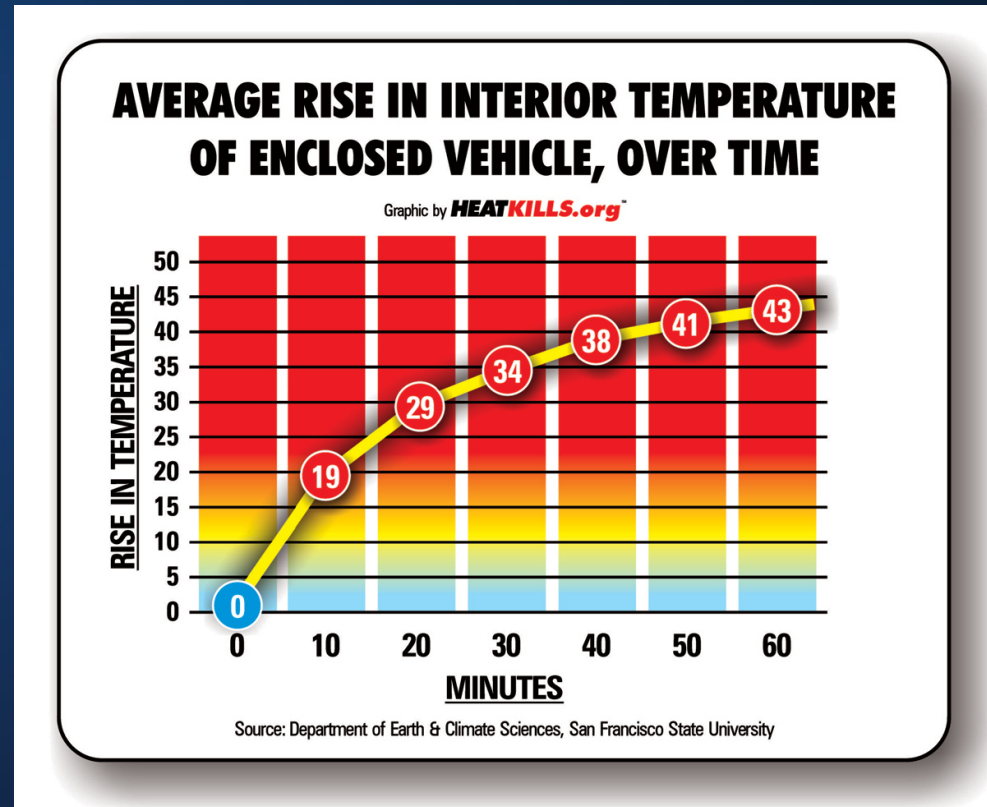
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

NWS logo

Forensic Evidence Environmental Foes

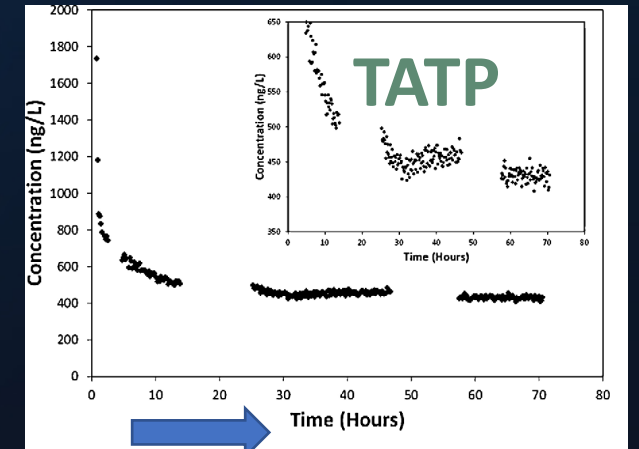
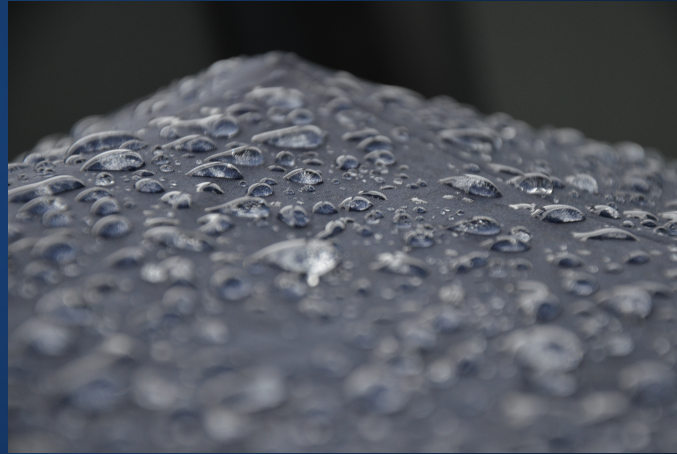
- Extreme temperatures
- Moisture/Humidity
- Light (UV)
- Bacteria
- Fungus/Mold
- Insects

