Formaldehyde Absorption by Keratin Based Products

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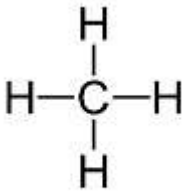
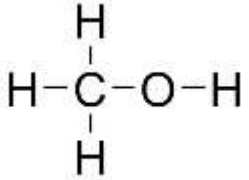
What is Formaldehyde

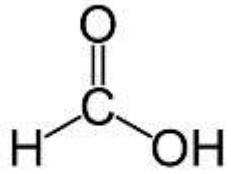
- Part of a group of single carbon organic molecules (simplest organic molecules)



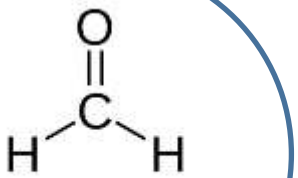
Methane



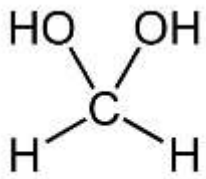
Methanol



Methanoic acid
(Formic acid)



Methanal
(Formaldehyde)



Methanediol

- Formaldehyde is the simplest carbohydrate but don't be fooled!

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Formaldehyde Properties & Uses

- **Some properties:**
- Boiling point: -19°C (gas at room temperature)
- Relative vapour density: 1.03 to 1.07 (air=1)
- Highly soluble in water (400g/l @ 20°C)
- Photo-oxidised in air (half life 1hr)
- **Common uses:**
- Precursor & cross-linking agent in building materials & consumer products
- Disinfectant & biocide
- Tissue fixative & embalming agent

Formaldehyde Hazards

- Irritation to eyes, skin & respiratory tract
- Skin sensitisation & contact dermatitis (prolonged exposure).
- May cause cancer by inhalation (Carcinogen category 1B)
- Suspected of causing genetic defects (Mutagen category 2)

Formaldehyde Sources

- **Sources include:**
- Solid wood
- Materials containing urea-formaldehyde or phenol-formaldehyde resins (such as fibreglass insulation, wood based panel products & floor coverings)
- Smoking
- Consumer products
- **Levels influenced by:**
- Age of the building
- Temperature & relative humidity
- Air exchange rate
- Weather & seasons

Formaldehyde – What's Safe

- 100 $\mu g/m^3$ is recommended to prevent sensory irritation in general population.
  - Sensory irritation to eyes >380 $\mu g/m^3$, 4hr
  - Conjunctival redness >600 $\mu g/m^3$, 4hr
  - Perception of odour >120 $\mu g/m^3$
- 210 $\mu g/m^3$ for protection of long term effects including cancer
- HSE Workplace Exposure Limit (10 min) - 2ppm (2,500 $\mu g/m^3$)

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Typical Domestic Formaldehyde Levels*

- BRE UK 1999 - 61.2 $\mu g/m^3$ mean, 171 $\mu g/m^3$ max
- GER ES IV Germany 2003-2006 – 47.7 $\mu g/m^3$, 68.9 $\mu g/m^3$ max
- EPOLIS Finland 41.4 $\mu g/m^3$ mean, 77.8 $\mu g/m^3$ max
- French Observatory 2003 -2005 – 46.7 $\mu g/m^3$ mean, 86.3 $\mu g/m^3$ max
- Canada 2005 - 29.5 $\mu g/m^3$ mean, $\mu g/m^3$ max
- Japan 1996 – 78 $\mu g/m^3$ mean, 600 $\mu g/m^3$ max
- Japan 2005 – 31 $\mu g/m^3$ mean, 300 $\mu g/m^3$ max

- Means are largely 95th percentile

*WHO Guidelines for Indoor Air Quality

Formaldehyde Mitigation

- **Source Control**
- Use low or formaldehyde free products, example wood-based panels:
  - Standard European Classification
    - E1 - <120 $\mu g/m^3$
    - E2 - >120 $\mu g/m^3$ <360 $\mu g/m^3$
  - Other Classifications
    - Range from 10 $\mu g/m^3$ to 50 $\mu g/m^3$

- **Formaldehyde Absorbent Materials**
- Keratin based materials such as sheep's wool are known to react and eliminate formaldehyde

What do UK Building Regulations say?

