

# Hair Analysis, An Innovative Biomonitoring Tool to Assess Tri-Cresyl-Phosphate (TCP) Exposure

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## Organophosphate Aircabin Contamination

- EASA study (2017) demonstrated **aircabin contamination with various organophosphate** compounds
  - Tri-Butyl-Phosphate (TBP) [Occ. 99-100% / up to 2.5  $\mu\text{g}/\text{m}^3$ ]
  - Tri-ChloroisoPropyl-Phosphate (TCPP) [Occ. 100% / up to 10  $\mu\text{g}/\text{m}^3$ ]
  - Tri-Phenyl-Phosphate (TPP) [Occ. 99% / up to 0.1  $\mu\text{g}/\text{m}^3$ ]
  - Tri-Cresyl-Phosphate (TCP) [Occ. 50-60% / up to 0.7  $\mu\text{g}/\text{m}^3$ ]
- **Flame retardant from lubricants** used in aircraft engines
- **Oil bleed from engine** to cabin indoor air
- Toxicological information:
  - Known **neurotoxic** compounds (cholinesterase inhibitor)
  - Some suspected to be **endocrine disruptors** (TBP & TPP) with low dose effects
  - **Acute toxicity** well documented vs. **Chronic toxicity** not sufficiently documented

## Exposure Assessment

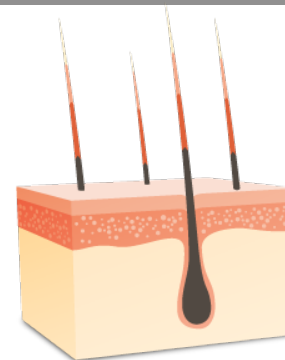
- Measurement of organophosphate in
  - environmental matrices (air / dust)
  - biological matrices (blood / urine) = **BIOMONITORING**
- Blood / Urine
  - Sampling by health professional [Blood]
  - Treatment, shipment and storage
  - Biohazard risks (VIH, Hepatitis ...)
  - Search for Parent compounds [Blood]  
vs Metabolite(s) [Urine]
  - Usually for acute exposure because  
of short detection windows: few hours [Blood]  
to few days [Urine]



**BLOOD OR URINE NOT SUITABLE  
FOR EASY BIOMONITORING**

## Hair Analysis

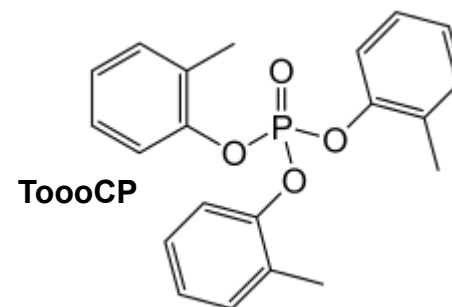
- Hair
  - Toxics in blood incorporate in hair structure during hair synthesis in scalp
  - Average growth speed: 1 cm / month
  - **Easy to Sample / Ship / Store**
  - Up to 6 months
  - Enable month by month history of exposure (cm by cm)
- Hair Analysis
  - R&D of analytical method financially supported by AVSA
  - Hair strand cut to monitor specific period
    - 0,5 to 3,5 months = 0 to 3 cm segment
  - Hairs **washed** to eliminate eventual external contamination
  - Hairs **grinded** to get fine powder
  - Accurate mass of hair powder **extracted** with organic solvents and analyzed using GC/MSMS technologies