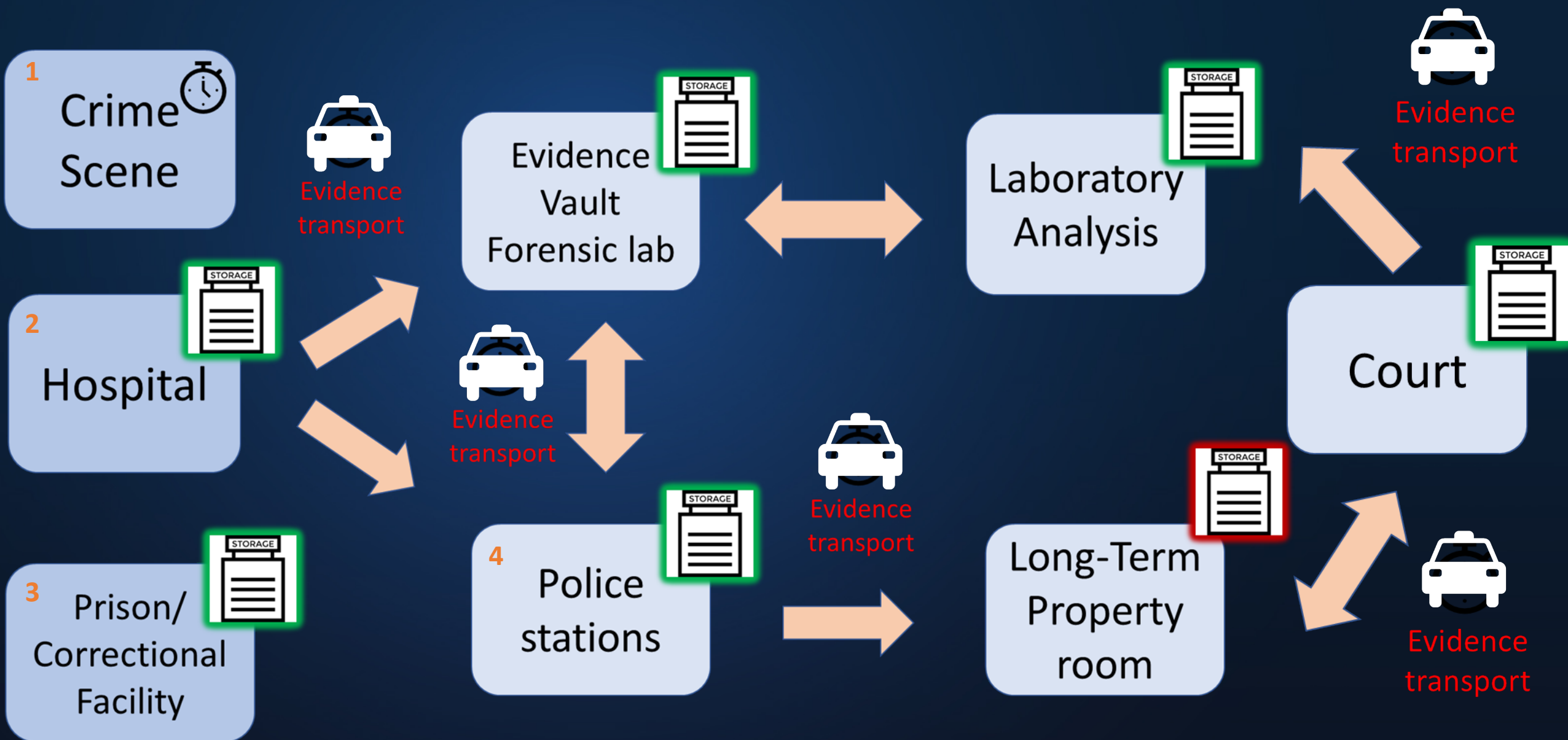


- At 70°F on a sunny day, after 30 minutes, the temperature inside a car is 104°F
 - After one hour, it can reach 113°F.
- When temperatures outside range from 80°F to 100°F, the temperature inside a car parked in direct sunlight can quickly climb to between 130°F to 172°F.

Effects of Environmental Conditions

- Condensation
- Evaporation/Volatilization
- Corrosion/Oxidation
- Hygroscopic
- Photodegradation
- Bacterial or microbial degradation
- Chemical breakdown
- Artifacts

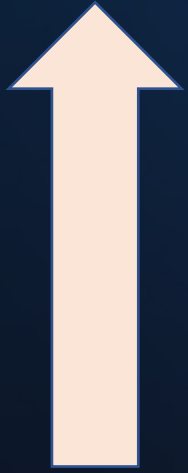




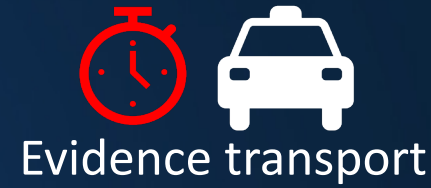
Temporary Storage Equipment



- The environmental requirements for temporary storage are the same as those for long-term storage
- Units used for temporary storage can include:
 - commercially manufactured evidence lockers
 - commercial storage containers
 - commercially manufactured temporary evidence freezers and refrigerators,
 - home refrigerators,
 - under-the-counter refrigerators,
 - repurposed lockers, and
 - rooms and closets



