

Synergistic exposure to noise and styrene and cochlear functionality in a sample of workers: preliminary results

Ricerca

Renata Sisto
30th International Congress on Occupational Health
Cancun, March 18 - 23, 2012

Introduction

The European Directive 2003/10/CE (protection of employees against the risks due to noise exposure) recommends of individuating and highlighting in the risk evaluation document the simultaneous exposure to noise and other ototoxic agents such as vibrations and EBTx organic solvents (styrene, toluene, xylene).

A quantitative criterion aimed at evaluating the risk due to possible synergistic interactions between different ototoxic risk factors is still missing.

Objective of this work is the study of the otoacoustic emissions as imaging of cochlear functionality in presence of simultaneous exposure to different ototoxic agents.

*Why the OAEs as biomarkers of exposure effect:
hearing functionality and OAEs*

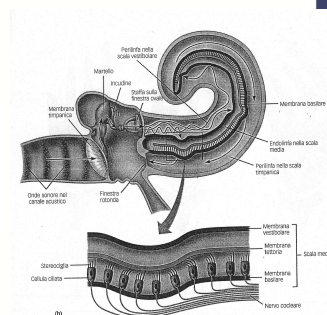
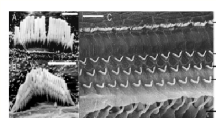
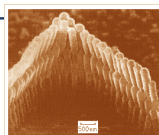
The hearing functionality is characterized by high sensitivity at the sound levels of the hearing threshold and by the response saturation at high stimulus level. The non linear amplification active feed back mechanism, providing the high sensitivity and sharp frequency resolution of the auditory system, is localized in the cochlea.

This active filter is localized in the cochlear outer hair cells (OHCs).

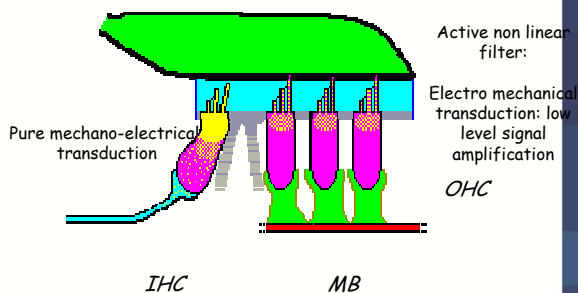
OHCs are the first part of the auditory system to be damaged by high level noise exposure.

The cochlear active filter produces otoacoustic emissions, whose characteristics are very sensitive to small variations of the cochlear filter parameters.

Inner ear (cochlea)

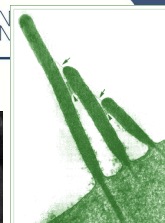
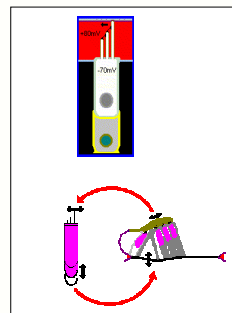


The outer hair cells (OHC)



<http://147.162.36.50/cochlea/cochleapages/theory/main.htm>

The outer hair cells (OHC)



Active non linear filter:

Electro mechanical transduction: low level signal amplification

Methods (DPOAE)

- The preliminary results of an experimental campaign are presented. Data have been collected in a factory of glass reinforced plastic products close to Perugia in the Centre of Italy.
- The cochlear functionality was monitored at the beginning and at the end of the work shift in a sample of exposed workers by means of tests based on the registration of otoacoustic emissions.
- Both transiently evoked otoacoustic emissions (TEOAEs) and distortion products otoacoustic emissions (DPOAEs) have been measured by means of the portable ILO292 (Otodynamics, Ltd) system.

Metodi (DPOAE)

The DPOAEs at the frequency $2f_1-f_2$ have been collected with a primaries ratio $f_2/f_1=1.22$, and an amplitude ratio $A_1-A_2=10\text{dB}$, in the range 1000-6400 Hz, with one third of octave frequency resolution.

The considered variable is the amplitude, in dB, of the response at the frequency $2f_1-f_2$ as function of the f_2 stimulus frequency.

The main generation region of the apical distortion product ($2f_1-f_2$) is supposed to be the f_2 tonotopic place where it is maximum the overlapping between the envelopes of the activity patterns of f_1 and f_2 .