## Monitored Chemicals and First Campaign

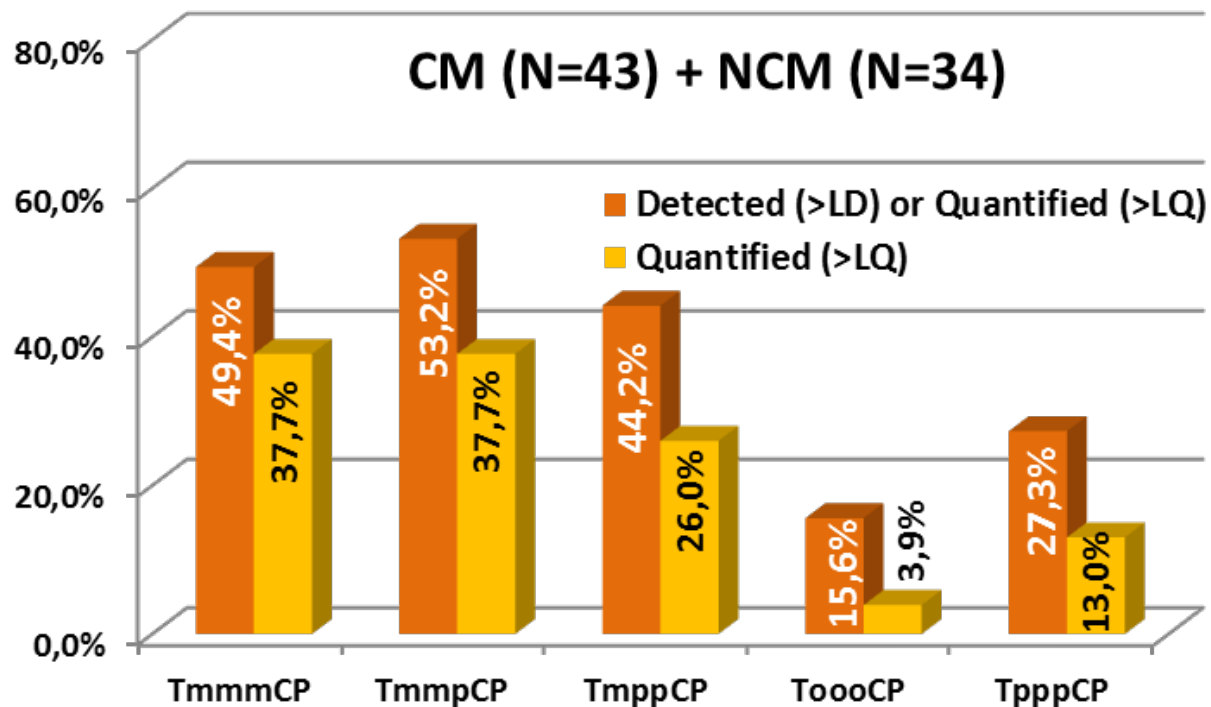
- 5 isomers of TCP out of 10 existing isomers
  - ToooCP + TmmmCP + TmmpCP + TmppCP + TpppCP

- Population studied: 81 subjects
  - 46 Crew Members (CM)
  - 35 Non Crew Members (NCM)