Mitigation Strategies



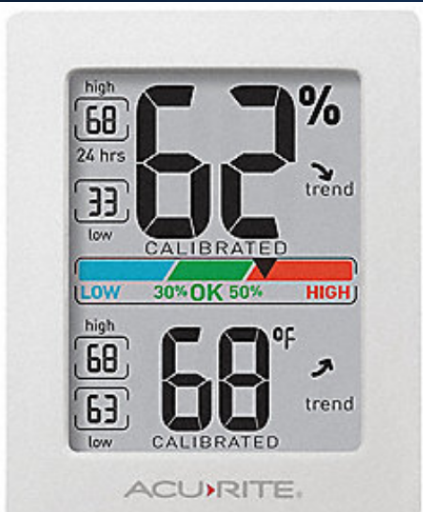
Cost-effective options



Insulated bags



Dessicant

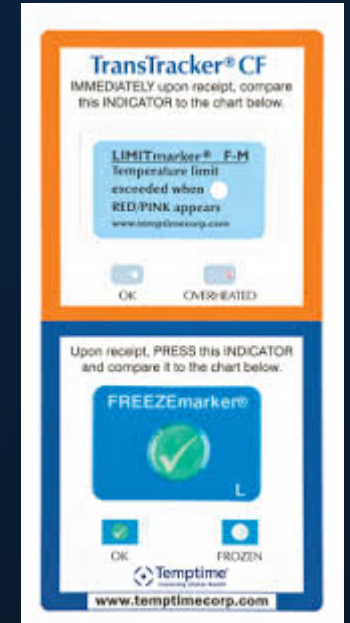
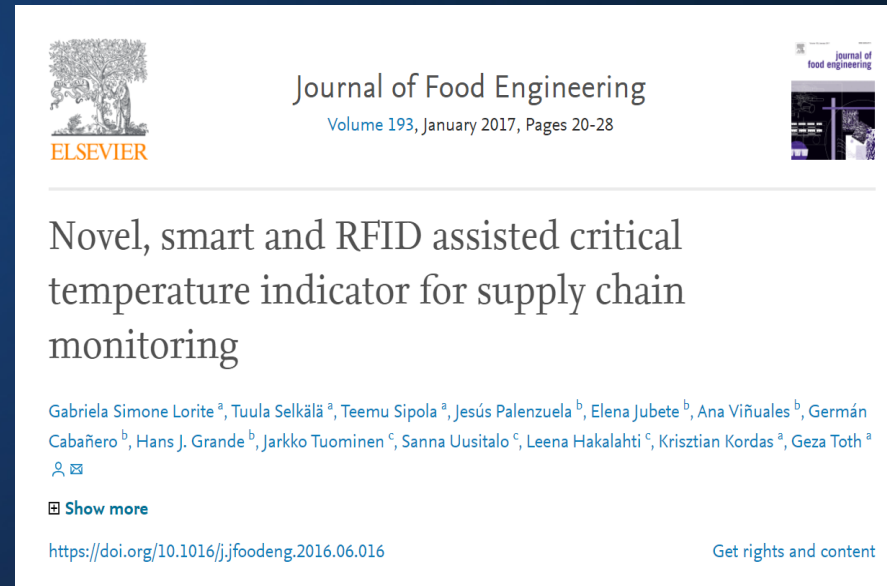


Temperature/humidity sensor



Ice packs

Advanced Technology



- A **time temperature indicator (TTI)** is a device or smart label that shows the time-temperature history
- Time temperature indicators are commonly used on food, pharmaceutical, and medical products to indicate exposure to excessive temperature

Literature Review

Types of Evidence (excluding biological samples)

- Digital Evidence
- Document Examination
- Explosives
- Firearms and ammunition
- Fire Debris
- Footwear Impressions
- Friction Ridge
- Geological Materials
- Gunshot Residue
- Materials (Trace)
- Odontology
- Seized Drugs
- Tire Impressions
- Toxicology
- Toolmarks
- Wildlife

Toxicology

Largest body of research investigating the stability of samples as a function of storage condition and time



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Research Article

Stability of Drugs of Abuse in Urine Samples at Room Temperature by Use of a Salts Mixture

Author(s): Manuela Pellegrini, Silvia Graziano, Luisa Mastrobattista, Adele Minutillo, Francesco Paolo Busardo*, Gianfranco Scarsella.

