Risk analysis for substances of very high concern in leather

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Status of leather chemicals

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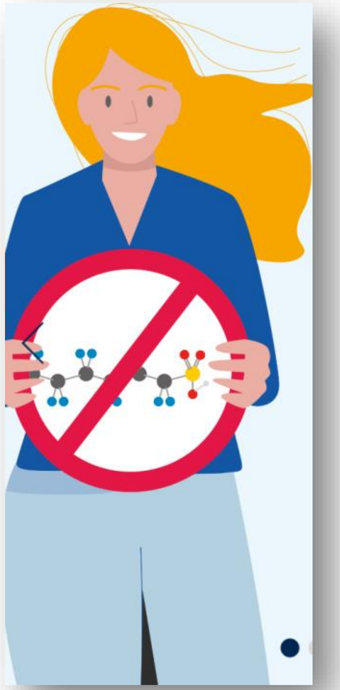


Regulatory Frameworks

The **EU REACH**, **US TSCA**, **Japan CSCL**, and **China's new chemical regulations** all aim to protect health and the environment. These frameworks are increasingly stringent, shaping global supply chains.

Compliance as a Competitive Edge

For leather exporters, proactive compliance with these global rules is now essential to remain competitive in international markets.

Shared Goals

Despite differences in approach, all major chemical control regulations share the goal of reducing risks to human health and the environment from harmful substances.

Status of leather chemicals

Complex Chemical Use

Over **2,000 chemicals** may be used in the leather production process, from raw hides to finished products, many of which are Substances of Very High Concern (SVHC).

Urgent Need for Standards

The presence of these chemicals in final products poses significant health and ecological risks, highlighting the urgent need for robust testing standards and risk reduction strategies.

LIN W, et al. Leather Science and Engineering, 2023,33(1):32-35,45.
SANG J, et al. Asian Journal of Ecotoxicology, 2015,10(2):123-130.

02

Risk Analysis of Three High-Risk Chemical Substances in Leather Products

DMF: Versatile Solvent & Health Hazard

DMF as a Universal Solvent

DMF is a low-molecular-weight solvent with a high dielectric constant, making it **miscible with water and most organic solvents**. It is widely used in the leather industry for synthesizing **waterborne polyurethane finishes, ensuring homogeneous reactions and superior film formation**.

Metabolism and Toxicity

In the human body, DMF is metabolized by P450 CYP2E1 into toxic substances such as N-hydroxymethyl-N-methylformamide (HMMF), N-methylformamide (NMF), and formaldehyde. The IARC classifies DMF as a **possible human carcinogen (Group 2B).**

Health Risks of DMF

DMF can enter the human body through **inhalation, skin contact, and ingestion**, causing damage to multiple organs including the liver, stomach, kidneys, respiratory system, and nervous system. Its **primary target organ is the liver**.

Regulation and Residue

The EU REACH Regulation lists DMF as a Substance of Very High Concern (SVHC), with a mass fraction **limit of 0.1% in articles**. Studies show that significant amounts of DMF remain in leather products, posing **risks to consumers and occupational workers**.

Jr K G, Sherman H. Drug and Chemical Toxicology, 1986, 9(2): 147-170.
Gartia Y, et al. Journal of Applied Polymer Science, 2013, 128(6): 3522-3527.

PFAS: Forever Chemicals

PFAS Properties

PFAS are characterized by their strong C-F bonds, which give them **excellent water- and oil-repellent properties**, making them useful in leather finishing.

Environmental Persistence

PFAS are known as **'forever chemicals'** due to their resistance to natural breakdown, potential for long-range transport, and bioaccumulation.

Regulatory Attention

In 2023, five European countries proposed restrictions on PFAS to the European Chemicals Agency, highlighting the need for better control.

REN KS, et al. Leather Science and Engineering, 2025,35(5):1-7.

Bisphenols: Structure, Use & Risk

Structure of Bisphenol Compounds

Bisphenol compounds consist of two phenolic rings connected by a carbon bridge or other structures. They have rigid symmetric aromatic rings and multiple hydroxyl groups, which facilitate further functionalization.

Application in Leather Tanning

In the leather industry, **bisphenol-based synthetic tanning agents** are widely used. These agents interact with leather fibers under aqueous conditions, enhancing filling properties and improving mechanical strength and dye uptake.

Health and Regulatory Concerns

Bisphenol A (BPA) is strictly regulated due to its **endocrine-disrupting** properties and **reproductive toxicity**. This has led to the adoption of alternatives like BPS, BPF, BPAF, and BPB, though their safety is still under scrutiny.