Methods: biological monitoring

The biological monitoring in urine matrix consisted in the determination of the urinary concentrations of the mandelic acid (MA) and of the phenylglyoxylic acid (PGA) that are the main oxydative metabolic products of the styrene.

The technique which was set up in order to determining these styrene metabolites uses the HPLC/MS/MS and isotopic dilution.

The ACGIH suggests as biological limit value (BEI) for these metabolites a total concentration (MA + PGA) of 400 mg/g of creatinine in the end shift urine sample.

Methods: styrene exposure evaluation

The biological monitoring also consisted in measuring the styrene concentration in saliva with a method based on GC/MS

The personal ambiental exposure was also evaluated by means of passive samplers (Radiello) and controlled flux e pompe a flusso controllato.

ACGIH limit exposure value:
TLV-TWA = 20 ppm (85.2 mg/m³)

METHODS

Also dosimetric evaluations of noise exposure have been performed by means of wearable phonometers Larson Davis model 805A. The exposed employees were monitored during the whole working shift.



The exposed sample

The occupationally exposed subjects were divided in two main groups:

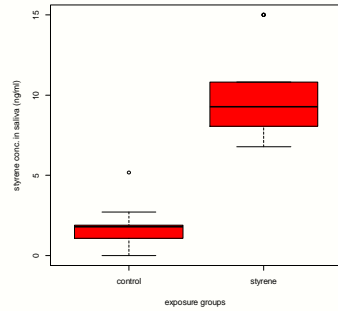
- 1) the group "**noise&styrene**" to which subjects exposed to high levels of noise
(average Lex,8h = 87.7 dBA, Lex,8h,max = 88 dBA e Lex,8h,min = 86.7 dBA)
and relatively low styrene concentrations belong
- 2) the group "**styrene**". In this group the subjects are exposed to moderate levels of noise
(average Lex,8h = 83 dBA, Lex,8h,max 84.2 dBA e Lex,8h,min = 80.7 dBA)
and high styrene concentrations.

Results

30th International Congress on Occupational Health
Cancun, March 18 – 23, 2012

INAIL

Boxplot of the variable styrene concentration in saliva
in exposed and control groups



The difference between the styrene group and the controls resulted statistically significant
Welch Two Sample t-test $p = 2.39E-05$

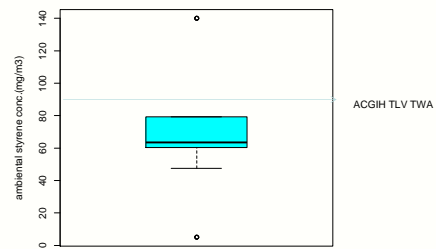
Occupational Hygiene Department - ex IPESL

Results

30th International Congress on Occupational Health
Cancun, March 18 – 23, 2012

INAIL

Boxplot of the variable styrene concentration measured
by Radiello personal samplers



Occupational Hygiene Department - ex IPESL

Results

30th International Congress on Occupational Health
Cancun, March 18 – 23, 2012

INAIL

| | PGA+MA conc (mg/g of creatinine) | Average | max | min | standard dev |
|-----------------------|----------------------------------|---------|-------|------|--------------|
| Group "styrene" | Shift beginning | 62.6 | 93.3 | 30.7 | 19 |
| | Shift end | 107.1 | 162.6 | 43 | 42 |
| Group "styrene&noise" | Shift end | 6.2 | 3.7 | 8.7 | 2.6 |
| controls | | 2.0 | 17.3 | 0.1 | 4.9 |

Very high levels of styrene metabolites concentration in the group "styrene"
about 10% lower in the group "styrene&noise"

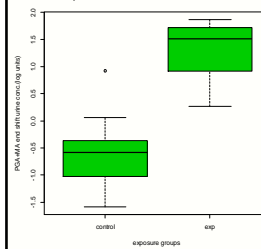
Occupational Hygiene Department - ex IPESL