Journal Name: Current Pharmaceutical Biotechnology

Volume 18 , Issue 10 , 2017 **DOI :** 10.2174/1389201019666171211155043

Journal Home

Long-Term Storage Conditions¹

Type of Evidence	Frozen	Refrigerated	Temperature Controlled	Room Temperature
Liquid Blood	Never	Best		
Urine	Best			

¹Biological evidence handbook provides storage guidance for the matrices of toxicology samples (blood and urine)

Long-Term Storage of Authentic Postmortem Forensic Blood Samples at -20°C: Measured Concentrations of Benzodiazepines, Central Stimulants, Opioids and Certain Medicinal Drugs Before and After Storage for 16–18 Years ^{FREE}

Ritva Karinen, Wenche Andresen, Anne Smith-Kielland, Jørg Mørland

Journal of Analytical Toxicology, Volume 38, Issue 9, November/December 2014, Pages 686–695, <https://doi.org/10.1093/jat/bku080>

Published: 11 July 2014



Forensic Science International

Volume 239, June 2014, Pages 6-10



Long-term stability of morphine, codeine, and 6-acetylmorphine in real-life whole blood samples, stored at -20 °C

Gudrun Høiseth ^{a, b, c, d}, Bente Fjeld ^c, Margrete Larsen Burns ^d, Dag Helge Strand ^a, Vigdis Vindenes ^a



Journal of Pharmaceutical and Biomedical Analysis
23 (2000) 1057–1063

JOURNAL OF
PHARMACEUTICAL
AND BIOMEDICAL
ANALYSIS

www.elsevier.com/locate/jpba

Stability of benzodiazepines in whole blood samples stored at varying temperatures

Anissa El Mahjoub, Christian Staub ^{*}

Institut Universitaire de Médecine Légale, 9, Avenue de Champel, 1211 Geneva 4, Switzerland

Received 24 February 2000; received in revised form 16 May 2000; accepted 27 May 2000

Drugs

Employer submitted an evaluation request because employees working in a vault used to store drug evidence were experiencing health symptoms.

This Health Hazard Evaluation (HHE) report and any recommendations made herein are for the specific facility evaluated and may not be universally applicable. Any recommendations made are not to be considered as final statements of NIOSH policy or of any agency or individual involved. Additional HHE reports are available at <http://www.cdc.gov/niosh/hhe/>

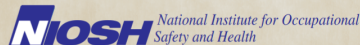


Evaluation of Police Officers' Exposures to Chemicals While Working Inside a Drug Vault – Kentucky

*Kenneth W. Fent, PhD
Srinivas Durgam, MSPH, MSChE, CIH
Christine West, RN, MSN, MPH
John Gibbins, DVM, MPH
Jerome Smith, PhD*

Health Hazard Evaluation Report
HETA 2010-0017-3133
July 2011

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention



➤ Findings:

Most of the temperatures and RH levels were acceptable. However, the RH levels in the drug vault during the July visit were > 50% which can promote mold growth.

➤ Recommendations:

Provide conditioned air to maintain an RH at 30%–50% to the drug vault throughout the year. This will help minimize mold growth.

Trace Drugs

Goal: Evaluate how environmental conditions affect the persistence and detection of trace drug residues

Trace Narcotics Sampling

- Sample collection can take place in harsh environments
- Critical to understand the availability of trace residues after exposure to varying environmental conditions.

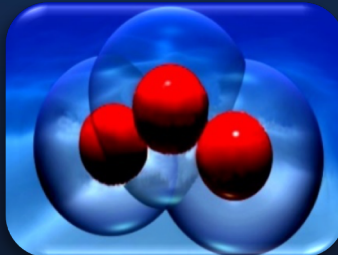
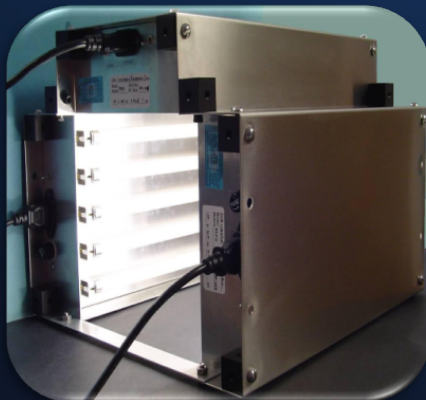


Public Health

- If residues are present in the environment could they cause harm?
- How long will a residue persist before it is no longer present? Can UV or Ozone be used to decontaminate?