- **Approved Document D -Toxic Substances** (only makes reference to U-F foam insulation)
  "To reduce the risks to the health of persons in buildings formaldehyde fumes given off by urea formaldehyde foam should not penetrate to the occupied parts of buildings to an extent which gives rise to an irritant concentration"
- **Approved Document F – Means of Ventilation** - Source Control 4.30
  "A complimentary strategy for achieving good indoor air quality is to reduce the release of water vapour and /or air pollutants into the indoor air, i.e. source control. e control is not considered within the main guidance of the Approved Document owing to limited knowledge about emission of pollutants from construction and consumer products used in buildings and the lack of suitable labelling schemes for England and Wales. Some construction products such as glass, stone and ceramics are by their nature low emitters of air pollutants. Currently, some paints are labelled for volatile organic compound (VOC) content, and some wood-based boards (class E1, BS EN 13986:2004) are available with low formaldehyde emission. This allow suitable products to be chosen when good indoor air quality is a priority, but at the present time it is not practical to make an allowance for use of these products in ventilation requirements...."
  ref BRE Digest 464 (2002) for further information

Keratin

- Structure fibrous protein.
- Main component of hair, wool feathers.
- Sheep's wool insulation can absorb emissions from within the building fabric
- Sheep's wool floor coverings – high surface exposure to internal air
- Feather, hair or sheep's wool fillings
- Sheep's wool wall coverings & fabrics

Wool Uses

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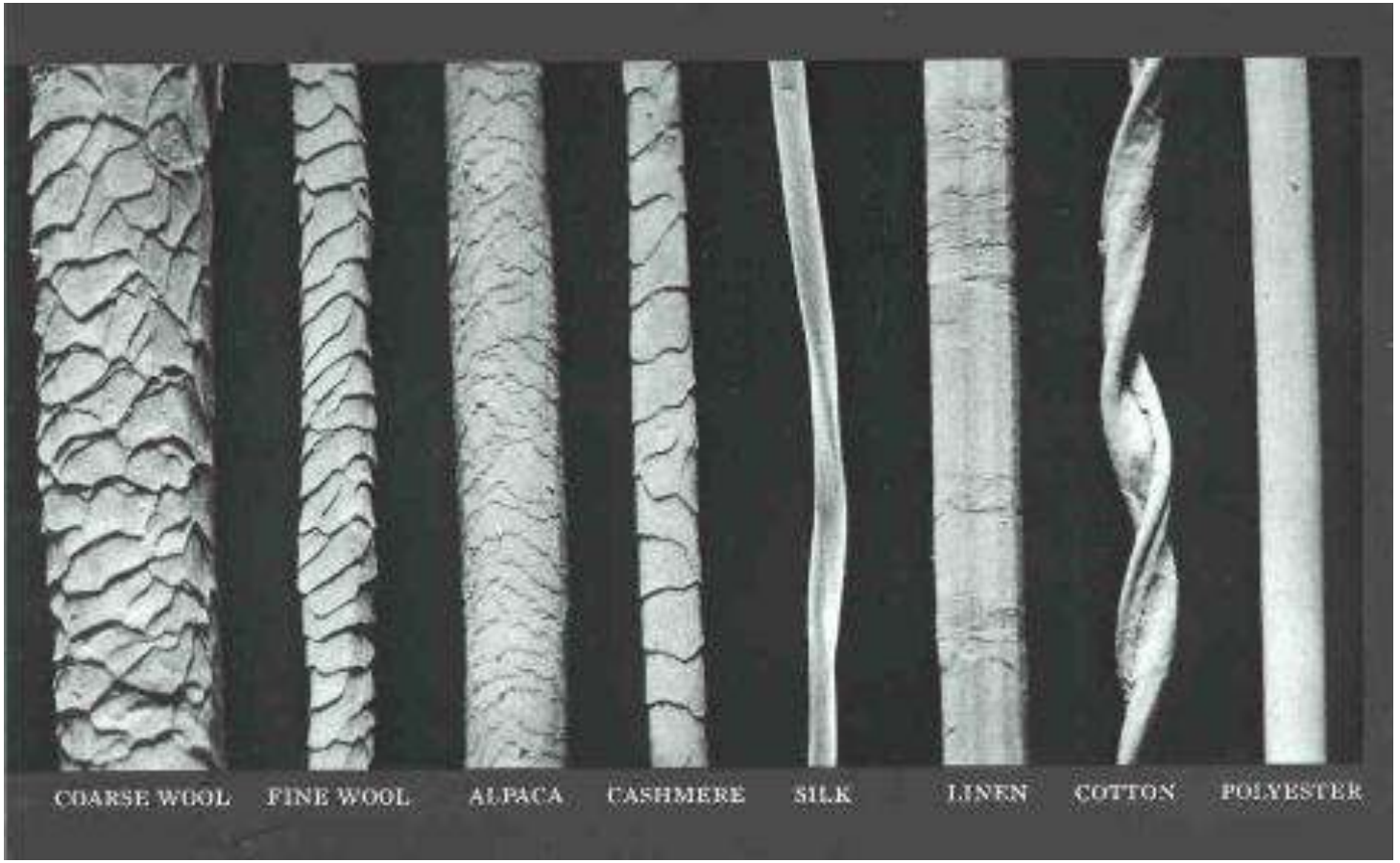
Sheep's Wool Under the Microscope