Formation and Residue in Production

During the synthesis of phenolic tanning agents, **side reactions** and **incomplete raw material reactions** can generate and leave behind bisphenol compounds. Different synthesis methods produce different types and levels of BPs.

03

DMF Risk Analysis Solution: Systematic Control from Source to End Product

Source: Polyurethane Screening

HPLC Method

An optimized HPLC protocol for detecting DMF in waterborne polyurethane uses deionized water extraction and membrane filtration.

Market Samples

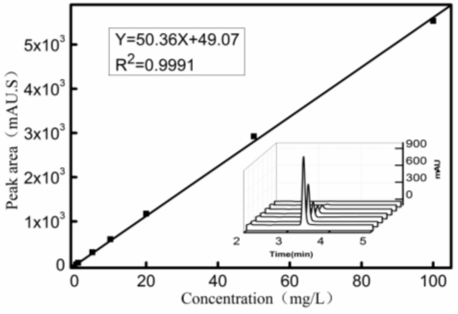
Testing market samples revealed DMF levels ranging from 52 mg/L to below the detection limit, showing the importance of raw material selection.

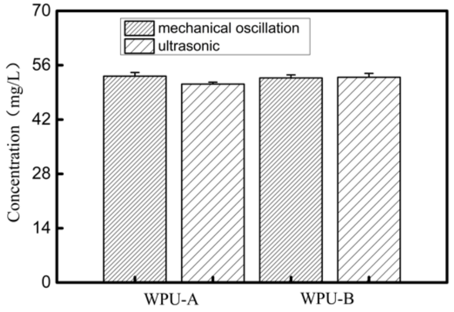
Detection Limits

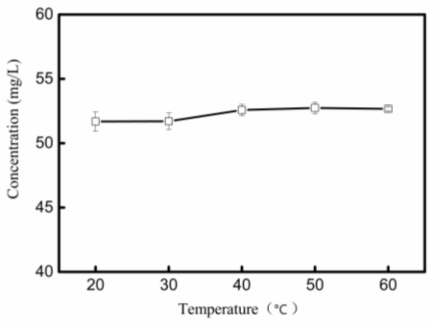
The method has a detection limit of 0.25 mg/L, with recoveries between 95% and 102% and RSD below 5%.

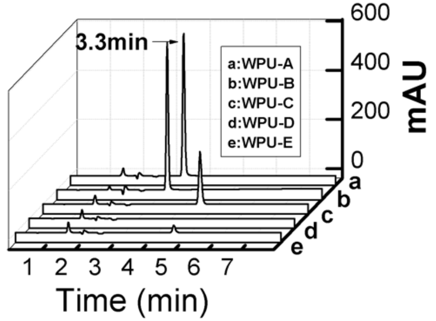
Risk Reduction

Screening for low-DMF content in raw materials can significantly reduce the introduction of DMF into the leather production chain.









Process: Residue & Migration

01 Residue Patterns

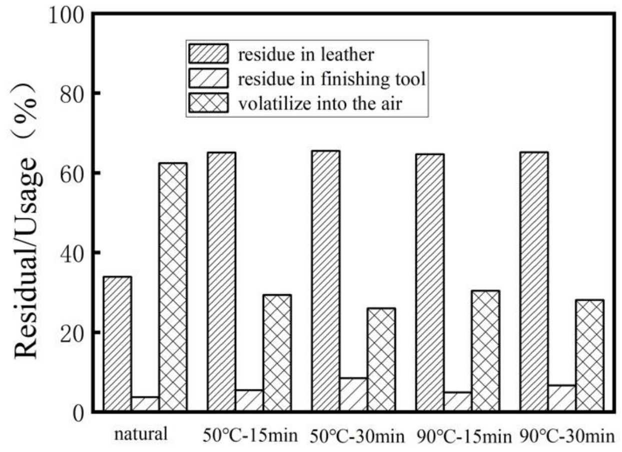
During leather finishing, 65% of DMF remains in the leather, while 25–30% volatilizes when dried at 50–90 °C.

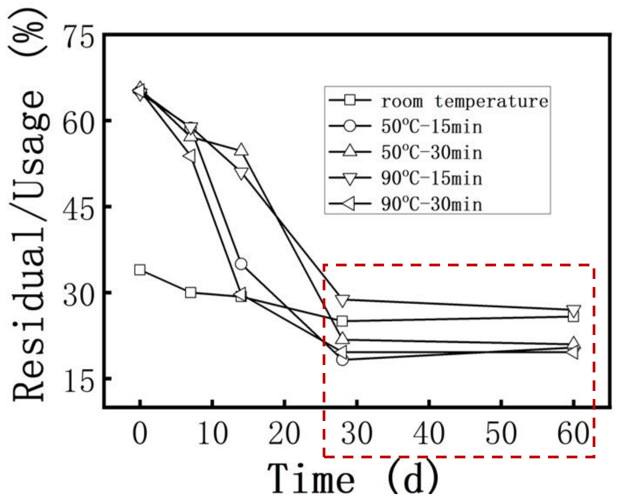
02 Temperature Impact

Higher drying temperatures lead to more DMF remaining in the leather, likely due to surface film formation trapping DMF beneath.