Drug	Time (days)	Environmental Condition
Cocaine	0	-4°C (24°F)
Fentanyl	7	Laboratory (70°F)
Furanyl	14	30°C (86°F)
Heroin	21	Ozone
MDMA	28	47°C (116°F)
MDPV	35	30°C/UV
Methylone		30°C /90% RH



Trace Drugs Results

Day 7	-4 °C	Lab	30 °C	Ozone	47 °C	UV
Cocaine						
Fentanyl						
Furanyl						
Heroin						
MDMA						
MDPV						
Methylone						

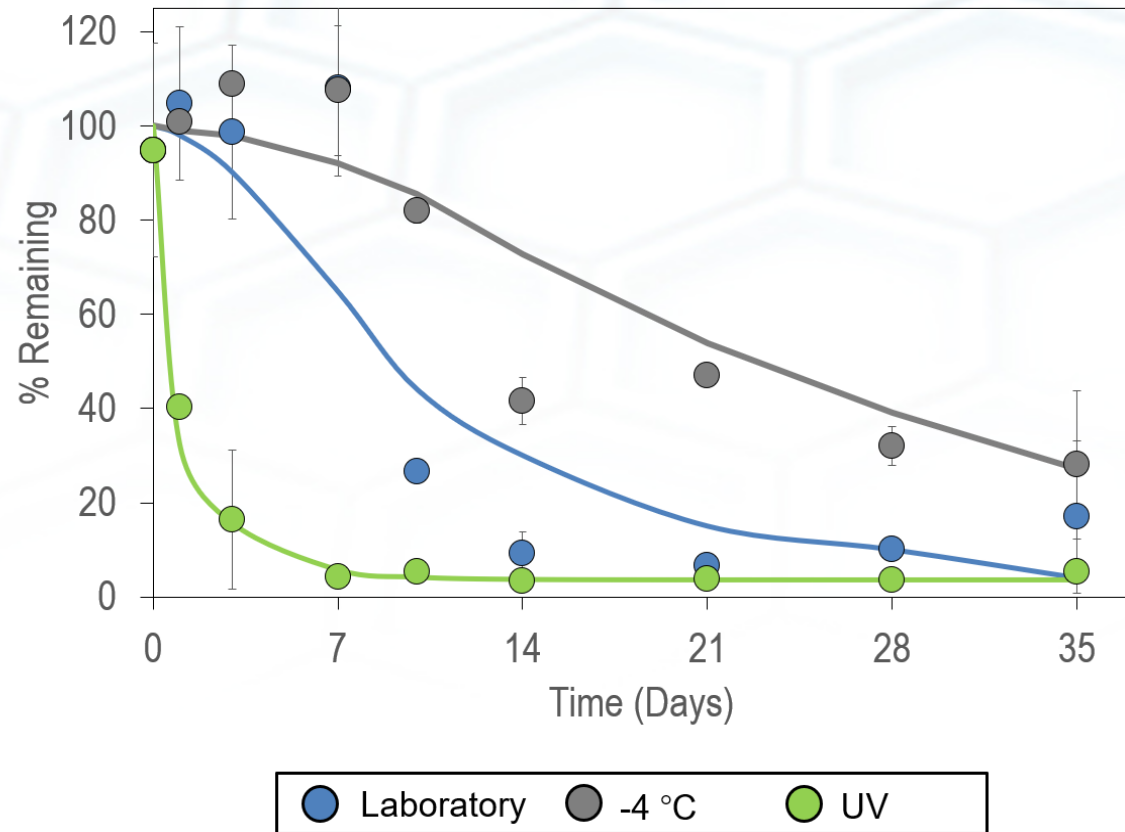
% loss

< 20 %

20 % - 50 %

> 50 %

MDMA Degradation



Unstable Drugs – Legal Implications

Laura A. Ciolino,¹ Ph.D.; Mantai Z. Mesmer,¹ Ph.D.; R. Duane Satzger,¹ Ph.D.;
A. Caroline Machal,¹ B.S.; Heather A. McCauley,¹ B.S.; and Angie S. Mohrhaus,¹ B.S.

The Chemical Interconversion of GHB and GBL: Forensic Issues and Implications*

REFERENCE: Ciolino LA, Mesmer MZ, Satzger RD, Machal AC, McCauley HA, Mohrhaus AS. The chemical interconversion of GHB and GBL: forensic issues and implications. *J Forensic Sci* 2001;46(6):1315–1323.

ABSTRACT: In this work, the interconversion of GHB and GBL in a variety of aqueous media was studied. The effects of solution pH and time were determined by spiking GHB or GBL into pure water and buffered aqueous solutions, and determining the GHB and GBL contents at various time intervals. The degree of GBL hydrolysis to GHB was determined for several commercial aqueous-based GBL products, and further studied as a function of time. The effects of temperature and time were also determined for five commercial beverages spiked with GHB or GBL. GHB and GBL contents were determined using high performance liquid chromatography (HPLC). GHB and/or GBL confirmations were made using gas chromatography-mass spectrometry (GC-MS) and/or infrared spectroscopy (IR).