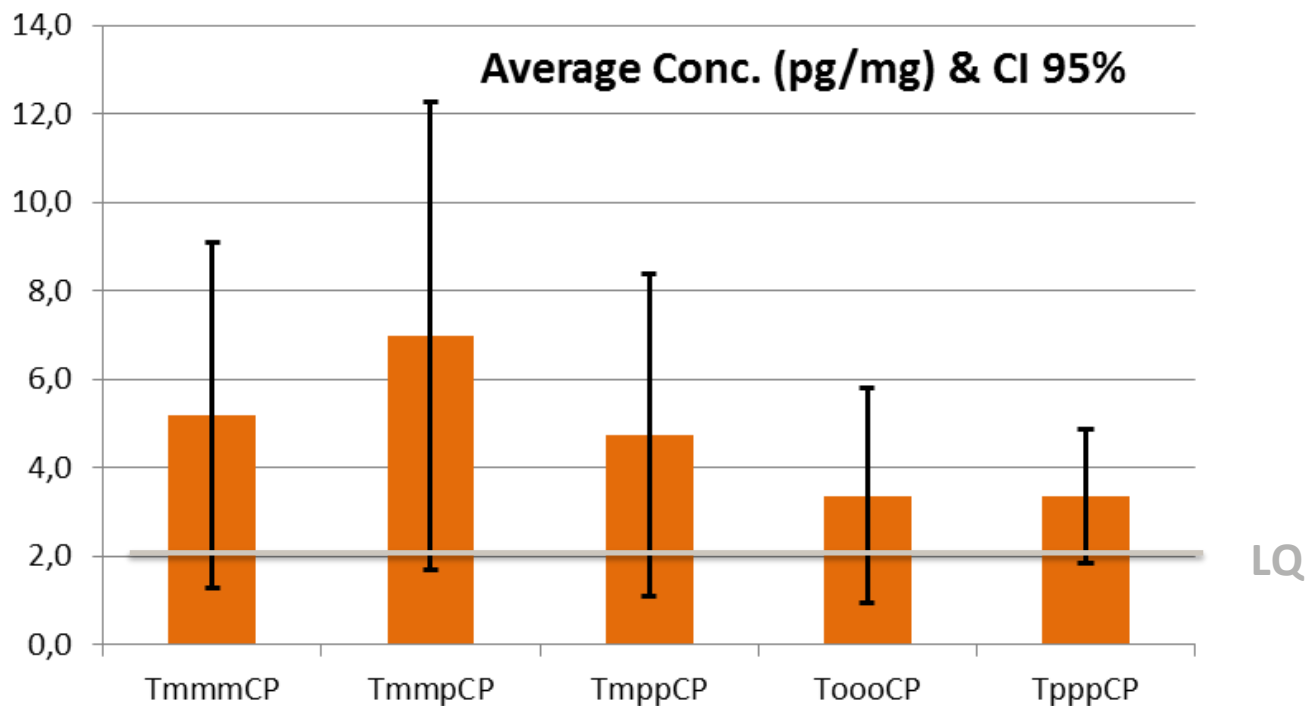
- Main Results
  - **4 samples with high concentration** = more exposed
    - 3 CM (6.5% of CM subjects)
    - 1 NCM (2.9% of NCM subjects)
  - For the 77 other samples
    - **Close exposure levels** for CM and NCM
    - **Close occurrence levels** for CM and NCM
    - Occurrence dependent of TCP isomer
      - TmmpCP = TmmmCP = TmppCP > TpppCP > ToooCP

## First Campaign Occurrence



- CM and NCM are exposed to TCP
  - *Environmental exposure hypothesis*
    - Origin of environmental contamination ?

## Mean Concentrations and 95% Confidence Interval



➤ Threshold value for over-exposure

Compound	TmmmCP	TmmpCP	TmppCP	ToooCP	TpppCP
Threshold [pg/mg]	9,1	12,3	8,4	5,8	4,9

## Evidences for Occupational Exposure

- Samples with high concentration = significant TCP exposure
- People with same environment should be tested for TCP
  - Wife / Husband
  - Children
- 2 samples from study have high TCP concentration
  - Wife / Husband were tested over the same time period
  - No TCP were detected in Wife/Husband sample
  - **Strongly suggest occupational exposure**
- More over-exposed case needs to be studied for identification of occupational and environmental exposure source(s)
  - *Is there a correlation between over-exposure with pathologies and symptoms of aerotoxic syndrom ?*



## Conclusion

- Development of an innovative tool to monitor TCP exposure over 1 to 6 months
  - *Hair test available on [www.syndrome-aerotoxique.com](http://www.syndrome-aerotoxique.com)*
- First biomonitoring campaign performed on 81 subjects
- Half of the subjects tested for TCP are positive and have been exposed to these chemicals
  - *Evidence for environmental exposure*
- Threshold values were determined and could be used to indicate excessive exposure
  - *Less than 10% of crew members are over-exposed to TCP*
  - *When over-exposed: wife/husband should be tested for TCP*
    - **Large difference between exposure levels strongly support occupational exposure hypothesis**

## Perspectives

- Raise funds to setup an international and large scale campaign to study organophosphate exposure among population and Crew Members
- Study links between exposure data and symptoms / pathologies in a clinical study
- Investigate the origin of the environmental exposure
  - *Daily environment pollution / Proximity to airport / Intensive aircraft traffic ?*
  - *TCP measurement in air and dust (outdoor and indoor)*
- Improve analytical methods to investigate other organophosphate compounds (TBP, TPP, TCP) found in indoor aircraft cabin
  - *Unlike TCP, these flame retardants are found in many daily used products and in many indoor environment*
- Development of easy blood test to investigate acute exposure

## Contact Information



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