03 Long-term Residue

After 30 days, DMF levels stabilize, with **20–30% remaining** in the leather long-term, posing a persistent risk.





Product: Rapid HS-GC Test

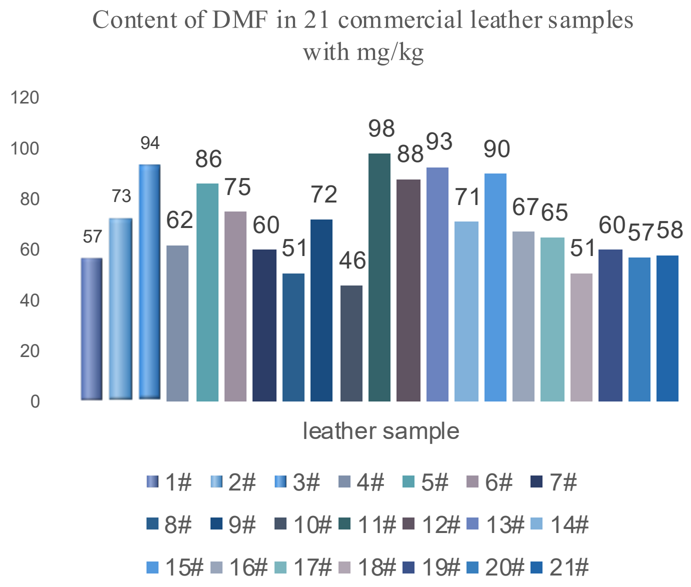
HS-GC Validation

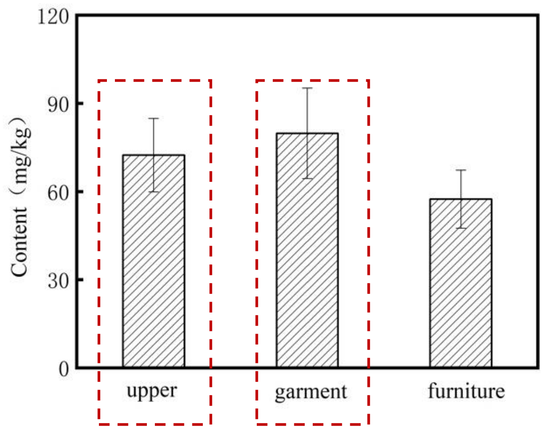
A validated headspace-GC method with 100 °C, 30 min equilibration provides stable recoveries and RSD below 1% for DMF detection in leather.

Market Screening

Screening 21 commercial leather samples showed all **below the 0.1% regulatory limit**, with **higher levels in garment and upper leathers**.

Garment and upper leather, often having thinner coatings, require higher leveling and film-forming properties from the finish; the addition of an appropriate amount of DMF can effectively improve the film formation of waterborne polyurethane emulsions.





Gartia Y, et al. Journal of Applied Polymer Science, 2013, 128(6): 3522-3527.

04

Conclusion

Lifecycle Risk Framework

Source Screening

Implement rigorous source screening to identify hazardous substances like DMF, PFAS, and bisphenols, and replace them with green, safer alternatives to reduce initial risks in leather production.

Process Optimization

Optimize production process parameters to minimize the use and residual levels of high-risk substances, ensuring more sustainable and less hazardous leather manufacturing practices.

Analytical Methods

Develop rapid and accurate analytical detection methods to reliably identify and quantify SVHCs in leather products, supporting effective risk assessment and compliance with regulations.

Regulatory Tracking

Enhance tracking and early warning of international regulations to proactively avoid international trade disputes, ensuring the leather industry can adapt to evolving environmental and safety standards.

Innovation & Standard Roadmap

01

Future Priorities

Continuous identification of emerging SVHC, development of green substitutes, rapid detection technologies, and synchronized standard revisions are key priorities.

02

Collaborative Innovation

University-industry-research collaboration is essential to accelerate technology transfer and support high-quality sustainable growth in the leather industry.

03

Technology Transfer

Effective technology transfer and standardization are critical for the industry's transition to greener practices and sustainable development.

04

Sustainable Growth

These efforts will drive the industry towards sustainable growth, ensuring compliance with global standards and enhancing market competitiveness.

THANKS FOR YOUR LISTENING