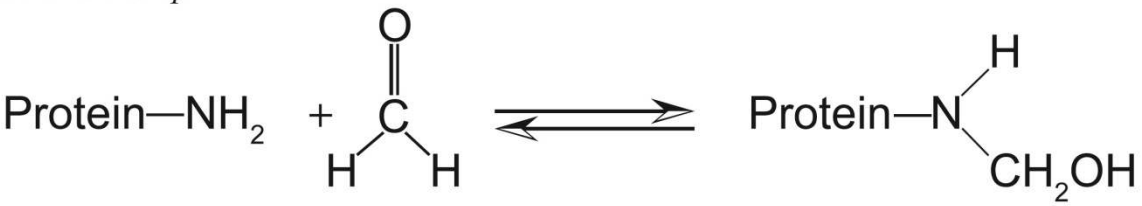


Protein – Formaldehyde Chemistry

- Proteins have a very complex chemistry
- Formaldehyde is known to react with proteins including keratin in many ways.
- Formaldehyde cross-links proteins and DNA which accounts for adverse health effects.
- Combination of reversible and irreversible reactions.
- Keratin formaldehyde reaction utilised to create shrink and crease resistance in wool

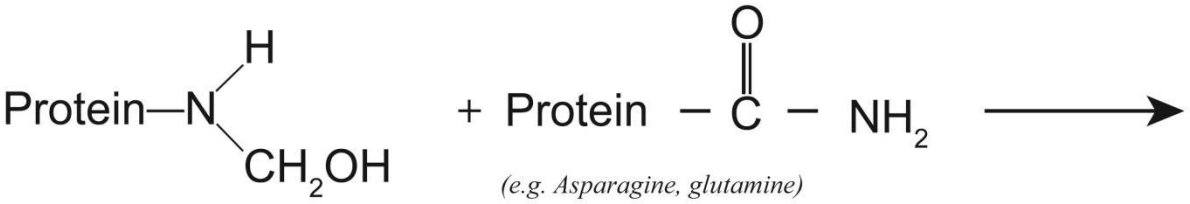
Reaction Scheme of Formaldehyde and Keratin Proteins

Reaction Step 1:

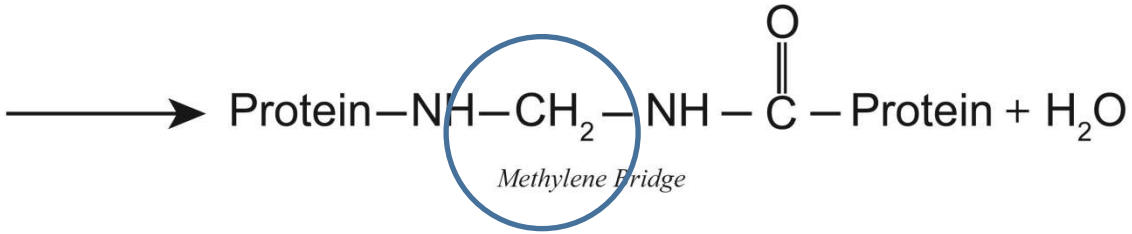


Aminomethyl derivative

Reaction Step 2 (condensation):



(e.g. Asparagine, glutamine)