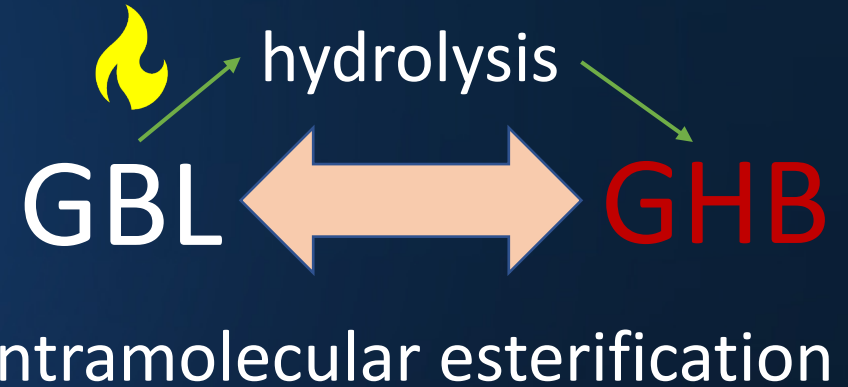
Solution pH, time, and storage temperature were determined to be important factors affecting the rate and extent of GBL hydrolysis to GHB. Under strongly alkaline conditions (pH 12.0), GBL was completely converted to GHB within minutes. In pure water, GBL reacted to form an equilibrium mixture comprising ca. 2:1 GBL:GHB over a period of months. This same equilibrium mixture was established from either GHB or GBL in strongly acidic solution (pH 2.0) within days. A substantial portion of GBL (ca. ½) was hydrolyzed to GHB in aqueous-based GBL products, and in spiked commercial beverages, after ambient storage for a period ranging from several weeks to several months. Heat increased and refrigeration decreased the rate of GBL hydrolysis relative to ambient conditions. These studies show that hydrolysis of GBL to GHB does occur in aqueous-based solutions, with samples and time frames that are relevant to forensic testing. Implications for forensic testing and recommendations are discussed.

KEYWORDS: forensic science, GHB, GBL, gamma-hydroxybutyrate

also drugs of abuse. GHB is typically manufactured either in clandestine laboratories or by end-users using GBL and sodium or potassium hydroxide in aqueous solution. The GHB product may be isolated as a powder, partially dried to a paste or wet mass, concentrated, or left as is in solution. However, at some point prior to consumption, the GHB product is typically redissolved and/or further diluted in aqueous-based media such as beverages. In addition to other illicit uses, GHB is commonly encountered in the “club drug” and “rave” scenes (4,5), and has frequently been detected in victims of drug-facilitated sexual assault or “date rape” (6–8).

GBL is frequently sold and consumed in aqueous solutions. Over the last several years, dozens of commercial GBL products have emerged under a variety of product names and labels (9). These products typically have label claims of 1 to 5 GBL per ounce and may also contain dyes, flavorings, nutritional supplements (e.g., vitamins), and other components. They have been marketed extensively over the Internet and in health food stores. Aqueous solutions of GBL are also sold in unlabeled containers from clandestine sources.

GHB and GBL are subject to interconversion in aqueous solution. GBL is converted to GHB via hydrolysis; GHB is converted to GBL via intramolecular esterification. In February 2000, GHB was added to the list of DEA Schedule I controlled substances (10). In this same legislation, GBL was made a List I chemical owing to its use in the manufacture of GHB (a “List I chemical” is defined in the Federal Controlled Substances Act as a chemical used in the manufacture of a controlled substance; the distribution of such chemicals is therefore monitored). Although GBL was not explicitly scheduled under the new law, the law does allow for GBL to be considered a scheduled analog of GHB depending on the specific circumstances (e.g., use and intent).¹ At the state level, the



- Results show that solution pH, time, and storage temp are important factors affecting the rate and extent of GBL hydrolysis to GHB.
- Heat increased and refrigeration decreased the rate of GBL hydrolysis relative to ambient conditions
- GHB is a Schedule I, GBL List I chemical (chemical used in the manufacture of a controlled substance)

Unstable Drugs – Legal Implications



Forensic Science International
Volume 195, Issues 1–3, 25 February 2010, Pages 108–120



Cathinone preservation in khat evidence via drying

John S. Chappell , Marsha M. Lee

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<https://doi.org/10.1016/j.forsciint.2009.12.002>

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Abstract

A primary concern with the forensic analysis of the khat plant (*Catha edulis*) has been the need to preserve the principle psychoactive component, cathinone, which converts to the less-active substance, cathine, after harvesting. The loss of cathinone has serious legal implications since it is a Schedule I controlled substance under federal regulations in the United States, while cathine is Schedule IV. A common misconception is that cathinone is highly unstable once the plant is harvested, and may be undetectable upon drying and prolonged storage. However, drying the plant material will preserve cathinone. Numerous seizures of a dried form of khat (referred to as “graba” in the United States) have been made in recent years, suggesting that drying the plant material is a viable approach to preserve khat evidence for both storage and reanalysis. A qualitative and quantitative study of the composition of khat samples seized as dried plant material has found the khat alkaloids to be relatively stable for a monitored period of 3 years, and cathinone has remained identifiable while stored at room temperature for over 10 years. Studies of green khat (received moist) have also determined that drying the moist leaves at either room temperature or by the application of heat are suitable methods to preserve cathinone in the dried material. These findings demonstrate that

- A primary concern with the forensic analysis of the khat plant is preserving the principle psychoactive component, cathinone, which converts into less active cathinine after harvesting
 - Cathinone – Schedule I controlled substance
 - Cathinine – Schedule IV controlled substance
- A quantitative study of the composition of khat samples seized as dried plant material found cathinone remained identifiable while stored at room temp for > 10 years.
- Drying the moist leaves at either room temperature or by the application of heat are effective means to preserve seized khat evidence for long-term storage.