Results

30th International Congress on Occupational Health
Cancun, March 18 – 23, 2012

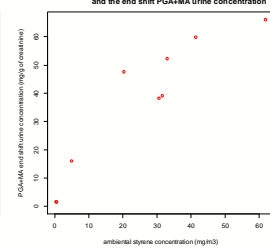
INAIL

Boxplot of the PGA+MA end shift urine concentration



Welch Two Sample t-test
 $p\text{-value} = 4.314e-05$

Correlation between the ambient styrene
and the end shift PGA+MA urine concentration



$R^2 = 0.86$

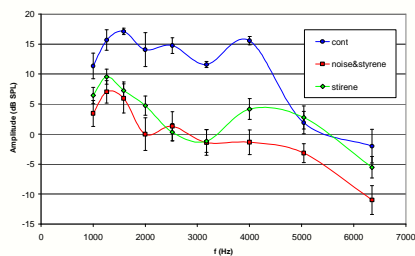
Occupational Hygiene Department - ex IPESL

Results

30th International Congress on Occupational Health
Cancun, March 18 – 23, 2012

INAIL

Comparison between DP in different exposure groups



DP amplitude at varying of the primary stimulus f_2 frequency in one third of octave bands.
The averaged data are shown relative to the groups 1) 2) and to the controls

Occupational Hygiene Department - ex IPESL

The exposed sample

30th International Congress on Occupational Health
Cancun, March 18 – 23, 2012

INAIL

In order to avoid confounding factors coming from previous exposure conditions, a sample has been selected inside the group "styrene":

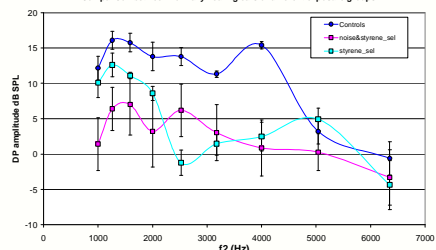
2a) group "styrene_sel": normally hearing subjects ($PTA = 20$ dB HL in the whole range 1-6 kHz), with occupational exposure duration $T_{exp_life} < 10$ years and current noise exposure level $Le_{x,8h,max} \leq 81$ dBA. Analogously inside the group "noise&styrene" the following sample has been selected:

1a) group "noise&styrene_sel": normally hearing subjects ($PTA = 20$ dB HL in the whole range 1-6 kHz), with occupational exposure duration $T_{exp_life} < 10$ years, with steady exposure conditions during the whole working life.

Occupational Hygiene Department - ex IPESL

Results

Comparison between normally hearing ears of different exposure groups



DP amplitude at varying of the primary stimulus f2 frequency in one third of octave bands. Only the comparison between normally hearing according to the standard audiometry based criterion groups of exposed is shown.

Occupational Hygiene Department - ex IPESL

Results

Result of a Student's test (significance criterion $p < 0.05$) relative to the comparison between the different exposure groups.

| f2 (Hz) | 1000 | 1260 | 1587 | 2000 | 2520 | 3175 | 4000 | 5040 |
|-----------------------------------|----------|----------|----------|----------|----------|----------|----------|------|
| t-test Cont.- "noise&styrene_sel" | 0.028343 | 0.017021 | 0.08862 | 0.085507 | 0.087583 | 0.075677 | 0.007953 | n.s. |
| t-test Cont.- "styrene_sel" | n.s. | n.s. | 0.027998 | 0.077849 | 0.000113 | 0.001195 | 0.001038 | n.s. |

The comparison between "noise&styrene_sel" and "styrene_sel" groups resulted not statistically significant in the whole frequency range

Occupational Hygiene Department - ex IPESL

Conclusions

The subjects belonging to the group "styrene" are exposed to styrene concentrations often very close if not higher than the TLV-TWA of 20 ppm (85.2 mg/m³). The urine concentrations of the styrene metabolites are also close to the ACGIH BEI index.

The tests based on otoacoustic emissions are capable of discriminating at a statistically significant level the exposed from the control subjects both in the case in which the major exposure is due to styrene, as in the group "styrene" and in the case in which the major exposure is due to noise.

The discrimination can be defined as sub-clinical and early with respect to the ipoacusia as the differences between exposed and controls are statistically significant also in the case in which in the exposed group only the ears with an hearing threshold level better than 20 dB HL in the whole range of audiometric frequencies have been selected.

Occupational Hygiene Department - ex IPESL