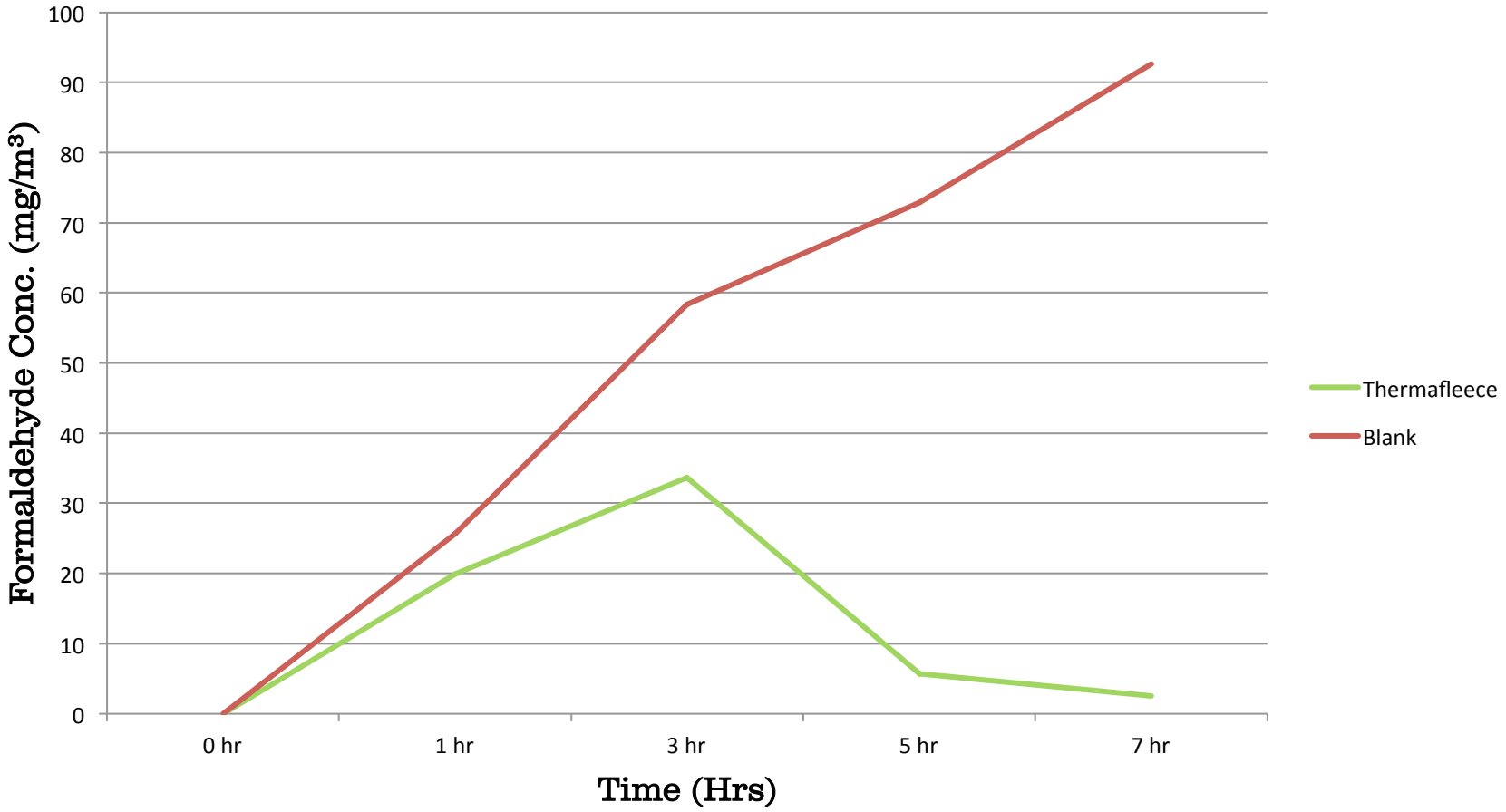


Methylene Bridge

Formaldehyde Absorption

- Thermafleece achieved a reduction from 90 mg/m3 to <3 mg/m3 Formaldehyde in 7 hrs with 10-15% desorption.
- WRONZ achieved reduction from 7mg/m3 to <0.1mg/m3 in 45 mins with no recorded desorption.
- In tests Thermafleece sheep's wool insulation absorbed 90mg formaldehyde per 1kg of insulation.

Formaldehyde Absorption Rate



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Prevention & Cure?

- Source control by using wool/keratin based materials inside and within the building fabric.
- Addition of wool based interior products including floor coverings in situations where elevated formaldehyde exists.
- Need to update our think and benchmark our current understanding or formaldehyde levels and mitigation measures.

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