Explosives

UNDP – United Nations Development Programme

RMDS/G 05.40 4th Edition (2006-07-20)

- Keep dry and well ventilated to prevent condensation
 - Keep as cool as possible and free from excessive or frequent changes of temperature;
 - Keep protected from direct sunlight; and
 - Keep free from excessive and constant vibration
- Some explosives attract and hold moisture, which may result in the degradation of explosive performance
 - **SAFETY:** Moisture also increases the potential for the formation of sensitive explosive crystals between the fuze and main body of the munition.
 - Every effort shall be made to ensure dry conditions prevail in storage and transportation.

Trace Explosives

Day 35	-4 °C	Lab	30 °C	Ozone	47 °C	90% RH	UV
HMX							
PETN							
RDX							
TNT							
ETN							

% loss	< 20 %	20 % - 50 %	> 50 %
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Fire Debris



Designation: E2451 – 13

Standard Practice for Preserving Ignitable Liquids and Ignitable Liquid Residue Extracts from Fire Debris Samples¹

This standard is issued under the fixed designation E2451; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This practice describes procedures for preserving residues of ignitable liquids in extracts obtained from fire debris samples and questioned ignitable liquid samples. Extraction procedures are described in the Referenced Documents.

1.2 This practice does not attempt to address all the issues regarding the short-term or long-term storage of ignitable liquid samples and ignitable liquid extracts from fire debris samples. The changes that may occur under various storage conditions have not been fully documented.

1.3 This practice cannot replace knowledge, skill, or ability acquired through appropriate education, training, and experience and should be used in conjunction with sound professional judgment.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

E1386 Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction

E1388 Practice for Sampling of Headspace Vapors from Fire Debris Samples

E1412 Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration With Activated Charcoal

E1413 Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Dynamic Headspace Concentration

E1459 Guide for Physical Evidence Labeling and Related Documentation

E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory

E1618 Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry

E2154 Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Solid Phase Microextraction (SPME)

3. Summary of Practice

3.1 Extracts obtained from fire debris samples and questioned liquids analyzed for the presence of ignitable liquid residues are retained and preserved for potential reanalysis by Test Method E1618.

4. Significance and Use

4.1 The archiving of extracts recovered from fire debris or liquids submitted in a fire investigation provides a mechanism to preserve extracts and liquids for reanalysis in the event that sample loss, sample degradation, or failure of the fire debris container occurs during post-analysis storage of fire debris evidence.

4.2 The nature of some extraction procedures, which may preclude reanalysis, is considered.

4.3 Changes to a preserved sample extract and the length of time it remains viable under storage conditions are unknown.

4.4 The concentration and composition of the ignitable liquid residue or the use of an alternate extraction/concentration technique used to preserve a sample extract of the fire debris sample may result in different findings between the analysis of the preserved sample and the original analysis.

5. Materials

5.1 *Airtight and Vapor-Tight, Volatile-Free Storage Containers*—The following are suggested container types:

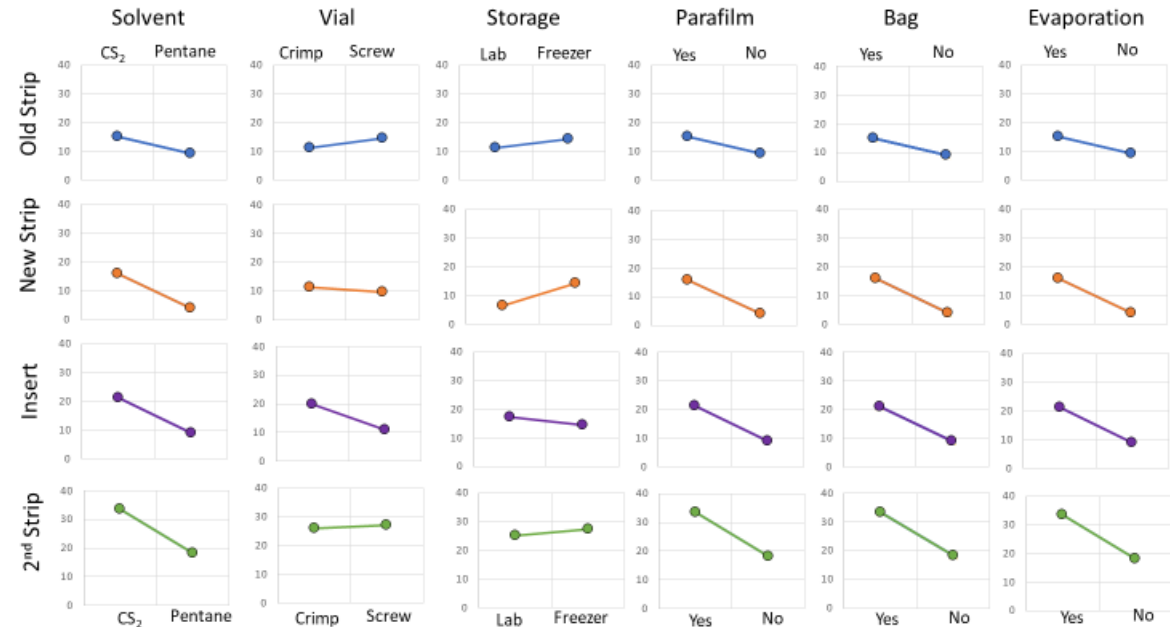
5.1.1 Septum crimp vials with PTFE-lined seals.

5.1.2 Screw cap glass vials with PTFE-lined seals.

5.1.3 Polymer evidence bags (this does not include polyethylene or polypropylene-type containers).

¹ This practice is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.01 on Criminalistics. Current edition approved June 1, 2013. Published July 2013. Originally approved in 2008. Last previous edition approved in 2008 as E2451 – 08. DOI: 10.1520/E2451-13.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.



Key Takeaways:

- Carbon disulfide is the preferred solvent
- No statistically significant difference measured for vial type, laboratory vs. freezer storage
- While parafilm shows improvements, it may introduce artifacts into evidence
- Heat sealed secondary packaging bag

Firearms



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NRAMUSEUMS.COM



Caring for Your Collectible Firearms

By Doug Wicklund, Senior Curator

Temperature	Ideally, firearms collections should be stored at about 70°F year-round. Variations in temperature cause wood stocks to expand and contract causing permanent cracks. Keep temperature constant.
Humidity	A middle ground figure of 50% relative humidity caters to both wood and metal components. Too much humidity and the metal parts corrode. Too little and stocks start cracking. Keep humidity consistent.

Ammunition

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SAAMI (Sporting Arms and Ammunition Manufacturers' Institute)

SAAMI Standards are published to provide safety, reliability, and interchangeability for commercial manufactures of firearms, ammunition, and components.

Temperature

A general rule of thumb for ideal storage temperatures is between **55°F and 85°F**.
Extreme high temperatures (over 150° F) should be avoided.



Ammunition manufacturers advertise their loaded ammo, if stored properly, to have a 10 year shelf life.

Documents

Fluctuations in temperature and humidity are damaging



Source: Head of Conservation Minnesota Historical Society

Temperature

- **Heat accelerates deterioration**: the rate of most chemical reactions is doubled with each increase in temperature (18°F)

Humidity

- High humidity promotes harmful chemical reactions in materials and encourages **mold growth and insect activity**
- Extreme low humidity (winter in centrally heated buildings) may lead to dessication and embrittlement.

Photographs

Source: Library of Congress

General Guidelines for the Proper Storage of Photographs and Negatives

- A relative dry (30-40% relative humidity), cool (room temp (<70°F) or below),
- Minimal exposure to all kinds of light; no exposure to direct or intense light
- Distance from radiators and vents
- Minimal exposure to sulfur-containing atmospheric pollutants

- Relative humidity is the single most important factor in preserving photographic prints
- For contemporary color photographs and for film negatives, however, temperature is the controlling factor that affects stability
 - Storage at low temperatures (40°F or below) is recommended

Key Takeaways

Monitor climate during the entire life cycle of evidence management

- All parties involved in chain custody must also follow best storage practices
- The goal is to maximize the preservation of evidence
 - Some materials have a shelf-life, are inherently thermally labile, etc.
- Minimize transit time between collection of evidence/laboratory analysis and storage
 - Law enforcement agency policy should reflect this effort
 - Consider implementing mitigation strategies for transport

Literature Review Results

- Temperature and humidity play a critical role in the preservation and integrity of forensic evidence
 - Avoid extreme temperatures and high humidity
 - Most evidence is stable at room temperature, 35-65% RH
- Consider safety aspects to storage conditions

Key Takeaways II

More research is needed to issue data-driven storage conditions recommendations

- Forensic labs have a wealth of information, consider publishing your data!

Considerations for researchers:

- Research studies should be performed using real-world conditions of forensic evidence transportation and storage (captures the effects of drying, packaging, etc.)
 - Environmental chambers do not always reflect real-world conditions
 - Studies should include time temperature trackers (TTI)
- Design of Experiments (DOE) can be employed to understand the relative effects of different factors on a response
 - Can greatly reduce the number of runs necessary for the same information

Leverage other Industries/Sources:

- Medical, pharmaceutical, food industries are all concerned with how storage conditions/transport affects products: leverage their practices and technologies
- Smithsonian Museum Conservation Institute, Library of Congress, etc.

Thank you!

Marcela.Najarro@nist.gov

(301)975-5395